The automatic access of emotion: Emotional Stroop effects in Spanish–English bilingual speakers

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The emotional Stroop task provides an experimental measure of selective attention to emotional information. In the current study, the emotional Stroop effect was examined in a Spanish–English bilingual speaking population. The results revealed that the emotional Stroop effect is a robust phenomenon and replicable within a bilingual population. Furthermore, highly proficient bilinguals demonstrated equal interference effects in both their first language and their second language. The current study provides evidence of the automatic activation of emotional components in words appearing in more than one language. These results are discussed with reference to previous findings in the literature on bilingual emotion word representation.

The emotional Stroop task is based on the original Stroop task (Stroop, 1935) and has been adapted to examine emotional stimuli. In the emotional Stroop task, participants are presented with emotion words (e.g., anger, fear, jealousy) and neutral words (e.g., boat, car, train) instead of colour congruent (RED in red ink) and colour incongruent (RED in blue ink) words. Participants are asked to simply respond, manually or vocally, to the colour of the words presented. The interference effect in the emotional Stroop task is a result of the emotional content of the words and not the incongruence of the words presented. The emotional Stroop task provides an experimental measure of selective attention to emotional information.

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Early theoretical frameworks established to explain the interference effect produced by emotional stimuli posited that the slower colour response to a negative emotion word compared to a neutral word was the result of a mechanism that automatically "grabs" or "captures" attention. It has been suggested that the mechanism that is responsible for processing negatively valenced emotional information is automatic, fast, and occurs early in processing (Bargh, 1997; Pratto & John, 1991; Williams, Watts, MacLeod, & Mathews, 1997). Recent evidence has suggested a second source of interference, a slow effect that occurs between trials (McKenna & Sharma, 2004). This latter effect has been described as an "emotional lingering" effect (McKenna, 1986).

The emotional Stroop effect has been examined in monolingual speaking populations across a range of methodological manipulations. It is equally important to study the emotional Stroop effect in a bilingual population to determine if the emotion words exert the same influence in both languages. It has been suggested that an individual's first language is often considered the language of emotional expressiveness, while the second language may be described as the language of emotional distance (Dewaele, 2004; Dewaele & Pavlenko, 2002). The emotional Stroop effect examines the automatic processing of emotionally charged lexical entries. However, a great deal of the research concerned with the representation of emotional information in the bilingual domain has focused on less automatic tasks such as task (code) switching (Gumperz & Hernandez, 1971; Javier & Marcos, 1989), rating tasks (Altarriba, 2003), recall tasks (Aycıçeği & Harris, 2004), and recognition tasks (Aycıçeği & Harris, 2004).

Altarriba (2003) collected concreteness, imageability, and context availability ratings of Spanish words representing concrete, abstract, and emotion word types from a group of Spanish–English bilinguals. The emotion words produced low mean ratings on the concreteness scale, but high mean ratings on the imageability and context availability scales. In fact, when these ratings were compared to data collected on English emotion words (Altarriba, Bauer, & Benvenuto, 1999), it was apparent that Spanish emotion words carry with them a higher level of context availability as compared to their English counterparts. It can be argued that an emotion word in one language might not have a single-word translation in another language. For example, Heredia and Altarriba (2001) noted that most Spanish speakers would agree that the emotion word cariño has no single equivalent in English. These results suggest that emotion words may be represented differently in L1 (native language) as compared to L2 (second language).

Differences in responses to emotion words in Spanish and English have also been obtained in recall data. Anooshian and Hertel (1994) asked Spanish–English bilinguals to rate 18 emotion words and 18 neutral words for ease of pronunciation, implied activity, and emotionality. The rating task
was followed by an unexpected recall test. Results revealed that more emotion words than neutral words were recalled when the words were presented in L1, but not in L2. It is important to note that 13 of the 18 emotion words were positive. Aycícği and Harris (2004) noted that the valence of the words might have resulted in the bilinguals recalling more emotion words in L1 as compared to L2, if, in fact, L1 is the language of emotional expressiveness. Aycícği and Harris (2004) extended Anooshian and Hertel’s (1994) paradigm to include a variety of emotion words (e.g., positive words and taboo words). In addition, they compared recall to recognition. Aycícği and Harris (2004) compared the recall and recognition for the following categories: (a) positive words (e.g., joy, love); (b) negative words (e.g., anger, death); (c) childhood reprimands (e.g., “shame on you!”, “don’t do that!”); and (d) taboo words (e.g., raped, breast), to neutral words (e.g., table, street).

