1993

Lexical access and recognition processes in compound bilinguals

John A. Maloney
San Jose State University

Order Number 1353036

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Maloney, St. John Aloysius, M.A.

San Jose State University, 1993

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

LEXICAL ACCESS AND RECOGNITION PROCESSES IN COMPOUND BILINGUALS

A Thesis

Presented to

the Faculty of the Department of Psychology

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

St. John A. Maloney

May, 1993

APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

Robert G. Cooper Jr.

Robert G. Cooper, Ph.D.

Laree Huntsman

Laree Huntsman, Ph.D.

Robert Fox

Robert Fox, Ph.D.

APPROVED FOR THE UNIVERSITY

Serena N. Stanford

ABSTRACT

LEXICAL ACCESS AND RECOGNITION PROCESSES IN COMPOUND BILINGUALS

by St. John A. Maloney

Semantic facilitation and translation priming effects in Spanish-English compound bilinguals were demonstrated with a lexical decision task. Compound bilinguals learned both languages by the age of 10 and were used to control for language dominance. Current language usage and form of usage were also examined for their effects. A 300-ms stimulus onset asynchrony was used between display of the prime word and the target word or nonword. The word interconnection hypothesis states that lexical items in different languages are directly and lexically connected to each other. The concept mediation hypothesis states that lexical items are processed by means of an amodal conceptual system. Partial support was found for the word interconnection model. English words were responded to faster compared to Spanish words. The implications of these results and the confounding factors found in the study are discussed and future research is suggested.

ACKNOWLEDGMENTS

A project is not completed until it is completed, and I can safely say this is completed. I want to thank the committee members of this thesis. I thank Dr. Bob Cooper for his patience and faith in my abilities. I also appreciate his excellent suggestions and contributions, including his well timed jokes. I consider him a colleague as well as a good friend. I want to thank Dr. Laree Huntsman for her wonderful suggestions and support. Also, Dr. Cooper and Dr. Huntsman gave valuable help to the preparation of this thesis as a poster presentation at the 1993 Western Psychological Association meeting in Phoenix, Arizona, April 22-25. Dr. Nusha Askari, presently at the University of San Francisco, also provided excellent support in the development of the proposal and her help is greatly appreciated. I also wish to thank Dr. Bob Fox for his suggestions and insight concerning subtle details.

I wish to also thank Sandra Rocco for her help and patience as my research assistant. I would also like to thank Dr. Nancy Eldred and Dr. Sheila Bienenfeld for their encouragement and support in this project. Finally, I want to thank three people who made my life much easier (we are talking majorly easier): Donna Boyd, Corky Smith, and Kate Caddell. They are secretaries in the Department of Psychology and are very good at what they do.

Friends must also be thanked for their emotional and technical support. I thank Sandy Lozito at NASA/Ames Research Center for her suggestions and data analysis skills. I also want to thank Kirsteen McCormack, Ildi Dihen, Matt Larkin, Patty Hoffman, Paul Nadeau, and Raul Soikes for their gifts of friendship. I am also especially grateful to Mariah M. for introducing me to CoDA directly and Al-Anon indirectly. Al-Anon saved my life, literally, and has been a very crucial variable in the completion of this project. "One day at a time."

I also would like to thank Dr. David Ludwig at the University of North Carolina at Greensborough for his statistical suggestions. I thank Dr. Joan Vernikos, Cindy Bollens, Dr. Patricia Cowings, and Bill Toscano at NASA/Ames Research Center, and Dr. Joe Kamiya at the University of California, San Francisco for their support and encouragement.

Finally, I would like to thank Paola Pariguana García for her unwavering support and love, which have helped me tremendously in the completion of this project. Animo!

This research was supported in part by a San Jose State University Foundation $2500 Graduate Student Stipend Award. Dr. Laree Huntsman was the sponsoring mentor and her help in obtaining this award was greatly appreciated.

That is all. Now read the thesis.

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San Jose State University

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Requests for reprints should be sent to St. John A. Maloney, Department of Psychology, San Jose State University, San Jose, California 95192.

Abstract

Semantic facilitation and translation priming effects in Spanish-English compound bilinguals were demonstrated with a lexical decision task. Compound bilinguals learned both languages by the age of 10 and were used to control for language dominance. Current language usage and form of usage were also examined for their effects. A 300-ms stimulus onset asynchrony was used between display of the prime word and the target word or nonword. The word interconnection hypothesis states that lexical items in different languages are directly and lexically connected to each other. The concept mediation hypothesis states that lexical items are processed by means of an amodal conceptual system. Partial support was found for the word interconnection model. English words were responded to faster compared to Spanish words. The implications of these results and the confounding factors found in the study are discussed and future research is suggested.

Lexical Access and Concept Mediation in Compound Bilinguals

This thesis addresses two models of storage and retrieval processes in bilingual memory: the word interconnection and concept mediation hypotheses. The word interconnection model suggests that words in bilingual memory are directly connected to each other lexically (Figure 1). This applies to both translation equivalents (e.g., COW and VACA) and semantically related words within (COW and HORSE) and between languages (COW and CABALLO). Language-switching occurs on a lexical level and does not require conceptual processing (Chen & Ng, 1989; Kirsner, Smith, Lockhart, King, & Jain, 1984). The concept mediation model states that lexical access is mediated by conceptual, non-linguistic processes (Figure 2). Each lexical item (i.e., word) is connected to a concept. It is these concepts which are associated with each other. Therefore, translation equivalents are connected through one shared concept while semantically related words are connected through two associated concepts, i.e., concepts which share some but not all meaning (Chen & Ng, 1989; Kirsner et al., 1984; Potter, So, Von Eckardt, & Feldman, 1984).

To examine these two hypotheses, variations of what Neely (1991) calls the single-word semantic priming paradigm have been used. This paradigm consists of two event trials shown sequentially. In the first event, a word (called the

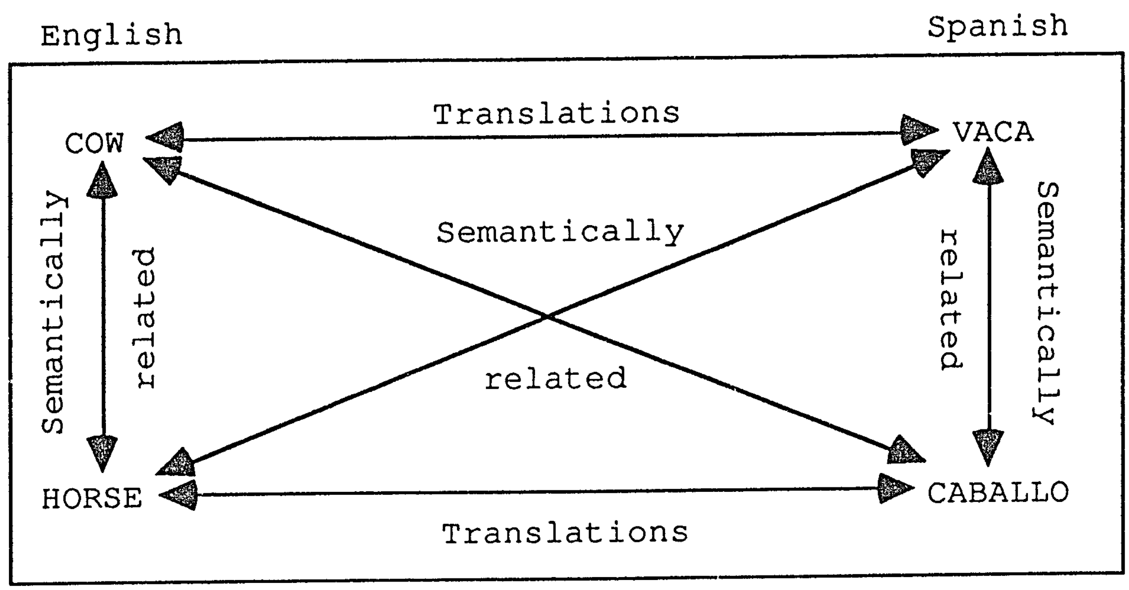

Figure 1. Model of word interconnection hypothesis showing direct lexical connections between translation equivalent and semantically related words, within and between languages. (Adapted from Chen & Ng, 1989; Kirsner et al., 1984.)

