The Influence of Cultural Context on Language Activation in Korean-English Bilinguals

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Abstract

Both languages for bilinguals are jointly activated even when performance is clearly restricted to one. The present study investigated the role of cultural cues on the relative level of joint linguistic activation. Twenty-two Korean-English bilinguals were presented with a picture and an audio cue and indicated via button press whether the heard label named the depicted object while EEG was recorded. In the critical blocks, the pictures represented exemplars that were more typically English or Korean, even though both exemplars take the same name in both languages (e.g., North American soup vs. Korean soup). English or Korean labels for the same set of pictures were presented in separate blocks. Reaction times were significantly faster for trials in which the auditory stimulus correctly named the object and the language matched the cultural bias. Providing the correct label in either language significantly attenuated the N400. A late positive component (LPC) was present for trials in which the label was correct, and was more positive when viewing Korean exemplars with English audio. No differences were seen when either English or Korean pictures were paired with Korean auditory stimuli. Therefore, effects of cultural context and semantic integration appear to be separate.

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Introduction

When bilinguals speak, factors such as familiarity with a language, environment, and task demands influence which language is produced. Substantial research has shown that to some degree, both languages are constantly active in the minds of bilinguals (e.g. Dijkstra, Grainger, & van Heuven, 1999; von Studnitz & Green, 2002), so bilinguals have a larger pool of lexical entries from which to choose than do monolinguals. The majority of research supports the interpretation that lexical access is nonselective for a specific language; that is, all viable lexical candidates across languages compete for selection in bilingual speech planning and production (see Kroll, Bobb, & Wodniecka, 2006, for a review). Lexical selection in the context of nonselectivity seems to be modulated by increased activation towards a target language, as well as inhibition of the non-target language. This inhibition could be either global, in which an entire language system is suppressed, or local, in which a specific competing distractor is suppressed (De Groot & Christoffels, 2006). A fluent Hungarian-English speaker has no need to activate English when ordering a pastry in one of Budapest's cafés yet the evidence suggests that this is exactly what happens; similarly, this same native Hungarian may pause or stutter when ordering a crème-filled pastry, rather than a *kremes*, at a café in Canada. In both situations one particular factor, context, seems to play a part in the selection of the suitable lexicon. The current study examined how lexical selection is influenced by the cultural context provided by objects, and the implications for lexical access and production in an increasingly bilingual, and bicultural, world.

Nonselectivity of Speech

The initial evidence for nonselectivity of linguistic access came from Poulisse (1997) who showed that in Dutch-English bilinguals, Dutch (their first language, L1) interfered with English production (L2), producing speech errors. These errors were attributed to a functional frequency effect in which the infrequently used L2 was likely to be influenced by the stronger L1. While this pointed to a nonselectivity of speech in that the L1 was involved in a context requiring L2 selection, the data did not specifically determine at what stage in speech planning the L1 had its effect on the L2. To determine the point in speech planning when this influence occurs, Hermans, Bongaerts, DeBot, and Schreuder (1998) utilised a ‘cross-language picture-word Stroop paradigm’. Dutch-English bilinguals with Dutch as L1 were asked to name pictures in English, with distractor words being presented either before, after, or during picture presentation. In one study these distractor words were presented in English and in another study they were presented in Dutch. Distractors were either semantically or phonologically related to the picture, phonologically similar to the Dutch translation (Phono-Dutch), or unrelated. Consistent with monolingual research in which semantically related words interfere with production and phonologically similar words facilitate production (Schriefers, Meyer, and Levelt, 1990; Kuipers, La Heij, and Costa, 2006), they found interference when the English semantic distractor (e.g. ‘valley’) was presented close in time to the picture (‘mountain’), and facilitation from the English phonological distractor (‘mouth’) at a greater range of presentation times. The most critical result showed interference with naming response times when the distractor was phonologically similar to the Dutch translation (‘bench’, similar to the Dutch translation of mountain, ‘*berg*’). They posited that this Phono-Dutch distractor activates the Dutch lemma (the meaning of a word before phonological information is selected), interfering with selection of the proper English name; thus, competition among candidates is resolved at the lemma level. This finding lent support to the idea that the non-target language is active and competing for selection in spite of task demands.

Furthering this argument, Costa, Caramazza, and Sebastián-Gallés (2000) examined Catalan-Spanish bilinguals and demonstrated that naming pictures in either their L1 or L2 was facilitated when the picture name had a cognate in the other language. Consistent with their view of language-specific selection (see Costa et al., 1999), these results were not interpreted as a language-nonselective mechanism. Rather, they proposed that phonological facilitatory effects between the nontarget and target languages are evidence of cross-language activation.

A series of studies by Kroll, Dijkstra, Janssen, and Schriefers (2000) examined cognate facilitation by testing both Dutch-English and English-French bilinguals in a cued naming paradigm wherein bilinguals named pictures in both pure and mixed language blocks. During mixed naming blocks, facilitatory effects were seen for naming pictures whose names were cognates, regardless of language of response. Pure language blocks found overall faster response times in the L1 than L2, but cognate facilitation effects only for the L2. Naming in the L2 was heavily influenced by L1 cognates, but L1 naming was much less susceptible to L2 influence. This pattern suggests that L1 phonology is constantly active during L2 production, but the absence of a cognate effect in the more proficient L1 during blocked naming suggests the bypassing of L2 options for selection in speech production. Influential effects of the L2 are not seen when the highly proficient L1 is the only language of production, though the overall pattern of results along with Costa et al. (2000) suggests an open system in which the L1 is generally receptive to L2 influence, and vice versa, for situations requiring the production of both languages.

