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AN ELECTROPHYSIOLOGICAL STUDY OF TRANSLATION IN SPANISH-ENGLISH BILINGUALS

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Abstract

Language processing in bilinguals is becoming an area of increased interest because the number of individuals speaking more than one language is increasing. The current study explored language processing in bilingual speakers and the link between translations and accessing concepts. Individuals involved in this experiment were raised speaking Spanish and later switched language dominance to English or grew up bilingual with English and Spanish and now consider themselves English dominant. Previous research has found that when an individual is a novice in their second language, there is translation occurring from their second language back into their first language, whereas when an individual is dominant in a language there is a semantic association between a word and the meaning (Sunderman & Kroll 2006). The current study hypothesized based on this research that as an individual becomes fluent in both languages, translation may not be as important as the semantic association between a word and its meaning. The current study utilized electroencephalography (EEG) which is a process of observing the brain's electrical activity through the use of electrodes. There were 5 females and 7 males included in this study. The total of 12 participants ranged in age from 19 to 31 and were all students at The Pennsylvania State University. Through the use of EEG, the current study evaluated if individuals were relying on translation cues or on semantic cues to access meanings of words. The results of this study revealed that these individuals did utilize the semantic association between a word and its concept, but the translation aspect was also active. Therefore, bilingual speakers in the current study who switched language dominance from English to Spanish activated both links of translation and semantics.

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Acknowledgments

I would like to thank my thesis/honors advisor, Carol Miller, for her guidance and support with this study and all her help over the past four years. I would also like to thank Maya Misra, Krista Wilkinson, Elizabeth Willis, and Debra Crowe for all of their help throughout this process.

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The current study addresses how being bilingual affects language processing in individuals who were brought up bilingual or only speaking Spanish, but who are now primarily English dominant. This study is a follow up study of Elizabeth Willis's undergraduate thesis in 2009 and her graduate thesis in 2011. Willis (2009, 2011) assessed individuals who were English-Spanish bilinguals that varied in Spanish proficiency and were English dominant. Willis's (2009, 2011) subjects were separated into a low and high proficiency group. The goal of the current combined study is to keep English language dominance constant, but to see if the results are different by native language. The current study assesses individuals who were raised English-Spanish bilingual or Spanish dominant but are now English dominant. The results of the current study may reveal if the current participants are more proficient than Willis's (2009, 2011) advanced group. The study will investigate how relationships between a Spanish word and an English word impact language processing for bilingual speakers. The primary research question will be how translation and semantic relationships between English and Spanish words are processed similarly or differently. This is an interesting question because there has been a lot of research on whether bilingual individuals access each language independently or if there is a translation process back into their native language. In the current study it is hypothesized that these individuals will be relying on the semantic representation of words instead of translation.

Previous Research

In previous research, there have been studies on bilingualism and how learning a second language can affect language processing. Talamas et al. (1999) found that less proficient second language learners depend on form, while more proficient second language learners depend on meaning. Talamas et al. (1999) relates to the current study because this group of bilinguals will be more proficient in their knowledge of both languages. Kroll et al.

(2002) performed similar research with bilinguals and found that the more advanced bilinguals could translate back and forth from each of their languages. Kroll et al. (2002) also found that it took a longer time for these participants to translate from their first language to their second language, than from their second language to their first language. Sunderman and Kroll (2006) have done similar research and discovered that more proficient bilinguals do not rely on translating back into their first language.

Timing of Acquiring a Second Language

In the current study, the bilinguals acquired their languages at different times. Hakuta (2009) defines sequential bilinguals as individuals who learned one language and then learned another language after the original and simultaneous bilinguals as individuals who are raised speaking more than one language.

Willis's (2009, 2011) participants would be considered solely sequential bilinguals because they were English monolinguals and then began to learn Spanish. In the current study, both sequential and simultaneous bilinguals were tested. About a third of the participants considered themselves simultaneous bilinguals, while the other two thirds would be considered sequential bilinguals. For all participants in this study, sequential bilinguals or simultaneous bilinguals, the dominant language was English. All participants were students from the Pennsylvania State University where English is the dominant language of the community and also university classes. Therefore, the current study keeps English language dominance constant, but will allow us to determine if the results differ from those found by Willis (2009, 2011).

Lexical processing

Another concept that is important in this study is the concept of lexical processing. Hakuta (2009) reported, "the size of the mental lexicon is one area of language in which growth continues through the life span…" (pg.173). Kroll et al. (2002) reports that the proficiency of a second language could affect lexical processing in terms of correctness and speed.

In the current study lexical processing was addressed through a translation recognition task which required the individual to access both their Spanish lexicon and their English lexicon. This challenged the use of their separate lexicons because their task was to indicate whether two words were a translation or not. Sunderman and Kroll (2006) found that all bilinguals have more difficulty when encountering a word that is similar in meaning or form.

In the current study, there was 4 critical "no" conditions for the stimuli. These stimuli were created by Willis (2009, 2011). An example of semantically related distractors is "paneuelo" and "glove" where the correct translation is "scarf." An example of semantic controls is "pelota" and "ham" where the correct translation is "ball." An example of translation related distractors is "cuerpo" and "bond" where the correct translation is "body." An example of translation controls is "noche" and "lady" where the correct translation is "night." An example of the filler condition is "juguete" and "toy" where the correct translation is "toy." This is the only condition where the answer would be "yes." See Table 1 on page 10 for more information.