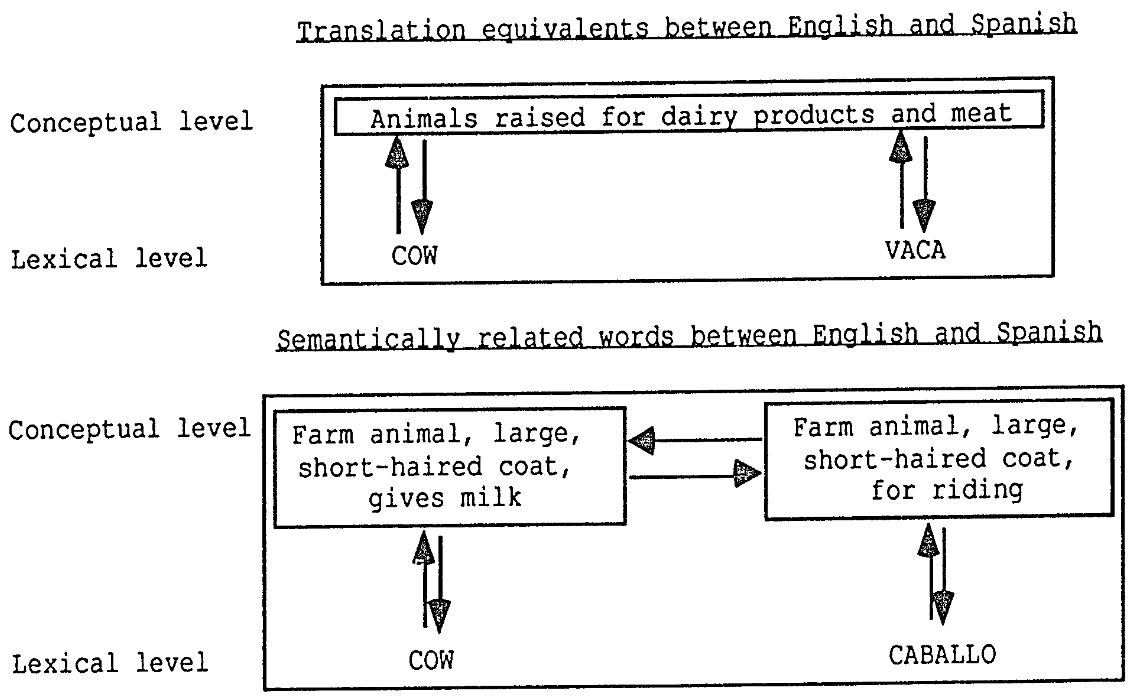

Figure 2. Model of concept mediation hypothesis. (Adapted from Potter et al., 1984.)

prime) is presented. No overt response is required. However, the prime establishes the semantic context for the second event, which is the presentation of a letter string (called the target). Subjects must respond to the target by making a word/nonword decision by pressing one of two keys on a keyboard. The task can be altered by asking subjects to name the target or alter the nature of the stimuli by using category primes with target exemplars. By manipulating the relationship between the prime and the target, one can influence the time it takes to recognize targets as words. For instance, response times are faster when the prime and target are semantically related (e.g., BREAD and BUTTER) rather than when they are not (e.g., DOCTOR and BUTTER). Meyer and Schvaneveldt (1971) provided the earliest example of this effect and it has been replicated numerous times since. Similar semantic facilitation is observed between languages (e.g., Chen & Ng, 1989; Schwanenflugel & Rey, 1986).

Kirsner et al. (1984), using a variation of the semantic priming task described above, examined three models of bilingual memory: the word interconnection, the concept mediation, and the word association models. The word association model suggests that lexical access occurs at a lexical level, not a conceptual one, and that translation equivalents are the only lexical items that are directly connected to each other between languages (Figure 3). Therefore, a word in English (e.g., COW) semantically related to a word in Spanish (e.g., CABALLO) is lexically connected through the translation of COW's semantically related word in English (i.e., HORSE). Semantically related words within a language are directly connected to each other, obviously. Kirsner et al. rejected the word association hypothesis on the basis of five experiments using English-French and English-Hindi bilinguals. In Experiment 1, they obtained facilitation only in an exact repetition condition. Facilitation occurred only in the translation condition when subjects had to actively translate the words previously in a training phase (Experiment 2). Even under conditions of active semantic processing, no between language facilitation was observed (Experiment 3). In each experiment, at least 15 min transpired between exposure to the prime word and response to the target (either as an exact repetition or a translation of the prime). It was therefore clear that between-language facilitation was transient and short lived, while exact repetitions were longer lasting, presumably from a reactivation of the orthographic features (Kirsner et al.). Translations showed a more lasting effect, but only when subjects intentionally translated the prime words beforehand. Because the word association model described by Kirsner et al. predicted equal reaction times for exact repetitions and translation equivalents, the authors dismissed this model.

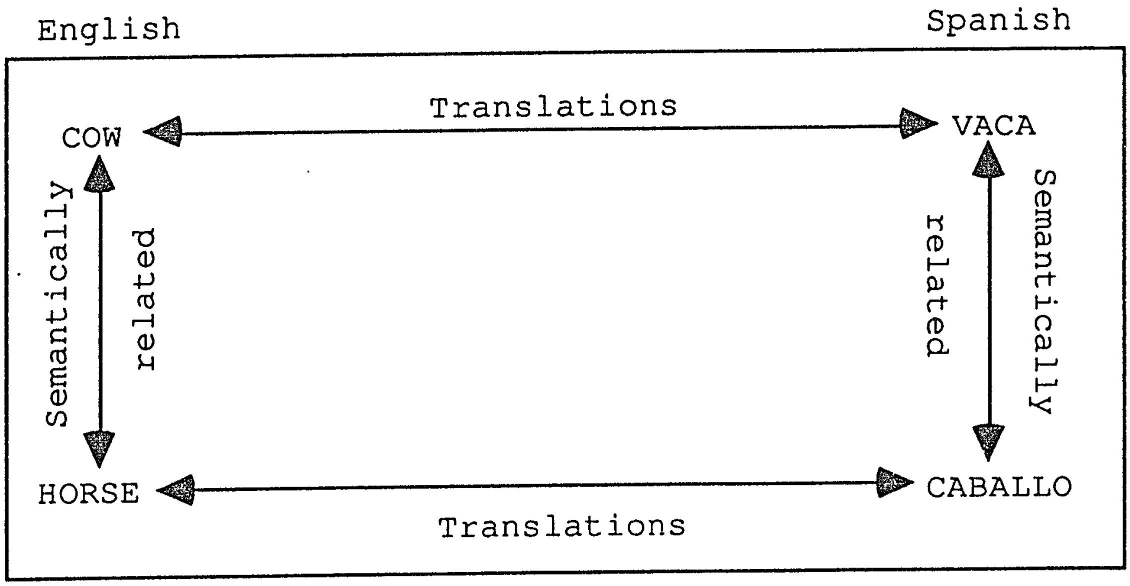

Figure 3. Model of the word association hypothesis. (Adapted from Chen & Ng, 1989.)

Kirsner et al. (1984) conducted two more experiments. In Experiment 4 they presented pairs of words in English and Hindi, two orthographically distinct languages. Word pairs were sequentially shown in mixed and monolingual conditions. In Experiment 5 they presented English and French word pairs serially with 0, 2, and 32 intervening items between the prime and target. They found semantic facilitation in both within- and between-language conditions in Experiment 4 but found a greater facilitatory effect in the within-language no-lag condition of Experiment 5. Though the authors obtained additional data to reject the word association hypothesis, they were unable to distinguish between the word interconnection and concept mediation hypotheses and, thus, suggested further research be done.

Schwanenflugel and Rey (1986) used a semantic priming task with 3 levels of semantic relatedness to pursue this issue further. Relatedness was defined in terms of high, medium, and low typicality as a category exemplar. They used 300- and 100-ms stimulus onset asynchronies in Experiments 1 and 2, respectively, to prevent any conscious, active translation of the prime. A stimulus onset asynchrony, or SOA, is the time between the presentation of the prime and target. Using neutral (i.e., READY and LISTO) and category-related primes in a lexical decision task, they found comparable reaction times within and between languages in Spanish-English bilinguals. The word interconnection model presented by Schwanenflugel and Rey was rejected, based on the prediction that within-language facilitation should be greater than between because between-language connections are naturally weaker than within (see also Potter et al., 1984). However, an alternative version of this model suggests that it is the number of connections between languages which influences performance on lexical decision tasks, not the strength. Schwanenflugel and Rey found comparable facilitation times between languages across levels of semantic distance, which contradict the prediction of such a model. Hence, the idea that semantic distance influences code-switching (i.e., language switching) was unsupported and rejected.

Instead, Schwanenflugel and Rey (1986) found support for the concept mediation model. Consistent with their findings, this model predicted equal facilitation between and within languages, since code-switching operates via a conceptual system, independent of language. Their results conflicted with those found by Kirsner et al. (1984), where within-language facilitation was greater than between (Experiment 4). Schwanenflugel and Rey were unable to determine a clear reason for this difference. However, their results were similar to Caramazza and Brones (1980) who showed code-switching did not increase category verification time. Additionally, Guttentag, Haith, Goodman, and Hauch

(1984) found equivalent facilitation effects when targets were flanked by between- and same-language words.

In an attempt to sort through the differences found between the results of Kirsner et al. (1984) and those of Schwanenflugel and Rey (1986), Chen and Ng (1989) used a lexical decision task comparing translation equivalent and semantically related word pairs. They used Chinese-English bilinguals. Using a 300-ms SOA, Chen and Ng found greater facilitation for translation equivalents than for between-language, semantically related words, lending support to the concept mediation model. That is, the model would predict translation equivalents to require less response time because such stimuli are processed through one concept node, rather than two in a semantically related setting. Chen and Ng's word interconnection model was therefore rejected because it predicted translation equivalents and semantically related words would elicit equal response times, since in both cases lexical items should be directly connected to each other.