One model that attempts to consolidate these findings is Dijkstra and Van Heuven's (2002) updated Bilingual Interactive Activation (BIA+) model. Visual word recognition in bilinguals is initiated through recognition of sublexical orthography, which then activates lexical orthographic candidates in parallel. Activation of these candidates is dependent upon their similarity to the initial input, as well as resting level activations based upon factors such as relative frequency or language proficiency. Additionally, the number of candidates activated can depend upon factors such as neighbourhood density, frequency of the word and its between- and within-language neighbours, and input codes (i.e. writing system). One specific language is then activated corresponding with the selected candidate, as well as phonological and semantic representations. This model involves structural connections between representations, and essentially separates languages into two subsystems. Though the languages are separate, the model suggests joint activation until a selection is made. This model was proposed for bilingual visual word recognition, but Dijkstra and van Heuven also claimed that it can be generalised to other modalities as well, such as auditory word recognition and production. The BIA+

model provides a theoretical framework from which joint activation can be grounded and expanded upon.

Inhibition of Language

Other evidence also points to the idea of an unwanted language being inhibited during speech production, rather than attention being directed to the target language. The framework for this argument was provided by Green's (1998) Inhibitory Control Model that posited that bilinguals balance global inhibition levels of the two languages, as well as reactively and locally inhibit inadvertent selection and output of the non-target language system. The relative level of inhibition of language systems is influenced by the current language task.

Meuter and Allport (1999) provided evidence in support of Green's idea of global inhibition in a dual language numerical naming task by utilizing the concept of 'Task Set Inertia': non-target tasks must be suppressed to complete the target task. The more practiced the non-target task, the greater the suppression required so as not to interfere with current task performance. A group of unbalanced bilinguals – bilinguals stronger in one language than the other – switched between their L1 and L2 to name numerals, though participants were unaware of when a switch would occur. Switch trials were responded to slower than to non-switch trials, but importantly, switch costs were greater when switching from L2 naming to L1, rather than the reverse. These results suggested that, similar to Task Set Inertia, non-target languages must be inhibited to correctly utilise the target language. The degree of suppression is reliant upon language proficiency, and therefore, more effort is required to inhibit strongly proficient languages. Activating previously suppressed languages requires a level of effort proportional to proficiency.

Other evidence for global inhibition of language comes from Linck, Kroll, and Sunderman (2009), who reported that English-Spanish bilinguals immersed in an L2 environment showed reduced L1 access. Spanish-English word pairs were presented to both ‘classroom learners’ and ‘immersed learners’ (those studying Spanish in a Spanish speaking environment), who were asked to make judgments about whether or not an English word was a correct translation of a Spanish word presented first. Distractors were created so that the English word could resemble the Spanish word in form (lexical-neighbour), the English translation in form (translation-neighbour), or be conceptually similar to the English translation (semantic-neighbour). For example, for the Spanish word ‘*cara*’ (‘face’), the distractor pairings would be ‘cara-card’, ‘cara-fact’, and ‘cara-head’, respectively. Results indicated that immersed learners experienced greater interference from semantic-neighbour distractors than classroom learners, but reduced interference from lexical-neighbour and translation-neighbour distractors. Linck et al. (2009) posited that these results were due to an increased processing of L2, and that the reduced sensitivity to perceptual overlap of lexical- and translation-neighbour distractors suggested an inhibition of the L1. Their hypothesis was that the environmental demands on immersed learners modified ‘resting state’ activation (the levels of activation of languages while participants are not under experimental manipulation): increased activation of L2, with inhibition of the unneeded L1. Participants were also required to perform two verbal fluency tasks: one in English, the other in Spanish. Verbal fluency tasks require participants to list as many words as possible within one minute, either under a phonological rule (i.e. all words beginning with a certain letter, such as ‘A’) or category (i.e. all words belonging to a specific category, such as ‘animals’). Typically, verbal fluency tasks have shown bilinguals performing similarly to or poorer than their monolingual counterparts during letter fluency, and poorer for category fluency (Gollan, Montoya, & Werner, 2002; Portocarrero, Burright, & Donovick, 2007). Linck et al.’s (2009) study found that for verbal fluency tasks, immersed learners produced significantly fewer English exemplars than classroom learners. In contrast, these immersed learners produced significantly more Spanish exemplars than classroom learners. The pattern of results for immersed learners closely resembles those expected of bilinguals in relation to monolinguals: immersion in an L2 environment seems to strongly activate the L2, simultaneously diminishing L1 production. These results lend further support to the pattern exhibited by Costa et al. (2000) and Kroll et al. (2000), namely, that the L1 is influenced by the L2 during selection and production.

La Heij (2005) provided support for local, rather than global, inhibition with a parsimonious theory of language selection. Conceptual information in the preverbal message – information about a word before any verbal selection or decision – does not uniquely specify one lexical item, but matches several options. This occurs with monolinguals, but is also the case for L1 words and L2 translations for bilingual language production. He posited a process of ‘complex access, simple selection’ in which the language of production is selected based on data contained in the preverbal message. Lemmas in both languages are activated to varying degrees depending on the overlap of information within the preverbal message as well as the information within the lemmas, which contain language cues. To match the preverbal specifications, only one or very few lemmas are selected, while the other options are inhibited. In this view, whole language systems are not suppressed, but only individual options within each.

Electrophysiological Data

Lexical selection has also been investigated using the neuroimaging technique electroencephalography (EEG). EEG is useful in that it provides a highly sensitive time-course measure (on the order of milliseconds) with known markers related to lexical processing. These are known as Event Related Potentials (ERPs) - brain waves that occur in relation to specific events - with components being named for the specific orientation of the brain waves and time courses of occurrence. ERPs are measured at the surface of the scalp, with amplitudes and latencies reflecting the time course and magnitude of cognitive processes.

