Effects of Cognate Status on Word Comprehension in Second Language Learners: An ERP Investigation

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Abstract

■ ERPs were used to explore the different patterns of processing of cognate and noncognate words in the first (L1) and second (L2) language of a population of second language learners. L1 English students of French were presented with blocked lists of L1 and L2 words, and ERPs to cognates and noncognates were compared within each language block. For both languages, cognates had smaller amplitudes in the N400 component when compared with noncognates. L1 items that were cognates showed early differences in amplitude in the N400 epoch when compared with noncognates. L2 items showed later differences between cognates and noncognates than L1 items. The results are discussed in terms of how cognate status affects word recognition in second language learners. ■

INTRODUCTION

The 1066 victory of William the Conqueror at the battle of Hastings and the subsequent centuries of Norman rule had enormous impact on the England of the middle ages. One of the legacies of this period can be found in the relationship of the French and English languages. The imposition of French on English during that time resulted in the incorporation of many tokens of French into English, a language already accepting of many borrowed forms. This shared history leaves the two languages today with a multitude of shared words like "table." This type of nonaccidental overlap of form in translation equivalents is what defines cognate words. Many English–French cognates have complete written overlap like "fruit" or near complete overlap like "mask" and "masque." In the study presented here, we examined the processing of cognate words such as these as compared with noncognate words by English–French beginning bilinguals.

Given the sharing of form and meaning across languages, cognates are likely to be special words for bilinguals. It is this special status that will be exploited in the present study to address different questions of bilingual lexical access. Because of their shared form with L1 items, cognates, during L2 acquisition, could be a learner's first foothold into the new lexicon. Presumably in the early stages of acquisition, this would result in different patterns of processing for cognates and noncognates while processing L2. In the case of L1 processing, if cognates showed different patterns of processing when compared with noncognates, this would be evidence of the L1 changing as a function of learning an L2 and also point to an integrated lexicon with nonselective access for the two languages.

In behavioral studies, cognate items have been shown to elicit different response patterns than noncognate items. Cognates are more rapidly recognized than noncognates in isolated word recognition tasks such as lexical decision (Lemhöfer & Dijkstra, 2004; Lemhöfer, Dijkstra, & Michel, 2004; Dijkstra, Grainger, & van Heuven, 1999). Cognate items have been shown to be translated more quickly than noncognate items (De Groot, 1992; Sanchez-Casas, Davis, & Garcia-Albea, 1992). Both Lemhöfer and Dijkstra (2004) and Dijkstra et al. (1999) tested cognates mixed with noncognate words from L2. However, studies testing cognate processing in an L1 context have given mixed results. Some authors failed to observe a difference between cognate and noncognate words in an L1 context (Gerard & Scarborough, 1989; Caramazza & Brones, 1979), whereas others did find effects (van Hell & Dijkstra, 2002; De Groot, Delmaar, & Lupker, 2000; van Hell & De Groot, 1998). Thus, in general, it would appear that word recognition in L2 benefits from cognate status, whereas word recognition in L1 is more impervious to such influences. This is in line with other observed asymmetries in bilingual lexical processing, such as the greater strength of translation priming from L1–L2 compared with L2–L1 (for a recent example, see Midgley, Holcomb, & Grainger, 2009a, 2009b).

Effects of cognate status on word recognition in L1 have, however, been documented. van Hell and Dijkstra (2002) showed clear effects of cognate status during L1 processing and this while testing two groups of trilinguals of different proficiencies in their L3. In two experiments, they used a lexical decision task in L1 (Dutch) to examine the influence of cognates from both L2 (English) and L3 (French). They found an advantage for L2 cognates for both groups of trilinguals. However, a significant advantage for L3 cognate

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items was observed only for the groups having more proficiency in L3. The group with less proficiency in L3 showed only a weak trend toward a cognate advantage. They concluded that a certain level of proficiency is necessary in the bilinguals' nontarget language relative to their target language to observe effects on processing in the target language. In other words, a bilingual must have enough fluency in an L2 or L3 for cognate status to influence L1 processing.

Strong cognate effects have also been reported in a variety of priming paradigms (Lalor & Kirsner, 2001; Bowers, Mimouni, & Arguin, 2000; Cristoffanini, Kirsner, & Milech, 1986), including masked priming (e.g., Gollan, Forster, & Frost, 1997; Sanchez-Casas et al., 1992; De Groot & Nas, 1991), where the contribution of strategic factors is less likely to have influenced the findings. Voga and Grainger (2007) found priming for both cognates and noncognates across different scripts (Greek and French). When cognates and noncognates were compared with unrelated primes, cognates showed greater priming, but when cognates and noncognates were compared with phonologically matched control primes, this advantage disappeared. Voga and Grainger concluded that this difference in priming size as a function of baseline comparison was evidence that the cognate advantage is simply due to the additional form overlap of cognates and not to some special status of cognate words. Taken together, this literature points toward an advantage in processing for words from a bilingual's two languages when the items share both form and meaning.

The Nature and Locus of the Cognate Advantage

In behavioral studies, the locus of the cognate effect is difficult to establish. In laboratory tasks such as lexical decision, demand characteristics of an experiment could exert their influence on performance in ways that are relatively uninformative about the word recognition system per se. Furthermore, the finding that a certain level of L2 proficiency is needed to observe behavioral effects on L1 processing raises the possibility that effects in participants with lower levels of proficiency were not observed because of poor measurement sensitivity. Perhaps a more sensitive measure could be used to observe L2 effects on L1 processing even at relatively early stages of second language acquisition. Consistent with this view, van Hell and Dijkstra (2002) showed a nonsignificant trend in less proficient bilinguals in the same direction as the significant effect they reported for the more proficient participants. Of interest here is whether with a more sensitive measure they would have found stronger evidence for an effect of cognate status on L1 even in relatively nonproficient learners of a second language. Such an effect would be strong evidence that even at early stages of becoming bilingual there are profound changes in the L1 as a function of learning a new language.

What mechanisms could be at the basis of the observed behavioral advantage in processing cognate words compared with noncognates in bilinguals and L2 learners? The most straightforward interpretation is in terms of increased exposure to the same orthographic and/or phonological patterns and, most critically, the same association between a given form representation and its corresponding meaning. This would account for why increased proficiency in the nonnative language causes an increase in the effects of cognate status when processing L1 words (van Hell & Dijkstra, 2002). The strong cognate advantage found when processing L2 words would be due to the cognate words benefiting from preexisting form–meaning associations in the L1. However, this specific processing advantage must be evaluated against a general background of overall differences in processing L1 and L2 words related to a multitude of other factors (Midgley et al., 2009a, 2009b).

Figure 1 provides one specific version of this general account of cognate effects, adapted from Voga and Grainger (2007), and pitched within the framework of the bilingual interactive activation model (Dijkstra & van Heuven, 2002; Grainger & Dijkstra, 1992). According to this account, it is the parallel activation of a cognate's word form representation in L1 and L2 that leads to increased activation in the semantic representation that they share. This increased activation level of the cognate's semantic representation then facilitates the stabilization in the mapping of word form representations onto semantics for cognate words as opposed to noncognate words. In the case of identical cognates, the same benefits in mapping word forms onto semantics will arise via shared whole-word orthographic representations and shared semantic representations.

ERPs and Bilingual Word Recognition

The present experiment examined the nature and the time course of cognate processing as it compares to noncognate processing in a bilingual's two languages by using electrophysiological measures. Electrophysiological measures are used because they more directly reflect the processing of items, being an on-line measure of brain activity rather, as in the case with RTs, just one data point after processing has been completed. ERPs are measures of the brain's electrical activity recorded at the scalp and obtained by averaging time-locked responses to stimuli onset, thus extracting the voltage signature of the processing of the items of interest from the background EEG. ERPs are multidimensional in that they contain time-course information and scalp distribution information in addition to the voltage measures. This multidimensionality is informative not only about the time course of word processing but also about differences in the nature of this processing. Finally, ERPs might provide a more sensitive measure of possible effects of cognate status in the L1 compared with the behavioral measures used in prior studies (for an example of such increased sensitivity, see Thierry & Wu, 2007).