EEG information

For this research, neural activity was measured by studying the brain's electrical activity. Molfese et al. (2001) explains that electrical activity is measured by putting electrodes on the participant's head in a process that is known as electroencephalography (EEG). Molfese et al. (2001) also reports that when the brain processes information, electricity is generated which can be recorded through EEG.

By presenting stimuli that affect neural activity, and time-locking the EEG to these stimuli, it is possible to examine how the brain's response differs to different types of stimuli (Kutas & Federmeier, 2000). Specifically, the activity from multiple trials of a single class of stimuli are averaged together. Then, the activity specific to the stimulus class remains, while the unrelated activity should average out. This process generates event-related potentials or ERPs, which can be used to evaluate cognitive process such as lexical access.

One major component involved in ERPs that is important while studying language processing is known as the N400. The N400 is sensitive to many different kinds of manipulations, but it is often found in tasks requiring lexical processing and can be affected by differing information that is presented, in particular, the semantics (Kutas & Federmeier. 2000). The N400 is known as the N400 because 400 ms after the presenting of a stimulus, there is a negative spike (Kutas & Federmeier. 2000). This component was first reported in a study by Kutas and Hillyard (1980), where they found that larger N400s were found to unexpected words at the ends of sentences. According to Kutas and Federmeier (2000), the N400 component can be affected by many different things such as out of place words and pairs of words that relate to each other semantically. According to Kutas and Federmeier (2000), not only does the N400 relate to semantics but it also gives information about language in regards to timing since the EEG can record when the spike occurs

Other ERP components discussed in this study are the N1, P200, and LPC enhancement. All of these terms are used to describe waveforms with specific timing and polarity, revealed in the ERP record. Molfese et al. (2001) reported that N1 represents the negative peak first seen after information is presented while P200 describes a positive peak that observed 200 ms after the information is present. Molefese et al. (2001) also explained that the "P" or "N" will always represent positive or negative while the number represents timing. The LPC is a "late positive component", typically observed after the N400 peak. The LPC is generally less of a discrete peak than the other components described and instead it represents a positive-going shift in the waveform that may have a fairly long duration.

Primary research question

The primary research question will be how semantic and translation relationships between English and Spanish words are processed similarly or differently when presented in different conditions. In the current study, there will be a visual analysis of the ERPs to further analyze the N400, P200, LPC1, and LPC2 components. By examining these visual components of the ERPs, we will be able to learn more about if the participants are translating words or accessing the word meaning. In the current study we hypothesized that as an individual becomes fluent in both languages, translation may not be as important as the semantic association between a word and its meaning. The hypothesis was based on previous research by Sunderman and Kroll (2006) that bilingual individuals access each of the concepts from each of their languages when they are proficient in both languages. This study is unique because it focuses on individuals who were primarily Spanish dominant either growing up bilingual with English and Spanish or who grew up Spanish monolingual. This study is unique from Willis's (2009, 2011) study because she focused on individuals who were English dominant and had some degree of Spanish knowledge. This study takes into consideration those individuals who may have "switched" dominant languages to see what the result may be. In this study if translation is more relied on by the participant, there will be lower accuracy, slower RT for translation distractors and ERP differences between the translation related controls and translation distractors. If semantics are relied more relied on by the participant, there will be lower accuracy, slower RT for semantic distractors and ERP differences between the semantic related controls and semantic distractors.

Methods

Participants

There were 12 adults included in this experiment ranging in age from 19 to 31. There were a total of 5 females and 7 males that participated in this study at The Pennsylvania State University. These participants ranged in schooling from a sophomore in college to a fourth year graduate student. The 12 participants were considered to have high proficiency in both English and Spanish.

Although 12 participants were used in this study, there were a total of 20 individuals who participated. However, certain criteria were applied to ensure that all individuals included in the analyses had a sufficiently high quality of data. For the 8 participants who were not included in the study, 3 of the individuals displayed too many eye blinks that interfered with the results, 2 of the individuals had critical channels displaying a flat line (due to experimenter error in participant set-up), 2 of the individuals had lower than 63% accuracy, and 1 individual displayed high impedances during set-up which could not be lowered (the equipment can only generate reliable recordings if electrode impedances are lowered sufficiently).

The individuals in this experiment were either Spanish-English bilingual from birth and became more dominant in English or grew up speaking Spanish and learned English as a second language, but over time became more dominant in English. Of the final group of 12 participants, there were 8 participants who considered themselves speaking primarily Spanish growing up, but now consider themselves more English dominant. The other 4 participants grew up bilingual with English and Spanish and now consider English their more dominant language. The 12 participants were asked to rate their Spanish skills which consisted of comprehension, speaking, writing, reading, and spelling. A 10 point scale was used with 10 being the highest rating and 1 being the lowest rating. The 12 participants had a Spanish self rating that raged from 6.2 to 10 with an average of 8.2. The participants had an English self rating that raged from 8.6 to 10 with 9.6 being the average. In this experiment, 6 of the participants lived abroad or traveled abroad for some time while the other 6 did not. The participants' native countries were the United States, Mexico, Puerto Rico, and Columbia. All of the individuals were right handed, not disabled in any way and had normal vision (or corrected to normal). The participants were each given 20 dollars for participating in this study which took about 2 hours to complete.

Experimental Task

Since the current study is an extension of Willis (2009, 2011) the same experimental overview, tasks, and stimuli were used.