The primary component of interest was the N400, a negative deflection with its maximal peak occurring around 400 ms post-stimulus presentation. The N400 is implicated in lexical-semantic processing, and was first reported by Kutas and Hillyard (1980) during a sentence reading task. Participants read sentences presented one word at a time in which one quarter of the sentences ended with a semantically anomalous word, with the degree of semantic incongruity varying from moderate to strong. No behavioural responses were made, but instead EEG was recorded from three electrode sites along the midline of the scalp (frontal, central, and parietal) as a measure of semantic processing. Sentences ending in semantically anomalous words elicited a negatively oriented waveform peaking around 400 ms after stimulus onset (later named the N400) which was largest for strongly incongruous words, but still present for moderately incongruous words. The effect was seen reliably at all three electrode sites and was suggested to be involved in the reprocessing of meaning when ongoing sentence processing was interrupted. Using similar tasks, this effect has also been seen in other languages (e.g. Balconi & Pozzoli, 2005), as well as in the auditory modality (e.g. Hagoort & Brown, 2000).

Holcomb, Grainger, and O'Rourke (2002) also found N400 effects for semantic processing influenced by orthographic and phonological form. In a joint EEG/lexical decision task in which participants decided upon the semantic categorization of words and pseudowords, stimuli with large lexical neighbourhoods elicited more negative amplitudes in the N400 region than stimuli with small neighbourhoods. These results indicated increased processing of stimuli due to coactivation of meanings from orthographic neighbours.

Guo and Peng (2006) examined how the N400 is implicated in linguistic activation in Chinese-English bilinguals performing a picture naming task. Participants viewed pictures one at a time and were instructed to immediately form the English (L2) name. In half of the trials, participants simply named the picture in English. The remaining trials presented a written word in Chinese (L1) following the picture, with the word being either the name of the picture or unrelated. This task was repeated for another group of participants with language presentation reversed, i.e. they formed Chinese names first and were presented with English words. They found that the mean amplitudes of the

N400 in response to picture names was less than for unrelated words, even though the picture names were presented in the language that was not initially instructed, and thus not explicitly active.

Other studies have also found modulation of the N400 due to implicit processing of form across languages. Thierry and Wu (2007) gave Chinese-English bilinguals a semantic decision task between pairs of English words. Unknown to participants, half of the word pairs contained a Chinese character repetition when translated. Behavioural results were unaffected with all semantically related pairs being responded to faster than unrelated pairs, regardless of the character repetition manipulation. However, the N400 showed attenuation when the word pairs contained translation repetitions. This result was not seen in English monolinguals, but was replicated in Chinese monolinguals with Chinese word pairs, confirming the interpretation that Chinese-English bilinguals were processing Chinese word form. This suggests that this effect in bilinguals was due to implicit L1 activation during L2 comprehension. Together with Guo and Peng (2006), these studies provided ERP evidence for parallel activation of language, with the N400 as a reliable marker.

The N400 has not only been found in linguistically related tasks, but has also been linked to semantic processing in masked picture priming (Eddy, Schmid, & Holcomb, 2006). Masked picture priming involved very briefly displaying pictures to participants, i.e. the ‘prime’, followed by a ‘mask’ to interrupt consolidation of the prime into memory. A target picture was then presented with an unrelated behavioural decision to be made (e.g. press a button when viewing food items, view passively for all other objects). When the target picture was unrelated to the prime, a prolonged N400 was elicited. When the target was a repetition of the prime, the N400 showed an attenuated negativity. The presence of the N400 reflected processing at the level of meaning and was more negative when integration of semantics between prime and target picture was more difficult. This finding was significant because participants did not explicitly process either the prime or its name, yet still showed signs of semantic integration.

As described above, the N400 has been found to be present for both words and pictures, reflecting integration of lexical and semantic knowledge (see Kutas & Federmeier, 2011, for a review). As such, the N400 is largest when there is dissonance between one's expectations and reality in linguistic processing. Additionally, the N400's amplitude is proportional to the dissonance in processing (Kutas & Hillyard, 1984). This property can thus be used as a rough estimate of the effect of an experimental manipulation. The current study made use of both visual and auditory stimuli, both capable of eliciting the N400, though the auditory N400 tends to begin earlier, last longer, and have a more frontal topography (Kutas & Van Petten, 1994).

Present Study

As stated previously, Hermans et al. (1998) provided evidence for interference between languages at the level of the lemma in which L1 activation interacts with L2 naming in the early stages of processing. Costa et al. (2000) and Kroll et al. (2000) investigated the effects of cognates on naming facilitation, claiming that phonological interactions between languages is evidence for a permeable system of influence. Meuter and Allport (1999) and Linck et al. (2009) showed that task set demands and immersion in an L2 environment affect the levels of activation and inhibition among languages. If lexical selection and production are nonselective as previous research suggests, then a number of factors must contribute to focusing attention on the target language to ensure correct language production. The current study investigated the role of one of these factors, context, in language selection.

Bilinguals have access to two language systems, but also frequently experience two cultures: one associated with each of these linguistic systems. Therefore, these different cultures may also influence how bilinguals interpret real world stimuli and how their minds function to select one language over the other. To control for cultural and linguistic familiarity, we examined Korean-English bilinguals who had Korean as their L1. This study presented stimuli biased towards one of the cultures to these bilinguals to determine the extent to which visually-presented cultural information biased language selection.

Common items in the two cultures often have different forms that are visually distinct. For example, a traditional Korean soup (국, romanised as guk) is distinctly different in appearance from a more 'typically North American' soup, such as tomato soup. Differences include the type of bowl the soup is served in, and ingredients present such as bean sprouts and soy bean paste. Therefore, we expected a Korean-English bilingual to have more automatic access to the Korean word '국' when viewing a picture of a Korean soup, in spite of instructions to name the picture in English. Similarly, a picture that is consistent with the North American concept, such as a bowl of tomato soup, would facilitate naming in English. Importantly, both items can be referred to as ‘soup’, but the prediction was that access to the word in each language should be influenced by the contextual representation of the item.

