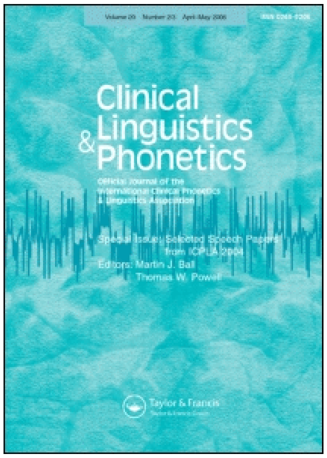

Clinical Linguistics & Phonetics
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713693308

Crosslinguistic semantic and translation priming in normal bilingual individuals and bilingual aphasia

To cite this Article: , 'Crosslinguistic semantic and translation priming in normal bilingual individuals and bilingual aphasia', Clinical Linguistics & Phonetics, 21:4, 277 - 303
To link to this article: DOI: 10.1080/02699200701243873
URL: http://dx.doi.org/10.1080/02699200701243873

Clinical Linguistics & Phonetics, April 2007; 21(4): 277–303

Crosslinguistic semantic and translation priming in normal bilingual individuals and bilingual aphasia

SWATHI KIRAN & KEITH R. LEBEL

Department of Communication Sciences and Disorders, University of Texas at Austin, USA

(Received 31 August 2006; Accepted 25 January 2007)

Abstract
The present study examined lexical representation in early Spanish-English bilinguals using an unmasked semantic and translation priming paradigm. In Experiment 1, participants were divided into two groups based on performance (more-balanced bilinguals, MB and less-balanced bilinguals, LB) on the experimental task. In Experiment 2, four patients with bilingual aphasia (BA) performed the same experiment. Results from both experiments revealed that all groups were more accurate for English targets (S-E direction) than Spanish targets (S-E direction). In Experiment 1, semantic priming was observed from English to Spanish in both the LB and MB groups although the effect was greater for the LB group. Further, only the LB group showed priming from Spanish to English. For both normal groups, there was no difference between translation and semantic priming effects. In Experiment 2, patients with bilingual aphasia demonstrated different patterns of activation with no clear trends. Two participants demonstrated greater priming from Spanish to English whereas two participants demonstrated the opposite effect.

Keywords: *Bilingual aphasia, translation, semantic, language proficiency*

Introduction

Approximately one-half (Grosjean, 1994) to two-thirds (Walraff, 2000) of the world is bilingual. A large number of research studies in bilingualism have aimed to understand whether a bilingual's words and concepts are represented in one shared memory store or separate memory stores (Altarriba, 1992; Fox, 1996; Keatley, 1992).

Two early models were proposed by Potter, So, Von Eckardt, and Feldman (1984) to understand the nature of a bilingual's semantic memory (see Figure 1a). In the Word Association Model, lexical representations from Language 1 are directly linked to the conceptual system whereas, the words of Language 2 are connected only to Language 1 and have no direct connections to the conceptual system. An alternate model called the Concept Mediation Model suggests that representations of the two languages are not directly connected. Instead the two language representations operate as separate systems that each directly connect to the amodal conceptual system (see Figure 1b). To test these two models, Potter and colleagues compared picture naming in L2 relative to L1 to L2

Correspondence: Swathi Kiran, CMA 7.210, Department of Communication Sciences & Disorders, University of Texas at Austin, Austin, TX 78712, USA. Tel: +1 512 232 3440. Fax: +1 512 471 2957. E-mail: s-kiran@mail.utexas.edu

ISSN 0269-9206 print/ISSN 1464-5076 online
DOI: 10.1080/02699200701243873

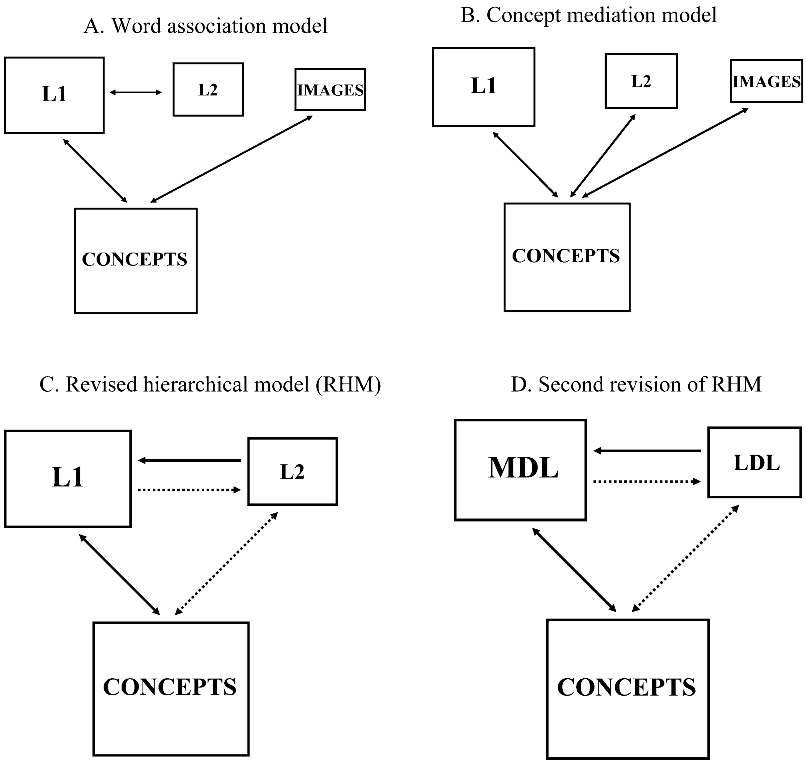

Figure 1. Schematic descriptions of four models of semantic memory. (a) The Word Association Model (Potter et al., 1984), (b) Concept Mediation Model (Potter et al., 1984), (c) Revised Hierarchical Model (RHM) (Kroll & Stewart, 1994), and (d) Second Revision of the RHM (Heredia, 1995; 1996).

translations. Results revealed that the times to translate and to name pictures in L2 were very similar, thus providing support for the concept mediation model. Kroll and Curly (1988), in a similar task observed evidence for the word association model in low proficiency bilinguals but for the concept mediation model in high proficiency bilinguals.

The Revised Hierarchical Model (RHM) (Kroll & Stewart, 1994) stemmed from studies that found asymmetrical translation and semantic priming effects which appeared to support both the word association and concept mediation models. According to this model, in less proficient bilinguals, L1 consists of a lexical store that is more developed than that of L2, and L1 has a very strong link to the conceptual system (see Figure 1c). L2 consists of a less well-developed lexical store and has a weaker link to the conceptual system. Furthermore, the link between the lexical stores of L1 and L2 may also be asymmetrical in that the connection from L2 to L1 is stronger than from L1 to L2. This notion is supported by studies that have found faster L2-L1 translation than vice versa (Kroll & Stewart, 1994; Sholl, Shankaranarayanan, & Kroll, 1995). The RHM was further refined by Heredia (1995, 1996) who studied translation in highly proficient Spanish-English bilinguals. Heredia proposed a Second Revision (R-2) of the Revised Hierarchical Model where emphasis is shifted from the chronological order in which languages were learned to relative language dominance. L1 is, thus, replaced by "Most Dominant Language" (MDL) and L2 by "Least Dominant Language" (LDL) (see Figure 1d).

Semantic priming in bilinguals

To understand whether a bilingual's semantic representations are linked across the two languages researchers have frequently used the semantic priming method. Semantic priming is based on the premise that, upon presentation of a word, the corresponding concept (represented as a node) and associated conceptual nodes are automatically accessed. Semantic priming effects are interpreted within the framework of spreading activation (Collins & Loftus, 1975) which suggests that when a conceptual node is accessed, activation automatically spreads throughout the network to surrounding nodes thereby increasing the chance of related nodes to also become activated. The semantic paradigm has been successfully adapted for use in studies with bilinguals. In these studies, the presentation of related (semantically related or translation equivalents) and unrelated words is varied across languages and language direction. For example, the words *dog* (*perro* in Spanish) and *cat* (*gato* in Spanish) are semantically related. The pair might be presented as *dog-gato* (semantically related, English to Spanish) or *perro-cat* (semantically related, Spanish to English) to examine crosslinguistic semantic priming. Alternatively, translation pairs such as *dog-perro* (*dog* in Spanish) can also be generated across both language directions.

Of the studies reviewed several have examined the nature of crosslinguistic and semantic priming in normal bilingual adults. There are several methodological aspects fundamental to interpreting crosslinguistic priming studies (the reader is referred to Altarriba and Basnight Brown (in press) for a detailed review). These include (a) the age of language acquisition, (b) the procedures for determining language proficiency, (c) inclusion/exclusion of cognates, (d) the nature of control stimuli, and finally (e) stimulus issues that overlap with monolingual studies such as word frequency, word length, and stimulus onset asynchrony.

Some investigations used bilinguals who acquired L2 sometime between childhood and adulthood (Chen & Ng, 1989; Kirsner et al., 1984) while others studied those who learned L2 during adulthood (Frenck & Pynte, 1987; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Meyer & Ruddy, 1974; Williams, 1994). A number of cross language studies included participants who learned both languages from birth or at a very young age (Altarriba, 1992; Gollan, Forster, & Frost, 1997; Grainger & Beauvillain, 1988; Jin, 1990; Keatley & de Gelder, 1992; Keatley, Spinks, & de Gelder, 1994; Larsen, Fritsch, & Grava, 1994; Schwanenflugel & Rey, 1986; Tzelgov & Eben-Ezra, 1992). The method for determining language proficiency has also been varied. Most proficiency data across studies was derived from self-ratings, although other studies used objective measures (e.g. reading comprehension testing, the TOEFL, or reading rate measurements) in addition to self-ratings to assess relative language abilities of participants (Jiang, 1999; Keatley et al., 1994; Schwanenflugel & Rey, 1986).