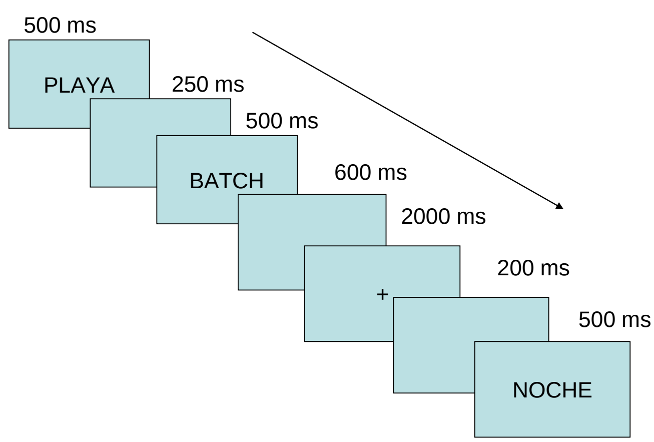
When each participant came in, they first completed an informed consent document and also two questionnaires. One questionnaire was about their language history such as what languages they learned growing up, languages learned in school, and any other countries they lived in. The other questionnaire was about the participant's demographic information and evaluated the hand (left or right) they used to complete different activities.

For the purposes of the current study, only results from the initial task, the Translation Recognition task, will be considered. For this task, the participant was directed to indicate if two words were direct translations of each other or not. The second task was called the Lexical Decision Task. In this task, the participant was shown made up Spanish words and also real Spanish words and they had to indicate whether the word was a real word or a nonword using the game controller. The third task was called the Simon Task which tested inhibition. The last task was called the Operation Span which tested working memory.

Stimuli

The Translation Recognition Task stimuli were created by Elizabeth Willis for her honors thesis and the stimuli and procedure used in the current study matches Willis's (See Willis 2009 and 2011 for more details.). For this task, the participant was shown a Spanish word followed by an English word. All of the words contained nine letters or fewer and were nouns. There were no words repeated and there were no Spanish words that were similar to English words. The participant's task was to press "yes" or "no" on a game controller to indicate if the two words were a direct translation of each other or not. All together there was a total of 320 English words and 320 Spanish words. There was an equal number of "yes" and "no" trials in regards to direct translation or not. Therefore there were 160 "yes" trials and 160 "no" trials. A diagram created by Willis (2009, 2011) showing the sequence of events is shown in Figure 1.

Figure 1. Organization and time constraints for stimuli from each item of Translation Recognition Task created by Willis. (See Willis 2009 and 2011)



In the current study, all the responses were “no” except for the fillers. There were four critical conditions for the “no” trials within the 160 trials. Therefore, there were 40 of each of the four critical conditions. In the first “no” condition, there were semantically related distractors. The English word shown was related to the correct translation of the Spanish word but it was not considered a direct translation. An example of this would be how the English word “glove” is related to the Spanish word “panuelo” but the correct translation would be “scarf.”

The second critical condition involved semantic controls for the semantically related distractors. These controls were unrelated to the Spanish word and obtained by using the MRC Psycholinguistic Database (http://www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm). They were matched based on the Kucera-Francis (KFFRQ) written frequency values to the distractors that were semantically related and their letter number. (see Willis 2009, 2011).

Translation related distractors were the third critical condition. For this condition the English word was only related by form to the translation of the Spanish word. An example of this would be the Spanish word, “cuerpo” and the English word “bond” with the correct translation being “body.”

The last critical condition was Translation controls. These items were also selected with the MRC Psycholinguistic Database(http://www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm) and acted as the matched (unrelated) controls for the translation related word pairs. A chart of the yes trials and critical conditions created by Willis (2009, 2011) is shown in Table 1. In the following Table 1, the answer is always “no” except for the fillers.

Table 1 Task 1 sample stimuli for critical conditions and yes trials created by Willis (based on Willis. 2009; 2011).

Condition	*Spanish word*	*English word*	*Correct Translation*	*Number of trials*
1. Semantically related Distractors	PANUELO	GLOVE	SCARF	40
2. Semantic controls	PELOTA	HAM	BALL	40
3. Translation related Distractors	CUERPO	BOND	BODY	40
4. Translation controls	NOCHE	LADY	NIGHT	40
5. Yes trials (fillers)	JUGUETE	TOY	TOY	160