Of particular interest to studies of word processing using ERPs is a negative-going component that starts around 250 msec postword onset and continues on until

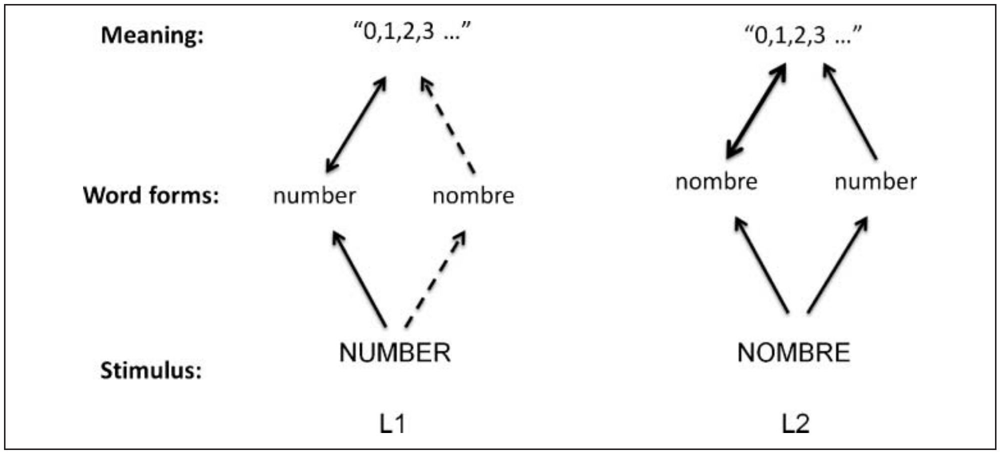

Figure 1. An account of the cognate advantage in terms of improved mapping between word form representations and meaning. Parallel activation of the word form representation of the cognate's translation equivalent leads to increased activation in semantic representations, which in turn facilitates the mapping of word forms onto semantics via top–down feedback. The benefits are greater for L2 cognates given the greater activation level of the L1 translation equivalent in this case compared with the activation of the L2 translation equivalent when processing an L1 cognate (thicker lines reflect more activation, dashed lines weaker activation).

about 600 msec. This ERP component, called the N400, has been shown to reflect lexical and semantic processes associated with word recognition, being larger whenever a word is more difficult to process or integrate into its surrounding context (Lau, Phillips, & Poeppel, 2008; Holcomb, 1993). Numerous studies have shown that the amplitude of the N400 is sensitive to a host of linguistic variables including word frequency (larger to low frequency words than high, e.g., Münte et al., 2001; Van Petten & Kutas, 1990) and orthographic neighborhood density (larger to words with more dense neighborhoods; Midgley, Holcomb, van Heuven, & Grainger, 2008; Holcomb, Grainger, & O'Rourke, 2002). These results plus the results of many other studies using single word stimuli (e.g., Holcomb & Grainger, 2006, 2007) suggest that an increased amplitude in the N400 component reflects an increased difficulty in processing the target word and more specifically in terms of settling on a unique form–meaning interpretation.

The Present Study

In the present experiment, we sought electrophysiological evidence for the cognate advantage reported in previous behavioral experiments and investigated whether this cognate effect differs while processing in L2 and L1. Participants read lists of words for meaning while making occasional button presses to probes from a specific semantic category (12% of all items).[1] The critical items were words that were either cognates or noncognates. In one block of trials, all items were in L1, and in the other block, all items were in L2. This design allowed us to directly compare ERPs to cognates and noncognates in the two language blocks. On the basis of previous ERP work investigating single word recognition and prior behavioral research on cognate processing, we expected to see reduced negativities to cognate words compared with noncognate words in the N400 time window because of their being relatively easier to process. Furthermore, on the hypothesis that the cognate advantage reflects an accumulation of the benefits of exposure to a given form–meaning association across two languages, then we would expect to see stronger effects when processing L2 words than when processing L1 words. This is because an L2 cognate word will benefit from much greater prior experience of its L1 translation equivalent than vice versa.

METHODS

Participants

Fifty participants were recruited and compensated for their time. The data from eight participants were not used because of excessive artifacts in their data or incomplete scalp recordings. Of the remaining 42, 33 were women. The mean age of participants was 20 years (*SD* = 1.7 years), all reported to be right-handed and had normal or corrected-to-normal visual acuity with no history of neurological insult or language disability. English was reported to be the first language learned by all participants (L1) and French their primary second language (L2). All participants were undergraduate students at Tufts University who were either currently enrolled in a French class or had previously studied French at Tufts.

The participants reported having started learning their L2 at a mean age of 12.1 years (range = 5–8 years, *SD* = 2.3 years). They had, on average, completed the equivalent[2] of 5.8 college semesters of their L2 (range = 3–8, *SD* = 1.4). Of our 42 participants, 18 reported taking part in L2 immersion programs abroad.

Participants' English and French language skills were surveyed by questionnaire. On a 7-point Likert scale (1 = *unable* to 7 = *expert*), participants reported their abilities to read, to speak, and to comprehend English and French as well as how frequently they read in both languages (1 = *rarely* to 7 = *very frequently*). The overall average of self-reported language skills in L1 was 7.0 (*SD* = 0.15) and in L2 was 4.4 (*SD* = 0.85). Our participants reported their average frequency of reading in L1 as 7.0 (SD = 0.00) and in L2 as 3.6 (SD = 1.32). Participants reported the use of L2 in daily life to be, on average, 9.6% (SD = 11.00%).

Stimuli

One hundred sixty (160) items were chosen that were cognates in English and French. These items were cognates with complete overlap of form (e.g., "table" in both English and French) and very close cognates ("victim" and "victime"). Of these 160 items, 50% were cognates with complete overlap and 50% were very close cognates. The mean orthographic overlap of the items was 89.0% (SD = 14.7%). This overlap was calculated by counting the number of letters that strictly overlap (for "victim" and "victime," six letters overlap giving 12 letters) and dividing by the total number of letters across the two languages (for "victim" and "victime," 13 letters, overlap is 92%).

One hundred sixty (160) items were chosen (80 L1 English items and 80 L2 French items) that were noncognates between English and French. That is, they had no obvious form overlap (e.g., "apple" and "pomme"). The mean orthographic overlap of these noncognate items was 7.2% (SD = 10.5%). All items in all conditions and for both languages were between four and seven letters in length. The L1 cognates had a mean frequency per million of 31.48 (SD = 49.94; Baayen, Piepenbrock, & Gulikers, 1995; CELEX English Database, 1993), whereas the L2 cognates had a mean frequency per million of 26.50 (SD = 30.91; Lexique database; New, Pallier, Ferrand, & Matos, 2001). These means were not statistically different, $t(318) = 1.19$, p = .24. The L1 noncognates had a mean frequency per million of 38.33 (SD = 43.16), whereas the L2 noncognates had a mean frequency per million of 28.17 (SD = 24.92). These means were not statistically different, $t(158) = 1.82$, p = .07. Furthermore, L1 cognate mean frequency compared with L1 noncognate mean frequency did not differ significantly, $t(238) = 1.16$, $p = .25$, nor did L2 cognate mean frequency differ from L2 noncognate mean frequency, $t(238)$ = 0.42, $p = .68$. To assess effects of lexical similarity in L1, we used the orthographic Levenshtein distance metric (OLD20; Yarkoni, Balota, & Yap, 2008). Because our L2 learners had a limited L2 vocabulary, we did not assess OLD20 in L2. The L1 cognates had a mean OLD20 value of 2.03, whereas the L1 noncognates had a mean OLD value of 1.74, $t(318) = 5.59$, $p < .001$.[3]

Two lists were formed, each list being composed of two blocks: an English block and a French block. Each list contained 80 English cognates and 80 English noncognates for the English block and 80 French cognates and 80 French noncognates for the French block as well as 80 fillers that were added to render the experimental manipulation less visible. The items in these two lists were counterbalanced to avoid repetition of the cognate items across language. That is to say that no one participant saw both an English cognate and its French equivalent. The items in each language block were in a pseudorandom order. Intermixed in each list was a second group of 40 probe items that were all members of the semantic category of "animal names" (probes were English animal names in the English block and French animal names in the French block). All participants saw the same animal names. The animal names varied in cognate status similar to the critical items (i.e., a mix of complete and close cognates and noncognates) and were also four to seven letters in length. The order of the language blocks was counterbalanced across participants.