Cognates have typically been avoided in crosslinguistic priming studies (Frenck & Pynte, 1987; Keatley et al., 1994; Kirsner et al., 1984; Larsen et al., 1994; Schwanenflugel & Rey, 1986; Williams, 1994). However, some of the studies reviewed did not specifically state whether cognates were included or excluded from stimuli (e.g. Grainger & Beauvillain, 1988; Keatley & de Gelder, 1992; Meyer & Ruddy, 1974). The nature of control stimuli used across studies is also varied. Some investigators used related vs. unrelated word pairs as a basis of comparison (Chen & Ng, 1989; Grainger & Beauvillain, 1988; Keatley & de Gelder, 1992; Keatley et al., 1994; Kirsner et al., 1984; Larsen et al., 1994; Meyer & Ruddy, 1974; Tzelgov & Eben-Ezra, 1992; Williams, 1994) while others used neutral targets, such as "XXXXX" (Keatley et al., 1994, Experiment 1; Schwanenflugel & Rey, 1986). Providing further variation, one study compared prime-target reaction times to target-only reaction times (Frenck & Pynte, 1987).

In addition to methodological issues specific to bilingual research, several procedural issues relevant to monolingual semantic priming also apply to crosslinguistic semantic priming studies. For instance, stimulus word length and word frequency influence the nature of word recognition. Some of the studies reviewed either were not successful (Chen & Ng, 1989) or did not report whether word length was controlled (de Groot & Nas, 1991; Jin, 1990; Larsen et al., 1994; Tzelgov & Eben-Ezra, 1992).

To minimize the expectancy generated by viewing two related stimuli during the priming task, there are three constraints that can be imposed on the stimuli. First, the nonword ratio (the ratio of nonwords to all trials in the stimulus set) should ideally hover around .50. In the studies reviewed, some studies achieved the optimal ratio of .50 (Gollan et al., 1997; Keatley & de Gelder, 1992; Keatley et al., 1994; Schwanenflugel & Rey, 1986; Williams, 1994) whereas others were much higher (i.e. .67–.75) (Chen & Ng, 1989; Frenck & Pynte, 1987; Meyer & Ruddy, 1974; Tzelgov & Eben-Ezra, 1992; Williams, 1994). Likewise, the relatedness proportion (ratio of related trials to all trials in the stimulus set) is optimally kept at a minimum in order to avoid development of a strategy/expectancy during the semantic priming task. Three studies reported using RPs of .25 or lower (Grainger & Beauvillain, 1988; Keatley & de Gelder, 1992; Keatley et al., 1994) while other studies used very high RPs (Chen & Ng, 1989; Frenck & Pynte, 1987). Finally, the stimulus onset asynchrony (SOA), the time interval between the onset of the prime and the target, used in this body of literature is varied (see Tables I and II).

Not surprisingly, of the approximately 20 studies that have investigated crosslinguistic semantic and translation priming in bilinguals, the results are quite variable. Among the crosslinguistic semantic priming literature reviewed (see Table I), there are no clear effects of language direction on crosslinguistic semantic priming in early (highly proficient) bilinguals in that half of experiments reported significant priming in the L1-L2 direction and a little over half also reported significant semantic priming effects in the L2-L1 direction. This trend suggests that early bilinguals might be indifferent to language direction effects as a group. Further supporting this notion is the fact that very few studies with early bilinguals found asymmetrical semantic priming effects (significant effects only in one language direction). For late bilinguals, the effect of language direction is less clear, although one might tentatively conclude that L1-L2 semantic priming is more robust than L2-L1 priming.

As for translation priming (see Table II) in early bilinguals, all experiments reviewed reported significant translation priming in the L1-L2 direction while only one-third found significant translation priming in the L2-L1 direction. The trends are similar in late bilinguals, i.e. robust L1-L2 priming and less consistent L2-L1 priming. Overall, the translation priming data suggest that L1-L2 priming is very robust and that early and late bilinguals process L1 primes in a similar way but what differentiates the two groups is performance in processing L2 primes.

A recent experiment by Basnight Brown and Altarriba (in press) took into account methodological considerations proposed by Altarriba and Basnight-Brown (in press) to examine translation and semantic priming in highly proficient Spanish-English bilinguals. For instance, cognates were excluded from the stimuli, a short SOA was used, an ideal NWR (.50) and RP (.23) were used, and words were controlled for length and frequency. In their first experiment (which will be the only experiment discussed here as the second experiment used masked priming, which is not of interest in the present study), semantic and translation priming were studied in 24 Spanish (L1)-English (L2) bilinguals using an unmasked priming paradigm with an SOA of 150ms and a lexical decision task. Significant translation priming was reported for both language directions and significant semantic priming only in the L2 (English)-L1 (Spanish) direction. Furthermore, translation effects

Table I. Summary of crosslinguistic semantic priming studies.

Crosslinguistic Semantic Priming			
Early Bilinguals	SOA	L1-L2	L2-L1
Basnight Brown & Altarriba (in press) Exp 1	150	N	Y
Basnight Brown & Altarriba (in press) Exp 2	100	N	N
Grainger & Beauvillain (1988) Exp 2	150	N	N
Grainger & Beauvillain (1988) Exp 2	750	N	Y
Keatley & de Gelder (1992) Exp 1	200	Y	Y
Keatley & de Gelder (1992)Exp 2	200	N	N
Keatley & de Gelder (1992) Exp 3	200	N	N
Keatley, et al. (1994) Exp 1	2000	N	N
Keatley, et al. (1994) Exp 1	250	N	N
Keatley, et al. (1994) Exp 2	200	Y	N
Kirsner et al. (1984) Exp 4 "unbalanced"	0	N	Y
Kirsner et al. (1984) Exp 4 "balanced"	0	Y	Y
Chen & Ng (1989) Exp 1	300	Y	Y
Chen & Ng (1989) Exp 2	300	Y	Y
Meyer & Ruddy (1974)	0	Y	Y
Schwanenflugel & Rey (1986) Exp 1	300	Y	Y
Schwanenflugel & Rey (1986) Exp 2	100	Y	Y
Late Bilinguals	SOA	L1-L2	L2-L1
Frenck & Pynte (1987) "Skilled"	500	N	N
Frenck & Pynte (1987) "Less Skilled"	500	Y	Y
Grainger & Beauvillain (1988) Exp 1	150		N
Grainger & Beauvillain (1988) Exp 1	750		Y
Jin (1990) Exp 1	150	Y	N
Kirsner et al. (1984) Exp 5	4500	Y	Y
Williams (1994) Exp 1a	728	Y	
Williams (1994) Exp 1b	720	Y	
Williams (1994) Exp 2a	50	Y	
Williams (1994) Exp 2d	240	Y	
Williams (1994) Exp 2c	50	N	
Varied Bilinguals	SOA	L1-L2	L2-L1
Larsen et al. (1994)	250	N	
Tzelgov & Eben-Ezra (1992) Exp 1	240	Y	Y
Tzelgov & Eben-Ezra (1992) Exp 1	840	Y	Y
Tzelgov & Eben-Ezra (1992) Exp 2	240	Y	Y
Tzelgov & Eben-Ezra (1992) Exp 2	840	Y	Y

Note: Blank cells indicate that the specific priming was not evaluated in that study. Exp: Experiment.

were larger than semantic priming effects. The authors suggested that most of their participants were more dominant in their L2 (English) than L1 (Spanish) at the time of the experiment. The results would then support others who have found priming from the dominant language to the less dominant language and are consistent with the Revised Hierarchical Model (Kroll & Stewart, 1994).

Rationale for current study

The present experiment aimed to replicate the findings of Basnight Brown and Altarriba (in press) by examining a more varied group of normal bilingual individuals and by extending

Table II. Summary of crosslinguistic translation priming studies.

Crosslinguistic Translation Priming			
Early Bilinguals	SOA	L1-L2	L2-L1
Altarriba (1992)	200	Y	N
Altarriba (1992)	1000	Y	Y
Gollan et al. (1997) Exp 1	50	Y	
Gollan et al. (1997) Exp 2	50	Y	
Gollan et al. (1997) Exp 3	50		N
Gollan et al. (1997) Exp 4	50		N
Chen & Ng (1989) Exp 1	300	Y	Y
Basnight Brown & Altarriba (in press) Exp 1	150	Y	Y
Basnight Brown & Altarriba (in press) Exp 2	100	Y	Y
Keatley & de Gelder (1992) Exp 4	200	Y	Y
Keatley et al. (1994) Exp 3	200	Y	Y
Grainger & Frenck-Mestre (1998) -LD	13		N
Grainger & Frenck-Mestre (1998) -LD	27		N
Grainger & Frenck-Mestre (1998) -LD	42		N
Grainger & Frenck-Mestre (1998) -LD	56		Y
Grainger & Frenck-Mestre (1998) -SC	13		Y
Grainger & Frenck-Mestre (1998) -SC	27		Y
Grainger & Frenck-Mestre (1998) -SC	42		Y
Grainger & Frenck-Mestre (1998) -SC	56		Y
Late Bilinguals	SOA	L1-L2	L2-L1
Jiang (1999) Exp 2	50	Y	N
Jiang (1999) Exp 3	100		N
Jiang (1999) Exp 4	250		N
Jiang (1999) Exp 5	250		N
de Groot & Nas (1991) Exp 3	60	Y	
de Groot & Nas (1991) Exp 3	240	Y	
Jiang (1999) Exp 1	50	Y	Y
Jin (1990) Exp 1	150	Y	Y
Williams (1994) Exp 2b	50	Y	

Note: Blank cells indicate that the specific priming was not evaluated in that study. Exp: Experiment, LD: Lexical decision, SC: Semantic Categorization.

this paradigm to patients with bilingual aphasia. Since Basnight Brown and Altarriba examined highly proficient bilinguals in their experiment, the present study differed from Basnight Brown and Altarriba's study in that participants were divided into two groups based on performance on the experimental task. This procedure allowed the specific examination of the role of language proficiency on crosslinguistic priming. Therefore, we predicted that less proficient bilinguals would benefit more from the primes (i.e. demonstrate greater priming effects) than more proficient bilinguals. Another perspective of semantic priming and corresponding lexical representation can be obtained from the study of bilingual aphasia. Whereas performance of monolingual patients with aphasia during semantic priming tasks has been extensively detailed, it is not clear how patients with bilingual aphasia perform on crosslinguistic semantic priming tasks and what variables potentially influence this process. We have previously examined semantic priming of concrete and abstract words in one individual with bilingual aphasia (Kiran & Tuchtenhagen, 2005). Results suggested a systematic deterioration of the normal bilingual system when compared to normal bilinguals. Specifically, the patient with aphasia performed worse on abstract words than concrete words in comparison to controls. Therefore, it is possible that patients with bilingual aphasia have similar semantic representations as normal individuals but the degree of lexical activation to these items is impaired. Alternatively, it is possible that brain damage results in selective loss to one or more aspects of lexical representation in bilingual individuals, which again, has implications for normal bilingual lexical semantic representations. To address these issues two experiments were conducted. In Experiment 1, 24 normal English-Spanish bilingual adults completed a lexical decision task examining semantic and translation priming. In Experiment 2, four patients with bilingual aphasia completed the same task with slight modifications in the procedures.