For the current study, Korean-English bilinguals were presented with a picture-audio matching task in which the pictures were biased towards one or the other culture while hearing either English or Korean labels. Bilinguals familiar with these cultures should have more readily generated a name consistent with the language native to these cultures. Furthermore, we used EEG in tandem with a blocked design of object presentation which allowed the investigation of the processes associated with the relative levels of activation of each language. The purpose was to understand the role of the cultural context in modifying the relative levels of activation of the two languages and altering access to each of the lexicons. It was predicted that viewing culturally biased pictures would increase activation of the associated language. This would reveal itself behaviourally with faster reaction times during trials in which pictures matched the audio label and language, as well as neurophysiologically with attenuated N400s to these same trials. It was expected that participants would respond slower and show larger N400s to trials in which the picture did not match the label or associated language.

Method

Participants

Twenty-five Korean-English bilinguals who have Korean as their L1 took part in the study. Three participants were removed from data analysis: based on tests of receptive vocabulary (explained in the next section) one was removed due to unsatisfactory English ability and one for unsatisfactory Korean ability. One more participant was removed due to excessive skin conductance in the EEG recording. The final analysis included 22 participants (16 female; age range 18-24 years, *M* = 20.5), all of whom were right-handed with no known neurological impairments. To ensure familiarity with both Western and Korean cultural information, all participants had lived in Korea at some point, for a minimum of one year. Korean was the first language for all participants, although 6 participants claimed to have higher proficiency in English than in Korean. Participants self-rated their level of bilingualism on a 5 point scale (1 indicating monolingual and 5 being fluently bilingual). These ratings produced a mean of 4.0 (*s.d.* = 0.8). With the exception of one participant who was paid for her participation, all other participants were recruited from the York Undergraduate Research Participant Pool and rewarded with course credit for their participation in the study. All participants filled out the Language and Social Background Questionnaire (Luk & Bialystok, in press) and signed a consent form informing them of the nature of the study prior to participating in any tasks (see Appendices B and C).

Background Measures

A computerised version of the Peabody Picture Test (PPVT-III *Form A*; Dunn & Dunn, 1997) was administered as a test of receptive English vocabulary prior to participation in the cultural manipulation task. Participants chose which of four visually presented pictures best represented a word heard through computer speakers, with a mouse click being used to make the selection and simultaneously advance the test to the next set of pictures. Words were graduated for difficulty starting at an age-specific baseline, and testing proceeded until participants made eight errors within any 12-item set. Standard scores were computed from raw scores based on participants' ages; the test has a mean of 100 with a standard deviation of 15.

Post-experiment, a test of receptive Korean vocabulary was also administered based upon *Form B* of the PPVT-III. The task follows the same format as *Form A* of the PPVT-III, but words were presented in Korean approximately matching the English words in levels of difficulty. Because the Korean version has not been standardised, this test is only a rough estimate of participants' levels of Korean knowledge.

Behavioural Task

Stimuli. A preliminary list of over 40 items that have both Korean and North American representations (bicultural items: e.g., 'soup' is an English bicultural item, '국' is a Korean bicultural item) were generated with pictures corresponding to each cultural meaning. Korean and English bicultural pictures were rated by a sample of 15 non-Korean participants for familiarity, visual complexity, difficulty in naming, and relevance to North American culture. Ratings were conducted using a 7-point Likert scale for each feature, with 7 indicating 'very' and 1 indicating 'not at all' (e.g., a rating of 7 for a picture would indicate the participant was 'very familiar' with the item, and 1 would indicate 'not at all familiar'). Therefore, each item was rated on four different measures. In this manner, our manipulation was intended to produce high ratings of familiarity and relevance to North American culture for English bicultural pictures, low ratings of familiarity and relevance to North American culture for Korean bicultural pictures, and low ratings in visual complexity and difficulty in naming for both English and Korean bicultural pictures to ensure strong label-object correspondence. Based on these ratings, 37 bicultural pairs were selected as stimuli for the study. The final set of items is listed in Appendix A. There was a significant difference between mean ratings for the Korean bicultural and English bicultural objects for familiarity ($p < .001$) and North American relevance ($p < .001$), and no significant difference for visual complexity or difficulty in naming ($ps > .05$). Another list of 60 items that were culturally neutral in representation (monocultural) was created and rated on the same measures. From this set, 37 items were selected to correspond with 37 bicultural items. These items are also listed in Appendix A. Comparing the 37 English bicultural pictures and the 37 monocultural pictures, there were no significant mean differences between familiarity, visual complexity, difficulty in naming, relevance to North American culture, syllable length, or log frequency (as obtained through the English Lexicon Project website), all $ps > .05$. Therefore, there were a total of 111 unique items in the stimulus set consisting of English bicultural pictures, Korean bicultural pictures, and monocultural pictures. Individual audio files stating the name for each item were recorded by a female native Korean L1 speaker with 24 years of Korean experience and 18 years of English experience. The same speaker recorded both Korean and English items to ensure acoustic matching across items (e.g., speaker's tone, pitch, and timbre).

Post-experiment, participants named and rated the bicultural stimuli on familiarity and relevance to North American culture in the same manner as our initial norming, to ensure our manipulation was correct.

Computer Task. Pictures were paired with the audio file relevant for each trial and participants decided as quickly as possible if the word named the pictured object by indicating "match" or "mismatch". The design manipulated cultural congruency and lexical match. Cultural congruency is the relation between the cultural bias in the picture and the language in which the picture is named in the auditory stimulus. For example, a picture of Korean soup and a Korean auditory stimulus (whether or not it is the correct name of the picture) is considered to be culturally congruent, whereas a picture of Korean soup and an English word is culturally incongruent. Lexical match refers to the relation between the picture and the word irrespective of language. For example, a picture of Korean soup and the word for soup in either English or Korean is considered to be a lexical match, but a picture of soup and a word other than "soup" in either language is a lexical mismatch. Table 1 presents examples of the different trial types possible during the experiment.