Procedure

The word stimuli in each list were presented as white letters centered vertically and horizontally on a black background on a 19-in. color CRT monitor. Presentation of all visual stimuli and digitizing of the EEG was synchronized with the vertical retrace interval (60 Hz refresh rate) of the stimulus PCs video card (ATI Radeon, Ontario, Canada) to ensure precise time marking of ERP data. The participants were seated so that their eyes were at a distance of approximately 1.5 meters from the screen. The maximum height and width of the stimuli were such that no saccades would be required during reading of the single word stimuli. Participant responses were made using a button box held in the lap throughout the experiment. A go/no-go semantic categorization task was used in which participants were instructed to read all words for meaning and to press a button whenever they saw a word referring to an animal name. Forty trials in each language block were animal names (12% of all trials; for a typical series of trials, see Figure 2). As can be seen, each trial began with the presentation of an item for a duration of 300 msec followed by a blank screen for a duration of 1000 msec. Each trial ended with a stimulus, indicating that it was permissible to move or to blink the eyes. This blink stimulus ["(- -)"] had a duration of 2000 msec followed by 500 msec of blank screen before the next item appeared.

After electrode placement, instructions for the experimental task were given in English, the L1 of the participants, then a short practice list in the language of the first block was presented to assure good performance during experimental runs and to accustom the participant to the coming language. A practice list was also run before the second block in the language of that block. There were four pauses within each block; the length of these pauses was determined by the participant. Each language block typically took 15 minutes to complete. Participants were asked to press a button on the response box every time they saw an animal name. At the end of the ERP experiment, participants were asked to give a translation of the English words that they had seen during the experiment. These postexperiment translations were graded for accuracy.

EEG Recording

Participants were seated in a comfortable chair in a sound attenuating room and were fitted with an elastic cap

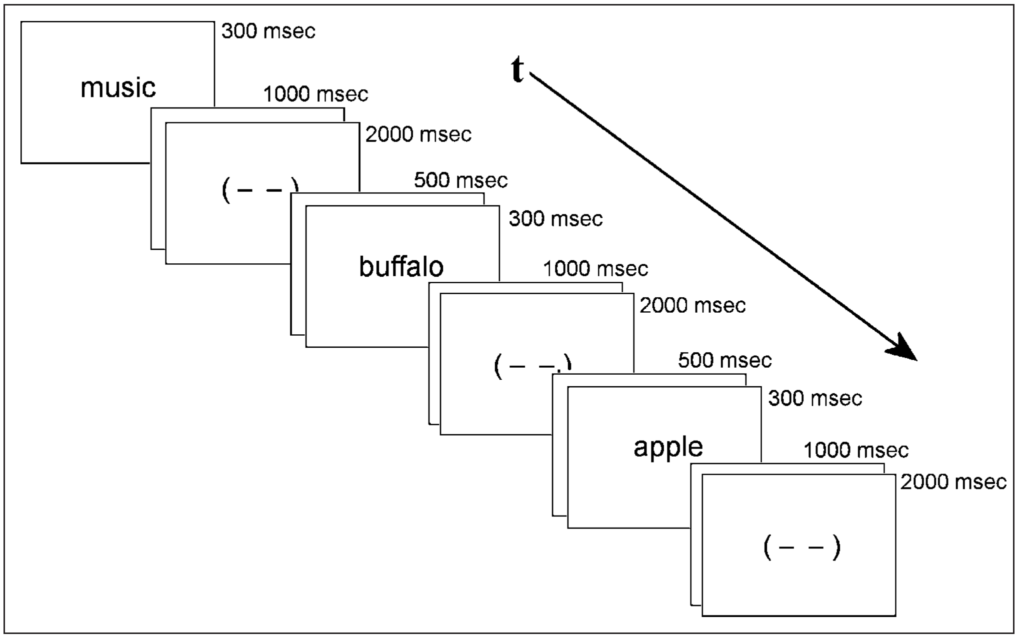

Figure 2. Schematic of three trials in the English block, a cognate, a probe word, and a noncognate. Only the probe word (buffalo) requires a button pressing response.

equipped with 29 tin electrodes (Electro-cap International, Eaton, OH; see Figure 3 for the location of electrodes). Two additional electrodes were used to monitor for eye-related artifact (blinks and vertical or horizontal eye movement); one below the left eye (VE) and one horizontally next to the right eye (HE). All electrodes were referenced to an electrode placed over the left mastoid process (A1). A final electrode was placed over the right mastoid process (A2—used to determine if there was any asymmetry between the mastoids; none was observed).[4] The 32 channels of electrophysiological data were amplified using an SA Instruments Bio-amplifier system (Stony Brook, NY)

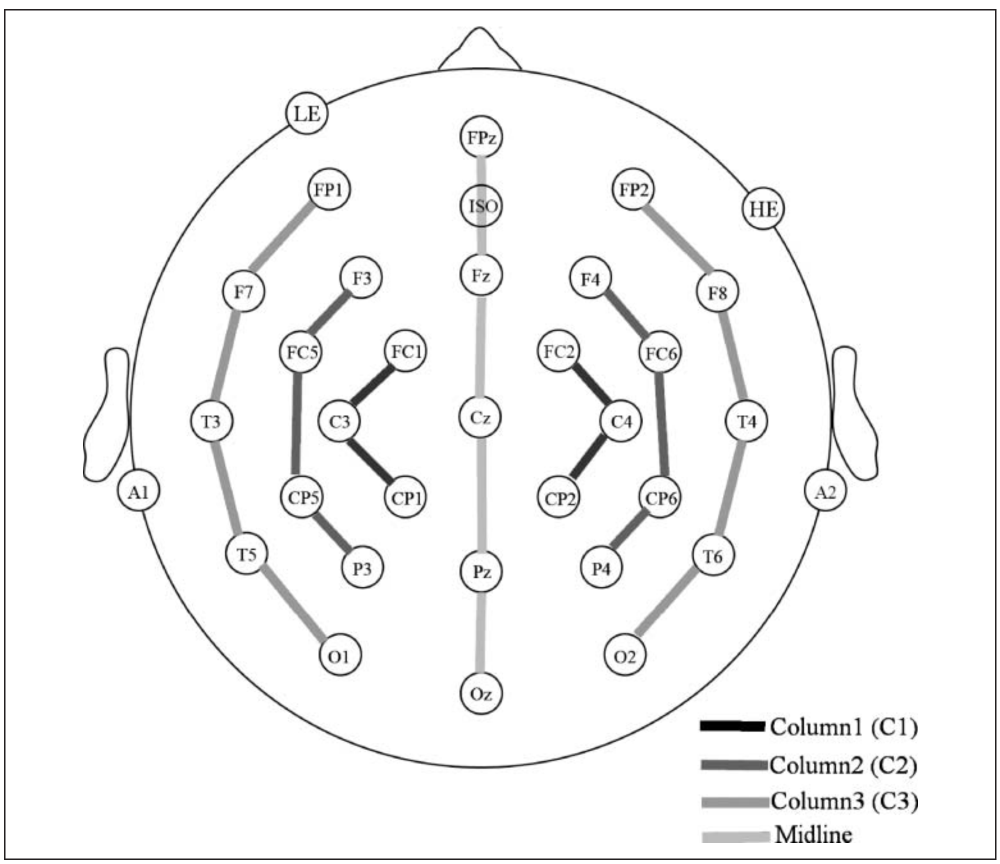

Figure 3. Electrode montage.

with 6 dB cutoffs set at 0.01 and 40 Hz. The output of the bioamplifier was continuously digitized at 200 Hz throughout the experiment.