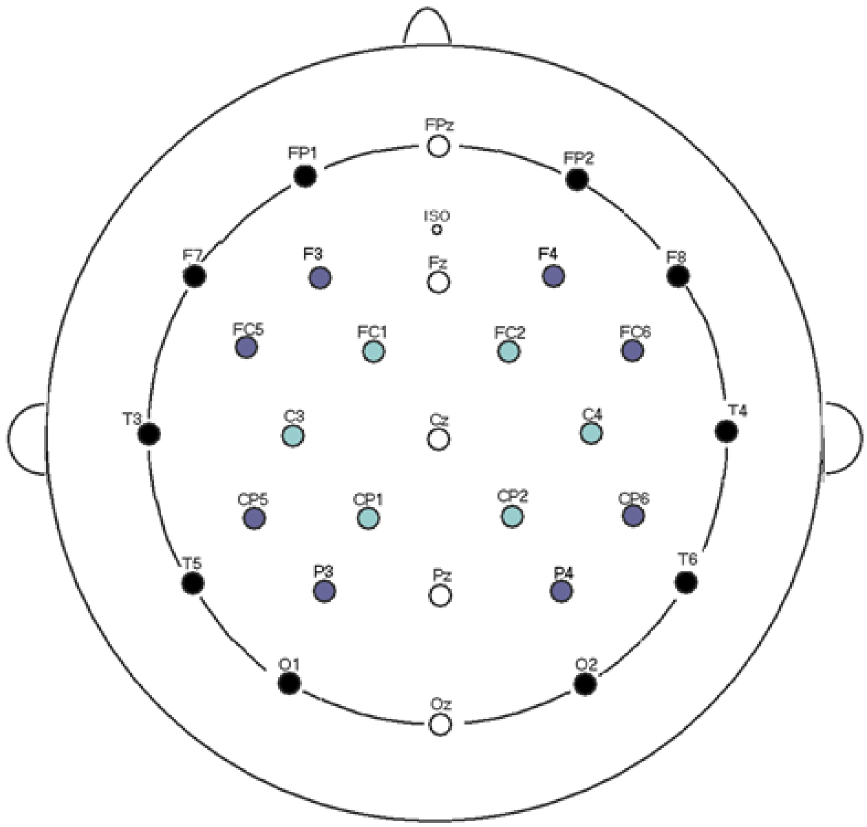
EEG Recording

At the start of the study, the participant was taken into a room where they were fitted with an electrode cap and several loose electrodes which recorded EEG. This process took about 45 minutes to an hour. The participant was then instructed to look at a computer screen and given a game controller which they could use to press buttons to record their answers.

The electrode cap used in this experiment recorded EEG waves from twenty-nine channels on the scalp. Each of the electrodes was located on a different place on the cap to pick up the EEG activity. There were a total of eleven electrodes that were located at 10-20 standard international system sites. Eight electrodes were matched pairs at right and left hemisphere frontal (F2/F4), temporal (T3/T4), central (C3/C4), and parietal (P3/P4) sites. There were ten more sites which were from the Modified Combinatorial Nomenclature system. Four of these were from the right and left centroparietal sites (CP1/CP2, CP5/CP6), and four were from the right and left hemisphere fronto-central sites (FC1/FC2, FC5/FC6). The last two from the Modified Combinatorial Nomenclature system were from the midline sites at the occipital pole (Oz) and the frontal pole (FPz). Three of the electrodes were located at (Fz) frontal, (Cz) central, and (Pz) parietal midline locations. There were also eight electrodes that were at modified 10-20 sites from the lateral positions 33% of the distance from FPz to T3/T4 (FP1'/FP2'), 67% of the distance from Oz to T3/T4 (T5'/T6'), 67% of the distance from FPz to T3/T4 (F7'/F8'), and 33% of the distance from Oz to T3/T4 (01'/02'). In addition, the electroculogram measured eye movements such as blinks and movements with two electrodes that were loose. One of these two loose electrodes was placed under the left eye and the other was placed right next to the right eye. The electrode next to the right eye (HE) measured eye movements that were to the sides and the electrode under the left eye (LE) accounted for eye blinks. There was also an electrode on the left mastoid located at A1 which served as the reference for all other electrodes and an electrode on the right mastoid located at A2 to account for any mastoid activity that was differential.

The impedances were lowered for the mastoid and scalp electrodes to below 5 kilo-ohms. To do this a gel was gently inserted into the center of the electrode using a blunt syringe. After that, the end of a wooden q-tip was gently pushed up and down to obtain the lower impedances. The same procedure was done for the eye electrodes until they were below 20 kilo-ohms. To amplify the EEG data a SA amplifier system was used which had a bandpass of 0.1 to 40 hertz. An illustration of the electrode montage provided by M. Misra is shown in Figure 2.

Figure 2. 32 Channel electrode montage (Figure provided by M. Misra)



Results

Visual Trends of ERP Waveforms

Semantic control conditions and semantically related distractors. In the visual analysis of the waveforms we will be primarily looking at the amplitude differences. The results of the ERPs for the semantic control conditions and semantically related distractors were: a negative peak at 125 ms (N1) followed by a positive peak at 250 ms (P200), a negative peak at 350 ms (N400), and ending with a positive slow wave. The major differences of the ERPs for the semantic control conditions and the semantically related distractors was the N400 attenuation in the semantically related distractors, which was seen at the negative peak at 350 ms. The other major component was the late positive component at the end, which is known as a LPC enhancement which start around 300-450 ms.

Most of the differences in amplitude in the ERPs were seen in the semantic controls and the semantically related distractors which seen more at the right hemisphere recording sites. Figure 4 shows the grand ERP averages for the semantically related distractors and the semantic controls.

