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Language Membership Identification Precedes Semantic Access: Suppression during Bilingual Word Recognition

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Abstract

Previous research suggests that bilingual comprehenders access lexical representations of words in both languages non-selectively. However, it is unclear whether global language suppression plays a role in guiding attention to target language representations during ongoing lexico-semantic processing. To help clarify this issue, this study examined the relative timing of language membership and meaning activation during visual word recognition. Spanish–English bilinguals performed simultaneous semantic and language membership classification tasks on single words during EEG recording. Go/no-go ERP latencies provided evidence that language membership information was accessed before semantic information. Furthermore, N400 frequency effects indicated that the depth of processing of words in the nontarget language was reduced compared to the target language. These results suggest that the bilingual brain can rapidly identify the language to which a word belongs and subsequently use this information to selectively modulate the degree of processing in each language accordingly.

INTRODUCTION

Language comprehension requires people to activate contextually appropriate representations quickly and efficiently. Bilinguals face particular challenges because of the potential for competition and interference from two sets of linguistic representations. Standard accounts of bilingual lexical access posit that incoming stimuli can activate knowledge of the contextually inappropriate language automatically and outside of conscious awareness (Wu & Thierry, 2010; Thierry & Wu, 2007; Kroll & De Groot, 2005). Because bilinguals rarely exhibit cross-language intrusions in their speech patterns (Gollan, Sandoval, & Salmon, 2011) and are generally unaware of any potential competition from the nontarget language, they must possess a strong language control mechanism. To function in a single target language, bilinguals need to attend to the target language while ignoring or inhibiting potentially active nontarget language representations. However, the locus of language control in the lexico-semantic processing stream remains unclear.

Bilinguals may manage cross-language interference using one of two hypothetical cognitive mechanisms. The selective access hypothesis proposes that bilinguals activate lexical representations solely from the contextually appropriate language while inhibiting

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representations from the nontarget language (Gerard & Scarborough, 1989). The nonselective access hypothesis proposes that bilinguals simultaneously activate mental representations from both languages and subsequently suppress candidates from the nontarget language (Dijkstra, Timmermans, & Schriefers, 2000). Most studies support the latter hypothesis (Midgley, Holcomb, Van Heuven, & Grainger, 2008; Van Hell & Dijkstra 2002; De Groot, Delmaar, & Lupker, 2000), but several recent studies have demonstrated the possibility of selective or partially selective access under certain conditions (Hoversten & Traxler, 2015; Titone, Libben, Mercier, Whitford, & Pivneva, 2011; Van Hell & De Groot, 2008; Schwartz & Kroll, 2006; Elston-Güttler, Gunter, & Kotz, 2005).

According to the Bilingual Interactive Activation Plus (BIA+) model, word stimuli cause matching lexical representations to resonate in long-term memory regardless of the language membership of the eliciting stimulus (Dijkstra & Van Heuven, 2002). Its predecessor, the BIA, included language nodes to represent each word's language membership and permitted each node to inhibit all words from the opposite language. BIA+ retained these nodes to allow for language membership identification but removed their inhibitory role in lexical processing. The newer model also made an explicit distinction between the word recognition system and a separate task/decision system that comprises all task-related processes. BIA+ assumes that neither the language nodes nor the task/decision system can directly affect any stage of lexico-semantic processing, including form level and semantic processing. Thus, the model supports a nonselective view of bilingual word recognition in which only bottom–up stimulus information can influence the activation of semantic representations from the lexicon regardless of language membership.

However, results of a study by Rodriguez-Fornells and colleagues suggest that bilinguals might be able to selectively block semantic processing of words from the nontarget language based on task instructions (Rodriguez-Fornells, Rotte, Heinze, Nösselt, & Münte, 2002). In their study, a mixed list of Spanish, Catalan, and pseudowords was presented to Catalan–Spanish bilinguals and Spanish monolinguals during EEG recording. For target language words only, participants made a button press to indicate whether a word began with a vowel or a consonant. Word frequency differences in the ERP waveforms (Rugg, 1990) were examined in target (go) and nontarget (no-go) languages to assess the degree of semantic processing that occurred in each language. As expected, low-frequency words elicited a larger N400 negativity than high-frequency words in the target language, but no such frequency effect was found in the nontarget language. These results suggest that participants selectively accessed words from the target language while suppressing access to nontarget words. This study questions the assumptions of the BIA+ model that neither language nodes nor task demands can directly influence lexical processing. However, this experiment used language membership and phonological classifications, so semantic access was not required for the task. For this reason, it is possible that participants were more easily able to suppress processing in the nontarget language than they would during natural word recognition (Bentin, Kutas, & Hillyard, 1993; Henik, Kellogg, & Friedrich, 1983).