Data Analysis

Averaged ERPs time locked to item onset of words in each category were formed off-line from trials free of ocular and muscular artifact and response errors (less than 8.1% of trials). ERPs were averaged separately for English cognates, English noncognates, French cognates, and French noncognates providing factors of language and cognate status in a 2×2 design. We also included a between-subject factor of block order to determine if receiving the items in one language first had a differential effect on any of our measures.

All items were baselined to the average of activity in the 100-msec pretarget period and were low-pass filtered at 15 Hz. The ERPs were then quantified by measuring the mean amplitude in three latency windows: 200–300 msec to capture pre-N400 activity and 300–500 msec to capture the N400 itself and 500–800 to capture late cognate effects.

To thoroughly analyze the full montage of 29 scalp sites, we employed an approach to data analysis that we have successfully applied in a number of previous studies (e.g., Holcomb, Reder, Misra, & Grainger, 2005). In this scheme, the 29 channel electrode montage is divided up into seven separate parasagittal columns along the anteroposterior axis of the head (see Figure 3). The electrodes in each of three pairs of lateral columns and one midline column are analyzed in four separate ANOVAs. Three of these analyses (referred to as Column 1, Column 2, or Column 3) involved an anterior/posterior Electrode Site factor with either three, four, or five levels as well as a Hemisphere factor (left vs. right). The forth "midline" analysis included a single anterior/posterior Electrode Site factor with five levels. We use the columnar approach to analyzing the spatial component of the ERP data because (a) they allow a complete statistical description of the data set (including a single site factor or collapsing across sites can miss subtle distribution effects) and (b) they provide both an anterior/posterior as well as a left/right comparison of effects that in numerous previous language studies have proven important in explicating effects. Although this approach does increase the number of comparisons, this is offset by both a more complete description of the data and by a cautious interpretation of analyses where only a single column produces a significant effect.

Significant interactions in the omnibus analyses involving factors of language and cognate status were decomposed with planned followed-up ANOVAs looking at each language (English and French) separately. The Greenhouse–Geisser (1959) correction was applied to repeated measures with more than one degree of freedom in the numerator. Finally, to more carefully track the temporal properties of cognate effects, we also performed time-course analyses (TCAs) comparing the cognate and the noncognate ERPs at each of the five midline electrodes and for the two languages in eight consecutive 50-msec windows between 100 and 800 msec.

Finally, to explore the relationship between our self-ratings/behavioral measures of second language knowledge and the electrophysiological effects of cognate status, we also performed a series of correlations.

RESULTS

Visual Inspection of ERPs

Plotted in Figure 4 are the grand mean ERP waveforms for cognate and noncognate L1 (English) items. Presented in Figure 4A are ERPs from all 29 scalp sites. In Figure 4B are enlarged plots of three midline sites. Figure 5 contains the same plots for the L2 (French) block of trials as well as a comparison at three midline sites of all L1 to all L2 words (Figure 5; so-called "language effects"). Figure 6A shows voltage maps at six points in time for L1 items and Figure 6B for L2 items. The voltage maps are a subtraction of ERPs for items that are cognates from ERPs for items that are noncognates (i.e., the "cognate effect"). Accompanying TCAs are presented in Table 1. As can be seen in Figures 3 and 4 for ERPs anterior to the occipital sites, the first visible component was a negative-going deflection between 90 and 150 msec after stimulus onset (N1). This was followed by a positive deflection occurring at approximately 150 msec (P2). A negativity followed the P2 peaking around 350 msec (N400). At occipital sites, the first observable component is the P1, which peaked near 100 msec and was followed by the N1 at 190 msec and a broad P2 between 250 and 300 msec. The P2 was followed by the N400 peaking between 400 and 500 msec.

Analyses of ERP Data

The 200- to 300-msec Epoch

An omnibus ANOVA on the mean amplitude values in this epoch revealed significant main effects of Language at all columns, midline, $F(1, 41) = 7.64$, $p = .009$; c1, $F(1, 41) = 9.14$, $p = .004$; c2, $F(1, 41) = 12.69$, $p = .001$; c3, $F(1, 41) = 7.59$, $p = .009$ (see Figure 4C), indicating that ERPs to L1 items tended to be more negative-going than ERPs to L2 items. There was also a main effect of Cognate status, but it reached significance only at Column 1, $F(1, 41) = 9.14$, $p = .004$. The two-way interaction between Language and Cognate status was reliable at all columns, midline, $F(1, 41) = 9.93$, $p = .003$; c1, $F(1, 41) = 11.76$, $p = .001$; c2, $F(1, 41) = 10.23$, $p = .003$; c3, $F(1, 41) = 9.23$, $p = .003$. There were no main effects or interactions involving the block-order variable in this epoch.

Follow-up analyses examining the effects of cognate status separately for the two languages in this epoch revealed effects at all columns for L1, midline, $F(1, 41) = 14.14$, $p = .001$; c1, $F(1, 41) = 16.03$, $p < .001$; c2, $F(1, 41) = 13.04$, $p = .001$; c3, $F(1, 41) = 11.01$, $p = .002$, with noncognates