Stimuli were presented in four blocks, with Table 2 providing details of the pictures and audio files used per block. The first and last blocks presented (neutral block 1 and neutral block 2) contained monocultural stimuli presented with English auditory cues. The two middle blocks used bicultural stimuli, presented first with English auditory cues (English block) and second with Korean (Korean block). This blocked design was intended to increase activation of English before participants switch to greater activation of Korean in the Korean block, and provided a measure of pre- and post-L1 activation with neutral block 1 and neutral block 2.

Pictures were presented on a computer monitor located approximately 50 cm in front of the participants, with audio being played through two Logitech speakers placed directly in front of the participants and underneath the monitor. The monitor and speakers were both connected to a Dell computer running E-Prime software. A fixation cross was presented on the monitor for a period between 500-1000 ms on a jittered randomisation, followed by a picture shown in the middle of the screen. The picture was presented simultaneously with an auditory file. Half of the pairs represented correct lexical matches in that the word named the displayed picture, and half were incorrect in that the word did not name the picture. In the bicultural blocks (English block and Korean block), half of the auditory files were culturally congruent with the picture in that the biased picture was named in the language with which it was associated, and half were culturally incongruent. Throughout all four blocks, no stimulus was presented with the same mismatch cue more than once. After hearing the auditory cue, participants responded with one of two buttons on the keyboard indicating a lexical match or mismatch, with the picture remaining on screen until a response was made. Once a response was registered, a blank screen was presented for 1000-2000 ms, randomised per trial, before the next trial began. Participants were instructed to not blink or make excessive eye movements while any visual cue (fixation cross, picture) was present. Between blocks, participants were allowed a break and continued when they were ready to proceed. The randomisation of the fixation cross pre-picture and blank screen post-response was included to circumvent anticipatory response effects.

Neutral block 1 contained monocultural stimuli with English auditory cues. Each of the 37 stimuli was presented twice: once with a match audio cue, and once with a pseudorandomly determined mismatch cue, for a total of 74 trials. The presentation order of stimuli was generated randomly by the program. This block was designed to increase activation of English.

The English block included bicultural visual stimuli with English auditory cues. There were 37 bicultural image pairs (37 Korean and 37 English), for a total of 74 stimuli. Each of the 74 stimuli was presented twice: once with a match audio cue and once with a mismatch cue, for a total of 148 trials. This block therefore had congruent match and congruent mismatch trials for English bicultural stimuli, and incongruent match and incongruent mismatch trials for Korean bicultural stimuli. Though Korean stimuli were included (and thus participants were expected to form Korean word representations), participants would still be required to reduce activation of their L1 to respond to the English audio.

The Korean block used the same bicultural stimuli but the auditory cues were presented in Korean, reversing the congruency associations. The format was the same as in the English block: 148 total trials of both Korean bicultural and English bicultural stimuli were shown twice each, once with a match cue, and once with a mismatch cue. Thus, English bicultural stimuli were presented as incongruent match and incongruent mismatch trials, while Korean bicultural stimuli were presented with congruent match and congruent mismatch trials. After both neutral block 1 and English blocks were designed with the intention of limiting activation of L1, this switch in the Korean block expected activation of the previously inhibited Korean.

Neutral block 2 was a replication of neutral block 1 using monocultural pictures with English auditory cues. Stimulus presentation order and mismatch auditory pairings were again randomised. This block was intended to reduce activation of L1 as a means to examine differences in performance pre- and post-L1 activation (i.e. between neutral block 1 and neutral block 2).

Only correct trials were included in the data analysis. Reaction time (RT) and accuracy were measured based on button press for a match/mismatch response. Any trials with RTs 2.5 standard deviations slower than a participant's mean RT for a given block were excluded from analysis as outliers.

EEG Recording. Before the task, participants were fitted with an EEG cap recording from active Ag/AgCl electrodes placed at 64 scalp sites (International 10/20 system) as well as the left and right mastoids. Using a BioSemi acquisition system (Biosemi Active Two, Amsterdam, Netherlands), continuous EEG recording was done at a sampling rate of 512Hz filtered online at a .01Hz low cutoff and 80Hz high cutoff, with offline referencing to an average mastoid measurement. Electrolytic gel was used to maintain impedances below a maximum of 20 kΩ per electrode throughout recording. Ocular artifacts were corrected using the adaptive correction method (Ille, Berg, & Scherg, 2002). Post-stimulus activity was compared to baseline neural activity (100ms pre-stimulus interval) with any differences suggesting task-related activity.

All analyses were conducted using the EEGLAB and ERPLAB toolboxes in

Matlab software. Continuous EEG was referenced to the left and right mastoids, with a baseline correction to the 100 ms pre-stimulus interval. Eye blinks and eye movements were modeled using Infomax independent components analysis (ICA) and removed from each participant's EEG recording. Trials with extreme voltages or drift caused by excessive skin conductance were removed from each participant's recording by visual inspection, as well as individual maximum amplitude and moving time window criteria.

Grand average waveforms were calculated from individual subject ERP data. Mean amplitudes were then calculated for time windows surrounding expectancy effects, based on previous literature and visual inspection: N400 (350-500 ms) and a late positive component (LPC) in the P600 range (550-750 ms). This LPC was previously unexpected, but has been implicated in code switching (e.g. Moreno, Federmeier, & Kutas, 2002) and pragmatic processes (e.g. Burkhardt, 2007; see Brouwer, Fitz, & Hoeks, 2012, for a recent review). Further implications of the LPC are addressed in the discussion section below.

Figure 1a presents the 3x4 electrode region of interest that was examined for the N400, extending anteriorly-posteriorly (AP) from frontal to central posterior electrodes, and covering a left to right width (LR) of three electrodes around the midline. The electrodes examined were F1, Fz, F2, FC1, FCz, FC2, C1, Cz, C2, CP1, CPz, and CP2. To examine the LPC a 2 (AP) x 3 (LR) region was analysed as presented in Figure 1b which included the electrodes Pz, P2, P4, POz, PO4, and PO8.