Experiment 1

The aim of Experiment 1 was to examine crosslinguistic semantic and translation priming during a lexical decision task in normal English-Spanish bilingual individuals. The research questions were: (a) what effect, if any, does language proficiency have on accuracy and reaction times on the priming task? It was predicted that proficient bilinguals will benefit equally from primes in each language while less proficient bilinguals will show greater priming asymmetry than proficient bilinguals, (b) what effect does language direction have on semantic and translation priming in Spanish-English bilinguals? Based on the literature discussed above, it was predicted that priming effects will be greater from English-Spanish than from Spanish-English, and (c) are there differences in the magnitude of priming between translation (e.g. *perro-dog*) and semantic priming (e.g. *perro-cat*)? Based on Basnight Brown and Altarriba's findings, it was predicted that the magnitude of translation priming effects will be greater than the magnitude of semantic priming effects.

Methods

Participants

Twenty-four Spanish-English bilingual individuals participated in this experiment. Participant ages ranged from 18 to 60 years, with a mean age of 26.1 years (SD=12.3). All participants were right handed. The average length of education was 16.2 (SD=2.3) years. All were of Mexican origin. There were equal number of males and females. Participants had normal or corrected-to-normal vision and no known reading or learning disorder. All participants had unremarkable neurological and medical histories.

Language profiles

To collect demographic information, participants were asked to fill out a language use and language history questionnaire rating their current language abilities that were adapted from Muñoz, Marquardt, and Copeland (1999). Of interest was what languages were used at home, in social situations, at work and in what modalities. The average age of acquisition was .0 (SD=.0) years for Spanish and 3.0 (SD=2.8) years for English. The definitions of the highest and lowest rating points on the scale were adapted from Muñoz et al.; however; a 10-point scale was used instead of the original 7-point scale (Basnight Brown & Altarriba, in press). A rating of 1 represented non-fluent (only knowing several words or a few simple sentences) and a rating of 10 indicated native or near-native fluency (completely comfortable like a native speaker). In order to characterize language proficiencies further, the ratings for speech and comprehension provided in the interviews were used to calculate a bilingual proficiency ratio (BPR) (Proficiency ratio=Average Spanish rating/Average English rating). The BPR for each participant was compared against those reported previously in normal Spanish-English bilinguals who fell into one of three proficiency groups: English dominant, Spanish dominant, or relatively balanced (Edmonds & Kiran, 2004). As can be seen from Table III, even though all participants acquired both languages before the age of 5 years, most rated themselves as being more proficient in English than in Spanish.

Word pairs

To answer the research questions of this study, two principal prime-target relationships were developed: crosslinguistic semantically related pairs and translation pairs. Forty critical words were used as the foundation for building all critical word pairs. Each word was paired with a semantically related word to form 40 semantically related (SR, e.g.

Table III. Accuracy performance on experimental task for English-Spanish (E-S), Spanish-English (S-E) and the difference between the two. Also illustrated are self ratings on the language use questionnaire in Spanish, English and the difference between those two scores. The BPR is shown for each participant (see text for details). Group assignments are based on difference scores on accuracy (see text for details).

	Accuracy Performance			Self-Ratings				
#	E-S	S-E	Diff	Sp Ave	Eng Ave	Diff	BPR	Group
1	77.1%	95.2%	18.1%	8.8	10.0	1.2	.88	MB
2	81.9%	96.4%	14.5%	7.8	10.0	2.2	.78	MB
3	73.5%	88.0%	14.5%	8.2	10.0	1.8	.82	MB
4	65.1%	91.6%	26.5%	3.7	9.3	5.7	.40	LB
5	74.7%	91.6%	16.9%	10.0	9.3	−.7	1.08	MB
6	81.9%	95.2%	13.3%	7.3	8.7	1.3	.84	MB
7	84.3%	98.8%	14.5%	8.2	10.0	1.8	.82	MB
8	65.1%	97.6%	32.5%	5.0	10.0	5.0	.50	LB
9	86.7%	94.0%	7.2%	10.0	9.8	−.2	1.02	MB
10	69.9%	89.2%	19.3%	7.7	10.0	2.3	.77	MB
11	68.7%	94.0%	25.3%	6.8	9.7	2.8	.70	MB
12	44.6%	85.5%	41.0%	6.7	9.7	3.0	.69	LB
13	60.2%	95.2%	34.9%	8.5	10.0	1.5	.85	LB
14	88.0%	98.8%	10.8%	9.3	8.8	−.5	1.06	MB
15	89.2%	95.2%	6.0%	7.8	10.0	2.2	.78	MB
16	84.3%	96.4%	12.0%	5.7	10.0	4.3	.57	MB
17	83.1%	98.8%	15.7%	6.5	10.0	3.5	.65	MB
18	86.7%	91.6%	4.8%	9.0	9.3	.3	.97	MB
19	73.5%	95.2%	21.7%	8.3	10.0	1.7	.83	MB
20	74.7%	94.0%	19.3%	7.7	8.3	.7	.93	MB
21	83.1%	96.4%	13.3%	7.2	10.0	2.8	.72	MB
22	72.3%	85.5%	13.3%	9.8	10.0	.2	.98	MB
23	67.5%	86.7%	19.3%	5.2	10.0	4.8	.52	MB
24	74.7%	79.5%	4.8%	7.3	9.8	2.5	.74	MB
Mean	75.4%	92.9%	17.5%	7.6	9.7	2.1		
SD	10.5%	4.9%	9.3%	1.6	.5	1.7		

Note: Diff: Difference, SP Ave: Spanish Average, Eng Ave: English Average, BPR: Bilingual Proficiency Ratio, MB: More balanced, LB: Less balanced.

cat-perro) word pairs. Since the focus of the present study was on *cross language* semantic priming, all word pairs contained one English word and one Spanish word. Further, one-half (20) of the word pairs contained an English prime and Spanish target (E-S) and the other half contained a Spanish prime and an English target (S-E) to balance language direction. To examine translation priming, each of the 40 target words was also paired with its corresponding translation (TR pairs; e.g. *cat-gato*). Again, one-half the word list was English-Spanish and the other half Spanish-English.

As a control condition, unrelated words were also used in the stimuli for the current investigation. Eighty critical unrelated words were identified and controlled for word length, frequency, cognateness, and homograph status (see below). Each of the 40 critical base pairs described above was paired with two unrelated words to create 80 unrelated controls (half of which were in the English-Spanish direction, and half Spanish-English). These word pairs were divided into 40 critical semantic unrelated (SU; *screw- lagarto*) and 40 critical translation unrelated (TU; *screw- jabón*) pairs. Critical unrelated targets were completely unrelated to primes. Additionally, 48 unrelated fillers (e.g. *steak-lluvia*) were developed. These were not controlled for length, frequency, cognates and homographs as they were not data points of interest and served only to achieve the optimal relatedness proportion (.23) for the experiment. Finally, 78 word-nonword pairs (36 English and 36 Spanish) were added to the word pairs to yield a nonword ratio of .46 (e.g. *drawer-loleno*). See appendix A for sample set of stimuli. These parameters were selected to eliminate any potential for expectancy based processing of the stimulus pairs. Consistent with Basnight Brown and Altarriba's (in press) study, the following methodological constraints were employed.

Semantic relatedness. Crosslinguistic SR pairs were developed using semantic relatedness ratings reported by Edmonds & Kiran (2004) in which participants rated word pairs in both Spanish and English on a scale from 1 to 4 (1 being very closely related, 4 being unrelated). The mean relatedness of English words was 2.11 (SD=.45) and the mean relatedness of Spanish words was 1.92 (SD=.48) yielding an overall difference of .19 ($t(78)=1.79$, $p>.05$) between the Spanish and English semantic relatedness ratings. Cognates and homographs were eliminated from the stimuli sets.

Word length and frequency. There is an inherent challenge in matching Spanish and English words for word length as approximately 90% of Spanish words are two- and three-syllables in length (Vitevitch & Rodriguez, 2005) while 80% of English words are one- and two-syllable words (Zipf, 1968). The average length of Spanish base pairs in the current study was significantly longer (2.65 (SD=.74) syllables) than the English base pairs (1.58 (SD=.71) syllables) ($t(78)=5.5$, $p<.01$). Nevertheless, words used in this investigation were representative of the typical word length in Spanish and English.