Ng and Wicha (2013) provided evidence that contradicted these results. Spanish, English, and pseudowords were presented to Spanish–English bilinguals during EEG recording. Each language was the target language in a separate block, and participants responded to all “people words” in that language. Significant frequency effects were found in both the target (go) and nontarget (no-go) languages in this study, which suggests that participants may not have selectively inhibited the nontarget language under these conditions. Unlike Rodriguez-Fornells and colleagues, Ng and Wicha argue for nonselective access to lexico-semantic representations of both languages in accordance with BIA+ predictions. Although this study improved on the study by Rodriguez-Fornells and colleagues by requiring participants to process target words at the semantic level, stimuli were not fully counterbalanced across tasks. As a result, low-level stimulus differences could have confounded their results. Additionally, they did not investigate the possibility of partial language suppression by assessing whether the frequency effect differed as a function of target and nontarget language.

Thus, at this point evidence is inconclusive with respect to whether or not language membership may constrain further lexico-semantic processing to one language only. Therefore, we directly examined the temporal relationship of the availability of language membership information relative to semantic information during visual word recognition. For a bilingual comprehender to effectively suppress activation of a word in the nontarget language, information about this word’s language membership must be available relatively early during word identification. If semantic access were completed before identification of a word’s language membership, then this membership information could not serve as a filter for subsequent processing and semantic access must occur in a purely language-nonselective manner as predicted by BIA+. If, instead, language membership identification regularly precedes semantic access, then semantic processing could potentially proceed in a selective manner. Therefore, the temporal relationship between language membership and semantic information during lexico-semantic access is a critical comparison to test the possibility of language-selective access.

In addition to determining the availability of these two types of information, we also tested to what extent language membership identification can influence subsequent lexico-semantic processing. BIA+ predicts that language membership will not influence any aspect of lexico-semantic processing. To examine this prediction, we compared effects of lexical frequency as a function of language membership information. A finding that language membership information modulates the effect of frequency (such that frequency effects are smaller in the nontarget language) would contradict this prediction. Thus, we directly tested the assumptions of the BIA+ model that bilingual lexico-semantic access proceeds in a purely nonselective manner and that neither language membership nor task demands can influence semantic access.

We used ERPs as a measure of online, neural processing to assess the timing of access to language membership and semantic information. In addition, we analyzed word frequency effects in the ERP waveforms in the target and nontarget languages to provide a neural index of the depth of word processing. Thirty-two Spanish–English bilinguals performed simultaneous language membership and semantic categorization for a set of English and Spanish nouns. In one half of the experiment, participants performed a Language Go Task (LGT) in which they made a go or no-go response decision on the basis of each word’s language membership (English or Spanish) and a left- or right-hand response decision on the basis of animacy (living or nonliving). In the other half of the experiment, participants performed a Semantic Go Task (SGT) in which they made a go/no-go decision on the basis of animacy and a response hand decision on the basis of language membership (see Table 3 for an illustration of coupling between go trials and response hand).

During EEG recording, robust ERP differences are often observed between go and no-go trials. Because these neural differences require a successful discrimination between go and no-go stimuli, the onset of these ERP differences can be used as a temporal marker for initial stimulus categorization (Nasman & Rosenfeld, 1990; Luck, 1998). Following this logic, we measured the latency of the go/no-go divergence in each task to compare stimulus categorization time for each type of information. If the latency of the go/no-go divergence in the SGT precedes that of the LGT, then this would provide evidence that animacy is categorized first, which would support the BIA+ claim that “language information becomes available rather late during (isolated) bilingual visual word recognition, usually too late to affect the word selection process” (Dijkstra & Van Heuven, 2002, p. 186). Conversely, earlier latency of the go/no-go divergence in the LGT than in the SGT would be consistent with the idea that language membership information can filter access to lexico-semantic representations in one specific language.

To examine depth of lexico-semantic processing, we also analyzed the ERP amplitude difference between high- and low-frequency words (divided in each category by a median split) in go and no-go trials in each task to investigate the depth of processing for target and nontarget words. If frequency effects are not modulated by the task relevance of a particular language, this would support the BIA+ assumption that neither language membership nor task demands can influence word recognition. The strongest evidence against this claim would be if frequency effects are modulated by task relevance across target and nontarget languages but not target and nontarget semantic category. Such a result would indicate that modulation of the depth of processing is unique to language membership information and not an effect of the dual task paradigm.

METHODS

Participants

Thirty-seven undergraduate Spanish–English bilinguals at the University of California, Davis, provided written informed consent to participate in the study and were compensated with course credit. Each participant completed a language history questionnaire modeled after the standardized Language Experience and Proficiency Questionnaire and the vocabulary section of the Nelson Denny Reading Comprehension Test to provide measures of proficiency and information about the manner of their language acquisition and usage (Table 1; Marian, Blumenfeld, & Kaushanskaya, 2007; Brown, Fishco, & Hanna, 1993). The 32 participants whose data were included in the final analyses were determined to be proficient and approximately equally balanced in the use of their two languages. None of the participants had a history of neurological or psychiatric impairment. All participants had normal or corrected-to-normal vision and were right-handed, as assessed by the Edinburgh Handedness Inventory (Oldfield, 1971).