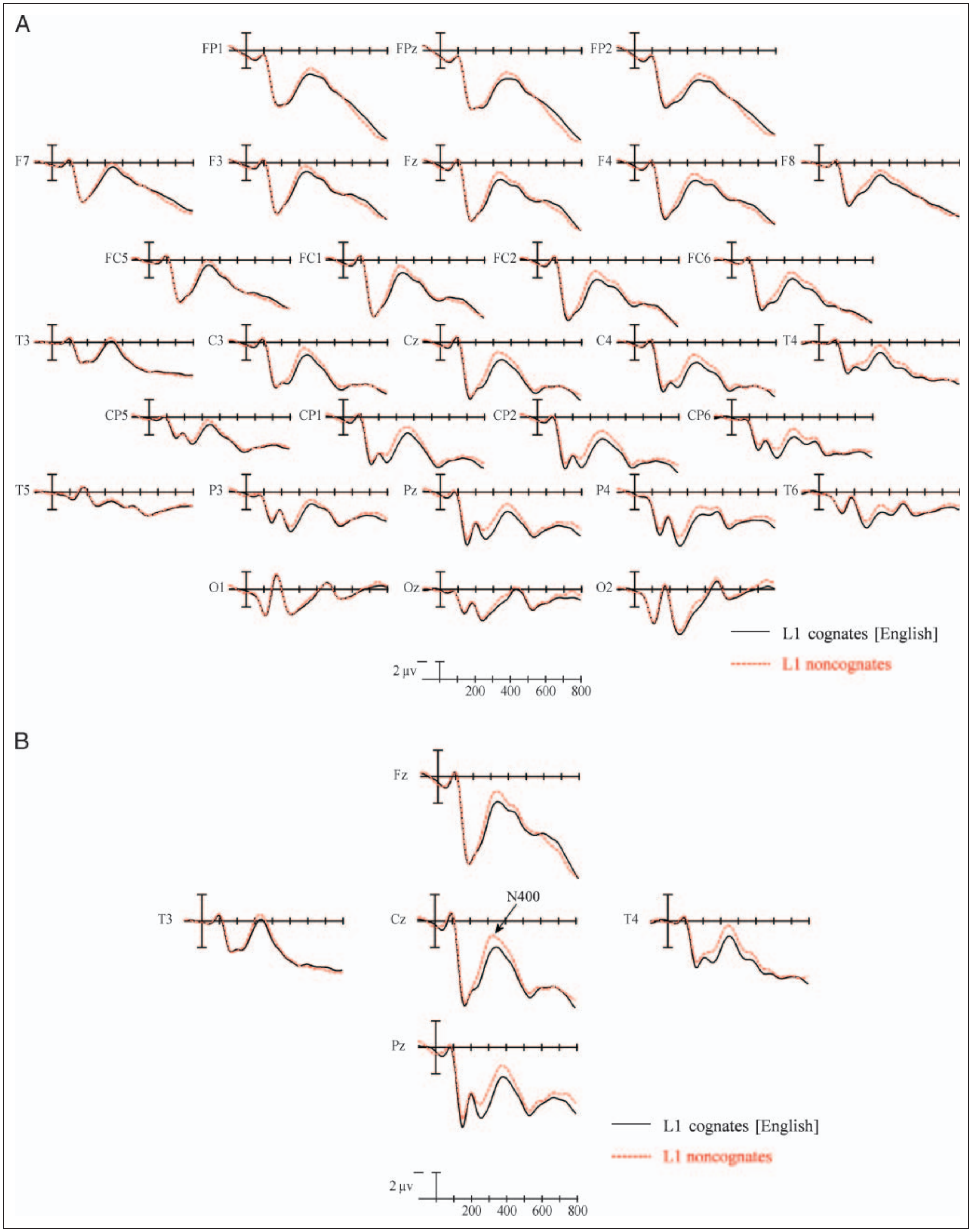

Figure 4. (A) Results of L2 learners reading L1 (English) items that are cognates or noncognates. (B) Enlargement of five sites from panel A.

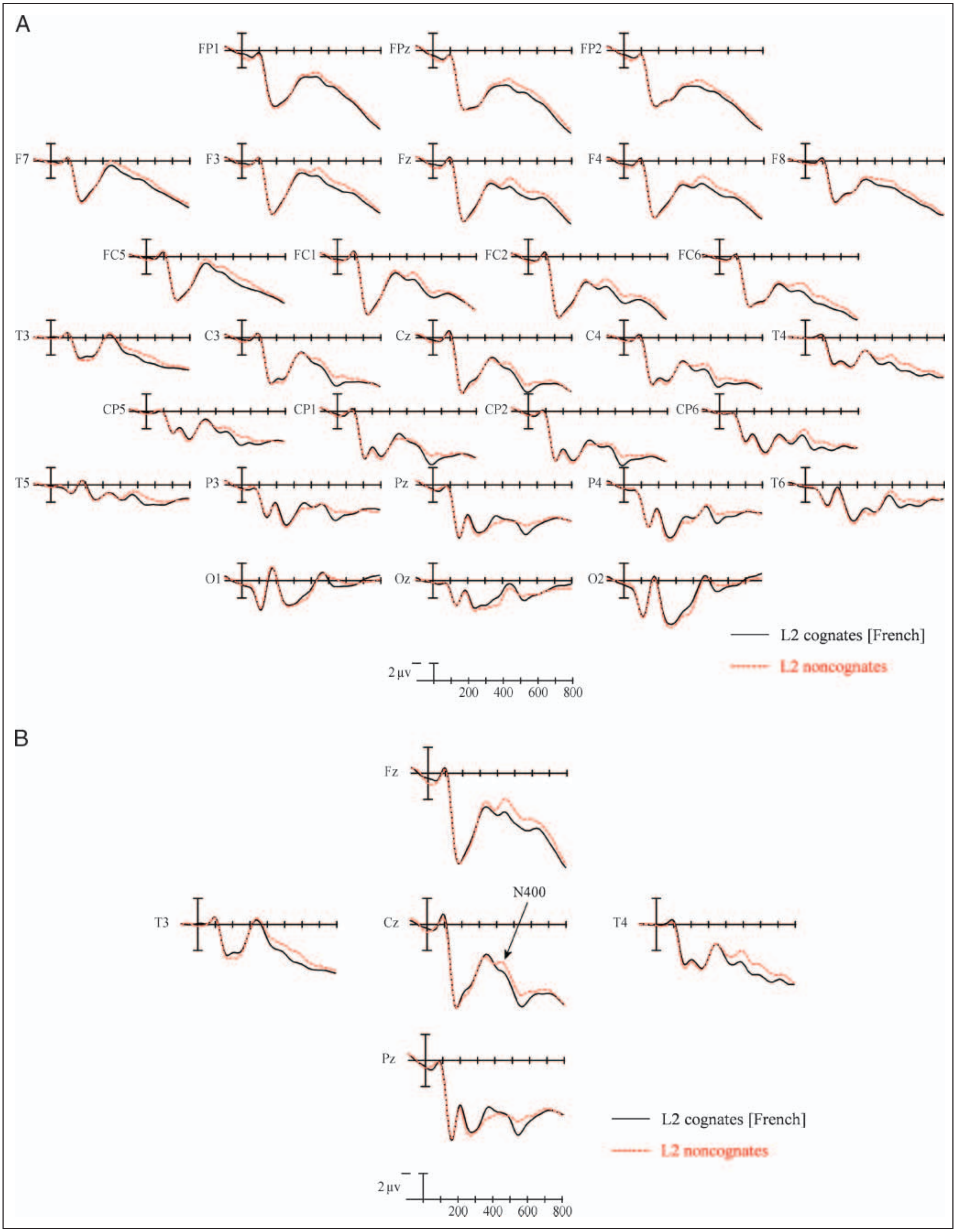

Figure 5. (A) Results of L2 learners reading L2 (French) items that are cognates or noncognates. (B) Enlargement of five sites from panel A. (C) Five sites showing language effects (L1 vs. L2).

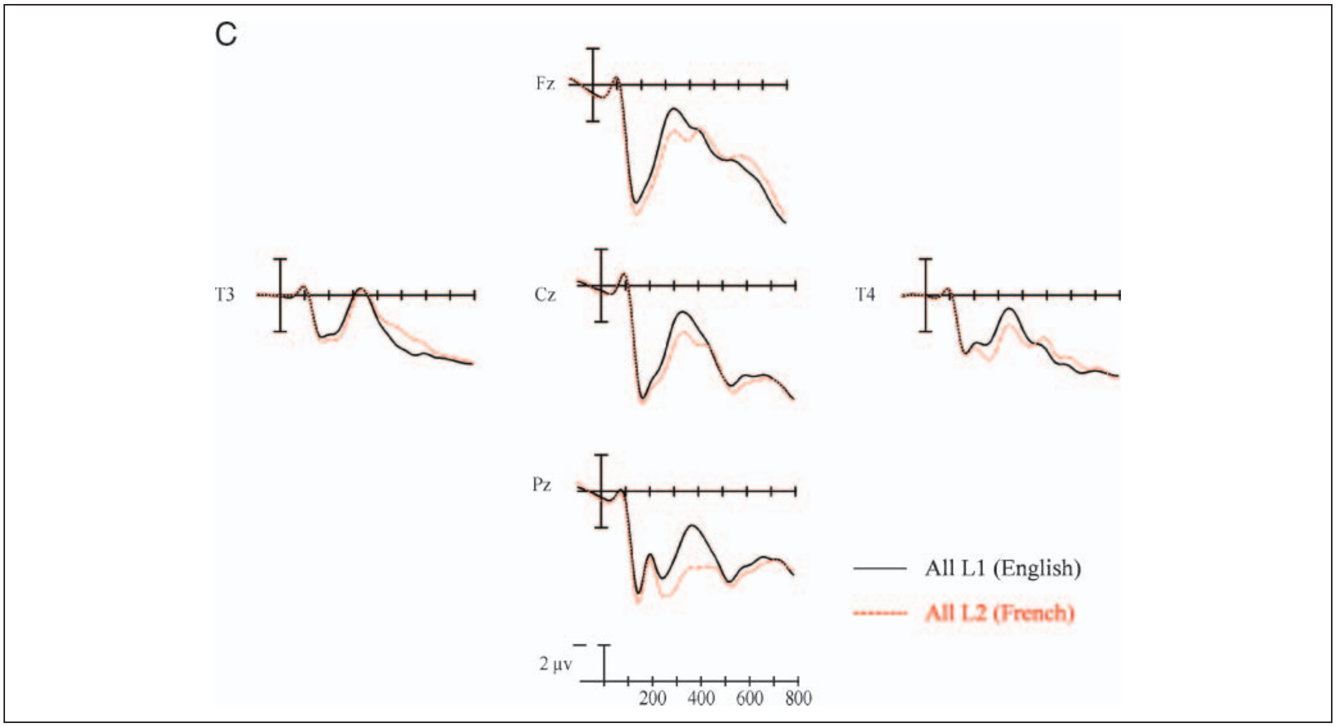

Figure 5. (*continued*)

being more negative than cognates. For L2, no effect of Cognate status was observed in this epoch.