Frequencies for English words were derived from Francis and Kučera's (1982) frequency dictionary. Word frequencies from this source are based on approximately 1 million words from various genres of printed text. Spanish frequencies were compiled from Alameda and Cuetos (1995). These word frequencies are based on a corpus of approximately 2 million words derived from various printed sources. In Spanish, a word may include masculine, feminine, as well as diminutive and augmentative forms (with their respective plural forms). All of these forms are listed separately in Alameda and Cuetos (1995). When a diminutive or augmentative form of a word existed, its English equivalent was determined using the Oxford Concise Spanish Dictionary (Rollin, 1998). If the meaning of the diminutive or augmentative was the same as the regular form of the word, then the frequency of occurrence of the additional forms (and their respective plural forms) were included in the calculation of the Spanish frequency count for that word. This was applicable to 16.5% of the Spanish words considered as stimuli. In order to allow for direct comparison across English and Spanish frequencies, values were adjusted for corpora size by halving the Spanish values to match the corpus size of 1 million used by Francis and Kučera.

Within each prime-target condition (e.g. semantic related, semantic unrelated, etc), frequencies were controlled for English and Spanish primes and targets. In the SR condition, the mean frequency for English words was 40.8 (SD=64.7) and 36.6 (SD=65.7) for Spanish words. In the SU condition, the mean frequency for English words was 37.6 (SD=47.1) and 35.1 (SD=53.7) for Spanish words. In the TR condition, the mean frequency for English words was 38.0 (SD=55.4) and 39.2 (SD=61.2) for Spanish words. In the TU condition, the mean for English words was 39.0 (SD=29.6) and 29.6 (SD=38.8) for Spanish words. The overall mean frequencies across conditions were 38.2 (SD=53.5) and 34.7 (SD=54.1) for English and Spanish respectively.

Nonwords. English nonwords were taken from the ARC Nonword database (Rastle, Harrington, & Coltheart, 2002) and consisted of orthographically legal sequences and monomorphemic syllables. Spanish nonwords were generated by changing one or more phonemes of real Spanish words. Consistent with the characteristics of English nonwords described above, Spanish nonwords were pronounceable and contained orthographically legal letter sequences. The average syllable length for English nonwords was 1.00 (SD=.0) syllables and the average length of Spanish nonwords was 2.64 (SD=.68) syllables. This matched well with the average length of English and Spanish real words in the stimuli.

Procedure

All experiments were presented on an IBM-Compatible notebook computer with an Intel Pentium III processor running Windows XP and loaded with E-Prime (Psychology Software Tools, Inc, Pittsburgh, USA: http://www.pstnet.com/eprime). Using the stimuli described above, eight different versions of the experiment were created. Within each version, each participant saw 166 word pairs presented in a random order: 10 crosslinguistic semantically related (SR), 10 crosslinguistic semantically unrelated (SU) 10 translation pairs (TR), 10 translation unrelated (TU), 48 unrelated fillers (UF), and 78 word-nonword pairs (NW). Within each of the above conditions, there were equal numbers of word pairs in each direction (English-Spanish and Spanish-English). To counterbalance the language seen first by each participant, versions 1–4 of the experiment started with English primes and versions 5–8 started with Spanish primes. The same unrelated filler pairs and nonwords were used in each of the eight versions of the experiment. Each participant viewed one stimulus list. Two practice versions were also created using 10 word-pairs. One practice version was designed for participants who were to see lists 1–4 and another for lists 5–8 so that the first language of practice blocks corresponded to the first language seen in the experiment. Aside from language order, all participants saw the same 10 practice pairs.

The experiment was conducted in a quiet area convenient to the participant and took approximately 30 minutes. Participants were required to sit in front of a computer screen with their left hand rested on the notebook keyboard. Each participant first completed the practice version that corresponded to the experiment version to which they were assigned.

Instructions appeared in English at the start of the practice and experiment for all participants. Words were displayed in black lowercase letters on a white background. Each prime-target trial began with a warning "*" that appeared in the centre of the screen for 500ms which was followed by the prime for 150ms, which was immediately replaced by the target. Participants used their left hand to press the "B" key on the keyboard (labelled with a "Y") if the target was a real word and the "N" key (labelled with "N") if it was not a real word. Participants were instructed to respond as quickly and accurately as possible. If there was no response after 1500ms, the target disappeared and the next trial started. The inter-trial interval (ITI) was 2000ms.

Results

Group classification

Consistent with procedures described by Edmonds and Kiran (2004), normal participants were divided into two groups (see Table III for group classification). Those who were within 1 standard deviation from the mean accuracy difference of 17.5% between English targets and Spanish targets were classified as relatively more-balanced bilinguals (MB). Those who were greater than or equal to 1 standard deviation above this mean were classified as relatively less-balanced (LB). For example, Participant 2 had a difference of 14.5% between performance in Spanish (E-S) and English (S-E), therefore was classified as MB while Participant 8 had a performance difference of 32.5% and was classified as LB. This resulted in a large group of MBs (n=20) and a small group of LBs (n=4). Performance data were chosen as the basis for participant grouping because some participants tended to either overrate or underrate their language abilities with respect to their performance on the task (e.g. P5, P17 and P23). Further, performance accuracy correlated only moderately with participant self-ratings ($r^2=.41$, $p=.045$) whereas reaction time on the task did not correlate with participant self-ratings.

Mean accuracy rates

Mean accuracies for critical word pairs (nonwords and fillers removed) were calculated for all participants in both language directions (see Figure 2). A 2 (group; MB, LB) × 2 (direction; E-S, S-E) × 4 (relationship; SR, SU, TR, TU) factorial ANOVA was performed on the critical pair mean accuracy rates as a subject analysis. There was a significant main effect on accuracy rates for group membership (F (1,176)=26.65, $MS_e=.46$, $p<.000001$), direction (F (1,176)=84.52, $MS_e=1.46$, $p<.00000001$), and relation (F (3,176)=3.89, $MS_e=.07$, $p<.01$). As expected the MB group's accuracy (86.0%) was significantly higher on the lexical decision task than the LB group's accuracy (75.5%). Also, all participants were significantly more accurate in the S-E (93%) than the E-S (75%) direction. A post-hoc test on the main effect of relation revealed that participants were significantly more accurate on TR (91.7%, $p=.02$) and SR (92.1%, $p=.01$) than SU (83.8%) and TU (86.3%) stimuli. This further demonstrates that related word-pairs had a significant effect on the subsequent processing of targets.

In addition to main effects on mean accuracy performance, there were two interaction effects. There was a significant interaction effect between group and direction (F (1,176)=30.86, $MS_e=.53$, $p<.0000001$). The MB group were stable across both language directions, whereas LB group showed decreased accuracy for Spanish targets (E-S

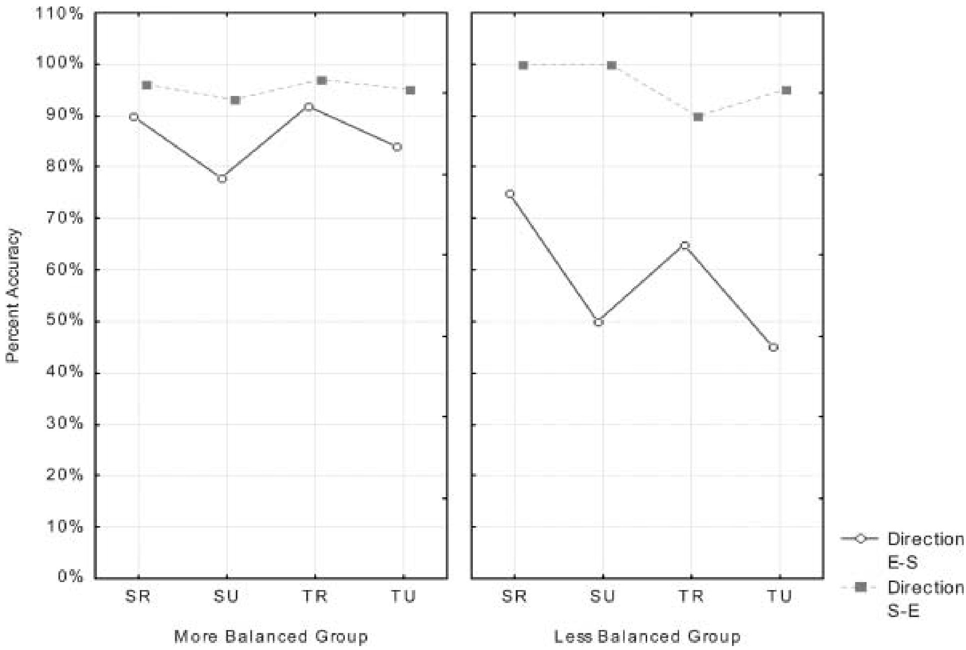

Figure 2. Mean per cent accuracy on the experimental task for semantic related (SR), semantic unrelated (SU), translation related (TR) and translation unrelated (TU) from English-Spanish and from Spanish-English priming for normal bilingual more balanced and less balanced groups in Experiment 1.

direction). There was also a significant interaction between direction and relation ($F(3,176)=3.43$, $MS_e=.06$, $p<.01$). Accuracies were high in English regardless of prime-target relationship, whereas relationship significantly influenced Spanish accuracy rates for both groups.

Mean reaction time

In order to assess the effects of prime-target relationship and direction on target response times, mean reaction times for correct responses were calculated for critical pairs (after removing nonwords and fillers). Outliers were also trimmed from the data by removing responses over 1200ms. This procedure for removing outliers has been reported elsewhere (Basnight Brown & Altarriba, in press) and others have used similar procedures (Grainger & Frenck-Mestre, 1998; Jiang & Forster, 2001). The removal of outliers resulted in the loss of 4.95% of the data.

A factorial 2 (group; MB, LB) × 2 (direction; S-E, E-S) × 4 (relation; SR, SU, TR, TU) ANOVA revealed significant main effects for group ($F(1,175)=15.59$, $MS_e=159{,}348$, $p<.0001$), direction ($F(1,175)=40.75$, $MS_e=416{,}414$, $p<.0000001$), and relation ($F(3,175)=4.00$, $MS_e=40{,}936$, $p<.00$) but no significant interaction effects. The main effect for group indicated that the MB group was faster overall (M=742ms, SD=115.8) when compared to the LB group (M=814ms, SD=131.4).