Stimuli

We selected 576 concrete nouns that were equally distributed across four categories: English living, English nonliving, Spanish living, and Spanish nonliving. The 144 words in each of these categories were matched across categories on length, concreteness, and log frequency per million in the SUBTLEX-US and SUBTLEX-ESP databases (Table 2; Cuetos, Glez-Nosti, Barbón, & Brysbaert, 2011; New, Brysbaert, Veronis, & Pallier, 2007; Coltheart, 1981). The four word categories were further divided by a median split into high- and low-frequency words (high: $M = 1.51$, range = 1.07–2.95; low: $M = 0.66$, range = 0.14–1.07). We excluded cognates, interlingual homographs, and Spanish words with non-English characters to eliminate language-ambiguous stimuli and low-level stimulus features unique to one language. Stimuli from each category were counterbalanced across eight lists of eight blocks each. Each word was presented once in each half of the experiment in different orders, such that each participant saw each word twice for a total of 1152 trials.

Procedure

Participants were seated 100 cm from a CRT monitor in an electrically shielded, sound-attenuated chamber. Stimuli were presented serially in the center of the screen in white uppercase Calibri font against a black background. Stimuli appeared between two fixed horizontal lines to preserve central fixation throughout the experiment. Each stimulus appeared for 400 msec with a jittered ISI of 1750–2100 msec. A fixation cross appeared after every third stimulus for 1000 msec to allow participants to blink, followed by 1500 msec of blank screen before beginning the next trial.

Participants performed concurrent semantic and language membership categorization during EEG recording. Participants were required to perform both classifications simultaneously to minimize possible differences in categorization difficulty. To investigate the time course of each categorization type, different response mappings for language membership and animacy were required in two separate tasks. At any given time, only one of these dimensions (language or animacy) determined whether a button response was required, whereas the other dimension determined the response hand. In one half of the experiment, participants performed an LGT in which they made a go or no-go response decision on the basis of the word’s language membership (English or Spanish) and a left- or right-hand response decision on the basis of animacy (living or nonliving). In the other half of the experiment, participants performed an SGT in which animacy information determined response execution and language membership information determined response hand (see Table 3).

Participants were instructed to respond to each word as quickly and accurately as possible. Each word appeared equally often in all response conditions (LGT go, LGT no-go, SGT go, SGT no-go) across lists. All participants performed every possible combination of response-to-category mapping in one of eight blocks. A practice set of 24 stimuli preceded each new task in each block (see Table 4 for an example task list). Task order was counterbalanced across participants such that half the participants performed all LGT tasks in the first half (four blocks) and all SGT tasks in the second half whereas the other participants performed all SGT tasks in the first half and LGT tasks in the second half of the experiment.

Recording

The EEG was recorded from 29 tin electrodes mounted in an elastic cap (Electro-Cap International, Eaton, OH). Additional electrodes were attached below the left eye and to the side of each eye to monitor blinks and horizontal eye movements. EMG electrodes were attached to the underside of each wrist to monitor response preparation in the absence of an overt button press. All electrode impedances were kept below 5 kΩ, except for the EMG electrodes, for which impedances were kept below 100 kΩ. The EEG signal was amplified using a Synamps Model 8050 Amplifier (Compumedics Neuroscan) with a bandpass of 0.05–100 Hz and digitally recorded at a sampling rate of 1000 Hz. Electrodes were referenced online to the right mastoid and re-referenced offline to the average of the left and right mastoids.

After EEG recording, independent component analysis was performed to isolate and remove blink, saccade, and muscle components (Makeig, Bell, Jung, & Sejnowski, 1996). EEG data were filtered with a 30-Hz low-pass filter. EMG data were filtered with a 3-Hz high-pass filter and 60-Hz and 120-Hz notch filters to better visualize recorded muscle activity. Sampling rate was then reduced to 250 Hz. 1400-msec EEG epochs were time-locked to the presentation of each stimulus with a 200-msec prestimulus base-line, and single-trial waveforms were screened and rejected for amplifier drift, muscle artifacts, eye movements, and response errors indicated by visible EMG activity (4.2% artifact and 7.0% error rejection). Four participants were rejected from further analysis because of missing data in excess of 30% attributable to artifacts and/or errors. One additional participant was rejected from further analysis because of excessively long response latencies (greater than two standard deviations above the mean). The remaining 32 participants are reported in all analyses.