Chen and Ng (1989) also demonstrated that translation facilitation occurs using short priming lags (300 ms), just as semantic facilitation does (e.g., Schwanenflugel & Rey, 1986). Kirsner et al. (1984) found no translation facilitation effect except under conditions of forced translation generation (Experiments 1 and 2). However, as mentioned previously, they used a 15 min lag between training and test sessions. We can infer from the results of Chen and

Ng and those of Kirsner et al. that between-language facilitation occurs only under short priming conditions (e.g., 300-ms SOA) and is very transient, while exact repetition facilitatory effects are longer lasting (Kirsner et al., Experiments 1 through 3).

However, one critique of Chen and Ng (1989) is their lack of within-language conditions in either language as a baseline for assessing these between-language results. If conceptual processes are really taking place, then there should be no difference between semantically related prime-target pairs between and within languages. Kirsner et al. (1984) also failed to use translations and semantically related words in the same experiment. Doing so would further strengthen arguments for or against the word interconnection and concept mediation models, in that it is the difference or similarity in times for translation equivalents and semantically related words which is the basis for distinguishing between the two models. Again, Schwanenflugel and Rey (1986) used only semantically related categories and their exemplars. It would be useful to compare the effects of translations, and semantically related and unrelated conditions between and within two languages.

Since it has already been established that facilitation occurs with translations and semantically related words using short SOA's (e.g., 300 ms) in a lexical decision task (Chen & Ng, 1989; Schwanenflugel & Rey, 1986), one can use such a design to evaluate the word interconnection and concept mediation models. The concept mediation model (see Figure 2) would predict no difference in between-language and within-language effects under a short SOA condition. It predicts greater facilitation for translations than semantically related words and greater facilitation for semantically related words than unrelated words, between languages. Since translations only access one concept node and semantically related words access two related ones, the former condition should require less time to process and respond. Reaction times in the semantically related and unrelated conditions between and within languages should be comparable.

However, exact repetitions should provide faster times than translation equivalents because repetition priming simply requires orthographic verification without lexical access (De Zuniga, Humphreys, & Evett, 1991). De Zuniga et al. argue that lagged repetition (i.e., repeating an item after varying numbers of other words or after a time delay) attenuates target response and that this may be due to the persistent activation of the item's lexical representation (Experiment 1). They also attribute immediate repetition effects to episodic factors, i.e., orthographic verification. Again in Experiment 1, they found immediate repetition faster when the targets were in the same script (i.e., handwriting vs. print) than when they were not. Therefore, it seems reasonable to assume that responses to exact repetitions, under immediate presentation conditions (300-ms SOA) will provide faster reaction times than translation equivalents, which require the relatively more lengthy process of lexical access.

The word interconnection hypothesis tested in this thesis and described by Kirsner et al. (1984), Schwanenflugel and Rey (1986), and Chen and Ng (1989) predicts translation equivalents and semantically related between-language facilitation to be comparable since lexical items are directly connected to each other in both conditions (see Figure 1). Within and between languages, semantically related times should be similar based on the tenets of the model. An alternative model of the word interconnection hypothesis might state that within-language links are weaker or number fewer than between-language ones. However, as explained earlier, Schwanenflugel and Rey (1986) demonstrated comparable times across levels of semantic distance within and between languages. Therefore, only the former version of the model will be examined.

To further examine priming effects and compare models, a surprise word recall task following the lexical decision task can be implemented. According to Potter et al. (1984), the more a word is processed, the more likely it is to be recalled. They asked subjects to (1) read a lexical item (i.e., an English word or Chinese character), (2) translate the item to the other language, or (3) name pictures in either language. In a word recall test following the experiment, subjects remembered more items when they were in the translation condition and when pictures were named in the second language (i.e., English). Recall was poorest when first language items (i.e., Chinese) were simply read. Following the results of Potter et al., the concept mediation hypothesis predicts the greatest recall for semantically related words since this condition requires the greatest amount of processing, accessing two associated concepts. Translation equivalents should provide the next highest level of recall, as they are processed through one concept. Semantically unrelated words would show the poorest recall, as they have no association with each other and it is assumed that priming aids in recall. The word interconnection model would predict recall to be equal for translation equivalent and semantically related conditions. In both conditions, direct lexical connections are shared with each other and should therefore be processed to the same extent. Recall is expected to be greater in these two conditions than in the semantically unrelated condition.

Another observation about studies by Chen and Ng (1989) and others (e.g., Frenck & Pynte, 1987; Kirsner et al., Experiment 5, 1984) is that they do not seem to control for fluency levels, only for length of use of each language. Chen and Ng found faster overall response time for first language (i.e., Chinese) targets. Kirsner et al. and Frenck and Pynte found similar results with first language targets (i.e., French). Dillon, McCormack, Petrusic, Cook, and Lafleur (1973) pointed out that the age of acquisition of each language is important in influencing the dominance of one language over another. They differentiated between compound and coordinate bilinguals. Extreme compound bilinguals, according to Dillon et al., acquire both languages simultaneously at an early age in a common context (e.g., home), while coordinate bilinguals learn one language at an early age in one context (e.g., home) and the other at a latter age in another context (e.g., school). The earlier both languages are learned then, the less likely language dominance should take place. However, as Schwanenflugel and Rey (1986) have shown, current language usage also influences language dominance. Schwanenflugel and Rey found a tendency for subjects to be more dominant in their second language (i.e., English) even though their first language was Spanish. A language profile questionnaire for each subject revealed that their current usage of language was dominated by English and not their first language (i.e., Spanish).

In this thesis, compound bilinguals were used to avoid language dominance problems. It was assumed that age-of-acquisition played a large role in the integration and organization of bilingual cognitive structures. Compound bilinguals should have more integrated and organized storage and retrieval systems (Dillion et al., 1973). Therefore, compound bilinguals should be expected to perform equally well (i.e., show comparable reaction times) when the target is in the first language (i.e., Spanish) or the second (i.e., English). However, since current language usage and form of usage (i.e., writing, reading, and speaking) might influence language dominance, a good measure of these variables would be useful as well. If current language usage and form of usage exert heavy influences on lexical decision task performance, then one should see dominance in the language that is more commonly used. In a lexical decision task, it would be important to note the degree of reading one language more than the other. If current language usage and form of usage do not influence lexical decision performance, then reaction times should be comparable between languages. Regardless, language dominance, or the lack thereof, should operate independent of performance on the different prime-target relation conditions of the lexical decision task (i.e., translation equivalent, semantically-related, and semantically-unrelated).

Method

Subjects

The participants in this study were 24 Spanish-English bilinguals. Subjects were mostly acquired from the introductory psychology subject pool at San Jose State University. None were paid. Average age was 20.9 years. All subjects were compound bilinguals. The definition of a compound bilingual was adjusted from Dillon et al. (1973) so that it refers to a person who has acquired both languages by the age of 10 regardless of whether acquisition occurred in a common context or two different ones. Spanish was the first language for all subjects. Average age of acquisition for English was 5.3 years. All subjects had normal or corrected-to-normal vision.

Design

The 2 X 2 X 3 design used a word/nonword lexical decision task and included one between-subjects factor: language of prime (English or Spanish). The design also contained two within-subjects factors: target language (English or Spanish) and prime-target relation (translation/repetition, semantically related, semantically unrelated).

Stimuli

One-hundred and twenty prime-target pairs were used in the experiment. For 60 pairs, the second item was a word (word trials) and for 60 pairs, it was a nonword (nonword trials). Of the word trials, 20 were translation/exact repetition trials (10 were translations, 10 were repetitions), 20 were semantically related, and 20 were semantically unrelated trials. In the word trials, all English words were of low to medium frequency usage, occurring 30 or fewer times per million (Francis & Kucera, 1982). Appendix B displays the frequency level of each word in English according to Francis and Kucera. In the word trials, all Spanish words were assumed to be low to medium frequency, occurring in the last four thousand or less concepts (Eaton, 1968). Eaton's rating system centers around English and is the integration of four separate semantic dictionaries (all different authors). An English word and its translations in French, German, and Spanish were considered one concept. Thus, concepts were grouped into thousands, with the first thousand being the most common (or highest frequency) concepts. The second group of thousand concepts would be considered the second most common group of concepts, and so on. If a word and its translation fell into different conceptual levels of commonness, a number was noted next to the word to indicate the appropriate level. For example, "4a" next to a word would indicate that the word belonged to the fourth group of thousand words. An "a" or "b" next to a number indicates whether it is in the first or second half, respectively, of the group. Not all numbers have letters next to them. Appendix B displays Eaton's ratings for Spanish words. English and Spanish words that have a "*" for frequency level do not appear in the lists of Francis and Kucera (English) or Eaton (Spanish) and were therefore assumed to be low frequency words. English and Spanish nonwords were constructed from targets from the word trials. Each nonword was created, following Chen and Ng (1989), by randomizing letters of the original words. Care was taken to assure that nonwords did not represent other words in either language nor known abbreviations or acronyms. All the nonwords were meaningless, though some were pronounceable. Words in nonword trials were mostly medium and low frequency, according to the definitions just mentioned above. See Appendix B for a listing of the word and nonword pairs. All words were nouns and none were more than 9 letters and three syllables long. See Appendix B for letter and syllable counts for each stimulus item. During the selection and construction of the stimuli, care was taken to ensure that the primes and targets were appropriately related or unrelated to each other. Three pilot subjects rated (seven point Likert scale: 1 = not related at all; 7 = related very much) the relatedness of each word pair. Related word pairs with averages of 4.0 or above were included, while those less than 4.0 were changed. Unrelated word pairs with averages of less than 4.0 were included, while those 4.0 or more were changed. Subjects indicated whether translation equivalents were appropriate or inappropriate and were encouraged to write suggestions down if they were the latter.