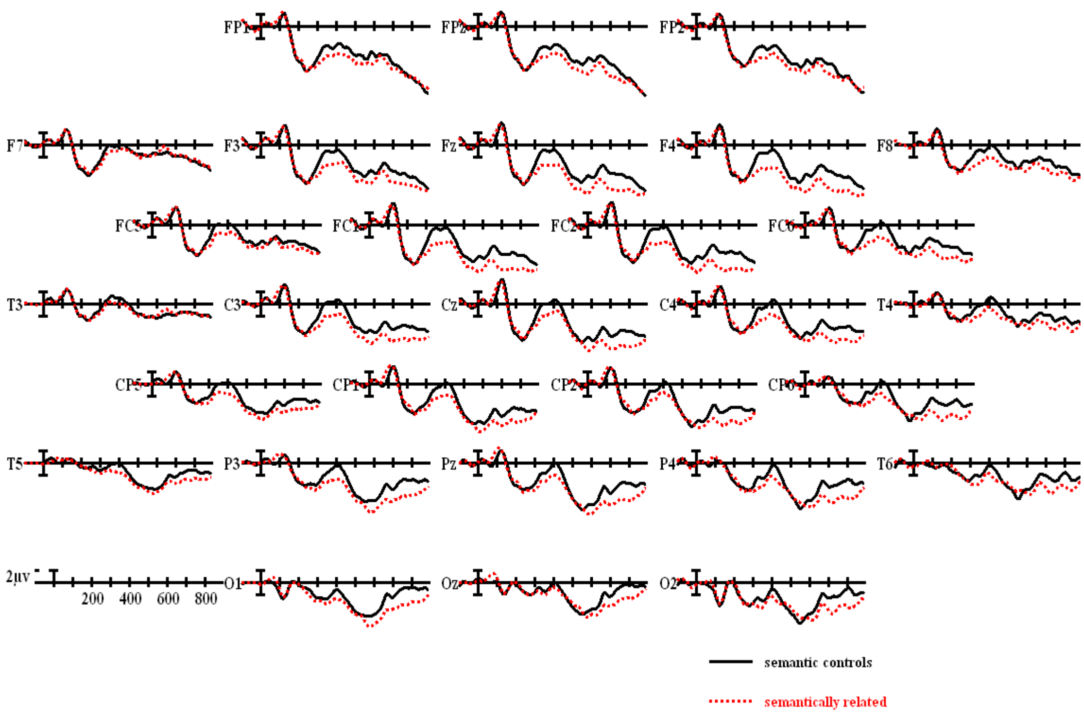


Figure 3. Semantic controls and semantically related distractors grand ERP averages.

Translation control conditions vs. translation related distractors. The major component of the ERPs for the translation control conditions vs. the translation related distractors was the positive peak at 250 ms, which is known as the P200 enhancement. There is an enhanced positivity for the translation related trials at the P200. The other major effect observed in these ERPs was at the LPC (late positive component) which was the slow positive wave at the end. Most of the differences in the ERPs seen in the translation control conditions vs. translation related distractors were seen at the center right portion of the head. In contrast, the results of the grand average ERPs for the semantic controls and semantically related distractors were: a negative peak at 125 ms (N1) followed by a positive peak at 250 ms (P200), a negative peak at 350 ms (N400), followed by more of a positive slow wave.

The effects observed for the semantic controls vs. the semantically related differed from those observed for the translation control conditions vs. translation related distractors in their timing. Through visual inspection, the semantically related condition showed a smaller N400 peak and more of a positive slow wave than the translation conditions. In contrast, the translation related condition differed earlier, on the P200 component. Figure 5 shows the grand ERP averages for the translation related distractors and the translation controls. averages.

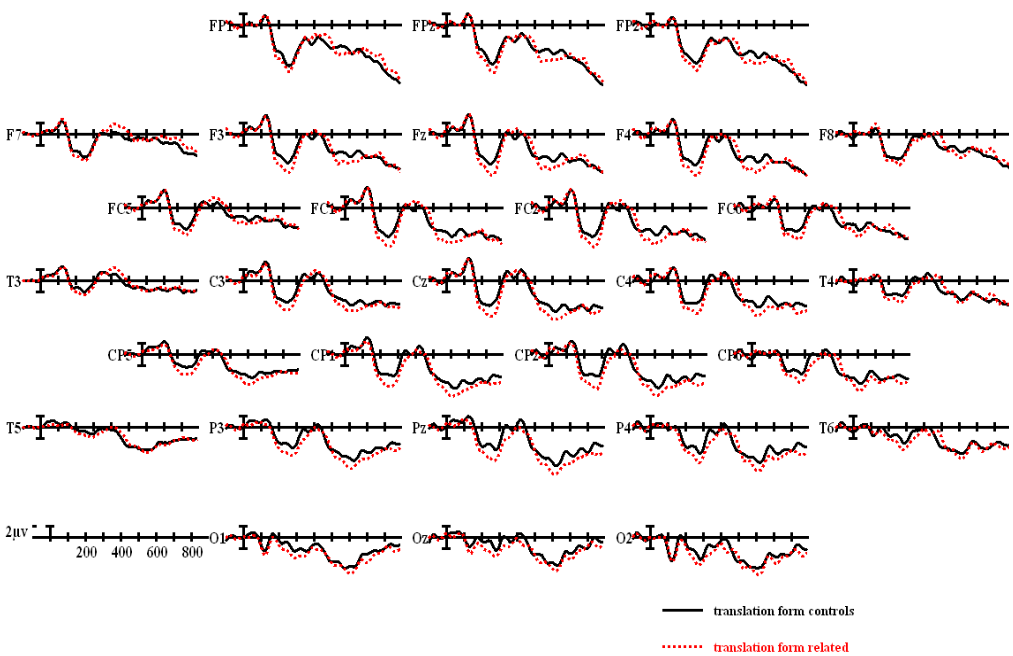


Figure 4. Translation control conditions vs. translation related distractors grand ERP averages.

Statistical Analysis

The statistics were done for within-subject effects on the dependent variable of amplitude of the ERP components. The Greenhouse-Geisser correction was used for this analysis. The statistical analysis was done using two 2 x 3 ANOVA tests for each ERP component (P200, N400, LPC 1, LPC 2). There were two levels of conditions and three levels of channels that were examined at the midline (Fz, Cz, Pz). In the current study we are not using electrode site as support. One of the ANOVAs examined the translation condition and the other ANOVA examined the semantic condition. For the semantic condition there were semantically related distractors and semantic controls for semantically related distractors. For the translation condition there were translation related distractors and translation controls for the translation related distractors.