ERP Analysis

EEG epochs were averaged to compute ERPs in each condition, and statistical analyses were performed on individual subject ERP averages. The Greenhouse–Geisser correction was used to adjust the reported p values for analyses with more than one degree of freedom. To isolate the effects of go/no-go categorization by task, no-go minus go difference waves were calculated from the raw waveforms. Latency analyses were performed on the difference waves with the factor Task (language go vs. semantic go) and the topographic factors listed below. For the mean amplitude analyses, Task (language go vs. semantic go) by Target (go vs. no-go) ANOVAs were performed with the additional factor Frequency (high vs. low) in the frequency effect analysis. To examine topographic differences in each effect, we performed midline and lateral ANOVAs in representative scalp areas. The lateral analysis included a factor of Anteriority (anterior vs. posterior) and a factor of Hemisphere (left vs. right) to represent four scalp areas (left anterior: F7, F3, FC5, FC1; left posterior: CP5, CP1, T5, P3; right anterior: F4, F8, FC2, FC6; right posterior: CP2, CP6, P4, T6). The midline analysis included five levels of the factor Anteriority that included one electrode each (AFz, Fz, Cz, Pz, and POz).

RESULTS

Behavioral

Response latency was significantly shorter in the LGT (*M* = 1000 msec, *SD* = 114 msec) than in the SGT (*M* = 1028 msec, *SD* = 122 msec; *t*(31) = 2.54, *p* = .016). Overall error rates did not differ between the LGT (*M* = 5.2%, *SD* = 2.8%) and the SGT (*M* = 5.6%, *SD* = 2.7%; *t*(31) = 1.38, *ns*). Across tasks, participants made slightly more errors in Spanish (7.6%) than in English (5.1%). Within each task, participants made more semantic classification errors (language go: 7.9%; semantic no-go: 7.9%) than language membership classification errors (language no-go: 2.5%; semantic go: 3.3%; *F*(1, 31) = 60.68, *p* < .001). This pattern of error rates suggests that the animacy categorization may have been more difficult than language membership classification. Critically, error rates did not differ across the LGT and the SGT, which suggests that the requirement to perform both categorizations simultaneously successfully minimized differences in overall difficulty across tasks.

Go/No-go Effect

In the grand-averaged ERP waveforms, early visual components preceded P2 and N400 peaks typically observed in response to visual word stimuli. Across both tasks, go trials produced enhanced positive amplitudes compared to no-go trials (Figure 1). The timing of the go/no-go divergences appeared to differ across tasks, occurring at approximately 300 msec poststimulus in the LGT and 400 msec poststimulus in the SGT.[1] To assess the time course of these effects, difference waveforms (no-go minus go) in each of the tasks were calculated and analyzed (Figure 2). Go/no-go differences waves likely represent a mixture of enhanced N2 effects for no-go trials and enhanced P3 effects for go trials (Figure 1).

We calculated 20% peak latency as the time point at which each difference waveform reached 20% of its peak amplitude in the 200–800 msec time window (Luck, 2005). The analysis on this measure revealed significantly earlier onset latency for the difference waves in the LGT than for those in the SGT (lateral: *F*(1, 31) = 18.86, *p* < .001; midline: *F*(1, 31) = 16.03, *p* < .001). This latency difference interacted with Hemisphere in the lateral analysis (*F*(1, 31) = 5.76, *p* = .023); the difference was more pronounced over the right hemisphere than the left hemisphere. No significant topographic effects were found in the midline analysis (*F*(1, 31) < 1, *ns*). The latency was earliest in both tasks over electrode POz, where 20% of the peak latency of the go/no-go difference wave was reached 94 msec earlier in the LGT (394 msec) than in the SGT (489 msec).

In addition to differences in latency, the go/no-go difference wave also showed more pronounced amplitudes in the LGT than in the SGT (Figure 2). These differences were confirmed by a Task (language go vs. semantic go) by Target (go vs. no-go) interaction on the mean amplitude of the raw waveforms in the 400–800 msec time window in the midline analysis (*F*(1, 31) = 7.683, *p* = .009) that did not interact with Anteriority (*F*(1, 31) = 1.245, *ns*). The mean amplitude of the go/no-go difference wave across all electrodes in the midline

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[1] Onset latency results mirror those of a behavioral pilot study (*n* = 8) in which participants made simple language membership and semantic categorizations to the same set of stimuli. Participants performed the language membership classification task (*M* = 733 msec, *SD* = 117) an average of 119 msec faster than the semantic classification task (*M* = 852 msec, *SD* = 150; *t*(7) = 5.84, *p* < .001).

analysis was significantly larger in the LGT (−1.62 μV) than in the SGT (−0.84 μV). In the lateral analysis, these differences were most pronounced at left posterior electrode sites, as confirmed by a Task × Target × Anteriority × Hemisphere interaction ($F(1, 31) = 28.886$, $p < .001$), whereby the Task × Target interaction was only significant over the left posterior cluster ($F(1, 31) = 5.15$, $p = .03$).