The participants in Aycícği and Harris (2004) study were Turkish–English bilinguals living in the United States for an average of 2.1 years. The participants were relatively late-learners of English. Results of word fluency tasks administered to the bilingual participants revealed that they were significantly more fluent in their first language as compared to their second language. These bilinguals were asked to rate each word for unpleasantness using a 7-point Likert scale, where 7 was maximally unpleasant. They viewed or listened to a single word at a time for 10 seconds. Both modality and language were mixed within a single block. They were instructed to think about the meaning of the word for the entire length of the trial before rating each word. Then, half of the bilinguals were given a surprise recall test and the other half was given a surprise recognition test.

The main effect of modality was not significant and modality did not interact with any other variable. The results from both the recall and recognition data suggested a stronger emotion word advantage (the emotion words were recalled better than the neutral words) in L2 as compared to L1. Specifically, the recall data revealed that in L1 only taboo words showed an emotion word advantage. In addition, negative words were recalled more poorly than neutral words. However, in L2, all emotion categories, except for the negative words, showed an emotion word advantage. The authors also computed language superiority scores by subtracting the L1 emotion advantage means from the L2 emotion advantage means. Results revealed a stronger emotion memory effect in L2 for words carrying negative associations. Recall of the positive words was similar in L1 and L2. The recognition data revealed that in L1, an emotion memory advantage was apparent only for taboo words. However, in L2, there was an emotion word advantage for positive words, negative words, and taboo words.

These results are quite different from those obtained by Anooshian and Hertel (1994). Aycícği and Harris (2004) offered many possible explanations
for these differences. First, the bilinguals were not of the same proficiency in L1 and L2 across the two studies (equally proficient in L1 and L2 vs. late learners of English, who reported better proficiency in L1). Second, the majority of the emotion words used by Anooshian and Hertel (1994) were positive, while Aycıçegi and Harris (2004) used a range of negative emotion words (reprimands, taboo words, and negative words) in addition to positive words. Finally, Anooshian and Hertel (1994) blocked language, whereas Aycıçegi and Harris (2004) mixed the languages within a block.

Recently, Harris, Gleason, and Aycıçegi (2005) attempted to determine when a first language is more emotional using psychophysiological measures. Skin conductance responses (SCRs) were measured as participants made valence ratings to taboo words, reprimands, aversive words, positive words, and neutral words. Results revealed that when a bilingual’s two languages are learned early in childhood (before the age of 7), they exhibit similar patterns of responses to emotion words in both their first language and second language. The results for late learners of L2, revealed stronger SCRs for reprimands in L1 as compared to L2. However, none of the other categories elicited different SCRs in L1 as compared to L2.

The evidence therefore suggests that the processing of emotion words in L1 and L2 varies greatly depending on factors such as proficiency and task. Santiago-Rivera and Altarriba (2002) noted that bilinguals tend to represent emotion words differently in their two languages. Specifically, when emotions words are learned in the first language they are more deeply coded, experienced in more contexts, and applied in various ways as compared to their L2 equivalents (see also Altarriba & Santiago-Rivera, 1994). However, evidence provided by Harris et al. (2005) suggests that the size of the interference effect in the two languages may vary depending on when they were learned. If both languages were learned early in childhood, then the size of the effect should be the same in both L1 and L2; however, if L2 was learned later in life one would expect the size of the effect to be larger in L1 as compared to L2.

**CURRENT EXPERIMENT**

The emotional Stroop effect was examined in a bilingual population. Specifically, we investigated the interference effect in L1 and L2. Given the reported differences in the processing of emotional information in L1 and L2, it is possible that the size of the interference effect (as assessed by the emotional Stroop task) may not be the same across the two languages. However, the emotional Stroop effect is a measure of the automatic access of emotion, much like skin conductance responses to emotion words. The Spanish–English bilinguals in the current study were highly proficient in
both languages and learned both of their languages prior to the age of seven. Given the results of the work conducted by Harris et al. (2005), it was quite possible that the bilinguals in the current study would show equal amounts of interference in both L1 and L2.