All stimulus items were shown on an IBM/PC compatible computer. All items appeared in the center of the screen with white lower case letters on a black background. Subjects sat approximately 60 cm away from the monitor.

Procedure

The subjects were tested individually in 1-hr sessions. Each session began by evaluating subject reading and writing fluency levels using the Ambiguous Word Language Dominance Test (Keller, 1978a) and the Flexibility Language Dominance Test (Keller, 1978b), respectively. In the first test (Keller, 1978a), subjects read a list of 100 words. Twenty-four of the words were considered ambiguous and could be pronounced in either language (e.g., RADIO). In the second test (Keller, 1978b), subjects were presented with six eight-letter nonwords and, from them, asked to write down as many words as possible in English and Spanish for 1 min each. Subjects could only use each letter once per word they constructed and each word they created had to use only the letters in the nonword. In both tests, the number of English words pronounced or created was subtracted from the number of Spanish words pronounced or created. The scoring was as follows: +24 to +18 = Spanish dominant; +17 to +11 = substantially Spanish dominant; +10 to +4 = moderately Spanish dominant; +3 to -3 = balanced bilingual; -4 to -10 = moderately English dominant; -11 to -17 = substantially English dominant; -18 to -24 = English dominant. Subjects were also given a language profile questionnaire adapted from Schwanenflugel and Rey (1986) which asked them to describe age-of-acquisition information, number of years of usage, percentage of day each language was used, and contexts in which each language was generally used. It also asked subjects to rate themselves as users of each language. Information from these tests and the language profile questionnaire is provided in Appendix C.

The experimental session consisted of 5 blocks of 24 trials each (12 word and 12 nonword trials per block). The order of these blocks was randomized across subjects for both groups. Within each block, trials were also randomized. Trials with nonwords which were derived from their original target words were not included in the same block. Within each block in the word pairs, three different kinds of prime-target relation conditions were presented (i.e., translation/repetition, semantically related, semantically unrelated), with 4 trials of each (in the translation/repetition condition, 2 of each were presented). The other 12 trials were nonword trials.

At the beginning of each experimental session (modeled after Chen & Ng, 1989), subjects were given verbal instructions and written instructions on the computer screen (see Appendix D for written directions), and 14 practice trials (7 word and 7 nonword trials). Twenty-eight of the non-ambiguous words in Keller (1978a) were used for stimuli in the practice session. The practice session was offered to familiarize the subjects with the experimental procedure and the characteristics of each trial. It was offered more than once if a subject still felt uncomfortable with the procedure. None of the words in Keller and the practice session were included in the experimental session. Each trial always began with an 800-ms presentation of a "+" in the center of the visual field, followed immediately with a 300-ms presentation of the prime word. The prime word appeared about 0.5 cm above where the "+" had been. Subjects were instructed to focus on the "+" and then read the prime word silently, but not to respond to it. The prime was followed immediately by a target item for 2 sec, which appeared about 0.5 cm below where the "+" had been. On each trial, the subject's task was to decide whether the presented target was a word or not. The instruction was to respond as accurately and as quickly as possible by pressing one of two keys on the keyboard indicating "WORD" or "NONWORD". Responses were made only with the index fingers of each hand. The order of these responses was counterbalanced across subjects to avoid handedness biases in the response time. If the subject did not respond within 2 sec, the computer recorded the trial as a no-response and it was considered an error. The computer then proceeded to the next trial. At the beginning of each trial, a message appeared on the screen that said "WHEN YOU ARE READY FOR THE NEXT TRIAL, PRESS THE SPACE BAR TO CONTINUE". Subjects were told to use their thumb to do this.

At the end of the experimental session, in a surprise task, subjects were asked to recall as many words from the experiment as possible within 5 min. Finally, the nature and purpose of the experiment and performance on the reading and writing fluency tests were explained to the subject.

Results

The mean reaction time (for correct responses) and accuracy rate results for word targets are summarized in Table 1. The dependent variable for analysis was each subject's average performance within each condition. Using the average reaction time, rather than each reaction time on each trial as a repeated measure, avoided uneven sample sizes and missing data problems. These data were subjected to separate 2 X 2 X 3 analyses of variance (ANOVAs) with one between-subjects factor (prime language) and two within-subjects factors (target language and prime-target relation). To test the predictions that differentiate the word interconnection and concept mediation models, student t-tests and F-tests were used. Word recall was analyzed in a similar fashion (ANOVA). Word reaction time and accuracy results will be described first. Then, nonword reaction time and accuracy results will be discussed, followed by a description of the word recall results.

Word Reaction Time

In the reaction time data, both priming groups performed similarly overall ($F(1,22)=0.347$, $p>.05$). English targets

Table 1

Mean reaction time and mean accuracy (out of ten trials) ± standard error for word and nonword responses

Language		Prime-target relationship			
Prime	Target	T/R	SR	SU	Nonword
English	English	776 ± 59	762 ± 38	858 ± 40	877 ± 31
		9.4 ± 0.3	9.6 ± 0.2	9.5 ± 0.2	9.4 ± 0.2
	Spanish	898 ± 75	897 ± 68	870 ± 64	865 ± 31
		8.3 ± 0.5	8.5 ± 0.3	9.3 ± 0.3	9.2 ± 0.1
Spanish	English	788 ± 35	802 ± 34	857 ± 26	884 ± 23
		9.5 ± 0.2	8.3 ± 0.2	9.5 ± 0.3	9.3 ± 0.1
	Spanish	914 ± 67	993 ± 57	926 ± 33	861 ± 21
		7.1 ± 0.6	8.1 ± 0.5	7.2 ± 0.5	9.4 ± 0.1

Note. T/R = translation/repetition; SR = semantically related; SU = semantically unrelated. Nonword target language refers to the language of word from which the nonword was derived.

were always responded to faster than the Spanish targets ($F(1,22)=14.418$, $p<.001$). No overall difference was found for prime-target relatedness ($F(2,44)=1.590$, $p>.05$). However, there was an interaction observed between target language and prime-target relation ($F(2,44)=7.410$, $p<.01$). Therefore, a student t-test was performed to compare translation equivalents and semantically related conditions in each target language. No differences were found for English targets ($t(23)=0.017$, $p>.05$) or Spanish targets ($t(23)=1.150$, $p>.05$). A one-way ANOVA was also performed in each target language to compare the semantically-unrelated condition with the translation equivalent and semantically-related conditions. Semantically unrelated response times were significantly slower than times for translation equivalents and semantically related word pairs, but only when the target was in English ($F(2,46)=11.492$, $p<.001$). Prime language did not interact with either target language or prime-target relation.

Accuracy rates were generally high in each condition, ranging from 9.6 to 7.1 out of 10. No speed-accuracy tradeoff was observed. Subjects were more accurate in the English prime group ($F(1,22)=7.061$, $p<.05$) and more accurate when the target was in English ($F(1,22)=2.399$, $p<.001$). No overall difference among prime-target relatedness was observed ($F(2,44)=1.321$, $p>.05$). A 2-way interaction between target language and prime-target relatedness ($F(2,44)=4.208$,

$p<.05$) was observed but this interaction was subsumed under a 3-way interaction between target language, prime-target relation, and prime language ($F(2,44)=8.581$, $p<.001$). To examine the 3-way interaction, four one-way ANOVAs were performed, two within in each prime language group. They compared semantically unrelated against semantically related and translation equivalent conditions for each prime language-target language condition. For the English prime group, the English target condition was not significant ($F(2,22)=0.121$, $p>.05$), while the Spanish target condition approached significance ($F(2,22)=2.279$, $p=.057$). For the Spanish prime group, the English target condition was significant ($F(2,22)=10.170$, $p<.001$), while the Spanish target condition approached significance ($F(2,22)=3.054$, $p=.068$)). Subjects in the English prime group performed better in the semantically unrelated condition when the targets were in Spanish. No difference was observed in the English target condition. In the Spanish prime group, subjects were less accurate in the semantically related condition when the target was in English, and more accurate in the same condition when the target was in Spanish.

Nonword Targets

Both the response times and accuracy rates showed no difference between prime language groups and target language origin (i.e., whether the nonword was derived from an English or Spanish word). Accuracy rates were all high. See Table 1 for response times and accuracy rates.

Word Recall

Word recall data are shown in Table 2 and was generally very low, ranging from 1.4 to 0.4 words recalled per condition. A 3-way significant interaction was found between target language, prime-target relation, and prime language ($F(2,44)=4.153$, $p<.05$). Four one-way ANOVAs were performed for each target language in each prime language to examine prime-target relation differences. Semantically related words were found to produce greater recall than exact repetitions and semantically unrelated words, but only in the Spanish prime-Spanish target condition ($F(2,22)=5.923$, $p<.01$). A significant main effect was found for prime-target relation ($F(2,44)=3.439$, $p<.05$), but this main effect was subsumed within the 3-way interaction just described between target language, prime-target relation, and prime language.