Frequency Effect

An amplitude difference in the frequency effect between go and no-go trials emerged in the LGT but not in the SGT (Figures 3 and 4). A Task (language go vs. semantic go) by Target (go vs. no-go) by Frequency (high vs. low) interaction was found in the 400–700 msec time window (lateral: $F(1, 31) = 5.32$, $p = .028$; medial: $F(1, 31) = 2.15$, *ns*). Frequency effects were larger for the target (go) language than for the nontarget (no-go) language in the LGT (lateral: $F(1, 31) = 12.52$, $p = .002$; midline: $F(1, 31) = 7.83$, $p < .01$), but no significant differences in the frequency effects were found in the SGT (lateral: $F(1, 31) < 1$, *ns*; midline: $F(1, 31) < 1$, *ns*). This effect did not interact with any topographic factors in either analysis (all Fs < 1.53, *ns*).[2] Despite the reduction in the size of the frequency effect for the nontarget language, the frequency effects for both target and nontarget categories in each task all reached significance (all Fs > 6.87, ps < .02). To further investigate the effect, we analyzed mean amplitude in the same 400–700 msec time window for a centroparietal cluster (Cz, CP1, CP2, Pz, P3, P4, and POz) where the frequency effect was maximal across both tasks. Although go and no-go trials in the LGT were significantly different ($p < .01$), the size of the frequency effect did not differ between LGT and SGT go trials or between LGT and SGT no-go trials (all ps > .05). On the basis of this analysis, the extent to which the effect was driven by greater suppression of nontarget language stimuli versus enhanced processing of language relevant stimuli is currently unclear.

DISCUSSION

The current study examined the temporal relationship between access to language membership information and access to animacy information. Specifically, the study aimed to assess whether language membership information (a) is available early enough during word processing to affect further semantic processing and (b) modulates ongoing word processing according to task demands. The latency at which go/no-go ERP waveforms diverged in each task indexed the earliest measureable time point by which the brain must have categorized the stimuli according to the go/no-go dimension (Nasman & Rosenfeld, 1990; Luck, 1998). N400 frequency effects were also analyzed to determine the depth of processing in target and nontarget categories. The BIA+ model of bilingual word recognition predicts that language membership information arrives too late in the processing stream to affect word recognition (Dijkstra & Van Heuven, 2002). According to this prediction, the SGT go/no-go divergence should occur earlier than the LGT go/no-go divergence. Additionally, ERP frequency effects in target and nontarget categories should not be modulated in either task.

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[2] To determine whether word repetition across halves may have affected our results, we examined the results separately for each half of the experiment. Because repetition did not change the overall pattern of results, we did not include this factor in the final analyses.

The results disconfirmed both predictions of BIA+. Onset latency of the go/no-go effect in each task indicated that participants differentiated target and nontarget words on the basis of language membership approximately 100 msec faster than on the basis of semantic category. This result provides evidence that the bilingual brain can indeed access language membership information before semantic access.[3] Critically, the primacy of language membership information allows for the possibility of selective access at the semantic level because access to language membership information must precede the completion of semantic access in order for it to influence ongoing semantic processing. Mean amplitude of the go/no-go effect was also larger in the LGT than in the SGT. This effect was driven by an enhanced go P3 in the LGT, suggesting that the two languages were more strongly identified or categorized than the semantic categories. This enhanced categorization effect may have been caused by clearer category boundaries for language membership or increased relevance of language membership identification in everyday interactions.

Furthermore, the frequency effect was modulated by the task relevance of a language but not the task relevance of semantic category information. Whereas a robust frequency effect was present in both target and nontarget SGT trials, it was reduced by approximately half in the nontarget compared to the target LGT trials. This result suggests that the bilingual brain can use language membership to modify the depth of processing in the target and nontarget languages.[4] Language membership information may be unique in this regard because of its temporal primacy. Because language membership information was available relatively early during lexicosemantic processing, this cue could serve to filter further processing of nontarget words. The absence of suppression effects in the SGT reveals that participants could not use animacy information in the same way to limit processing in the nontarget semantic category. In this task, bilinguals needed to fully process both target and nontarget words to decide whether or not to respond. Even for nontarget words, animacy information arrived too late to affect the overall depth of processing.

The combination of evidence that language membership categorization occurred earlier than animacy categorization and that frequency effects were significantly reduced as a function of task demands indicates that the brain is capable of selective lexico-semantic access in balanced bilinguals. However, the frequency effect remained significant in the suppressed nontarget language, suggesting partial rather than complete selectivity. Although theories of bilingual lexico-semantic access are typically framed as entirely either language selective or language nonselective, the current results support a more nuanced distinction. Language membership information seems to have arrived early enough to filter ongoing word processing, but some degree of semantic processing was still observed in the nontarget language.

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[3] As pointed out by a reviewer, it may be the case that the onset of the go/no-go difference wave reflects the completion of language membership categorization rather than the earliest stage at which language membership is available. It may be possible that the accumulation of language membership information begins earlier than 300 msec poststimulus onset. Regardless of whether language membership decisions are initiated or completed before animacy decisions, this difference in timing appears to have important consequences for the depth of processing of nontarget words.