The 300- to 500-msec Epoch

An omnibus ANOVA on the mean amplitude values in this epoch revealed significant main effects of Cognate status at all columns, midline, $F(1, 41) = 8.86$, $p = .005$; c1, $F(1, 41) = 9.53$, $p = .004$; c2, $F(1, 41) = 11.21$, $p = .002$; c3, $F(1, 41) = 13.46$, $p = .001$, as well as three-way interactions of Language × Cognate Status × Electrode Site at all columns, midline, $F(4, 164) = 7.34$, $p < .001$; c1, $F(2, 82) = 9.36$, $p = .001$; c2, $F(3, 123) = 9.56$, $p < .001$; c3, $F(4, 164) = 4.39$, $p = .021$. There were no main effects or interactions involving the block-order variable in this epoch.

Follow-up analyses examining the effects of Cognate status separately for the two languages revealed effects of Cognate status at all columns for L1, midline, $F(1, 41) = 23.44$, $p < .001$; c1, $F(1, 41) = 16.18$, $p < .001$; c2, $F(1, 41) = 15.48$, $p < .001$; c3, $F(1, 41) = 14.70$, $p < .001$. These analyses suggest that during the English task, noncognate words tended to produce more negative-going ERPs in this epoch than cognate words across the scalp.

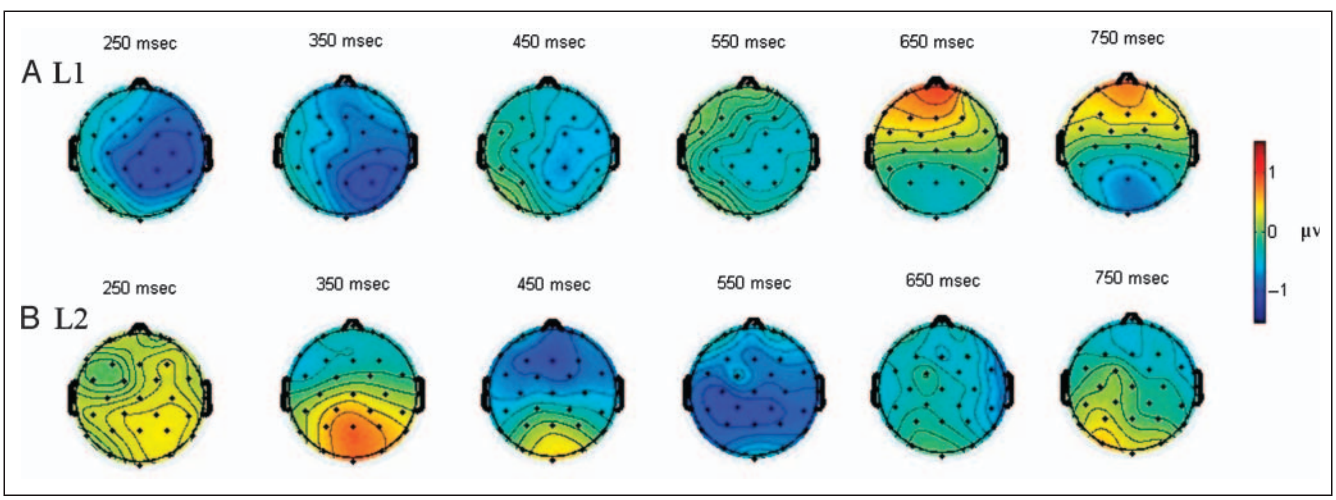

Figure 6. Scalp voltage maps at six time points showing the difference in voltage between (A) L1 noncognate items and L1 cognate items and (B) the difference in voltage between L2 noncognate items and L2 cognate items (units are in microvolts).

Table 1. TCA of the Cognate Effect in the 50-msec Epochs at Five Midline Sites

		100+	*150+*	*200+*	*250+*	*300+*	*350+*	*400+*	*450+*	*500+*	*550+*	*600+*	*650+*	*700+*	*750+*
L1:	FPz	—	—	—	N > C	N > C	N ⋙ C	N ~ C	—	—	—	C ≫ N	C > N	C ⋙ N	—
	Fz	—	—	—	N ⋙ C	N ⋙ C	N ≫ C	N ~ C	—	—	—	C > N	C > N	C > N	—
	Cz	—	—	N > C	N ⋙ C	N ⋙ C	N ≫ C	N > C	~	—	—	—	—	—	N ~ C
	Pz	N > C	—	N > C	N ⋙ C	N ⋙ C	N ⋙ C	N ≫ C	N > C	N ~ C	N > C	—	N > C	N > C	N ⋙ C
	Oz	—	—	—	N ~ C	N ≫ C	N ≫ C	—	—	—	—	—	—	N > C	N ≫ C
L2:	FPz	—	—	—	—	—	—	N > C	N ⋙ C	N > C	N > C	N ~ C	—	N ~ C	—
	Fz	—	—	—	—	—	—	N ≫ C	N ⋙ C	N ≫ C	N > C	—	N ~ C	N ~ C	—
	Cz	—	—	—	—	—	—	N > C	N > C	N ≫ C	~	—	—	—	—
	Pz	—	—	—	—	—	C > N	—	—	N ≫ C	~	—	—	—	—
	Oz	—	—	—	C ~ N	C ≫ N	C ⋙ N	C > N	—	N > C	—	—	—	C > N	C ~ N

C = cognates; N = noncognates; letter on the left is more negative than the one on the right—ns, $p > .1$/~$.01 > p \geq .05$/>$.05 > p \geq .01$/≫$.01 > p \geq .001$/⋙$.001 > p$.

For the L2 block (French target words), there was no main effect of Cognate status; however, there were significant interactions of Cognate Status × Electrode Site in all analysis columns, midline, $F(4, 164) = 12.21, p < .001$; c1, $F(2, 82) = 9.86, p = .001$; c2, $F(3, 123) = 14.59, p < .001$; c3, $F(4, 1641) = 9.53, p = .001$. These interactions can be best understood by examining Figure 5. Although French noncognates tended to produce more negative-going ERPs at anterior and central sites than French cognates, at the more posterior sites, cognates tended to be more negative going than noncognates.

The 500- to 800-msec Epoch

An omnibus ANOVA on the mean amplitude values in this epoch revealed significant main effects of Cognate status in all four columnar analyses, midline, $F(1, 41) = 4.41, p = .042$; c1, $F(1, 41) = 6.17, p = .017$; c2, $F(1, 41) = 6.94, p = .012$; c3, $F(1, 41) = 4.39, p = .042$. There was also a two-way interaction of Language × Electrode Site, midline, $F(4, 164) = 3.75, p = .026$; c1, $F(2, 82) = 4.47, p = .021$; c2, $F(3, 123) = 4.07, p = .034$, and a three-way interaction of Language × Cognate Status × Electrode site, midline, $F(4, 164) = 7.39, p = .001$; c1, $F(2, 82) = 3.96, p = .039$; c2, $F(3, 123) = 6.32, p = .004$; c3, $F(4, 164) = 4.00, p = .027$. There were no main effects or interactions involving the block-order variable in this epoch.