Word recall for word-nonword pairs provided almost no recall and showed no significant difference between prime language groups.

Discussion

The first results discussed will be those of target language dominance. Then, results concerning the word interconnection and concept mediation models will be discussed. Finally, a summary will be presented along with a

Table 2

Word recall ± standard error

Language		Prime-target relationship		
Prime	Target	T/R	SR	SU
English	English	1.4 ± 0.4	1.3 ± 0.4	0.9 ± 0.2
	Spanish	1.4 ± 0.3	0.8 ± 0.3	0.7 ± 0.2
Spanish	English	0.8 ± 0.2	0.6 ± 0.2	0.7 ± 0.2
	Spanish	0.6 ± 0.2	1.5 ± 0.4	0.4 ± 0.1

Note. T/R = translation/repetition; SR = semantically related; SU = semantically unrelated.

suggestion of future experiments needed to resolve some of the issues raised in this thesis.

The most consistent finding of this study was that subjects responded faster to English targets than Spanish targets, regardless of what language the prime was in (Figure 4). Two explanations are possible to explain this phenomenon: (1) subjects were more familiar with reading English, and (2) word length and number of syllables were greater for Spanish words than English. Based on the language profiles of subjects in Appendix C, subjects were clearly dominant in English with respect to reading (Keller, 1978a). Subjects rated themselves better readers of English and used English more often and in more contexts. Schwanenflugel and Rey (1986) similarly found current language usage heavily influenced target language responses in a lexical decision task.

The results indicate that language familiarity plays a large role in access to lexical representation. That is, the more familiar one is with a language, the faster one accesses the meaning of its lexical items. This presents a potential problem to Dillon et al.'s (1973) tenet that age-of-acquisition heavily influences language dominance. However, Dillon et al. defined compound bilinguals as people who learn both languages early--by age 6--in the same context (e.g., home). Coordinate bilinguals learn one language early in life--by age 6--in one context (e.g., home and the other

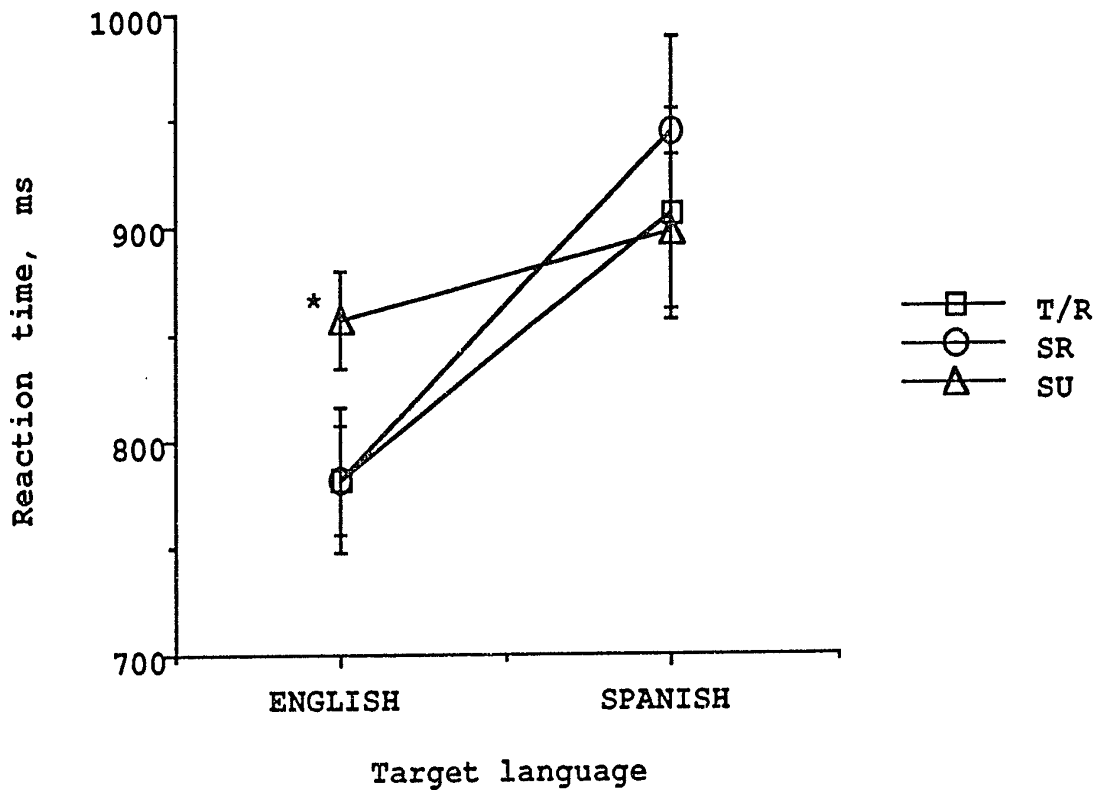

Figure 4. Word responses ± standard errors across English and Spanish priming groups. (T/R = translation/repetition; SR = semantically related; SU = semantically unrelated. *SU significantly different from T/R and SR in English target language condition, $p<.001$.)

language later in life--after age 6--in another context (e.g., school). The operational definition used in this thesis for a compound bilingual was simply that subjects acquired both languages by the age of 10. This was done to increase the subject pool, but may have influenced the target language dominance observed. It is possible that what were assumed to be compound bilinguals, were in fact coordinate. Furthermore, one's history of language usage, which was not examined in this thesis, may influence lexical decision performance. More research is needed to examine these factors individually.

An alternative explanation for the faster responses to English targets is that English words were both shorter in letters and syllables than Spanish words. According to Howard (1991), word recognition time increases with word length and presumably number of syllables. Unlike English, Spanish orthography-to-phonology rules are much more consistent. Thus, Spanish words, especially low frequency words, tend to be longer than their English counterparts. Words high in frequency in a given language tend to be shorter, relative to low frequency words. Appendix B shows the word frequency values for each lexical item in this study. Words low in frequency (10 occurrences out of a million is the common definition) do indeed tend to be longer and contain more syllables. Spanish words in this experiment were harder to identify as high or low frequency because of

Eaton's (1968) indirect rating system. Clearly, better definitions of Spanish frequency levels are needed and once these definitions are established, better control of frequency range can be accomplished. Further repetitions of this experiment need to control for and match word length, number of syllables and word frequency more closely.

Support was found for the word interconnection hypothesis, but was found only in the English target condition (see Figure 4). This model predicts comparable reaction times for translation equivalents and semantically related words, and predicts that these two conditions will provide faster reaction times than semantically unrelated words. Semantically unrelated words elicited slower responses than the other two conditions (Figure 4), which are indeed comparable. Furthermore, facilitation of a translation equivalent or semantically related prime was not greater when the prime was in English rather than Spanish. As just pointed out, discrimination within prime-target relation was obtained only with English targets. This might be explained by the fact that subjects were faster overall to English targets, which would indicate that subjects were less fluent readers in Spanish. Thus, they might be more influenced by surface features, such as word length and number of syllables. Since they seem to be less fluent in Spanish, the ability to note relatedness between words would be attenuated to the point where no difference might be observed between responses to related and unrelated word pairs. However, word recall presents a potential problem, since the only significant difference found does not provide support for the word interconnection model. Semantically related words were recalled more, but only in the Spanish prime-Spanish target condition (Figure 5). This would provide support for the concept mediation model were it not for the generally low recall of 1.4 to 0.4 words per condition. Essentially, this was a floor effect. Thus, the word recall data was dismissed as insignificant. Although word accuracy results were also a bit odd, but in a direction which indicated that no speed-accuracy tradeoffs occurred, they were dismissed as contributing no confounding effects.

Although the word interconnection model was supported in this thesis, much evidence has been found in support of the concept mediation model (e.g., Chen & Ng, 1989; Potter et al., 1984; Schwanenflugel & Rey, 1986). Chen and Ng, for example, found translations to elicit faster responses than between-language semantically related words, and between-language semantically related words to elicit faster responses than between-language semantically unrelated words. Although there was no within-language baseline used to assess between-language results, Chen and Ng's between language results do conflict with the between-language results found here. It is not clear why the results found here and in Chen and Ng differ, since the design is essentially the same.