The main effect of language direction revealed that all participants were faster at responding in the S-E direction (M=695ms, SD=106.7) than in the E-S direction (M=814ms, SD=104.7). Finally, the main effect of relation suggested that prime-target relation had a significant effect on target RTs but a post-hoc analysis did not reveal any significant effects among the four prime-target relations (SR, SU, TR, & TU). However, trends seen in Table IV revealed that RTs were faster for related versus unrelated pairs in both groups.

Priming effects

Gross priming effects were calculated by subtracting the mean response time for a related condition from the corresponding control condition (e.g. mean RT for SU pairs minus mean RT for SR) and are presented in Table IV. Greater priming was observed from English to Spanish than was observed than from Spanish to English. For the MB group, there was a positive priming effect for SR pairs and TR pairs in the English-Spanish direction. However, there were no priming effects in the opposite direction (Spanish-English) for this group. Like the MB group, the LB participants also showed priming effects in the E-S direction and these effects were of a greater magnitude than in the MB group. Unlike the MB group, the LB group also showed a priming effect in the opposite (Spanish-English) direction although these effects were less than the E-S direction.

Discussion

Results of Experiment 1 revealed that both groups showed the same trends (e.g. high accuracy in English) but there were differences in the magnitude of effects observed. Where the two groups differed most was in performance on Spanish targets (E-S direction) in that the LB group showed poorer performance in this direction when compared to the MB group. Further, accuracy rates were equal across the four relations for English targets (S-E). In contrast, accuracy rates were higher for related words (SR, TR) than unrelated words for the Spanish targets.

The priming effects revealed that for more-balanced bilinguals, exposure to English primes facilitated the accessing of Spanish targets but not vice versa. These results are in agreement with those of Basnight Brown and Altarriba (in press). Further, for the LB

Table IV. Mean reaction times for critical word pairs for the More Balanced and Less Balanced normal individuals.

More Balanced (n=20)	SR	SU	Priming effect	TR	TU	Priming effect
E-S	788 (94.1)	831 (76.3)	+43	778 (101)	807 (103)	+29
S-E	673 (118)	672 (85.7)	−1	695 (94)	692 (122)	−3
Difference	−115	−159		−83	−115	

Less Balanced (n=4)	SR	SU	Priming effect	TR	TU	Priming effect
E-S	861 (63)	1022 (124)	+161	762 (41)	911 (155)	+149
S-E	733 (129)	807 (108)	+74	717 (80)	753 (93)	+36
Difference	−128	−215		−45	−158	

Note: SR=Semantic Related, SU=Semantic Unrelated, TR=Translation Related, TU=Translation Unrelated.

group, seeing English primes greatly facilitated the subsequent processing of Spanish targets, and Spanish primes facilitated the processing of English targets as well (to a lesser degree). In both groups, there was little to no difference between the magnitude of SR priming effects and the magnitude of TR priming effects suggesting that translation equivalents and semantically related words may have been processed in a similar way.

Experiment 2

Experiment 2 examined semantic and translation priming in four individuals with bilingual aphasia. Semantic priming effects in bilingual aphasia have thus far only been examined in the form of case studies (Lalor & Kirsner, 2001; Kiran & Tuchtenhagen, 2005). In this exploratory experiment, details regarding premorbid language proficiency, post morbid language performance and the extent of language impairment were described for four participants in order to understand the potential influence of these factors on priming outcomes. The main assumption in this experiment was that participants with aphasia will demonstrate priming effects but the patterns of activation may be influenced, among other factors, by the nature of the language impairment.

Methods

Participants

Four participants with bilingual aphasia were recruited from local area hospitals. Several participant selection criteria were met in order for these individuals to be involved in the experiment: (a) diagnosis by a neurologist of a stroke in the left hemisphere (encompassing the grey/white matter in and around the perisylvian area) confirmed by a CT/MRI scan, (b) onset of stroke at least nine months prior to participation in the study, (c) right-handed prior to stroke, (d) bilingual speakers of English and Spanish who reported being "functional" in both languages in most situations prior to their stroke, (e) adequate hearing, vision, and comprehension to engage fully in testing and treatment, (g) stable health status. See Table V for demographic information for each participant.

Language proficiency. Each participant and his/her family member was interviewed and asked to complete a language-use questionnaire (Muñoz et al., 1999). Questions focused on the manner and time of acquisition for both languages as well as use patterns over time with an emphasis on use and proficiency immediately prior to the CVA. Consistent with Munoz et al., ratings were obtained on a 7-point scale (1=not fluent; 7=native proficiency). As in the normal bilinguals, BPR for each participant was compared against those reported previously in normal Spanish-English bilinguals who fell into one of three proficiency groups: English dominant, Spanish dominant, or relatively balanced (Edmonds & Kiran, 2004). For example, P1's BPR (1.16) most closely resembled the balanced bilingual group BPR (.99), whereas P2 (.79) and P3 (.57) and P4 (.71) most closely resembled the English dominant group (.88). Per participant and family reports, Participants 1–3 reported equal levels of impairment and recovery in English and Spanish subsequent to their stroke. Participant 4, however, experienced greater impairment in Spanish than English subsequent to the stroke.

The diagnosis of aphasia was determined by administration of the *Western Aphasia Battery* (Kertesz, 1982) in English. Results showed that all four patients were characterized

Table V. Demographic data, language history and language proficiency ratings across English and Spanish for four participants with aphasia.

Demographic information						Language history and proficiency				
Pt	*Male/ Female*	*Age (yrs)*	*Education*	*Etiology*	*MPO*	*Family/Social*	*Work*	*Reading/Writing*	*Self-ratings (E/S) (1–7)*	*BPR*
1	F	53	10 years (Mexico)	Left MCA CVA	9	-Spanish only until 21 years -Prior to CVA, 100% English at home -Spanish and English with grown children -English and Spanish with friends	Factory: 50% English 50% Spanish	-Educated in Spanish -Continued to write in Spanish (letters, lists) -Learned and used English -Read English and Spanish materials	Speech: 6/7 Comp: 7/7 Reading: 7/7 Writing: 7/7	1.16
2	M	53	12 years (US)	Left MCA CVA	8	-Both languages from birth -Prior to CVA, Spanish primarily with mother -100% English with spouse -No Spanish with friends	Surveyor: 70% English 30% Spanish	-Educated in English -No Spanish training -Read in English for leisure	Speech: 7/5 Comp: 7/6 Reading: n/a Writing: n/a	.79
3	F	56	12 years (US)	Left MCA CVA	9	-Both languages from birth -Prior to CVA, 80% English and 20% Spanish with husband -Spanish only with mother-in-law	Retail: 70% English 30% Spanish	-Educated in English -No Spanish training -Read and wrote English only at work -Read in English for leisure	Speech: 7/3 Comp: 7/5 Reading: n/a Writing: n/a	.57

Table V. Continued.

Demographic information						Language history and proficiency				
Pt	*Male/ Female*	*Age (yrs)*	*Education*	*Etiology*	*MPO*	*Family/Social*	*Work*	*Reading/Writing*	*Self-ratings (E/S) (1–7)*	*BPR*
4	F	55	2 years college	Left MCA CVA	11	-Both languages from birth -Married to bilingual Spanish speaker -Spanish with children, siblings with friends	Clerk in community education for English as a second language 50% English 50% Spanish	Educated in English High school equivalent in Spanish - Self taught -Can read and write English and Spanish materials	Speech: 7/6 Comp: 7/6 Reading: 7/4 Writing: 7/4	.78

MPO: Months Post Onset; E: English; S: Spanish; Comp: Comprehension; MCA: Middle Cerebral Artery; CVA: Cerebral Vascular Accident; BPR: Bilingual Proficiency Ratio.

as nonfluent/Broca's aphasia with varying levels of severity. P1, P3 and P4 presented with moderate aphasia (P1 AQ=74.7; P3 AQ=68.9; P4 AQ=70) characterized by nonfluent speech, impaired comprehension, and naming deficits, with relatively spared reading comprehension of single words and phrases, whereas P2 presented with severe aphasia (P2 AQ=38). Additionally, P2 exhibited characteristics consistent with apraxia of speech (AOS), including effortful speech with groping articulation and variable articulation errors. Three of the four participants were previously involved in a treatment study examining the effects of naming treatment on crosslinguistic generalization (Edmonds & Kiran, 2006) which was completed at least 6 months prior to the experiment.

In addition to the *WAB*, four subtests on *Psycholinguistic Assessment of Language Processing in Aphasia* (PALPA, Kay, Lesser, & Coltheart, 1992) that assess semantic processing skills were also administered in English. All participants demonstrated relatively high accuracy (above 90% accuracy) on the two word-picture matching tests of the PALPA. Performance on the synonym judgment task was comparatively less accurate for all participants (range=70–81% accuracy).

In order to characterize the nature of language impairments in both languages, several additional tests were administered in English and Spanish. These included portions of the *Bilingual Aphasia Test* (*BAT*) (Paradis, 1987) and *The Boston Naming Test* (Goodglass, Kaplan, & Weintraub, 1983). All subtests of the BAT were administered, but only those relevant to the present experiment only are shown in Table VII. Importantly, Part C of the *BAT* was also administered to evaluate recognition and translation of words across languages since the current study investigated crosslinguistic priming. Since the number of items in each of the subtests of BAT are relatively few (5–10 items), we used a criteria of at least 20% difference in performance across the two languages. For instance, P1's performance on naming was worse in English (66% accuracy) than in Spanish (100% accuracy). Of the 14 relevant subtests, P1's performance was worse in English on 4/14, worse in Spanish on 1/14 and equivalent on the rest of the subtests. Likewise, P3's performance was worse in English on 2/14 and worse in Spanish on 2/14 and performance

Table VI. Language performance on tests administered in English only for WAB (Kertesz, 1982) and PALPA (Kay et al., 1992) for the four participants with aphasia.