Follow-up analyses examining the effects of Cognate status separately for the two languages revealed no effects at any column for L1 (all $p > .150$). For L2, Cognate status was marginally significant at midline and Column 1, $F(1, 41) = 3.83, p = .057$ and $F(1, 41) = 3.39, p = .073$, and reached significance at Columns 2 and 3, $F(1, 41) = 5.78, p = .021$ and $F(1, 41) = 7.82, p = .008$. As can be seen in Figure 5, noncognates tended to be more negative going than cognates at the more lateral sites in this epoch.

Time-course Analysis

Behavioral Results and Correlations

Participants averaged 39.4 ($SD = 1.7$) of 40 hits in their L1 (98.4%) and 34.2 ($SD = 4.3$) of 40 hits in their L2 (85.5%) for the animal probe words. Participants produced false alarms on an average of 0.5 items ($SD = 0.86$) in L1 (0.3%) and on 3.1 items ($SD = 2.56$) in L2 (1.6%). Participants were significantly better, as expected, at the semantic categorization task in their L1. There was a main effect of language, $F(1, 41) = 11.57, p = .002$.

In a post-ERP session, participants were asked to translate the critical and probe items that they had previously seen in the experiment from L2 into L1. The overall mean score of correct translations was 74.7% ($SD = 8.71$), with 88.8% ($SD = 10.52$) for probe items, 84.1% ($SD = 7.64\%$) for cognates, and 49.1% ($SD = 19.16\%$) for noncognates.

A series of correlations was also run to explore possible relationships between the ERP measures of the cognate effect (ERPs to cognates subtracted from noncognates) for both languages (L1 and L2) in each of the three temporal analysis windows (200–300, 300–500, and 500–800 msec) at the Cz electrode site. Variables entered into these analyses included self-ratings of comprehension, listening, and reading in L2, number of L2 language classes taken, percent correct on the post-ERP translation task, and whether the participant has been immersed in L2. The only variable that correlated significantly with any of the ERP cognate effects was immersion. Participants that had had a significant immersion experience in L2 tended to have smaller L2 differences between cognates and noncognates in the 300- to 500- and 500- to 800-msec time windows than those that had not had such an experience ($r = -.33, p = .03$ and $r = -.30, p = .05$, for the two time windows, respectively). However, L2 immersion was associated with a larger cognate/noncognate difference in the 200- to 300-msec window in L1 ($r = .37, p = .02$). In other words, immersion was associated with an increase in the early cognate effect in L1 and a decrease in the later L2 cognate effect.

Several studies have reported differences in L2 performance as a function of the order in which the L1 and the L2 blocks of trials are presented (e.g., Jared & Kroll, 2001). Therefore, in addition to including block order as a variable in the ANOVA design, we also examined the correlation between L1/L2 block order and our ERP measures of the cognate effect. We found no relationship between any of the ERP cognate effects and the order in which the L2 and L1 blocks of trials were administered (all rs < .17, ps > .27).

DISCUSSION

In this experiment, testing a group of second language learners, we sought electrophysiological evidence for effects of cognate status reported in prior behavioral research. We recorded and compared ERPs with cognate and noncognate words while participants were processing blocked lists of words in their L1 (English) and their L2 (French). ERP negativities in the region of the N400 component were found to be sensitive to cognate status in both language blocks. As in a number of previous behavioral studies (Lemhöfer & Dijkstra, 2004; Lemhöfer et al., 2004; Dijkstra et al., 1999; De Groot, 1992; Sanchez-Casas et al., 1992), there were robust effects of cognate status when participants were processing words in L2. In the present experiment, ERPs were more negative for noncognates (i.e., larger N400s) than cognates, although this effect did not start until around 300 msec and did not become widespread across the scalp until after 550 msec. Perhaps more interestingly, because there have been fewer behavioral studies showing these effects, there were also cognate effects in the L1 block. Like L2, noncognates generated more negative-going ERPs than cognates, but this difference started earlier, in a 200- to 300-msec window. These effects were widespread across the scalp and continued through the traditional 300- to 500-msec N400 window but did not continue on into the final 500- to 800-msec window.

The principle effect of cognate status in the present experiment was therefore a reduced negativity (smaller N400 amplitude) to cognate words compared with noncognate words in both L1 and L2. This fits with the general hypothesis that the mapping of form to meaning is facilitated in cognate words. Other examples of an interpretation of reduced N400 amplitude as reflecting greater ease in mapping form onto meaning in single word recognition are effects of word frequency (Münte et al., 2001; Van Petten & Kutas, 1990), effects of orthographic neighborhood (Midgley et al., 2008; Holcomb et al., 2002), and effects of masked primes (Holcomb & Grainger, 2006, 2007).

Perhaps the central finding of the present experiment is that of an influence of cognate status on word recognition in the first language (L1). Prior behavioral research had provided mixed findings on this particular issue. Several previous studies had not found cognate effects in L1 (Gerard & Scarborough, 1989; Caramazza & Brones, 1979), and others found an influence of cognate status on L1 items only in relatively proficient participants (van Hell & Dijkstra, 2002). Here, using electrophysiological measures, we were able to observe cognate effects in language learners processing words in their L1.

The ERP data were also informative with respect to the timing of cognate effects. These effects began to emerge at about 200 msec in L1 but not until about 400 msec in L2. In the Introduction, we hypothesized that the cognate advantage seen in behavioral research would reflect an accumulation of the benefits of exposure to a given form–meaning association across two languages. This could arise either via the partial activation of the orthographically similar translation equivalent in the case of close cognates (see Figure 1) or via shared whole-word orthographic representations in the case of identical cognates. We expected these effects to be larger in L2 than that in L1 given the greater amount of prior exposure in L1 compared with L2, and this was indeed found to be the case in the late time window (500–800 msec) in our experiment. However, the model presented in Figure 1 would also predict that cognate effects should arise earlier in L2 than L1 because the propagation of activation associated with the L1 translation equivalent during processing of an L2 cognate word will be faster than that associated with the L2 translation equivalent during the processing of an L1 cognate. The early timing of the L1 cognate effect found in the present study suggests that a different mechanism is at play here compared with the L2 cognate effect.

The precise timing of the L1 cognate effect suggests that it might be more a reflection of activation at the level of word form representations as opposed to the mapping of these word forms onto semantics. One possibility is that L1 cognates acquire a special status in L2 language learners because of the key role they play in L2 vocabulary acquisition. Such a special status can be envisaged within the theoretical framework provided by the revised hierarchical model (RHM; Kroll & Stewart, 1994), combined with the parallel activation account of cognate effects proposed in Figure 1. A modified version of the model shown in Figure 1, which includes connections between the word form representations of translation equivalents, is provided in Figure 7. Upon presentation of an L1 cognate word, the L2 translation equivalent is partially activated. According to the modified model in Figure 7 and after the RHM, L2 word forms have strong associative links with their L1 translation equivalents. Therefore, the partially activated L2 cognate word will send activation directly to its L1 translate, hence facilitating processing at the level of whole-word orthographic representations. Given the asymmetry in the associative links between the word form representation of translation equivalents hypothesized in the RHM, this account of the early L1 cognate effect predicts that during the processing of L2 cognates, partially activated L1 word forms will exert most of their influence via semantics, as proposed in Figures 1 and 7.