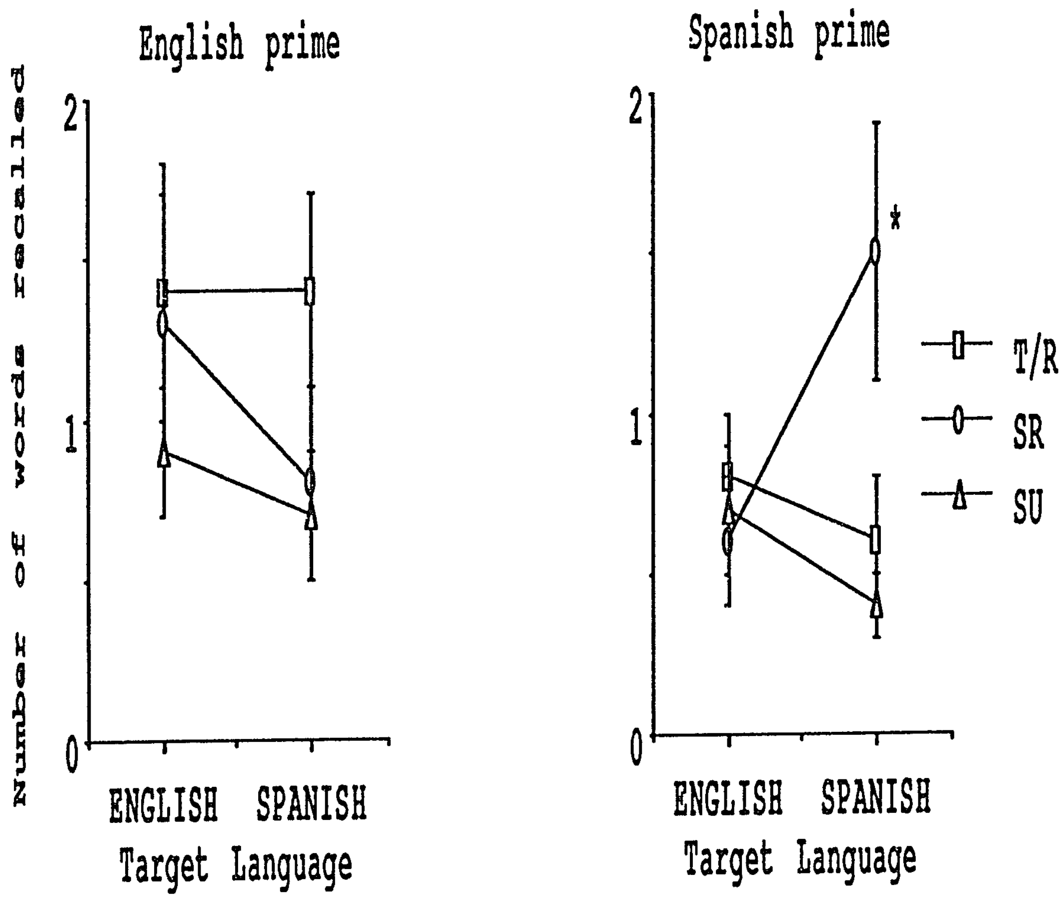

Figure 5. Word recall for English and Spanish prime groups. (T/R = translation/repetition; SR = semantically related; SU = semantically unrelated. *SR significantly different from T/R and SU in Spanish target language condition, $p<.01$.)

Further research must be conducted to explore this issue. It should be noted that using within-language conditions as a baseline for assessing between-language performance in this thesis was a helpful measure and provided comparable results. Any future research conducted to investigate these models should include this in its design.

Another interesting finding of this study concerns exact repetitions. Exact repetitions and translation equivalents could not be distinguished from one another in either target language condition. Translation/repetitions were faster overall for English targets than Spanish targets. It is not clear why this is. De Zuniga et al. (1991) have pointed out that through orthographic reactivation, exact repetitions should elicit a faster response than repeating the word in a different script (e.g., print and handwriting). A likely possibility is that some degree of lexical representation is taking place both within and between languages. It may also indicate the existence of a subject strategy, which will be discussed shortly.

Based on these results, it might be concluded that the stimulus set is confounded. As just noted, word length, number of syllables, and definitions of word frequency are all potential confounding factors. Furthermore, the degree of word relatedness is questionable, based on these data. It is believed the standards used to establish word relatedness were not stringent enough. Increased care must be insured.

It is also entirely possible that differences in the prime-target relation observed only within the English target condition and not in the Spanish target condition are due to cultural differences in relatedness, which can sometimes differ drastically (Schwanenflugel, Blount, & Lin, 1991).

On the other hand, Shelton and Martin (1992) point out that people often confuse semantic relatedness for word association. In their experiments, they used a single presentation lexical decision task, presenting each word alone and expecting a word/nonword response, with a 300-ms SOA. They concluded that automatic priming (i.e., no conscious priming) occurred with words that were associated with each other, but not with words that were semantically related but had no association (Experiments 3 and 4). Therefore, words that are associated with each other should show an even greater priming effect than words that are not semantically related and have no association with each other. Since the contrast between associated words and non-associated, unrelated words should be greater than that between semantically related and semantically unrelated words, a smaller priming effect should be observed between semantically related and unrelated words. Thus, the absence of a semantic priming effect observed in the Spanish target condition may be due to a low level of relatedness and/or association for semantically related words. However, one problem in interpreting the results found in this thesis within the context of Shelton and Martin is the difference in priming paradigms.

The single presentation lexical decision task Shelton and Martin (1992) used eliminates two types of subject strategies. The first kind is called an expectancy strategy. It involves reading the prime and then generating possible targets for it. Using this strategy, the subject will respond WORD faster when the target matches one of the generated targets. Because related words are generated, responses to such words will be faster compared to unrelated words. In this experiment, expectancy strategies were avoided by using a short SOA, which prevented the subject from consciously generating potential targets. The second kind of subject strategy is called a post-lexical checking strategy, where the subject does not respond to the target until the semantic relation between it and the prime is assessed. The subject will again be faster to respond WORD since, in determining a relationship between the prime and target, if there is a relation, the target must be a word. Responses tend to be faster for related words than unrelated, using this strategy, since establishing that words are related takes less time than establishing that they are not (Balota & Lorch, 1986; Shelton & Martin, 1992). This sort of strategy was possible in this study and may account for the results found with the reaction times. In the English target condition, when words were related, either in the translation equivalent or semantically-related condition, subjects responded faster than in the semantically-unrelated condition. This strategy may also account for the results found in the Spanish target condition. Since it is assumed subjects were less familiar with Spanish, then the ability to differentiate between related and unrelated words should be attenuated. Future research must be designed to prevent the use of both of these strategies.

Certainly, another possibility for the results is that subjects simply did not look at the prime. Since the target appeared about 1 cm below the prime, the prime could have easily been ignored. This seems unlikely, however, based on the semantic priming effects found for English targets.

In summary, then, English targets elicited faster responses than Spanish targets, regardless of the prime language. This might be attributable to (1) word length, (2) the number of syllables, (3) word frequency, (4) the age-of acquisition for each language, (5) the history of language usage, (6) current language usage, and/or (7) the form of usage. More studies must be conducted, controlling these variables more closely, to identify the origin of these target language effects.

Also, support was found for the word interconnection hypothesis, where translation equivalents and semantically related words elicited comparable and faster reaction times than semantically unrelated words. Word recall results contradicted the prediction of this model but were dismissed because of overall low recall attributed to a floor effect. The basis for support of the word interconnection model was observed with English targets but not Spanish targets. This difference was explained as possibly being due to post-lexical checking subject strategies.

It was also suggested that the stimulus set might be confounded by (1) word length, (2) the number of syllables, (3) word frequency, (4) poor relatedness ratings, (5) cultural differences in relatedness, and/or (6) the lack of word association (as explained in Shelton & Martin, 1992). Again, further research needs to be conducted to attenuate the influence of these factors.

Two studies are suggested, in particular. In a design similar to the one used here, the following changes should be made. (1) Words in each language should be matched more closely for word length, number of syllables, and word frequency (semantic facilitation is supposedly amplified with low frequency words (Neely, 1991)). (2) Relatedness between and within languages should be more closely constrained (e.g., use only "very related" words). (3) Compound bilinguals who conform to Dillon et al.'s (1973) definition and who are classified as "balanced" bilinguals according to Keller (1978a, b) should only be used. Incorporating these changes is a time consuming process and reduces one's subject pool dramatically, but it must be done. These strategies would allow one to compare the word interconnection and the concept mediation models, between and within languages, and examine target language responses more clearly.

In a second experiment, use a single presentation priming paradigm, similar to Shelton and Martin's (1992) design, with the same constraints as just explained above. However, create two distinct conditions: associated words and words semantically related but not associated. Words must be associated with each other between as well as within languages, if possible. This design would get rid of the post-lexical checking and expectancy generation strategies and isolate priming effects to automatic processes instead of conscious ones. It would also establish if automatic semantic processing were occurring between and within languages and provide additional evidence for or against either model of lexical access.

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Appendix A

Approved Proposal Form

APPROVED BY THE MASTER'S THESIS COMMITTEE

____
Robert Cooper, Ph.D.

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Nusha Askari, Ph.D.

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Robert Fox, Ph.D.