Test	P1	P2	P3	P4
Western Aphasia Battery (WAB)				
Spontaneous speech (%)	65.0	40.0	70.0	60
Auditory comprehension (%)	88.5	61.5	87.5	89
Repetition (%)	74.0	38.0	44.0	64
Naming (%)	81.0	53.0	73.0	77
Reading (%)	60	50	66	65.5
Aphasia Quotient	**74.7**	**38.0**	**68.9**	**70**
Aphasia Type	Nonfluent/ Broca's	Nonfluent/ Broca's	Nonfluent/ Broca's	Nonfluent/ Broca's
PALPA				
Spoken Word-Picture Matching (%)	97.5	92.5	95.0	90
Written Word-Picture Matching (%)	97.5	95.0	95.0	92.5
Auditory Synonym Judgments (%)	81.7	DNT	72.0	75
Written Synonym Judgments (%)	70.0	76.7	73.0	77

Note: DNT: Did not test.

Table VII. Performance on tests administered in English and Spanish for four participants with aphasia on Boston Naming Test (Goodglass et al., 1983) and Bilingual Aphasia Test (Paradis, 1987).

	P1		P2		P3		P4	
	English	Spanish	English	Spanish	English	Spanish	English	Spanish
Boston Naming Test (BNT) (%)	48.3	55.0	35.0	1.67	33.3	30.0	41	18
Bilingual Aphasia Test (BAT)								
Pointing (%)	100	100	100	60.0	100	100	100	100
Semi-complex commands (%)	100	100	25.0	25.0	100	90.0	100	100
Verbal auditory discrimination (%)	83.3	100	72.2	50.0	89.0	89.0	89	89
Naming (%)	66.7	100	42.9	DNT	95.0	79.0	100	32
Word Repetition (%)	96.7	96.7	73.3	DNT	77.0	77.0	77	87
Series (automatics) (%)	66.7	100	0.0	0.0	33.0	33.0	0	0
Semantic Categories (%)	80.0	80.0	80.0	60.0	60.0	60.0	80	80
Semantic opposites (%)	40.0	50.0	70.0	10.0	20.0	10.0	30	10
Semantic Acceptability (%)	100	100	60.0	40.0	100	100	100	80
Synonyms (%)	80.0	80.0	100	0.0	0.0	60.0	100	60
Antonyms I (%)	80.0	60.0	60.0	40.0	60.0	40.0	100	40
Antonyms II (%)	100	80.0	40.0	0.0	0.0	40.0	40	40
Reading words (%)	70.0	100	0.0	0.0	90.0	10.0	100	80
Reading sentences (%)	50.0	70.0	16.7	DNT	0.0	0.0	0	0
Bilingual Aphasia Test – Part C								
Recognition of words (Spanish to English) (%)	100	n/a	100	n/a	100	n/a	DNT	n/a
Recognition of words (English to Spanish) (%)	100	n/a	10.0	n/a	80	n/a	DNT	n/a
Translation of words (Spanish to English) (%)	60.0	n/a	0.0	n/a	40.0	n/a	DNT	n/a
Translation of words (English to Spanish) (%)	60.0	n/a	0.0	n/a	50.0	n/a	DNT	

Note: DNT: Did not test.

was equivalent across the two languages on the other subtests. In contrast, P2 demonstrated relatively worse performance in Spanish on 7/14 of the tests and P4 demonstrated relatively worse performance in Spanish on 6/14 subtests. To summarize, P1 demonstrated slightly worse performance in English, P3 demonstrated relatively equivalent performance in English and Spanish, whereas P2 and P4 demonstrated relatively impaired performance in Spanish compared to English.

Performance on the *Boston Naming Test* (Goodglass et al., 1983) was similar. P1 and P3 demonstrated relatively equivalent performance across the two languages whereas both P2 and P4 were relatively more impaired in Spanish than in English.

Stimuli

Stimuli used were the same as those used in Experiment 1. The order and number of stimuli in each list were identical to Experiment 1.

Procedures

The procedures employed in Experiment 2 were identical to those in Experiment 1 with one exception. Primes were presented for 300ms (instead of 150ms) to allow adequate time for patients to process the primes. Further, if there was no response after 3000ms (instead of 1500ms), the target disappeared and the next trial started. These times have been employed in our previous monolingual aphasia priming studies and appear to be sufficient in facilitating priming effects in this population (Kiran & Thompson, 2003; Kiran, Ntourou, & Eubanks, in press). The visual fixation (500ms) and ITI (2000ms) were kept consistent with Experiment 1.

Results

Mean accuracy rates

Mean accuracies for critical word pairs (nonwords and fillers removed) were calculated for the four participants in both language directions. Figure 3 illustrates differences in accuracy rates across the different real word ("yes") responses for the four participants. Given that the four individuals presented with varying levels of (a) aphasia severity, (b) language impairments across the two languages, and (c) pre-morbid language use history, the data were not statistically analysed. Instead, individual inspection revealed that Participants 1 and 2 showed high accuracy rates for all targets (P1=94%; P2=97% accuracy). Conversely, Participants 3 and 4 performed relatively poorly on the task (P3=42%; P4=70% accuracy).

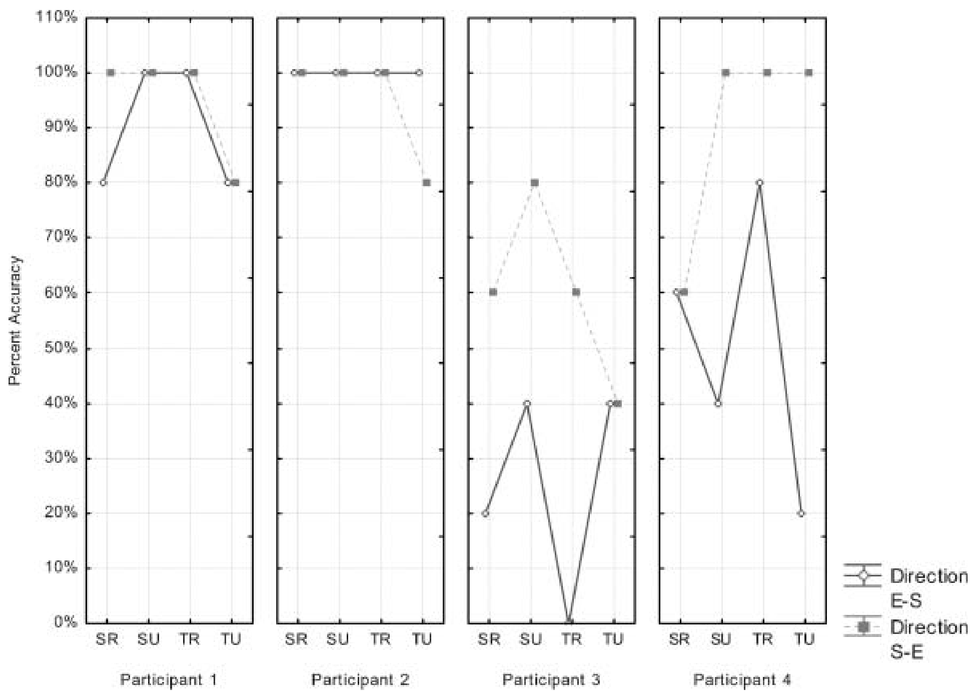

Figure 3. Mean percent accuracy on the experimental task for semantic related (SR), semantic unrelated (SU), translation related (TR) and translation unrelated (TU) from English-Spanish and from Spanish-English priming for four individuals with bilingual aphasia in Experiment 2. Data for Participant 3 is at 0% accuracy on TR for English-Spanish condition.

Mean reaction times

As in the control data, mean reaction times for correct responses were calculated for critical pairs (after removing nonwords and fillers). Approximately 11% of the reaction times exceeded 3000ms and were eliminated from the data analysis. Results from Experiment 2 revealed that all four participants demonstrated a varied but interesting set of observations (see Table VIII). First, P1 was different from the rest of the participants as she did not demonstrate any priming (i.e. faster reaction times) except under the English-Spanish translation condition. Participant 2 demonstrated semantic priming from English primes to Spanish targets and from Spanish primes to English targets. This participant also demonstrated translation from Spanish primes to English targets. Participant 3 also showed semantic priming from English primes to Spanish targets and translation priming from Spanish primes to English targets. P4 showed priming across all conditions except semantic priming from Spanish primes to English targets.

Discussion

Results from Experiment 2 revealed no consistent patterns, hence individual data were more informative. For instance, P1 was premorbidly equally proficient and showed relatively lower performance levels in English when compared to Spanish on the *BNT* and *BAT*. On the experimental tasks, she performed with relatively high accuracy and showed

Table VIII. Mean reaction times for critical word pairs for the four participants with bilingual aphasia.

	SR	SU	Priming effect	TR	TU	Priming effect
P1						
E-S	1888	1673	−214	1536	1797	+261
S-E	1913	1828	−85	2031	2022	−9
Difference	24	54		495	225	
P2						
E-S	1006	1148	+142	1345	1256	−88
S-E	1483	1557	+73	1407	1558	+151
Difference	477	408		61	301	
P3						
E-S	1859	2750	+891	All errors	2459	
S-E	2073	1638	−434	2103	2483	+380
Difference	214	−1111			24	
P4						
E-S	1766	2065	+298	1329	2533	+1203
S-E	1574	1405	−169	1637	2019	+381
Difference	−192	−659		308	−514	

Note: SR=Semantic Related, SU=Semantic Unrelated, TR=Translation Related, TU=Translation Unrelated. P3 has no data for TR (E-S) as all her responses were errors.

faster reaction times in Spanish compared to English but did not show semantic priming effects. P2 was premorbidly more proficient in English and showed a greater impairment in Spanish than English on the *BAT* and *BNT*. This participant also performed with high accuracy on the experimental task and like P1, demonstrated faster reaction times for Spanish targets than English targets. P2 also demonstrated crosslinguistic semantic and translation priming effects. P3 was premobidly more proficient in English than Spanish and was equally impaired in both languages on the *BAT* and *BNT*. This participant demonstrated very low accuracies on the experimental task. She also responded inconsistently to the two different languages with reaction times faster in English for some targets and not others. Finally, P4 was premorbidly more proficient in English and more impaired in Spanish than English on the *BAT* and *BNT*. This patient performed with moderate accuracy on the experimental task. She responded faster to English targets than Spanish targets and showed priming for all conditions. These findings suggest that in bilingual aphasia, crosslinguistic priming effects are dependent upon a complex interaction between proficiency, language impairment and priming.