The majority of the literature concerned with bilingual emotion word representation has found differences in the processing of emotional information in L1 as compared to L2. Differences have been found in rating tasks (Altarriba, 2003), recall tasks (Annoshian & Hertel, 1994), recognition tasks (Aycicegi & Harris, 2004), and in the code-switching literature (Gumperz & Hernandez, 1971; Javier & Marcos, 1989). Recent skin conductance response research (a more automatic measure of emotional processing) has suggested that differences in the emotional processing of words may depend on the age of acquisition for L2. However, if the two languages are learned early in life, as in the current study, then the processing of emotional information may be the same in L1 and L2.

Method

Participants. Sixty-four Spanish–English bilinguals from the University at Albany, State University of New York, campus were paid or received course credit for their participation in the current experiment. Participants had normal or corrected-to-normal visual acuity and no known reading disorders. They viewed six plates from Ishihara’s (1939) test of colour blindness and passed this test. In addition, all participants completed the Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996). As we were interested in examining the influence of emotional stimuli in a non-clinical population, we excluded 3 additional participants who scored above 13 on the BDI.

Participants were asked to complete a language history questionnaire (LHQ). The LHQ was a self-rating tool used to assess the participants’ relative spoken, written, and conversational skills in both Spanish (L1) and English (L2). The Spanish–English bilinguals rated themselves significantly higher in all of their English skills as compared to their Spanish skills (see Table 1).

TABLE 1
Mean (standard deviation) self-ratings of English and Spanish spoken comprehension, written comprehension, and speaking skill

<table>
<thead>
<tr>
<th></th>
<th>Spanish ratings</th>
<th>English ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spoken comprehension</td>
<td>9.1 (1.1)</td>
<td>9.5 (0.8)</td>
</tr>
<tr>
<td>Written comprehension</td>
<td>8.7 (1.4)</td>
<td>9.5 (0.8)</td>
</tr>
<tr>
<td>Speaking skill</td>
<td>9.0 (1.2)</td>
<td>9.5 (0.8)</td>
</tr>
</tbody>
</table>

Note: Self-rating of language skills (1 =very little, 10 =native-like). Participants reported being significantly better in all three skill areas in English.
In addition, the bilingual participants began speaking English at 4.9 years old and reading English at 6.5 years old. They began speaking Spanish at 1.9 years old and reading Spanish at 6.9 years old. There was a significant difference between when they started speaking their two languages, $t(63) = 6.35, p < .05$, but not when they started reading their two languages, $t(63) = 0.76, p = .452$. Finally, they reported speaking English 81% of the day and Spanish 19% of the day, a significant difference, $t(63) = 13.70, p < .05$. It seems that the bilinguals in the current study encountered, spoke, and read English (L2) more often than Spanish (L1). This suggests that the L2 may in fact be their more proficient and dominant language, even though it is not their native language. Heredia (1997) suggested that it is possible for a bilingual’s second language to become the more dominant language. In other words, it is easier for a bilingual to access their second language lexicon if it is used more often.

**Materials.** Two different word types were used in the current experiment: (1) negative emotion words (e.g., nervous, panic), and (2) neutral words (e.g., seat, deck). In total there were 16 negative emotion words and 16 neutral words used. The emotion words were low in valence and high in arousal, according to the Bradley and Lang norms (1999). Arousal has been defined as an invigorating response to stimulation (Duffy, 1957, 1972). The neutral words were chosen from a single category of words (boat parts). Although the neutral words all formed one specific category, boat parts, one may argue that some of the words have other, more dominant meanings. For example, the word *boom* may be associated more with the sound from thunder or an explosion. However, it is important to note that the emotional Stroop effect occurs when the neutral words are selected from a range of categories or all from one category (McKenna & Sharma, 1995). The emotional Stroop effect is not simply a category effect (i.e., the emotional words all form one category, while the neutral words may not).