APPROVED BY THE DESIGN AND ANALYSIS COMMITTEE

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Appendix B

Word List

English	FREQ	LTR	SYL	Spanish	FREQ	LTR	SYL
ant	6	3	1	hormiga	4b	7	3
antler	*	6	2	cuerna	*	6	2
anvil	1	5	2	yunque	8	6	2
arrow	13	5	2	flecha	4a	6	2
bacon	8	5	2	tocino	5a	6	3
badge	5	5	1	divisa	6b	6	3
bark	13	4	1	corteza	4b	7	7
basin	5	5	2	bol	*	3	1
basket	15	6	2	cesto	5b	5	2
beaver	2	6	2	castor	*	6	6
beech	2	5	1	haya	8	4	2
belly	23	5	2	panza	5b	5	2
berry	3	5	2	baya	*	4	2
birch	1	5	1	abedul	8	6	3
blanket	29	7	2	manta	*	5	2
blemish	2	8	2	tacha	5b	5	2
blister	2	7	2	ampolla	8	7	3
blizzard	7	8	2	ventisca	*	8	3
boar	1	4	1	verraco	*	7	3
bodice	1	6	2	almilla	*	7	3
braid	*	5	2	trenza	4b	6	2
brake	2	5	1	freno	4b	5	2

English	FREQ	LTR	SYL	Spanish	FREQ	LTR	SYL
brooch	*	6	1	alfiler	4b	7	3
broom	2	5	1	escoba	5b	6	3
brow	6	4	1	ceja	4b	4	2
cabbage	4	7	2	col	5a	3	1
cage	1	4	1	jaula	6b	5	2
canister	2	8	3	lata	6b	4	4
canvas	19	6	2	lona	*	4	2
cap	17	3	1	gorra	6a	5	2
carton	1	6	2	envase	*	6	3
cask	1	4	1	tonel	8	5	2
cherry	1	6	2	cereza	*	6	3
chute	2	5	1	tolva	*	5	2
clam	3	4	1	almeja	7a	6	3
claw	1	4	1	zarpa	*	5	2
cocoon	3	6	2	capullo	6b	7	3
colt	13	4	1	potro	4b	5	2
cookie	3	6	2	galleta	*	7	3
curtain	11	7	2	cortina	4b	7	7
dimple	*	6	2	hoyuelo	8	7	3
ditch	9	5	1	zanja	*	5	2
doyen	*	5	2	decano	8	6	6
droplet	*	7	2	gotita	*	6	6
dwarf	2	5	1	enano	*	5	3
ebb	*	3	1	reflujo	*	7	3
egret	1	5	2	garceta	*	7	3

English	FREQ	LTR	SYL	Spanish	FREQ	LTR	SYL
elk	1	3	1	ance	*	4	2
elm	2	3	1	olmo	*	4	2
emery	*	5	3	esmeril	*	7	7
enamel	1	6	3	esmalte	6a	7	3
fabric	15	6	2	tejido	*	6	3
fang	*	4	1	colmillo	*	8	3
fern	1	4	1	helecho	8	7	3
fig	2	3	1	higo	8	4	2
fir	2	3	1	abeto	8	5	3
flea	*	4	1	pulga	6b	5	2
fuzz	3	4	1	tamo	*	4	2
glint	2	5	1	destello	*	7	3
gobbet	*	6	2	trocito	*	7	3
grapnel	*	7	2	arpeo	*	5	3
groan	1	5	1	gemido	4a	6	6
groin	4	5	1	ingle	*	5	2
helmet	1	6	2	casco	4a	5	2
ingot	*	5	2	lingote	*	7	7
ivory	13	5	3	marfil	4b	6	2
jab	1	3	1	pinchazo	7b	8	3
jalopy	1	6	3	cacharro	*	8	3
jowl	2	4	1	quijada	8	7	3
kale	1	4	1	berza	*	5	2
keel	5	4	1	quilla	*	6	2
kernel	3	6	2	semilla	5a	7	3

English	FREQ	LTR	SYL	Spanish	FREQ	LTR	SYL
kettle	3	6	2	caldero	*	7	3
kite	1	4	1	cometa	4b	6	3
knuckle	2	7	2	nudillo	*	7	3
lag	1	3	1	retraso	8	7	7
ledge	4	5	1	repisa	*	6	3
leek	*	4	1	puerro	*	6	2
lid	19	3	1	tapa	*	4	2
lizard	*	6	2	lagarto	6a	7	3
locust	6	6	2	langosta	6b	8	3
loom	5	4	1	telar	*	5	2
loon	1	4	1	bobo	5a	4	4
minaret	*	7	3	alminar	*	7	3
minstrel	2	8	2	juglar	8	6	6
molar	1	5	2	muela	6b	5	5
molasses	1	8	3	melaza	*	6	3
mucus	2	5	2	moco	*	4	2
mud	31	3	1	lodo	4a	4	2
mushroom	2	8	2	hongo	*	5	2
muzzle	10	6	2	hocico	6b	6	3
navel	2	5	2	ombligo	*	7	3
notch	6	5	1	muesca	*	6	2
nozzle	4	6	2	tobera	*	6	3
nun	2	3	1	monja	8	5	2
orange	9	6	1	naranja	4a	7	3
oyster	6	6	2	ostra	6a	5	2

English	FREQ	LTR	SYL	Spanish	FREQ	LTR	SYL
pantry	2	6	2	despensa	8	8	3
parade	23	6	2	desfile	*	7	3
peach	2	5	1	durazno	*	7	3
peal	1	4	1	repique	*	7	7
pellet	*	6	2	bolita	*	6	3
pig	8	3	1	cerdo	4b	5	2
plague	3	6	1	peste	4b	5	2
pleat	*	5	1	pliegue	5b	7	3
plover	*	6	2	chorlito	*	8	3
plumb	1	5	1	plomada	*	7	3
pottery	15	7	3	alfar	*	5	2
rabbit	11	6	2	conejo	4a	6	3
rack	7	4	1	estante	7a	7	7
racoon	*	6	2	mapache	*	7	3
rag	7	3	1	trapo	4b	5	2
rake	8	4	1	rastro	6a	6	2
rapier	1	6	3	estoque	*	7	7
ream	*	4	1	resma	*	5	2
reed	*	4	1	carrizo	*	7	3
reef	*	4	1	arecife	*	7	7
reel	2	4	1	carrete	*	7	7
scallop	*	7	2	venera	*	6	3
shack	1	5	1	choza	5a	5	2
sheath	4	6	1	vaina	8	5	2
sherry	4	6	2	jerez	*	5	2

English	FREQ	LTR	SYL	Spanish	FREQ	LTR	SYL
shingle	*	7	2	ripia	*	5	3
shovel	5	6	2	pala	8	4	2
sieve	1	5	1	tamiz	*	5	2
sludge	4	6	1	fango	*	5	2
slug	8	4	1	babosa	*	6	3
snail	1	5	1	caracol	4a	7	3
spear	2	5	1	lanza	3a	5	2
spout	1	5	1	chorro	5b	6	2
sprig	1	5	1	espiga	*	6	3
spring	102	6	1	resorte	5a	7	3
steak	8	5	1	biftec	*	6	2
swan	2	4	1	cisne	6a	5	2
talon	*	5	2	garra	5a	5	1
tassel	1	6	2	borla	6b	5	5
thigh	9	5	1	muslo	8	5	2
thimble	1	7	2	dedal	8	5	2
thistle	*	7	2	cardo	8	5	2
tier	*	4	1	grada	4b	5	2
tinsel	2	6	2	oropel	*	6	3
toad	4	4	1	sapo	6a	4	2
trash	2	5	1	basura	6a	6	3
tray	18	4	1	bandeja	7a	7	3
trigger	11	7	2	gatillo	*	7	3
tuft	*	4	1	copete	*	6	3
tureen	*	6	2	sopera	*	6	3

English	FREQ	LTR	SYL	Spanish	FREQ	LTR	SYL
turkey	3	6	2	pavo	4b	4	2
turnip	*	6	2	nabo	7a	4	2
twine	*	5	1	guita	*	5	2
urchin	*	6	2	pilluelo	*	8	3
vulture	4	7	2	buitre	*	6	2
walnut	4	6	2	nuez	5b	4	2
walrus	1	6	2	morsa	*	5	2
wasp	2	4	1	avispa	8	6	3
wig	1	3	1	peluca	8	6	3
yawn	1	4	1	boztezo	*	7	3
yew	*	3	1	rueca	6b	5	5
yoke	1	4	1	yunta	*	5	2
zenith	1	6	2	cenit	*	5	2

Note. An "*" refers to an English word which does not appear in Francis and Kucera (1982) or a Spanish word which does not appear in Eaton (1968). These words were assumed to be low frequency.

Word Pairs

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
Translation equivalents				
Within languages				
	(English)	(English)	(Spanish)	(Spanish)
1	lid	lid	tapa	tapa
2	loom	loom	telar	telar
3	brake	brake	freno	freno
4	shingle	shingle	ripia	ripia
5	tinsel	tinsel	oropel	oropel
6	mushroom	mushroom	hongo	hongo
7	molasses	molasses	melaza	melaza
8	cabbage	cabbage	col	col
9	parade	parade	desfile	desfile
10	cherry	cherry	cereza	cereza
Between languages				
	(English)	(Spanish)	(Spanish)	(English)
1	plumb	plomada	plomada	plumb
2	ditch	zanja	zanja	ditch
3	colt	potro	potro	colt
4	plover	chorlito	chorlito	plover
5	scallop	venera	venera	scallop
6	fig	higo	higo	fig
7	rabbit	conejo	conejo	rabbit

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
8	sherry	jerez	jerez	sherry
9	racoon	mapache	mapache	racoon
10	pellet	bolita	bolita	pellet
Semantically related				
Within languages				
	(English)	(English)	(Spanish)	(Spanish)
1	talon	claw	garra	zarpa
2	dimple	notch	hoyuelo	muesca
3	oyster	clam	ostra	almeja
4	arrow	spear	flecha	lanza
5	lizard	toad	lagarto	sapo
6	cask	basin	tonel	bol
7	ant	wasp	hormiga	avispa
8	canvas	fabric	lona	tejido
9	orange	peach	naranja	durazno
10	thistle	fern	cardo	helecho
Between languages				
	(English)	(Spanish)	(Spanish)	(English)
1	basket	envase	cesto	carton
2	pig	verraco	cerdo	boar
3	fir	tamo	abeto	fuzz
4	tureen	bandeja	sopera	tray
5	swan	garceta	cisne	egret
6	navel	panza	ombligo	belly