Results

Background Measures

A paired samples *t*-test revealed that participants significantly differed on standard scores of the two tests of receptive vocabulary, $t(21) = 4.46$, $p < .001$, showing higher proficiency in Korean than English (Korean PPVTB *M* = 116, *s.d.* = 17; English PPVTA *M* = 93, *s.d.* = 13). This result is consistent with the finding that age of acquisition of Korean (*M* = 1.0 years, *s.d.* = 1.2) was significantly earlier than acquisition of English (*M* = 9.4 years, *s.d.* = 3.4), $t(21) = 13.73$, $p < .001$.

Post-experiment, participants rated the stimuli on levels of familiarity and relevance to North American culture. Similar to the procedure used in creating the stimuli, ratings were conducted using a 7-point Likert scale with 1 indicating ‘not at all familiar or relevant’ and 7 indicating ‘very familiar or relevant’. Paired samples t-tests showed that ratings showed no differences between levels of familiarity ($p > .05$), with participants being highly familiar with both North American (*M* = 6.58, *s.d.* = .56) and Korean objects (*M* = 6.49, *s.d.* = .79). Ratings for relevance to North American culture were significantly different between North American items (*M* = 5.69, *s.d.* = .66) and Korean items (*M* = 2.27, *s.d.* = .90), $t(21) = 16.47$, $p < .001$. The high familiarity of objects indicated that naming was not an issue, and the cultural bias of objects was readily apparent to participants.

Behavioural Performance

Reaction time and accuracy data for all four blocks are presented in Table 3. Accuracy for all trials types throughout the four blocks approached ceiling, and due to a lack of variance among accuracy rates, any differences among RTs could not be attributed to a speed-accuracy trade-off. Accuracies are therefore reported in Table 3, but were excluded from further analysis. All repeated measures ANOVAs that were conducted used the Bonferroni confidence interval adjustment when comparing main effects, and the Greenhouse-Geisser correction was applied in any instance where the assumption of sphericity was violated. Pairwise comparisons were conducted for all significant ($p < .05$) main effects and interactions.

Neutral block 1 and neutral block 2 RTs were examined in a 2-way ANOVA for block and lexical match. A significant effect of block was found ($F(1, 21) = 25.12$, $p < .001$, $\eta_p^2 = .55$) with participants responding more rapidly in neutral block 2 than neutral block 1, as well as significantly faster RTs to match trials than to mismatch trials ($F(1, 21) = 10.80$, $p = .004$, $\eta_p^2 = .34$). No significant interaction was found ($F < 1$).

To examine the effects of cultural context on RTs, the English block and Korean block were compared using a 3-way repeated measures ANOVA examining block, cultural congruency, and lexical match. Participants responded more rapidly in the Korean block than the English block ($F(1, 21) = 5.40$, $p = .03$, $\eta_p^2 = .20$), and to culturally congruent trials than to incongruent trials ($F(1, 21) = 10.94$, $p = .003$, $\eta_p^2 = .34$). There was a marginal effect of lexical match ($F(1, 21) = 3.87$, $p = .062$, $\eta_p^2 = .16$), but a significant interaction between cultural congruency and lexical match ($F(1, 21) = 5.71$, $p = .026$, $\eta_p^2 = .21$). Pairwise comparisons revealed that congruent match trials were responded to significantly faster than incongruent match trials ($p = .003$), but there were no difference in RTs between congruent mismatch trials and incongruent mismatch trials

($p > .05$). In other words, if the word did not name the picture, there was no further effect of cultural congruency. There were no interactions with block, indicating that the effects of cultural congruency and lexical match applied equally to each block.

ERP Data

The ERP waveforms in the ROI are presented in Figures 2 and 3. Analyses of the N400 revealed a similar ERP pattern throughout the four blocks with all trials eliciting a negative-positive-negative series of peaks. However, the negative peak occurring in the N400 region was attenuated in lexical match, but not mismatch, trials. Figures 4 and 5 show the ROI for LPC analyses, with ERPs showing a late positive component for match trials, but not mismatch trials. The general trend of the ERP data showed an overall increase in positivity throughout all four blocks.

Because the design manipulated cultural context of the stimuli as well as the language of presentation, analyses were divided by examining the average values of the waveforms from neutral block 1 and neutral block 2[1], and the English block against the Korean block. The N400 was analysed by examining mean amplitudes of the ERP waveforms in the 350 to 500 ms time range, and the LPC was examined using mean amplitudes during the 550 to 750 ms range.

Neutral Blocks N400. To explore expectancy effects shown by the N400 in both neutral blocks, a 3-way repeated measures ANOVA was run on mean amplitude between 350 and 500 ms examining lexical match, AP site, and LR site. The Bonferroni confidence interval adjustment was used when comparing main effects, and the Greenhouse-Geisser correction was applied to all results where sphericity was violated.

1. Neutral block 1 and neutral block 2 were originally included as separate levels in the analyses, but no relevant main effects or interactions with block were revealed. Values were combined to simplify the analyses.

A large effect of lexical match ($F(1, 21) = 125.64$, $p < .001$, $\eta_p^2 = .86$) revealed greater negativities for lexical mismatch trials than match trials. There were additional main effects of AP electrode position ($F(3, 63) = 55.77$, $p < .001$, $\eta_p^2 = .73$) and LR electrode position ($F(2, 42) = 6.79$, $p = .006$, $\eta_p^2 = .24$) with greater negativity at frontal and fronto-central electrodes, and along the midline.

Significant two-way interactions were found between lexical match and AP electrode position ($F(3, 63) = 11.49$, $p = .001$, $\eta_p^2 = .35$), and lexical match and LR electrode position ($F(2, 42) = 4.09$, $p = .037$, $\eta_p^2 = .16$). During match trials, comparing every level of AP electrode site against each other revealed significant differences in amplitudes (*p*s < .05), with the greatest negativities at frontal electrodes. Midline electrodes also showed greater negativities than right electrodes ($p = .004$). Conversely, mismatch trials did not elicit any difference in amplitudes between frontal and fronto-central electrode sites ($p > .05$), and midline electrodes were significantly more negative than both left and right electrode sites ($p = .025$ and $p < .001$, respectively).