The emotional and neutral words were matched for frequency (Kučera & Francis, 1967; Lund & Burgess, 1996) and length. A recent study conducted by Larsen, Mercer, and Balota (2006) indicated that the lexical characteristics of the emotion words, as compared to the neutral words, in many emotional Stroop studies are quite different. Therefore, in an attempt to control the lexical characteristics of the two word types in the current study, the emotion and neutral words were also matched in terms of orthographic neighbourhood size, mean reaction time for lexical decision and mean naming time as assessed by the English Lexicon Project (Balota et al., 2002; see Table 2).

The emotion words and neutral words were presented in separate blocks (this is typical in the emotional Stroop literature; see McKenna, 1986; McKenna & Sharma, 1995; Myers & McKenna, 1996). The order in which
the blocks appeared, as well as the colour of the words (i.e., blue or green), were counterbalanced across participants. The words were translated into Spanish (see Appendix). The average frequency of the English emotion words and neutral words did not significantly differ from each other, \( t(15) = 0.695, p > .05 \) (Kučera & Francis, 1967). The average frequency of the Spanish emotion words (59) and the average frequency of the Spanish neutral words (70) did not significantly differ from each other, \( t(15) = 0.434, p > .05 \) (Alameda & Cuetos, 1995). In addition, the frequency of the English emotion words did not significantly differ from the frequency of the Spanish emotion words, \( t(15) = 1.12, p > .05 \) and the frequency of the English neutral words did not significantly differ from that of the Spanish neutral words, \( t(15) = 1.03, p > .05 \). It is important to note that although these databases provide information about the frequency of the items, they may not speak to the familiarity of the items to the bilingual participants. The average length of the English emotion words and English neutral words did not significantly differ from each other, \( t(15) = 1.85, p > .05 \). The average length of the Spanish emotion words (7.2) and Spanish neutral words (6.7) did not significantly differ from each other either, \( t(15) = 0.826, p > .05 \). However, the English emotion items were slightly shorter in length as compared to the Spanish emotion items, \( t(15) = 2.46, p < .05 \), and the English neutral items were also shorter in length than the Spanish neutral items, \( t(15) = 3.37, p < .05 \).

Each participant viewed both blocks of words (emotion and neutral). Also, within each block, language was blocked, such that, the participants viewed emotion and neutral words in both languages, Spanish and English, separately (a typical methodological manipulation in the bilingual domain; see Altarriba & Basnight-Brown, 2007). Half of the emotion (and neutral) items appeared in English and the remaining emotion (and neutral) items appeared in Spanish. The words were not repeated in the two languages. In other words, each participant viewed eight emotion words in English, eight emotion words in Spanish, eight neutral words in English, and eight neutral words in Spanish. Each word was only presented to the participant once.

### TABLE 2

<table>
<thead>
<tr>
<th></th>
<th>Negative emotion words</th>
<th>Neutral words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kučera &amp; Francis Frequency</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>HAL log Frequency</td>
<td>8.7</td>
<td>9.0</td>
</tr>
<tr>
<td>Length</td>
<td>6.1</td>
<td>5.1</td>
</tr>
<tr>
<td>Orthographic Neighbourhood Size</td>
<td>3.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Mean Lexical Decision Time</td>
<td>625.5</td>
<td>638.8</td>
</tr>
<tr>
<td>Mean Naming Time</td>
<td>635.6</td>
<td>620.7</td>
</tr>
</tbody>
</table>
Word type, language, and the colour in which the words appeared were counterbalanced across participants. Participants completed 6 practice trials prior to the critical trials in each block. The words in the practice trials were not repeated in the critical trials.

The programs for this experiment were created using Micro Experimental Laboratory (MEL) software (Schneider, 1988, 1990). All experiments were presented on a computer screen interfaced with an IBM-PC computer. The words were on a black background. The words appeared in large font (each letter was drawn on a grid of approximately 75 × 75 dots in “mel.fnt” in the MEL program, which can fit 12 lines of 30 characters per screen).