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
7	wig	trenza	peluca	braid
8	muzzle	quijada	hocico	jowl
9	sludge	lodo	fango	mud
10	birch	haya	abedul	beech
Semantically unrelated				
	Within languages			
	(English)	(English)	(Spanish)	(Spanish)
1	ivory	groin	marfil	ingle
2	twine	sheath	guita	vaina
3	cookie	yawn	galleta	boztezo
4	thigh	nozzle	muslo	tobera
5	walrus	nun	morsa	monja
6	badge	turnip	divisa	nabo
7	walnut	shack	nuez	choza
8	gobbet	fang	trocito	colmillo
9	flea	broom	pulga	escoba
10	elk	vulture	ance	buitre
	Between languages			
	(English)	(Spanish)	(Spanish)	(English)
1	pantry	manta	despensa	blanket
2	sieve	casco	tamiz	helmet
3	kettle	langosta	caldero	locust
4	anvil	baya	yunque	berry
5	bacon	nudillo	tocino	knuckle

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
6	reed	pala	carrizo	shovel
7	ledge	semilla	repisa	kernel
8	kite	cuerna	cometa	antler
9	turkey	ceja	pavo	brow
10	trigger	puerro	gatillo	leek

Nonword Pairs

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
	Within languages			
	(English)	(English)	(Spanish)	(Spanish)
1	emery	dli	esmeril	ptaa
2	tassel	oolm	borla	lraet
3	rapier	ebkra	estoque	nfroe
4	bark	sihlgne	corteza	aiipr
5	doyen	iltsne	decano	eooprl
6	rack	orhmmsuo	estante	ohgno
7	peal	smlsaeso	repique	mzlaae
8	beaver	gbacbae	castor	lco
9	minstrel	rdpaae	juglar	elsfdei
10	droplet	hryecr	gotita	rzeeac
11	urchin	acwl	pilluelo	przaa
12	spout	ohtcn	chorro	mseuac

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
13	blizzard	lmca	ventisca	eaamjl
14	spring	aprse	resorte	aalzn
15	rag	oadt	trapo	aops
16	yoke	ibnsa	yunta	olb
17	trash	spwa	basura	vpsiaa
18	jalopy	iacbfr	cacharro	dtjeio
19	cocoon	ahepe	capullo	oaurznd
20	bodice	enrf	almilla	chhleoe
21	minaret	bknltae	alminar	aantm
22	rake	tlmhee	rastro	csaoc
23	tier	sluotc	grada	aotnlasg
24	mucus	yrbre	moco	aaby
25	cage	klnkcue	jaula	lnduiol
26	blemish	ovhsle	tacha	plaa
27	grapnel	nreelk	arpeo	mllsiae
28	elm	rnaetl	olmo	uencra
29	tuft	wrbo	copete	aecj
30	zenith	lkee	cenit	eouprr
	Between languages			
	(English)	(Spanish)	(Spanish)	(English)
1	yew	dmlaaop	rueca	bpmul
2	reef	jzaan	arecife	tdcih
3	lag	oprto	retraso	otle
4	reel	oohlictr	carrete	reovlp

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
5	canister	nrevae	lata	locspal
6	molar	igho	muela	igf
7	loon	ojncoe	bobo	trbiab
8	ingot	zrjee	lingote	yhrsre
9	groan	amhpaec	gemido	crnoao
10	curtain	aitblo	cortina	eltlpe
11	ebb	snveae	reflujo	ocnrta
12	kale	rrcveao	berza	arbo
13	enamel	oamt	esmalte	zfzu
14	brooch	aeadjbn	alfiler	rtva
15	thimble	rtcaega	dedal	geetr
16	pottery	zpnaa	alfar	yelbl
17	chute	erntza	tolva	adbri
18	keel	ijqdaua	quilla	wljo
19	blister	oold	ampolla	dmu
20	pleat	ehche	pliegue	ahya
21	glint	ilgne	destello	nrgoi
22	snail	nvaia	caracol	athhse
23	dwarf	zbteooz	enano	ywna
24	plague	rteaob	peste	zlnzoe
25	cap	jnmao	gorra	unn
26	ream	aobn	resma	uipntr
27	slug	ahzoc	babosa	acskh
28	sprig	mllcloio	espiga	agfn

	English prime group		Spanish prime group	
	Prime	Target	Prime	Target
29	steak	cbseoa	biftec	oombr
30	jab	rbiute	pinchazo	ltvruue

Note. The language of the nonword refers to the language of the word from which the nonword was derived.

Appendix C

Language Dominance Profile

(adapted from Schwanenflugel & Rey, 1986)

	English prime	Spanish prime	Combined
Age in years	20.8	21.0	20.9
Reading fluency (Keller, 1978a)	-8	-13	-11
Writing fluency (Keller, 1978b)	2	-1	0
Age when English learned	5.7	4.8	5.3
Age when Spanish learned	0.0	0.0	0.0
Number of years used			
English	14.1	15.6	14.9
Spanish	20.1	21.0	20.9
Most comfortable speaking			
English	17%	50%	33%
Spanish	25%	8%	17%
Both	58%	42%	50%
Frequency of switching languages			
Never	0%	0%	0%
Rarely	0%	0%	0%
Sometimes	25%	33%	29%
Often	50%	58%	54%
Almost always	25%	8%	17%

	English prime	Spanish prime	Combined
Difficulty of switching languages			
Very difficult	0%	0%	0%
Somewhat difficult	17%	33%	25%
Relatively easy	42%	33%	38%
Very easy	42%	33%	38%
Rating of a 7-point scale (1 = strongly disagree, 7 = strongly agree)			
I speak each language very well	4.4	4.8	4.6
I speak English very well	4.8	5.3	5.1
I speak Spanish very well	5.0	4.8	4.9
I read each language very well	4.8	5.3	5.1
I read Spanish very well	5.3	5.8	5.6
I read English very well	4.8	5.1	4.9
I write each language very well	4.3	4.6	4.4
I write English very well	4.9	5.2	5.0
I write Spanish very well	4.1	4.2	4.1
Percentage of day each language spoken			
English	66%	67%	66%
Spanish	39%	36%	38%

	English prime	Spanish prime	Combined
Percentage of day each language read			
English	94%	83%	88%
Spanish	8%	15%	12%
Percentage of day each language written			
English	91%	92%	91%
Spanish	9%	6%	8%
Most common contexts I speak English in are			
Home	50%	67%	58%
Family	0%	33%	17%
Friends	75%	67%	71%
School	92%	100%	96%
Work	50%	58%	54%
Other	0%	33%	33%
Most common contexts I write English in are			
Home	83%	42%	63%
Family	0%	25%	13%
Friends	25%	17%	21%
School	83%	100%	92%
Work	42%	42%	42%
Other	0%	25%	13%

	English prime	Spanish prime	Combined
Most common contexts I read English in are			
Home	83%	58%	71%
Family	0%	25%	13%
Friends	33%	25%	29%
School	83%	100%	92%
Work	42%	33%	38%
Other	0%	25%	13%
Most common contexts I speak Spanish in are			
Home	92%	100%	96%
Family	0%	17%	8%
Friends	58%	67%	63%
School	17%	25%	21%
Work	25%	25%	25%
Other	0%	0%	0%
Most common contexts I write Spanish in are			
Home	67%	50%	58%
Family	8%	8%	8%
Friends	8%	17%	13%
School	0%	25%	13%
Work	0%	17%	8%
Other	8%	17%	13%

	English prime	Spanish prime	Combined
Most common contexts I read Spanish in are			
Home	75%	50%	63%
Family	8%	8%	8%
Friends	25%	8%	17%
School	0%	25%	13%
Work	0%	17%	8%
Other	8%	25%	17%
Highest level of education completed			
High school	0%	8%	4%
Some college	92%	83%	88%
College	8%	8%	8%

Appendix D

Written Instructions on the Screen

You will be presented with 5 blocks of 24 trials each. In each trial you will be presented with two letter-strings. The first will always be a word, in either Spanish or English. The second will be either a word or not a word. If it is a word, it will be in either Spanish or English. If it is not a word, or a 'non-word' as we are calling it here, then it will simply be a jumble of letters which contains no meaning.

Your task will be to decide if the second letter string in each trial is a word or not a word. If you decide it is a word, press the 'z' key on the lower left of your keyboard with your left index finger. If you decide it is a NON-WORD, press the '/?' key on the lower right of you keyboard with your right index finger. You index fingers will be resting above these two keys at all times throughout the experiment (except, of course, when you are relaxing).

Please respond as QUICKLY and as ACCURATELY as you can.

PRESS THE SPACE BAR KEY TO CONTINUE

Note. There were two versions of these instructions, i.e., one for left handed WORD responses ('z') and one for right ('/?').