General discussion

The present study investigated crosslinguistic semantic and translation priming in early Spanish-English bilinguals and in participants with bilingual aphasia. Normal participants were divided into two groups based on performance (more-balanced bilinguals and less-balanced bilinguals). The four participants with bilingual aphasia were documented with varying levels of pre-morbid language proficiency and post morbid language impairment. Results from the normal individuals and patients with aphasia will be discussed separately.

Crosslinguistic priming in normal bilingual individuals

To examine crosslinguistic priming in normal individuals, we posed three questions. First, how does language proficiency influence lexical access and semantic representation in normal bilinguals? Second, what effect does language direction have on semantic and translation priming? And finally, are there differences in the magnitude of priming between translation and semantic priming. Our data revealed several interesting observations. First, more balanced (MB) bilinguals were faster and more accurate than less balanced (LB) bilinguals on the experimental task. Further, both groups were highly accurate for English targets (S-E direction) and what differentiated the two groups was the performance on Spanish targets (E-S direction) with the LB group performing worse on Spanish targets. Specifically, both groups showed priming from English primes to related Spanish targets (E-S direction), although the magnitude of this effect was greater in the LB group than the MB group. Only the LB group, however, showed priming from Spanish primes to related English targets (S-E direction). Thirdly, while both groups demonstrated faster reaction times and higher accuracies for related words (SR and TR) compared to unrelated words (SU and TU), the magnitude of these effects were greater for the LB group. For both groups, there was no difference between the magnitude of semantically related (SR) and translation related (TR) priming effects.

Collectively, these results are generally consistent with findings by Basnight Brown and Altarriba (in press) in that they suggest priming effects are greater from the more dominant language (MDL; English) to the less dominant language (LDL; Spanish). An important point raised by Basnight Brown and Altarriba (in press) and by Heredia (1996) is the observation of a dominant shift in English-Spanish bilingual individuals living in the United States. In our study, despite all normal participants being early Spanish-English bilinguals, 21/24 participants rated themselves as being more proficient in English than in Spanish, a finding in resonance with previous studies. Therefore, all our participants were more proficient in English than Spanish and consequently, the distinction between the two groups was on the relative accuracy across the two languages on the experimental task resulting in a more-balanced (MB) group and a less balanced group (LB).

A major finding of this study was that the marked asymmetry in priming from English-Spanish was greater for the LB group than the MB group. Specifically, for the MB group, priming effects only resulted from English primes whereas for the LB group, priming was observed from English-Spanish and from Spanish-English. These patterns are consistent with previous studies that reported larger priming effects in the L1-L2 direction (Altarriba, 1992, short SOA; Gollan et al., 1997, Experiments 1 and 2; Grainger & Frenck-Mestre, 1998; Jiang, 1999, Experiment 2) and can be explained by Heredia's (1996) Second Revision of the Revised Hierarchical Model (RHM-2), Kroll and Stewart's (1994) Revised Hierarchical Model and de Groot's Mixed Model (de Groot, 1992). All these models emphasize flexibility in the connections between L1 and L2 and the conceptual system as a function of language proficiency. Our results on the normal bilinguals illustrate how important this flexibility is to understanding differences between more and less proficient bilinguals.

We will use Heredia's RHM-2 model to explain our results since it is consistent with our participants who have undergone a shift in dominance (English being the more dominant language and Spanish being the less dominant language). Specifically, for both MB and LB groups, the connections between the MDL and the conceptual system are stronger than those between the LDL and the conceptual system based on the evidence that English targets were responded to faster and more accurately than Spanish targets in both groups. It is hypothesized that both participant groups differ in the strength of connection between LDL and the conceptual system in that the MB group has a stronger LDL-conceptual system link than the LB group. This assertion is based on the evidence of greater priming effects (or slower response times in Spanish) in the E-S direction for the LB group than the MB group.

Another assumption of the RHM-2 is the asymmetry in the interlexical connections between LDL-MDL where connections between LDL-MDL are stronger than vice versa (see Figure 1). Extending this hypothesis, we suggest that the LDL-MDL connection was stronger for the LB group than MB group in our study. Consequently, given the relatively lesser proficiency in Spanish, viewing Spanish primes likely necessitated the implicit activation of related English targets. As a result, English related targets were responded to faster than unrelated targets. Similar priming effects were not observed for the more balanced group, perhaps since the asymmetry between the two language proficiencies may not have been as significant to result in any benefit from viewing related Spanish primes.

Crosslinguistic priming in bilingual aphasia

Individual analyses of the participants provide an insight into the nature of crosslinguistic priming in aphasia. Recall that P1 was equally proficient in English and Spanish whereas P2, P3, and P4 were all more proficient in English. Further, P1 showed greater impairments in English, P3 equal impairments in both languages whereas P2 and P4 showed greater impairments in Spanish. With regards to the experimental task, Participants

2, 3 and 4 demonstrated crosslinguistic semantic priming from English primes to Spanish targets. However, only P2 demonstrated semantic priming from Spanish primes to English targets. Additionally, P1, P2 and P4 showed translation priming from Spanish primes to English targets. These data tentatively suggest that priming effects interact with language proficiency and the degree of language impairment in the two languages although it is premature to make any inferences regarding the specific influence of these variables. Arguably, crosslinguistic semantic priming in bilingual aphasia is inherently more complicated than semantic priming in monolingual aphasia. However, some assumptions that account for impaired priming effects in monolingual aphasia may also be applicable for interpreting priming in bilingual aphasia. For instance, recent studies have suggested that patients with Broca's aphasia show reduced lexical activation levels (Utman, Blumstein, & Sullivan, 2001) and are unable to adequately integrate lexical activation (Milberg, Blumstein, Giaovanello, & Misurski, 2003). Therefore, some of these fundamental changes in language processing abilities as a consequence of brain damage may also underlie the abnormal priming effects that were observed in the patients with bilingual aphasia.

Limitations and future directions

One of the main limitations of the present study is the small number of N for the less balanced normal group and participants with bilingual aphasia. Even though the number of participants in the LB group was determined based on each participant's performance on the experimental task, this group was fairly homogenous in its performance. Unlike the LB group, the bilingual aphasia participants were fairly heterogeneous in their demographics and consequently, on their performance on the experimental task, precluding any clear statistical analysis. Also, the PALPA was administered only in English and not in Spanish. While it would be interesting to detect a difference in offline semantic processing performance across the two languages on this task, there is a practical time constraint of administering all the standardized tests in both languages in order to interpret the results of the 30 minute semantic priming task. While highlighting the need to examine greater numbers of patients on an individual case basis, the present results provide preliminary evidence for crosslinguistic priming in bilingual aphasia and serve as a starting point for future studies addressing this issue.

In the present study, no differences were found in both participant groups/experiments in the magnitude of priming effects between translation pairs (TR) and semantically related pairs (SR), a finding in contradiction to that of Basnight Brown and Altarriba (in press). This discrepancy may be attributed, at least in part, to differences in the stimuli used across studies. Basnight Brown and Altarriba used semantic attributes as words pairs (e.g. *sugar-sweet*) (J. Altarriba, personal communication, 11 October 2005) while the present study used words that belonged to the same semantic category (e.g. *whale-shark*). It can be argued that semantic attributes and category coordinates may entail slightly different networks of activation. Further contributing to the difficulty in interpreting TR priming effects is the notion that translation can take two different routes (words association route or concept mediation route) and the design of the current study does not allow for the differentiation between the two.

Finally, a potential drawback of the study is that we divided our participants based on their accuracy on the experimental task. If, however, participants were classified into the two groups based on their language proficiency (using the Muñoz et al., questionnaire), the two groups were still unequal (20 more balanced and four less balanced). Of concern was the observation that two of those less balanced individuals (P16 and P23) were different from those whose performance on the task was less balanced (P12 and P13). As part of the study, we also collected language use information (Peña, Gutierrez-Clellen, Iglesias, Goldstein & Bedore, in development). In this questionnaire, participants completed an estimation of time (calculated in percentage) spent in each language during a typical weekday and weekend. Average percent values were calculated for each language in terms of language use during a typical day. If participants were divided based on average percent language use, 20 individuals still formed the more balanced group and four individuals formed the less balanced group. More worrisome, three of the four individuals in the less balanced group (P2, P16, and P17) were different from those classified based on accuracy or language proficiency. Therefore, language proficiency and language use were simply not accurate measures of how participants performed on the task. As a result, dividing participants based on their overall accuracy on the task seemed to be the most parsimonious and accurate way of interpreting the present results. Clearly, the lack of a clear relationship between language use, language proficiency and actual performance is a bigger methodological issue concerning bilingual research and requires careful and systematic examination.

To conclude, the present study contributes to the existing evidence that language proficiency and direction play a central role in crosslinguistic semantic and translation priming. Differences between relative proficiencies may manifest themselves as asymmetrical performance across directions in crosslinguistic priming. Further, priming effects from English to Spanish are greater than Spanish to English, and this asymmetry is greater for the LB group than the MB group. Preliminary data from four participants with bilingual aphasia clearly show that semantic/translation priming in this group is impaired. The results of the present study have clinical implications as well. These results provide important evidence regarding lexical processing mechanisms in patients with aphasia that allow interpretations of abnormal crosslinguistic interference between the two languages in bilingual patients. Further, these data illustrate possible mechanisms of interaction between the two languages which serve as a guide to understanding the effect of therapy on crosslinguistic generalization patterns in patients with aphasia.