Procedure. All participants were tested individually. Instructions appeared in English on the computer screen and were reinforced verbally by the experimenter. The experimenter remained in the room for the duration of the experiment. A given experimental trial proceeded as follows: a fixation row of plus signs, “++++++”, appeared for 300 ms (milliseconds) in the centre of the screen at the beginning of each trial. Then, this fixation was replaced by a word that appeared in the centre of the screen for 1700 ms. Regardless of the time it took the participant to respond, the word remained on the screen for the entire 1700 ms and was then replaced immediately by the fixation row of plus signs (previous Stroop studies have used a similar procedure, see Egloff & Hock, 2002; Mohanty et al., 2005). Participants were instructed to press the “m” key on the keyboard with their right index finger if the word appeared in blue and the “z” key with their left index finger if the word appeared in green. They were told to respond as quickly and as accurately as possible. If participants pressed the wrong key, the word “ERROR” appeared on the screen for 750 ms.

Results

Analysis of errors. Errors accounted for less than 2% of the data in each of the four conditions—Spanish emotion words (1.4%), English emotion words (1.2%), Spanish neutral words (1.8%), and English neutral words (1.4%). A two-way analysis of variance (ANOVA) for errors was conducted with Word Type (emotion or neutral) and Language (Spanish or English) as within-subjects factors. There were no main effects of word type, \( F(1, 63) = 2.03, p = .159 \), or language, \( F(1, 63) = 2.74, p = .103 \). In addition, the interaction between word type and language was not significant, \( F(1, 63) = 2.03, p = .159 \).

Analysis of response latencies. Only data for correct responses were included. Response times less than 300 ms and over 1500 ms were treated as outliers. In addition, response times that exceeded 2.5 standard deviations
above or below the mean for each participant were replaced by the value at 2.5 standard deviations above or below the participant’s mean. A two-way analysis of variance (ANOVA) was conducted with Word Type and Language as within-subjects factors. The results revealed a significant main effect of word type, such that neutral words were responded to faster than emotion words, $F(1, 63) = 14.84, p < .05$. There was also a significant main effect of language, such that the bilinguals responded faster to the ink colours of the words when they appeared in English (L2) than when they appeared in Spanish (L1), $F(1, 63) = 14.66, p < .05$. However, the interaction between word type and language was not significant, $F(1, 63) = 1.26, p > .05$ (see Figure 1). The pattern of results was similar in both Spanish (L1) and English (L2). The effect size for the interference produced by the negative emotion words in each language was computed using the Cohen’s $d$ statistic. When participants responded in their first language (Spanish), there was an interference effect of 28 ms, $t(63) = 2.03, p < .05, d = 0.36$. When participants responded in their second language (English), there was an interference effect of 48 ms, $t(63) = 4.03, p < .05, d = 0.71$. The emotional Stroop effect was obtained in both languages, however the size of the interference effect was larger in English (L2) than Spanish (L1); however, this was not surprising as English was the more dominant language for this particular population of Spanish–English bilinguals.

**Discussion**

Emotional Stroop effects are robust and were demonstrated in the current study using negatively valenced emotion words and neutral control words in two distinct languages. This effect was demonstrated in L1 (+28 ms) and in L2 (+48 ms) in a group of Spanish–English bilingual speakers. Although the effect in English appears larger than the one in Spanish, the interaction between word type and language was not significant. It is often difficult to interpret null results; however, it appears that when tasks are used that

![Figure 1. Mean reaction time (in ms) of emotion and neutral words in English and in Spanish.](image-url)
promote the automatic access of emotional information, the language difference that has been reported elsewhere using different measures is reduced or diminished. The current results coincide with the psychophysical results reported by Harris et al. (2005) for bilinguals who learned both L1 and L2 prior to age seven. The present findings provide additional support for the notion that Stroop interference may be determined by language proficiency (Mägiste, 1984, 1986; Tzelgov, Henik, & Leiser, 1990). According to Mägiste (1986), the degree of interference observed in a language is directly related to the proficiency of that language. “It is the degree of language experience that determines whether equivalent or different amounts of interference will be obtained between languages in a Stroop-like task” (Mägiste, 1986, p. 113). Since the bilinguals in the current study were highly proficient in both of their languages, and learned both by age 7, it was not surprising that the effect was equal in L1 and L2.