No other comparisons for the N400 in the neutral blocks were significant (*p*s > .05). The overall analyses revealed the attenuation of the N400 during lexical match trials and a large N400 for mismatch trials, with a general trend towards greater negativities at frontal and fronto-central electrodes along the midline.

English and Korean Blocks N400. A 5-way repeated measures ANOVA was conducted to compare the N400 between the English block and Korean block, examining block, cultural congruency, lexical match, AP site, and LR site. The Greenhouse-Geisser correction was applied to any results in which sphericity was violated.

A main effect of lexical match was found ($F(1, 21) = 117.96$, $p < .001$, $\eta_p^2 = .85$) with mismatch trials showing greater negativity than match trials (-8.84 µV and -5.25 µV, respectively). Main effects of AP electrode location ($F(3, 63) = 64.81$, $p < .001$, $\eta_p^2 = .76$) and LR electrode location ($F(2, 42) = 6.26$, $p = .01$, $\eta_p^2 = .23$) revealed a similar pattern as neutral block 1 and neutral block 2 with more negative waveforms at frontal, fronto-central, and midline electrodes. Main effects of block and cultural congruency were not significant (*p*s > .05).

An interaction was found between block and lexical match ($F(1, 21) = 11.87$, $p = .002$, $\eta_p^2 = .36$). Pairwise comparisons showed that mismatch trials were more negative than match trials in both English and Korean blocks, but this difference was more pronounced in the Korean block than the English block (difference of -4.32 µV compared to -2.87 µV, *p*s < .001).

Other two-way interactions were found between lexical match and LR electrode position ($F(2, 42) = 5.05$, $p = .011$, $\eta_p^2 = .19$), and AP electrode location and LR electrode location ($F(6, 126) = 3.06$, $p = .022$, $\eta_p^2 = .13$). Match trials elicited more negative amplitudes at midline electrodes than at right electrodes ($p < .001$), while mismatch trials elicited more negative amplitudes at midline than at left ($p = .009$) and right electrodes ($p < .001$). Left electrodes showed a greater negativity at frontal than at fronto-central electrodes ($p = .023$) as well as decreasing negativities toward posterior electrode positions (all comparison *p*s < .001), while midline and right electrodes did not show this difference between frontal and fronto-central electrodes ($p > .05$). This topography mirrors the ERP waveforms seen in neutral block 1 and neutral block 2.

A final two-way interaction was found between block and LR electrode position (F(2, 42) = 3.98, p = .045, η_p^2 = .16) which was modulated by a three-way interaction between block, cultural congruency, and LR electrode position (F(2, 42) = 5.28, p = .017, η_p^2 = .20). In the English block, incongruent trials elicited less negative amplitudes at right electrodes compared to left (p = .041) and midline (p < .001) sites, but incongruent trials in the Korean block elicited less negative amplitudes at left sites compared to midline sites (p = .032) as well as right sites compared to midline sites (p = .001).

No other comparisons examining the N400 between the English and Korean blocks were significant (ps > .05). Overall analyses revealed a similar pattern as the neutral blocks. Match trials elicited an attenuated N400 compared to mismatch trials, with greatest negativities at frontal and fronto-central electrodes along the midline. No effects of cultural congruency were seen in the N400.

Neutral Blocks LPC. To investigate the hypothesis that the LPC is involved during pragmatic processing, neutral block 1 and neutral block 2 were combined and compared in a 3-way repeated measures ANOVA examining lexical match, AP site, and LR site. Because these blocks did not manipulate any cultural context, the results provide a measure of how lexical match influences the LPC.

The manipulation of lexical match was significant (F(1, 21) = 81.06, p < .001, η_p^2 = .79) with match trials eliciting more positive waveforms than mismatch trials. Parieto-occipital electrode sites showed more positive waveforms than parietal sites (F(1, 21) = 54.43, p < .001, η_p^2 = .72), but there was no difference between LR electrode positions (p > .05).

Significant two-way interactions were found between lexical match and AP electrode location ($F(1, 21) = 10.76$, $p = .004$, $\eta_p^2 = .34$), and lexical match and LR electrode location ($F(2, 42) = 6.90$, $p = .008$, $\eta_p^2 = .25$). Parieto-occipital sites showed more positive amplitudes than parietal sites, but the difference in amplitudes was greater for mismatch trials than for match trials (2.43 µV and 1.35 µV, respectively, *p*s < .001). The most lateral electrode sites showed the most positive amplitudes compared to midline and medial sites during mismatch trials, but the least positive amplitudes during match trials.

No other comparisons were significant (*p*s > .05). Based upon visual inspection of the waveforms and results of the ANOVA, match trials elicited a prominent late positive deflection, while mismatch trials resulted in a flat waveform with no noticeable deflection. This LPC was most positive at parieto-occipital sites.

English and Korean Blocks LPC. A 4-way repeated measures ANOVA was run using match trials only in the English block and Korean block examining block, cultural congruency, AP site, and LR site. This was based upon visual inspection, analysis of the neutral blocks indicating that mismatch trials do not elicit any deflection in the waveform, as well as other research indicating that semantic/lexical mismatches do not elicit an LPC (e.g. Moreno et al., 2002). In the English block and Korean block, the effect of cultural context on an LPC elicited by match trials was of interest.

Main effects of AP electrode location ($F(1, 21) = 21.85$, $p < .001$, $\eta_p^2 = .51$) and LR location ($F(2, 42) = 3.95$, $p = .047$, $\eta_p^2 = .16$) revealed more positive amplitudes at parieto-occipital and midline electrodes. There were no main effects of block or cultural congruency (*p*s > .05).