References

Alameda, J. R., & Cuetos, F. (1995). *Diccionario de frecuencias de las unidades lingüísticas del castellano*. Oviedo (Spain): Departamento de Psicología, Universidad de Oviedo.

Altarriba, J. (1992). The representation of translation equivalents in bilingual memory. In R. J. Harris (Ed.), *Cognitive Processing in Bilinguals* (Vol. 4, pp.157–174). Amsterdam: Elsevier.

Altarriba, J., & Basnight Brown, D. M. (in press). Methodological considerations in performing semantic and translation priming experiments across languages. *Behaviour Research Methods, Instruments, & Computers*.

Basnight Brown, D. M., & Altarriba, J. (in press). Differences in semantic and translation priming across languages: The role of language direction, age of acquisition, and language dominance. *Memory and Cognition*.

Chen, H. C., & Ng, M. L. (1989). Semantic facilitation and translation priming effects in Chinese-English bilinguals. *Memory and Cognition*, *17*, 454–462.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, *82*, 407–428.

de Groot, A. M. B., & Nas, G. L. J. (1991). Lexical representation of cognates and noncognates in compound bilinguals. *Journal of Memory and Language*, *30*, 90–123.

de Groot, A. (1992). Determinants of word translation. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *18*, 1001–1018.

Edmonds, L. A., & Kiran, S. (2004). Confrontation naming and semantic relatedness judgments in Spanish/English bilinguals. *Aphasiology*, *18*, 567–579.

Edmonds, L. A., & Kiran, S. (2006). Effect of semantic naming treatment on crosslinguistic generalization in bilingual aphasia. *Journal of Speech, Language, and Hearing Research*, *49*, 729–748.

Fox, E. (1996). Cross-language priming from ignored words: Evidence for a common representational system in bilinguals. *Journal of Memory and Language*, *35*, 353–270.

Francis, N. W., & Kučera, H. (1982). *Frequency analysis of English usage*. Boston, MA: Houghton Mifflin.

Frenck, C., & Pynte, J. (1987). Semantic representation and surface forms: A look at across language priming in bilinguals. *Journal of Psycholinguistic Research*, *16*, 383–396.

Gollan, T. H., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and noncognates in Hebrew-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*, 1122–1139.

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

Grainger, J., & Beauvillain, C. (1988). Associative priming in bilinguals: Some limits of interlingual facilitation effects. *Canadian Journal of Psychology*, *42*, 261–273.

Grainger, J., & Frenck-Mestre, C. (1998). Masked priming by translation equivalents in proficient bilinguals. *Language and Cognitive Processes*, *13*, 601–623.

Grosjean, F. (1994). Individual bilingualism. In R. E. Asher (Ed.), *The encyclopaedia of language and linguistics* (pp. 1656–1660). Oxford: Pergamon Press.

Heredia, R. R. (1995). Concreteness effects in high frequency words: A test of the revised hierarchical and the mixed models of bilingual memory representations. Unpublished Doctoral Dissertation, University of California, Santa Cruz.

Heredia, R. R. (1996). Bilingual Memory: A Re-Revised Version of the Hierarchical Model of Bilingual Memory. *The newsletter of the Centre for Research in Language, University of California, San Diego*, *10*, January.

Jiang, N. (1999). Testing processing explanations for the asymmetry in masked cross-language priming. *Bilingualism: Language and Cognition*, *2*, 59–75.

Jiang, N., & Forster, K. I. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory and Language*, *44*, 32–51.

Jin, Y.-S. (1990). Effects of concreteness on cross-language priming in lexical decisions. *Perceptual and Motor Skills*, *70*, 1139–1154.

Kay, J., Lesser, R., & Coltheart, M. (1992). *The Psycholinguistic Assessment of Language Processing in Aphasia (PALPA)*. Hove: Lawrence Erlbaum Associates.

Keatley, C. W. (1992). History of bilingualism research in cognitive psychology. In R. J. Harris (Ed.), *Cognitive Processing in Bilinguals* (Vol. 4, pp.15–49). Amsterdam: Elsevier.

Keatley, C. W., & de Gelder, B. (1992). The bilingual primed lexical decision task: Cross-language priming disappears with speeded responses. *European Journal of Cognitive Psychology*, *4*, 273–292.

Keatley, C. W., Spinks, J. A., & de Gelder, B. (1994). Asymmetrical cross-language priming effects. *Memory and Cognition*, *22*, 70–84.

Kertesz, A. (1982). *The Western Aphasia Battery*. Philadelphia, PA: Grune & Stratton.

Kiran, S., Ntourou, K., & Eubanks, M. (in press). Effects of typicality on category verification in inanimate categories in aphasia. *Aphasiology*.

Kiran, S., & Thompson, C. K. (2003). Effect of typicality on online category verification of animate category exemplars in aphasia. *Brain and Language*, *85*, 441–450.

Kiran, S., & Tuchtenhagen, J. (2005). Imageability effects in normal Spanish-English bilingual adults and in aphasia: Evidence from naming to definition and semantic priming tasks. *Aphasiology*, *19*, 315–327.

Kirsner, K., Smith, M. C., Lockhart, R. S., King, M. L., & Jain, M. (1984). The bilingual lexicon: Language-specific units in an integrated network. *Journal of Verbal Learning and Verbal Behaviour*, *23*, 519–539.

Kroll, J., & Curley, J. (1988). Lexical memory in novice bilinguals: the role of concepts in retrieving second language words. In P. M. Gruneburg, & R. Sykes (Eds.), *Practical Aspects of Memory* (Volume 2). New York: John Wiley & Sons.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*, 149–174.

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

Larsen, J. D., Fritsch, T., & Grava, S. (1994). A semantic priming test of bilingual language storage and the compound vs. coordinate bilingual distinction with Latvian-English bilinguals. *Perceptual and Motor Skills*, *79*, 459–466.

Meyer, D. E., & Ruddy, M. G. (1974). Bilingual word recognition: Organization and retrieval of alternative lexical codes. Paper presented at the Eastern Psychological Association, Philadelphia, PA.

Milberg, W., Blumstein, S., Giaovanello, K. S., & Misuirski, C. (2003). Summation priming in aphasia: Evidence for alterations in semantic integration and activation. *Brain and Cognition*, *51*, 31–47.

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. (1987). *The assesment of bilingual aphasia*. Hillsdale, NJ: Lawrence Erlbaum.

Peña, E., Gutierrez-Clellen, V., Iglesias, A., Goldstein, B., & Bedore, L. (in development). *Bilingual Spanish-English Assessment (BESA)*.

Potter, M. C., So, K.-F., Von Eckardt, B., & Feldman, L. B. (1984). Lexical and conceptual representation in beginning and proficient bilinguals. *Journal of Verbal Learning and Verbal Behaviour*, *23*, 23–38.

Rastle, K., Harrington, J., & Coltheart, M. (2002). 358,534 nonwords: The ARC Nonword Database. *The Quarterly Journal of Experimental Psychology*, *55A*, 1339–1362.

Rollin, N. (1998). *The Oxford Concise Spanish Dictionary*. Oxford: Oxford University Press.

Schwanenflugel, P. J., & Rey, M. (1986). Interlingual semantic facilitation: Evidence for a common representational system in the bilingual lexicon. *Journal of Memory and Language*, *25*, 605–618.

Sholl, A., Sankaranarayanan, A., & Kroll, J. F. (1995). Transfer between picture naming and translation: A test of asymmetries in bilingual memory. *Psychological Science*, *6*, 45–49.

Tzelgov, J., & Eben-Ezra, S. (1992). Components of the between-language semantic priming effect. *European Journal of Cognitive Psychology*, *4*, 253–272.

Vitevitch, M. S., & Rodríguez, E. (2005). Neighbourhood density effects in spoken word recognition in Spanish. *Journal Of Multilingual Communication Disorders*, *3*, 64–73.

Utman, J., Blumstein, S. L., & Sullivan, M. (2001). Mapping from sound to meaning: reduced lexical activation in Broca's aphasics. *Brain and Language*, *79*, 444–472.

Walraff, B. (2000). What global language? *Atlantic Monthly*, *286*, 52–63.

Williams, J. N. (1994). The relationship between word meanings in the first and second language: Evidence for a common, but restricted, semantic code. *European Journal of Cognitive Psychology*, *6*, 195–220.

Zipf, G. K. (1968). *The psycho-biology of language: An introduction to philology*. New York: Houghton Mifflin.

Appendix A: Sample Stimuli

English Primes- Spanish Targets			
razor-caballo	TU	snake-velis	SU
drill-sombrilla	TU	toilet-carretilla	SU
hanger-araña	TU	alligator-escoba	SU
butterfly-mariposa	TR	squirrel-conejo	SR
deer-ciervo	TR	corn-guisantes	SR
leg-pierna	TR	desk-mesa	SR
rainbow-umbierto	NW	bucket-borrador	UF
bathtub-campico	NW	vase-dedo	UF
leaf-midion	NW	carrot-rodilla	UF
Spanish Primes - English Targets			
campana - peas	TU	escuela-horse	SU
pap-vesta	TU	pollo-comb	SU
cerrilla-window	TU	pepino-frog	SU
cobija - blanket	TR	calcetin-shoe	SR
sandia - watermelon	TR	fresa-grapes	SR
tenedor - fork	TR	chivo-deer	SR
gusano -stom	NW	ballena- rattle	UF
zorillo-drenge	NW	arbol-horn	UF
nube- plab	NW	zorro- toast	UF

SR=Semantic Related, *SU*=Semantic Unrelated, *TR*=Translation Related, *TU*=Translation Unrelated, *NW*=Nonword, *U*=Unrelated Filler.