Emotion word representation has been investigated in the bilingual domain using a variety of tasks (e.g., recall, recognition, rating data). The majority of the research in this domain indicates that emotion words seem to be processed differently in L1 and in L2. For example, Anooshian and Hertel (1994) found greater recall of emotional items in L1 as compared to L2 (using mostly positive stimuli), whereas Ayçiçeği and Harris (2004) found greater recall and recognition of negative emotional stimuli in L2 as compared to L1. These conflicting data suggest that emotional differences may depend upon the nature of the stimuli (positive words or negative words), the presentation of the stimuli (mixed or blocked), the proficiency of the bilinguals investigated, and age of acquisition. Unlike most of the previous research, the current study provided an automatic measure of selective attention to emotional information. The results indicated that the interference produced by the emotional stimuli was equivalent in both L1 and L2. It is important to note that the similar interference effects in L1 and L2 may be a result of the bilingual population investigated. The current bilinguals were highly proficient in both L1 (Spanish) and L2 (English). In fact, the self-reported data from the Language History Questionnaire suggested that L2 had actually become the more dominant language. The bilinguals in the current study reported using English more often than Spanish; however, they reported extremely high proficiency ratings in both languages. Future investigations should examine the emotional Stroop effect using a range of bilingual participants, late L2 learners, balanced bilinguals, etc. It is possible that differences may arise as a result of age of acquisition (see Harris et al., 2005).

The current work also has implications for theories and models related to the representation of more than one language in memory. Specifically, any
model that purports to explain the encoding, storage, and retrieval of more than one language in memory must take into account the idea that different word types might be represented differentially in bilingual memory (see Altarriba, 2000, for further discussion). That is, emotion words may be stored differently as compared to non-emotion or neutral words.

While some models of bilingual memory emphasise the acquisition of the first and second language in terms of developmental principles (e.g., Kroll & Stewart, 1994), other models that consider word features and characteristics as a basis for their mental representations advocate depictions that are more network-like or distributed in nature (e.g., de Groot, 1993; Finkbeiner, Forster, Nicol, & Nakamura, 2004). These latter models accrue to the linguistic features of words—semantic meanings, orthographic and lexical overlap, morphological overlap, etc.—in their descriptions of the representation of words across languages. The current results would suggest that general linguistic models depicting the representation of more than one language in memory must be able to distinguish the representation of different classes of words (e.g., concrete, abstract, emotion) in their accounts of the acquisition, storage, and retrieval of those words. As the notion that emotion words are a distinct class of words in the mental lexicon is a rather new idea in the literature, the current work indicates that this area of inquiry can easily be expanded to include the representation of those word types across two or more languages. This line of work would clearly inform theories of bilingual word processing as well as those related to the functioning of bilingual memory.

The current work extended the emotional Stroop paradigm to investigate the representation of emotion words in a second language, indicating that emotion words produce interference in both L1 and L2. Although the Stroop task has been employed extensively in the bilingual literature to investigate the automatic activation of colour words in L1 and L2, the current work represents the first attempt to examine the automatic activation of emotion words in a modified Stroop task. Research that has investigated the “bilingual Stroop effect” has focused on the interference caused by colour words both within and between languages. In other words, the focus has been on the congruency between the language in which the colour words are written (e.g., English) and the language in which the answers are requested (e.g., English) or on the incongruence between the language in which the colour words are written (e.g., English) and the language in which the answers are requested (e.g., Spanish).
REFERENCES


## APPENDIX

Emotion and neutral stimuli in English and their Spanish equivalents

<table>
<thead>
<tr>
<th>Emotion words</th>
<th>Neutral words</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>Spanish</td>
</tr>
<tr>
<td>nervous</td>
<td>nervioso</td>
</tr>
<tr>
<td>grief</td>
<td>dolor</td>
</tr>
<tr>
<td>upset</td>
<td>bravo</td>
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<tr>
<td>greed</td>
<td>avaricia</td>
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<td>anxiety</td>
<td>ansiedad</td>
</tr>
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