In the P200 semantic comparison there were no significant effects found in the semantic comparison, electrode, or between the semantic comparison condition and the electrode. The semantic comparison condition had no significant effect $F(1,11) = 0.45$, $p = .836$). The electrode site also had no significant effect $F(2,22) = 2.640$, $p = .129$). In the current study we are not using electrode site as support. The interaction of the semantic comparison condition with the electrode had no significant effect $F(2,22) = .160$, $p = .758$). In the P200, there was a significant effect found in the translation comparison condition ($F(1,11) = 5.224$, $p=.043$). The electrode site had no significant effect ($F(2,22) = 1.850$, $p = .199$). The interaction of the translation comparison condition with the electrode had no significant effect ($F(2,22)= .30$, $p=.912$).

In the N400, there were no significant differences found in the semantic comparison condition, electrode, or between the interaction of the semantic comparison condition and the electrode. The electrode had no significant effect $F(2,22) = 2.819$, $p= .109$). The interaction of the semantic comparison condition with the electrode had no significant effect (F(2,22) = .649, p=.482) The semantic comparison condition had no significant effect F(1,11)=2.043, p=.181.

In the N400 translation comparison there was a significant effect found at the electrode (F(2,22) = 5.046, p=.029). There was no significant difference found in the translation comparison condition F(1,11)=.254, p=.624). There was also no significant effect found with the interaction of the translation comparison condition and electrode F(2,22)=1.642, p=.226).

In the LPC 1 semantic comparison there were no significant effect found. For the semantic comparison condition there was no significant effect (F(1,11)=1.6333,p=.228). There was no significant effect of the electrode (F(2,22)=.678,p=.461). There was also no significant effect found in the interaction between the semantic comparison and the electrode (F(2,22)=1.845, p=.189). In the LPC 1 translation comparison there was a trend found for the translation comparison condition (F(1,11) = 4.420, p=.059). There was no significant effect at the electrode (F(2,22)=1.515,p=.245). There was no significant effect found at the interaction of translation comparison condition with the electrode (F(2,22)=.129,p=.776).

In the LPC 2 semantic comparison there was a trend found in the semantic comparison condition (F(1,11) = 3.940, p=.073). There was a significant effect of electrode (F(2,22)=4.394,p=.034). There was no significant effect found between the interaction of the semantic comparison condition and electrode (F(2,22)=0.26,p=.938). In the LPC 2 translation comparison there was no significant effect found at the translation comparison condition (F(1,11)=.824,p=.383). There was no significant effect found at the electrode (F(2,22)=.943,p=.389). There was no significant effect found between the interaction of the translation comparison condition and at the electrode (F(2,22)=1.856,p=.196).

Behavioral Results

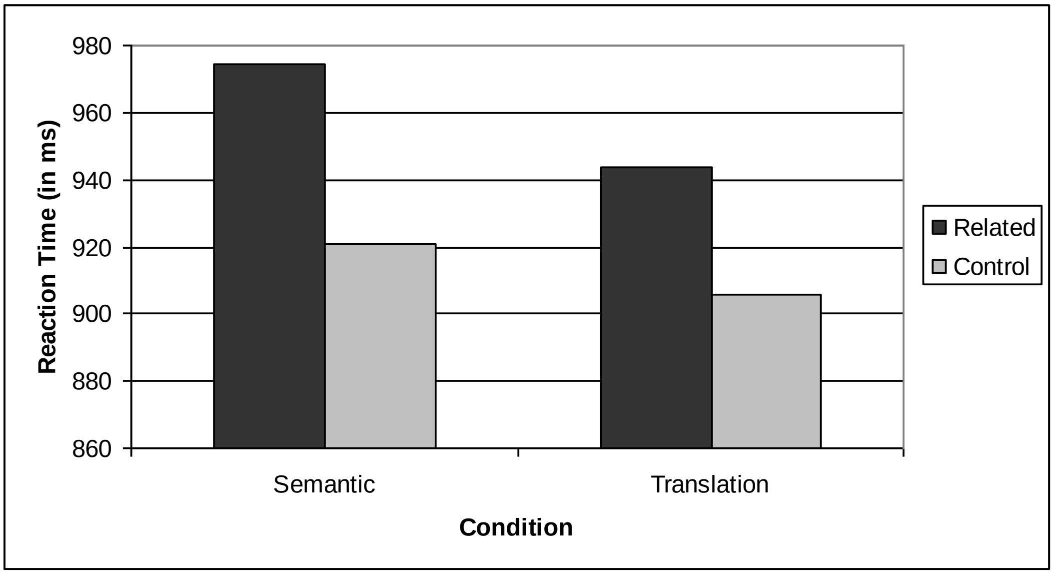
For this study, the 12 subjects' mean reaction times varied by critical condition. The fastest reaction time was found for the translation controls (905.7 ms), followed by semantic controls (920.9 ms), then the translation related distracters (944.0 ms), and ending with the semantically related distracters (974.6 ms). Therefore, participants were slower for the two types of distractors with either a semantic or form relationship than for the matched controls. The slowest times were found for those distractors with a meaning-based relationship to the correct translation.

For percent accuracy, the participants showed the highest accuracy for the semantic controls (95.8%), followed by the translation controls (93.5%), then the translation related distractors (91.9%), and ending with semantically related distractors (78.3%). In general, accuracy was high for all types of items except for the semantically related distractors.