[4] Because neither go trials nor no-go trials significantly differed in their frequency effects across tasks, it is possible that the modulation of the frequency effect was driven by enhanced processing of the target language and/or restricted processing of the nontarget language. For simplicity, we will refer to the effect as a suppression effect, but it should be noted that facilitation for the target language may also contribute.

This study can also shed light on the discrepancy between the results of Rodriguez-Fornells and colleagues' (2002) study (that points toward a fully selective model of bilingual word processing) and Ng and Wicha's (2013) study (that supports nonselective access). The differences between the current study and Rodriguez-Fornells and colleagues likely resulted from the inclusion of the semantic categorization task in place of their phonological judgment task. The phonological judgment task may be less typical of natural language processing in that it focuses on very basic elements of form. Ng and Wicha, on the other hand, included the semantic categorization task but did not match words in each category on features known to affect ERP waveforms such as length and concreteness (Kutas & Federmeier, 2011). Additionally, the current study directly compared differences in the degree of processing between target and nontarget words. The frequency effect in the nontarget language, although significant, was reduced by about half from that in the target language. A close inspection of the waveforms in Ng and Wicha's study suggests that their participants may have suppressed processing in the nontarget language by approximately the same amount reported in the current study.

The current results may prove difficult to integrate into the BIA+ framework. According to this framework, neither language nodes nor task demands can influence word processing. The BIA+ model could accommodate our first result, which is that language membership identification precedes semantic access, because the model does not necessarily constrain the temporal relationship between activation of the language nodes and the semantic layer. However, modulation of frequency effects in the current study suggests that the task relevance of a particular language can influence the depth of lexico-semantic processing. Not only do these results suggest a more active role of the language nodes in word recognition, but they also call into question the model's separation between the task/decision system and the word recognition system. The original BIA model would better accommodate these results because it allows for top–down inhibition of the language nodes on words from the opposite language as well as the influence of task demands on lexicosemantic processing.

The suppression of a nontarget language is a critical skill bilinguals need to function in a monolingual language context while minimizing nontarget language interference. Although nonselective accounts hypothesize complete lexico-semantic access of both target and non-target words, selective accounts predict complete suppression of task-irrelevant linguistic information. In contrast to these all-or-nothing accounts, results from the current study suggest that top–down attention may use language membership information to dynamically adjust the gain on lexico-semantic processing. An important question for future research will be to what extent the successes or failures of this suppression mechanism depend on features of the surrounding context or individual differences in language experience and executive control.

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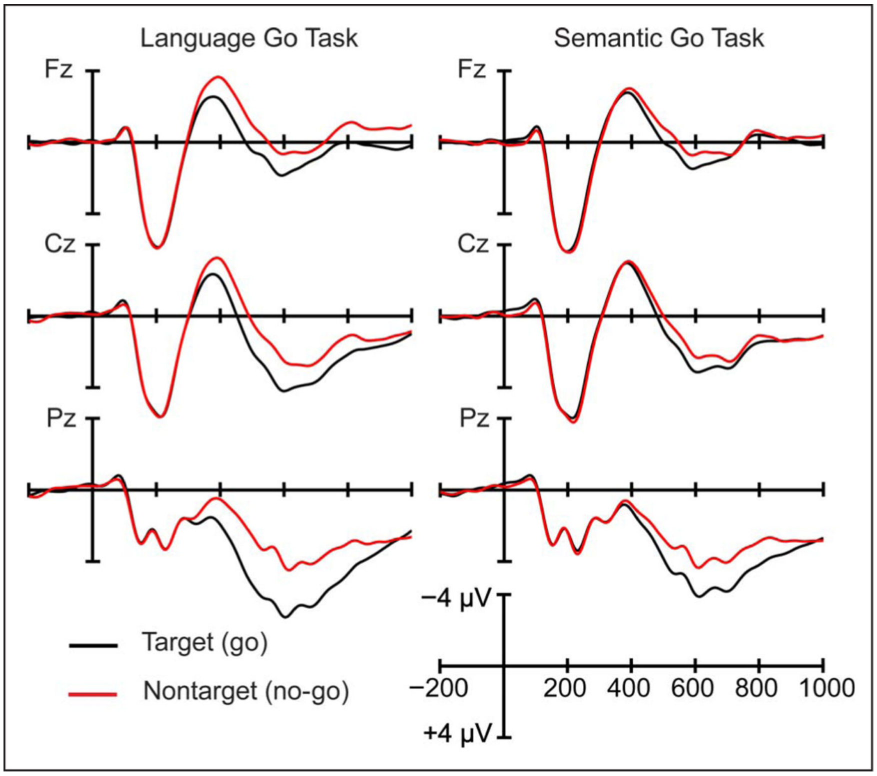

Figure 1.

Grand-averaged go and no-go waveforms in LGT and SGT. A 15-Hz low-pass filter was applied for display purposes only.