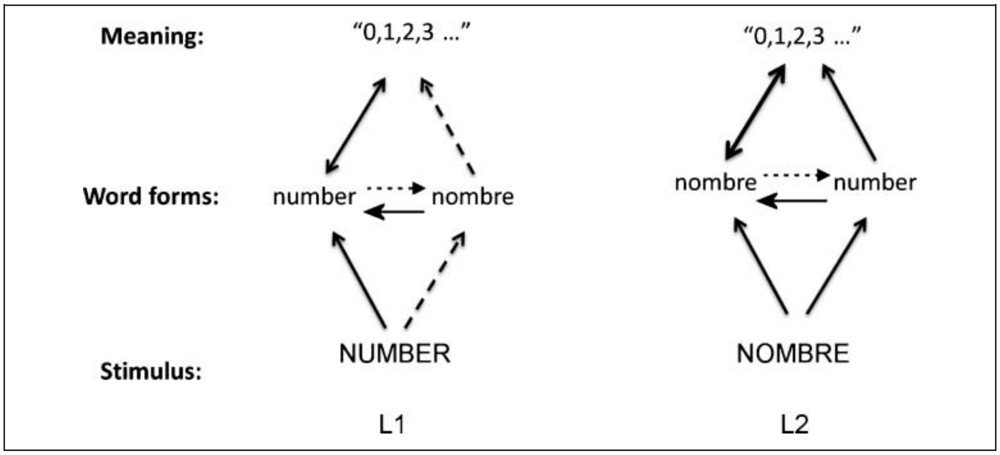

Figure 7. Extension of the framework presented in Figure 1 to include direct connections between whole-word form representations of translation equivalents. After the RHM, these connections are hypothesized to be stronger from L2 to L1 than vice versa (full arrows vs. dashed arrows). This added connectivity contributes to the cognate advantage for L1 words but has little influence on the cognate advantage for L2 words, which continues to be driven mainly by semantic feedback.

The correlation results provide further support for this account of cognate effects in L1 and L2. It was found that immersion experience in L2 was associated with an increase in the early effect in L1 and a decrease in the later L2 cognate effect. That is, participants with an immersion experience in L2 showed a larger difference between cognates and noncognates in L1 in the 200- to 300-msec time window, whereas the same participants showed a smaller difference between cognates and noncognates in L2 in later time windows compared with participants that had no immersion experience. Finding a correlation between immersion in L2 and the size of the early L1 cognate effect suggests that this particular process might be sensitive to the overall greater exposure to L2 that is likely to be concomitant with an immersion experience. Certainly, the amount of exposure to L2 word forms should determine the strength of form–form associations that are thought to develop in the initial phases of L2 acquisition. Furthermore, the amount of exposure to L2 forms should lead to an increase in strength of the pathways linking such word forms to semantics, hence diminishing the difference between L1 and L2 words in terms of speed of access to semantics and therefore causing a reduction in the cognate advantage in L2. Although our other measures of L2 proficiency did not correlate significantly with the size of cognate effects, they did show a similar pattern. Performance on the post-ERP translation task, for example, correlated significantly with immersion experience ($p < .01$) and also showed albeit nonsignificant correlations with cognate effects in L1 and L2 that went in the same direction as the correlation with immersion experience. To more fully investigate these tentative proposals, future work should compare cognate effects measured using ERPs in participants with different levels of proficiency in their L2 and different manners of exposure to the L2.

The pattern of effects found in L2 also differed with respect to the L1 pattern in one other notable way, that is, the reversed cognate effect found in posterior sites at around 300 msec poststimulus onset in L2. One speculative possibility is that this effect might reflect a conflict in the mapping of orthography to phonology that is exaggerated in the case of cognate words because the same orthographic pattern maps onto two distinct pronunciations (e.g., the different pronunciations of the word "table" in French and English). Previous behavioral studies have documented such effects of competing phonology (e.g., Schwartz, Kroll, & Diaz, 2007). The fact that this is only seen in L2 can be explained by the relative dominance of the L1 pronunciation over the L2 pronunciation of cognate words. Furthermore, the timing of this putative phonological effect is in line with estimates of phonological influences on visual word recognition in monolinguals (e.g., Grainger, Kiyonaga, & Holcomb, 2006). A second possibility is that this effect reflects a kind of code switching from L2 to L1 that might occur for cognate items. Several previous studies have reported more positive-going ERPs during code and task switching (e.g., Christoffels, Firk, & Schiller, 2007; Astle, Jackson, & Swainson, 2006). However, because our items were presented in pure language blocks, it seems unlikely that participants would have engaged in this type of overt switching.

Another possibility for the smaller/reversed cognate effects over more posterior sites in L2 could be related to a relatively more anterior N400 distribution for learners of L2. Midgley et al. (2009a, 2009b) reported a robust anterior negativity for L2 words but a reduced posterior N400 in L2 learners (of similar proficiency to those studied here) compared with more proficient bilinguals. Furthermore, their proficient bilinguals produced a comparatively larger posterior N400-like component than their L2 learners. They speculated that the posterior N400 was associated with proficiency and only develops later in the learning process once L2 representations are more stable. If correct, this could explain why N400-like cognate effects found at anterior sites in the current study's L2 learners did not extend to the back of the head. This would be because the posterior N400 process had not yet emerged for processing L2 words. As a result, L2 noncognates produce little activity in this system. However, L2 cognates, because of their similarity to L1 words, might be expected to produce comparatively larger posterior N400s because they activate the existing posterior L1 system.

Are cognates special in any way that would not be predicted by a simple combination of shared form and meaning across languages and the effects of cumulative exposure to such shared representations? On the basis of the results of their masked priming study, Voga and Grainger (2007) suggested not (for similar conclusions on the basis of cognate effects found in language production, see Strijkers, Costa, & Thierry, 2010). On the other hand, Van Hell and Dijkstra and others (e.g., De Groot et al., 2000; Dijkstra et al., 1999; Dijkstra, van Jaarsveld, & Ten Brinke, 1998) have argued that cognates have a special type of representation in the mental lexicon, and cognate effects are not just cumulative frequency effects (i.e., that it is not just the sum of the frequencies of the cognate items across languages that is driving the cognate effect). One possibility, proposed by Sánchez-Casas and García-Albea (2005), is that cognates share a common abstract morphological representation that provides the link between their word form representations in each language. This proposal fits with the supralexical model of morphological representation proposed by Giraudo and Grainger (2001), whereby word form representations from the same morphological family (e.g., rich, richer, richness) are interconnect via a higher level abstract morphemic representation. In the case of cognate words (e.g., rich, riche), these supralexical morphological representations would be not only modality independent but also language independent. This account of the representation of cognate words can be easily adapted to fit within the general account of cognate facilitation effects proposed in Figure 1. It suffices to replace the shared semantic representations in this model with shared morphemic representations. However, contrary to the morphemic account, Voga and Grainger (2007) failed to find evidence for cross-language morphological priming effects in conditions where there was a robust cognate priming effect, suggesting that shared morphemic representations were not the basis of the cognate effect.

In the light of the present results, we prefer to adopt Voga and Grainger's (2007) position that shared form and meaning suffices to account for the effects of cognate status in the recognition of L2 words. For words in L1, on the other hand, and the population of second language learners tested in the present study, we would argue that cognate words do indeed have a special status in that they provide a privileged access to the meaning of L2 words via their L1 translation equivalents.

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Notes

1. We and others have used this task to assess ERP word processing effects in a variety of studies, and the results in this task usually do not differ from those using other tasks that rely on shallower processes (e.g., Holcomb et al., 2002); thus, we feel that the demands of making a deep semantic judgment in our go–no-go semantic categorization task would not appreciably alter the pattern of word processing effects.

2. One year of classroom high school L2 learning was scored as one semester. Any and all classroom learning of L2 before high school were scored as one semester.

3. Because there were significant differences between English (L1) cognate and noncognate items in overall lexical/orthographic similarity, with noncognates having relatively higher similarity to other English items, we reran all of the ERP analyses reported in the Results section on the ERPs reaveraged from a subset of cognate and noncognate items that were better matched on their OLD20 similarity. In these analyses, which resulted in omitting the ERP data for 11 of 80 cognates and 11 of 80 noncognates (mean OLD20 values of 1.90 and 1.85), $t(274) = 1.22, p > .221$, we found the exact same pattern of ERP effects reported in the Results section.

4. Although we routinely record actively from the right mastoid process (A2), we only rereference to the average of A1 and A2 when there is a notable difference in one of our independent variables at the A2 site. As can be seen in Figures 4A and 5A, where we included the A2 site, there were no such effects in the current data set.

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