The following Figure 3 shows the mean percent accuracy (bottom) and the mean reaction times (top) as a bar graph. Comparing the semantically related distractors and the semantic controls, it took the 12 subjects about 53.7 ms longer to respond to the semantically related distractor items than the semantic control items. It took the 12 subjects about 38.3 ms longer to respond to the translation related distractors than to their controls. Overall, there was a smaller change between the translation related and control conditions as compared to the semantic related and control conditions as seen in both the reaction time and in the percent accuracy. One thing that stood out about the percent accuracy and the reaction time was that the order of the items in accuracy was almost the same order as the reaction time. The order of percent accuracy reported that the semantic controls were the most accurate at

95.8% followed by the translation controls at 93.5 %, while the fastest reaction time was reported at the translation control at 905.7 ms followed by the semantic control at 920.9 ms. This is interesting because the rest of the conditions were in the same order for both accuracy and reaction time, but the semantic and translation controls were reversed for the accuracy vs. the fastest reaction time.

T-tests were conducted to compare each critical condition to its matched control for both reaction time and accuracy. Significant relationships were found in the semantic conditions for both reaction time (RT): $t(11)=3.447$, $p= 0.005$, and percent correct: $t(11)=-5.929$, $p=.000$. There was a trend seen between the translation related and translation control conditions for (RT): $t(11)=2.098$, $p=.060$. The difference between the translation conditions for percent correct was not significant: $t(11)=-.875$, $p=.400$. In Figure 5, bar graphs illustrate percent accuracy and reaction time for the translation distractors and their controls and the semantically related distractors and their controls.



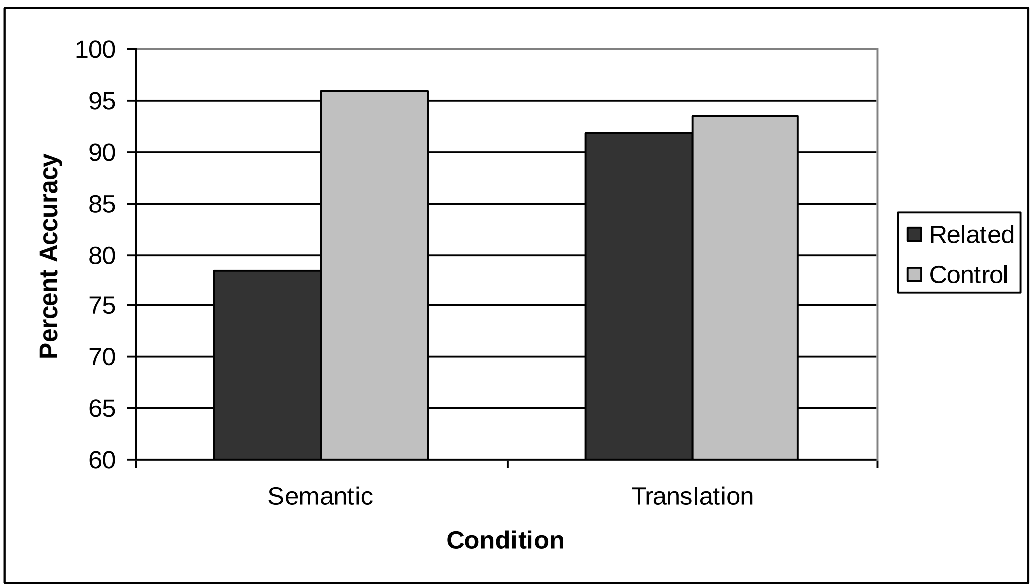


Figure 5. The top bar graph displays the mean reaction times for the translation distractors and their controls and the semantically related distractors and their controls. The bottom graph shows the percent accuracy for the translation distractors and their controls and the semantically related distractors and their controls.

Discussion

The purpose of this study was to examine language processing in bilinguals who were raised Spanish dominant or bilingual with English and Spanish but who switched to English dominance. The research question involved whether bilinguals access concepts directly or "translate" from their primary language into their second language. The hypothesis was based on previous research by Sunderman and Kroll (2006) that bilingual individuals access each of the concepts from each of their languages since they are advanced in both languages. The current study hypothesized based on this research that as an individual become fluent in both languages, translation may not become as important as the semantic association between a word and its meaning.

There has been previous research on bilingual language processing that relates to the current study and how learning more than one language affects language processing. Talamas et al. (1999) discovered that less proficient bilinguals depend on form, while more proficient bilinguals depend on meaning. Kroll et al. (2002) found that the more advanced an individual was in a second language the easier they could translate back and forth in these languages.

In the current study, electroencephalography (EEG) was utilized to examine brain activity in four tasks but primarily the Translation Recognition Task. The stimuli for this task were created by Willis and the procedure and stimuli used in this study match Willis's (2009, 2011). The Translation Recognition Task had four critical conditions for "no" trials. The first condition was semantically related distractors, the second critical condition was semantic controls for the semantically related distractors, the third critical was translation related distractors, and the four critical condition was translation controls for translation related distractors.

In the visual analysis of the ERP, the P200 and N400 were both seen in the translation condition and semantic condition. The ERPs in both conditions started with a negative peak at 125 ms (N1) followed by a positive peak at 250 ms (P200), a negative peak at 350 ms (N400), and ends with a positive slow wave. Therefore, the P200 and N400 are seen in both the translation condition and semantic condition. P200 shows enhanced positivity for translation related trials at P200. There was a P200 significant effect in the translation comparison that was found in statistical data as well. This shows increased positivity for translation condition, so this shows that the participants were translating. The difference between translation distracters and controls were found in center right hemisphere.

In the visual analysis of the ERP for the semantic condition, the N400 was more attenuated for semantically related distractors, than for the semantically related controls. Since the N400 was more attenuated for semantically related distractors this shows that the participants were accessing the meaning of words. This also relates to the behavioral data because semantically related distractors were less accurate. They had access to concepts and not getting confused by form. Most of the differences between the semantic distractors and controls seen in right hemisphere.