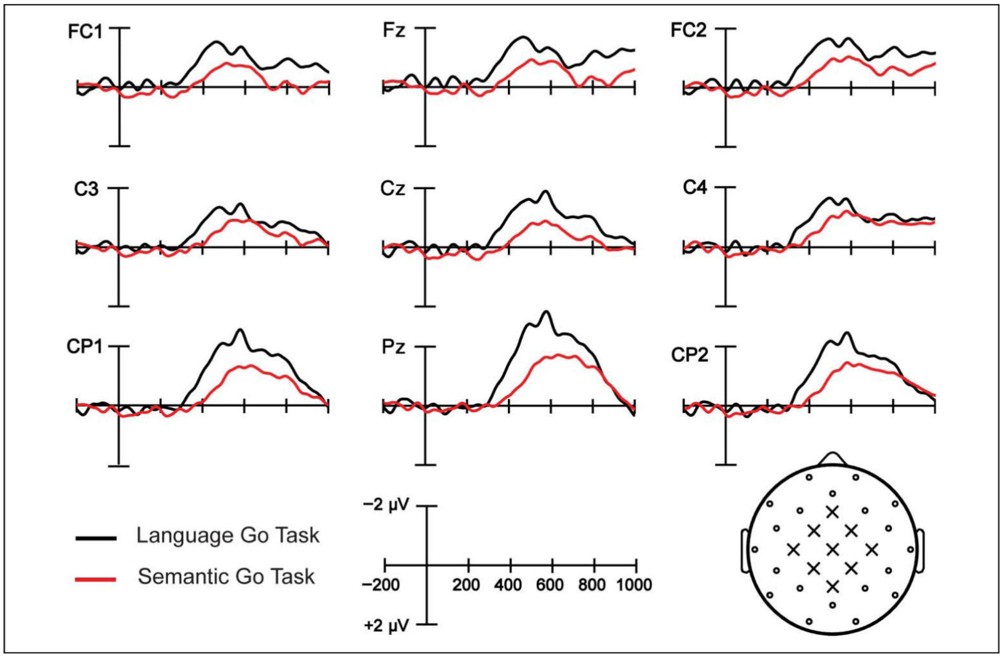

Figure 2.

ERP difference waves representing the go/no-go effect in LGT and SGT. Difference waves were calculated by subtracting go trials from no-go trials for each task.

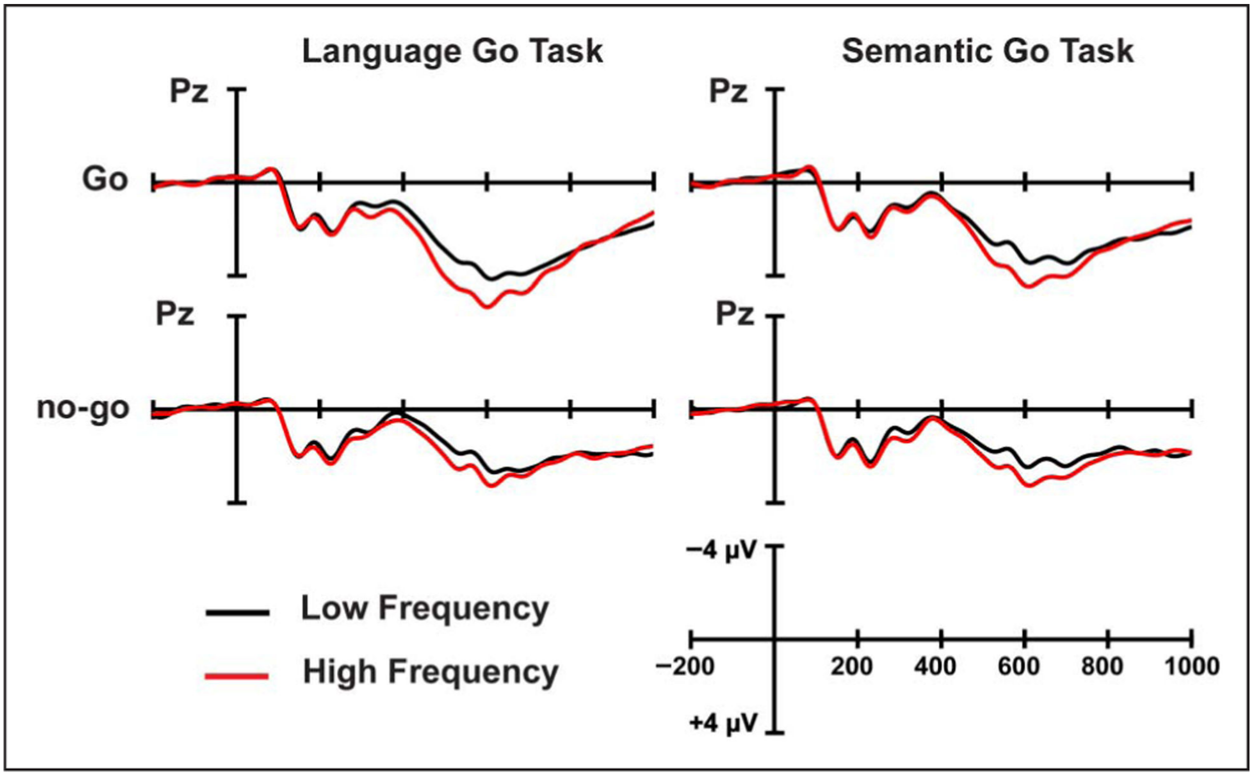

Figure 3.