For P200 component, there was a significant effect in the translation comparison condition which matches the visual data because the P200 shows enhanced positivity for the translation condition. This suggests that the participants were translating. There was no significant effect in electrode or in interaction of translation condition with electrode.

There was no significant effect for P200, N400, or LPC 1 for the semantic condition. There was a LPC 2 significant effect found at the electrode, which matches the visual data. There was a trend seen in semantic comparison condition at P200.

In the behavioral data, it took the participants longer to respond to the distractor items in both conditions. It took participants 30.6 ms longer to respond to semantically related distractors than to translation related distractors, which suggests that they were accessing the meaning of words since it was taking longer. Willis also found that semantically related distractors took participants longer to respond to than translation related distractors (2009). This also relates back to the N400 attenuation of semantically related distractors in the visual analysis. Semantic distractors were less accurate at 78.3% than semantic controls at 95.8%. The current study revealed that the semantic controls were almost 20% more accurate in comparison to the translation controls that were only 2% more accurate. These results suggest that the individuals did have access to the concepts from the second language, but the 2% suggests that the translation was also an active component. Since the translation distractors were not as accurate, the results suggest that the individuals were not getting confused by the form of the words. This relates back to the visual data (above) since the N400 was attenuated for semantically related distractors. This does not match statistical data though because no significant effects found with the N400.

For the behavioral results, it took the participants longer to respond to the semantically related distractors and the translation related distractors than it took for them to respond to the semantically related controls and the translation related controls. This suggests that it took them longer to process the differences in the distractors which were trying to "trick" them than the controls. This also suggests that the participants were accessing concepts.

The percent accuracy and reaction time were almost in the same order which provided interesting information. The grand mean reaction times starting from the fastest were: translation controls, semantic controls, translation related distractors, and semantically related distracters. The percent accuracy started with semantic controls, translation controls, translation related distracters, and then semantically related distractors. This an interesting finding because the reaction time and percent accuracy were almost in the same order, but the semantic related controls and translation related controls were reversed. Overall, the findings in the current study suggest the participants were more accurate responding to the semantically related controls but faster responding to the translation related controls. This suggests that the participants in this study were translating and accessing the concepts, but they were just faster at responding when they had to access the concepts.

In the visual trends of the ERPs for the semantically related distractors and semantically related controls, most of the differences in the ERPs were seen at right hemisphere recording sites. One difference between the semantically related distractors and the semantically related controls was the N400 attenuation. In the visual trends of the ERPs for the translation related distractors and translation related controls, at the P200 there was enhanced positivity and there was also a slow positive wave at the end known as the late positive component. The translation related distractors and translation controls were seen in the central hemisphere on the right portion. Overall these visual trends showed a difference in timing and the translation related conditioned showed the P200, while the semantically related condition showed the N400.

To examine whether participants were translating, we will inspect the visual, statistical and behavioral data for translation. In the visual data, there was P200 enhanced positivity for translation related trials at P200. The statistical data supports the visual data with P200 significance also found in the translation comparison condition. This shows increased positivity for translation. For the behavioral data in this study, it took the participants longer to respond to the distractor conditions than to the control conditions. The finding in this study is consistent with the data found in Willis's study (2009, 2011). The participants responded faster to translation related distractors than to semantically related distractors in both the current study and in Willis's study (2009, 2011). This suggests that they were not relying on translation. Overall for the translation condition in the current study, there is evidence that the participants were translating in the visual and statistical data, but not in the behavioral data.

To examine whether participants were accessing the concepts directly and relying on the semantics we will also examine the visual, statistical, and behavioral data for the semantic related conditions. In the visual data the N400 is more attenuated for semantically related distractors, which suggests that the participants were accessing the meaning of the words. In the statistical data there was no N400 significance found in any of the conditions, which does not support the visual data. In the behavioral data is took longer to respond to the distractor conditions than to the control conditions. As stated above in the translation section, this is also consistent with the results from Willis's study (2009, 2011). As also found in Willis's study it took the participants longer to respond the semantically related distractors than to the translation related distractors (2009, 2011). In the current study it took the participants 30.6 ms longer to respond to the semantically related distractors than to the translation related distractors. This suggests that the participants were accessing the meaning of the words since it took them longer (Willis 2009, 2011). These results relate back to Willis's study and match what she found (2009, 2011). This behavioral data also relates back to the N400 attenuation of the semantically related distractors in the visual analysis. The semantic distractors were also less accurate at 78.3 % than the semantic controls at 95.8%. This suggests that the participants were accessing the concepts and not getting confused by form. This data also relates back to the visual analysis since the N400 was attenuated for semantically related distractors. Overall, for the semantic condition there is evidence that the participants were accessing the concepts in the visual data and the behavioral data, but there was no statistical significance regarding the N400.

The main question of this study was whether individuals who were raised speaking Spanish who became English dominant or individuals who were raised bilingual who became more English dominant depend more on translating words from their second language or if they are accessing the direct concepts. The data from this study in the translation and semantic conditions was not consistent throughout the statistical, visual, and behavioral data but it did show evidence of both translation and semantics, or accessing the concepts, being active.

This study relates to Willis's (2009, 2011) findings because Willis reported that semantic and translation links were important in the bilinguals in her study. In Willis's (2009, 2011) study there was a group of more proficient bilinguals and less proficient bilinguals which differs from the current study. This study found similar results as Willis's because evidence of both translation and semantics were found (2009, 2011). Future research may inquire at which age this language dominance shift occurs, the reason for dominant language switching, and how later effects of language switching may affect language processing

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