Grand-averaged waveforms for high- and low-frequency words in go and no-go trials in LGT and SGT at electrode Pz, where the frequency effect was maximal.

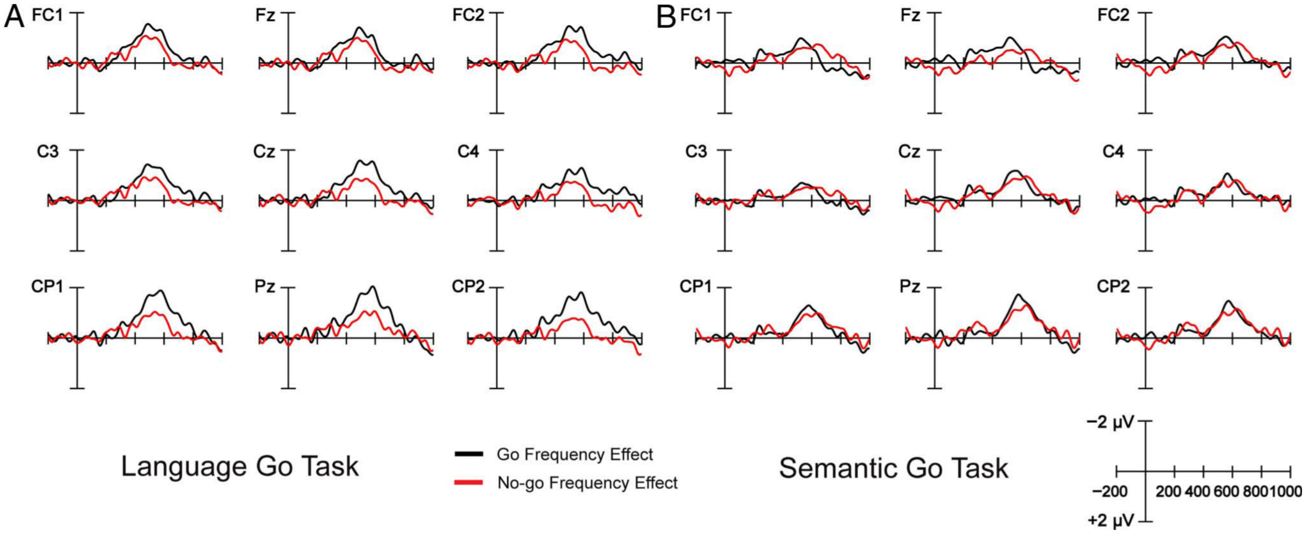

Figure 4.

ERP difference waves representing the frequency effects for go and no-go trials in (A) LGT and (B) SGT. Difference waves were calculated by subtracting high-frequency word trials from low-frequency word trials for each condition.

Table 1.

Participant Scores and Standard Deviations Provided by Language History Questionnaire and Proficiency Testing

Spanish	
Age of acquisition	Native
Mode of acquisition	Home
Use	Daily
Reading (1–7)	6.1 (.98)
Speaking (1–7)	6.4 (.74)
Listening (1–7)	6.8 (.46)
Writing (1–7)	5.5 (1.3)
English	
Age of acquisition	4.2 (2.3)
Mode of acquisition	School
Use	Daily
Reading (1–7)	6.5 (.64)
Speaking (1–7)	6.5 (.69)
Listening (1–7)	6.7 (.46)
Writing (1–7)	6.2 (.83)
Vocabulary test (%)	72 (12)

Table 2.

Stimulus Characteristics in Each Condition

	English		**Spanish**	
	Living	**Nonliving**	**Living**	**Nonliving**
Frequency	1.10	1.08	1.08	1.08
Length	5.84	5.84	5.85	5.81
Concreteness	559	556	561	558

Table 3.

Example Categorizations for Each Task

Language Go Task	**Left Hand (Living)**	**Right Hand (Nonliving)**
Go (English)	GIRL	COIN
No-go (Spanish)	TORO	AGUA
SGT	*Left Hand (English)*	*Right Hand (Spanish)*
Go (Living)	GIRL	TORO
No-go (Nonliving)	COIN	AGUA

Table 4.

Example Tasks across Blocks for a Participant on List 1

Block	Go Category	Right Hand Category
1	English	Living
2	English	Nonliving
3	Spanish	Nonliving
4	Spanish	Living
5	Living	English
6	Living	Spanish
7	Nonliving	Spanish
8	Nonliving	English