A two-way interaction between block and LR electrode location was significant ($F(2, 42) = 5.32$, $p = .015$, $\eta_p^2 = .20$) with midline and medial electrodes becoming more positive between the English block and Korean block, while lateral electrodes did not change in amplitude between these two blocks.

The interaction between block and cultural congruency was marginal ($F(1, 21) = 3.75$, $p = .07$, $\eta_p^2 = .15$). Based upon visual inspection, as well as the question of interest as to what effect context plays on linguistic activation, further pairwise comparisons were conducted. In the English block, incongruent trials were significantly more positive than congruent trials (difference of 1.43 µV, $p = .04$), but this difference was not seen in the Korean block ($p = .34$). Congruent trials were significantly more positive in the Korean block than English block (difference of 1.64 µV, $p = .001$), but incongruent trials showed no difference in amplitudes between blocks ($p > .05$).

No other comparisons in the ANOVA were significant (*p*s > .05). The analyses revealed the most positive ERPs at parieto-occipital sites along the midline for both blocks. Incongruent trials elicited a more positive waveform than congruent trials in the English block, yet no effect of cultural context was seen in the Korean block as waveform amplitudes did not vary as a function of cultural congruency.

Discussion

How does the cultural context of objects influence linguistic activation in bilinguals? Previous work has investigated how bilinguals nonselectively activate both languages during lexical comprehension and production (e.g. Kroll et al., 2006), as well as other work showing that bilinguals may actually inhibit one language (e.g. Green, 1998; Meuter & Allport, 1999). Electrophysiological studies have also investigated joint activation, primarily by looking at the N400 ERP waveform as an indicator of semantic activation and integration across languages (e.g. Guo & Peng, 2006; Thierry & Wu, 2007). The current study used behavioural measures and ERP results from a picture-audio matching task to examine how the cultural context of objects influenced linguistic activation in Korean-English bilinguals. Behavioural responses indicating either match or mismatch between the audio label and the picture resulted in quicker RTs to match trials than mismatch trials when objects were culturally neutral. When objects were culturally biased, culturally congruent match trials were responded to faster than culturally incongruent match, congruent mismatch, and incongruent mismatch trials, with the latter three not different from each other. These findings suggest that both the semantic match between audio and picture, as well as congruence between audio and cultural manipulation, influence participants' levels of language activation and subsequent RTs. ERP results showed large effects from the lexical manipulation with greatly attenuated N400s to match trials regardless of cultural congruency. An LPC was elicited during match trials and showed greater positivity to culturally incongruent items than to congruent items during the English block, but no difference between culturally congruent and incongruent match trials during the Korean block. These results indicate that participants process object labels differently depending on contextual manipulation, as well as language of audio label.

This study used two measures to examine how cultural context influenced linguistic activation: behavioural RTs to lexical decisions, and active ERP recording. Although these measures were both used to evaluate lexical decision making in the framework of cultural manipulation of objects, the results from each were somewhat different. Each measure indicated different aspects of performance, necessitating the need for both to provide a more detailed evaluation of linguistic activation than through either alone.

Behaviourally, RTs to lexical match decisions were compared between both neutral blocks, and between the English and Korean blocks. Accuracies approached ceiling for all trial types in each block, indicating that faster RTs in later blocks were not the result of speed-accuracy tradeoffs. Additionally, faster RTs in neutral block 2 compared to neutral block 1, and in the Korean block compared to the English block, suggest that overall decreases in RTs throughout the blocks are largely due to practice effects, since the presentation order in which neutral block 1 was first and neutral block 2 was last was fixed across participants.

Meuter and Allport's (1999) results suggest that switching from L2 (English) to L1 (Korean) should have led to slower naming RTs. However, the shift in language from the English block to the Korean block showed the reverse effect: RTs were faster in the Korean block than the English block despite this prediction. Switching from L1 audio in the Korean block to L2 audio in neutral block 2 also led to faster RTs. Based on overall block RTs, these results again suggest heavy influence of practice. One possible reason that practice effects were so prominent is that items were repeated from neutral block 1 in neutral block 2, and from the English block in the Korean block. Repeated exposure to these items would increase familiarity during the task, and thus increase the ease of access to naming. Repeated practice of the required motor responses would also further increase reaction speed.

Although the language of audio did not seem to have an independent effect on overall RTs between blocks, the interaction between language of audio, cultural context, and lexical match did influence reaction times. The English and Korean blocks were critical in that strong cultural contextual manipulation took place, and thus were expected to influence linguistic activation in specific ways: Korean items should have activated Korean labels, while North American items would activate English labels. With this prediction, North American items in the English block should have been responded to more quickly than Korean items, and the reverse would hold true in the Korean block. Match trials elicited significantly faster RTs than mismatch trials in the neutral blocks, and thus the same would be expected in the English and Korean blocks. What was found in the English and Korean blocks was a combination of these ideas, specifically, that match trials were responded to faster *only if* the items were culturally congruent with the audio language.

If one language were to be inhibited as predicted by global inhibition, both culturally congruent and incongruent match trials would have been responded to at the same speed – no cross-language name should have been activated. Instead, the results suggest that culturally incongruent trials did indeed activate cross language labels. After activating the cross language label, participants then needed to inhibit this label while simultaneously activating the label corresponding to the current language block to make a correct decision. For example, during the English block a participant may be presented with a picture of '국' while hearing the label 'soup'. RT data show that this response takes longer than if they were shown a picture of 'soup' with the same label, despite both being lexically matched. One possibility is that participants activate the label for '국' before activating 'soup' to respond; the same would hold true when listening to Korean labels and viewing pictures of '국' or 'soup'. Another possibility is that labels are activated simultaneously regardless of cultural manipulation or audio language. The slower RTs to culturally incongruent trials could be due to this extra processing in resolving competition. Based upon behavioural RT results alone, the data suggest that it is not solely the language of presentation, but the interaction between audio and the context of the object, that directs attention to naming.

Electrophysiological results from ERP analyses provided an alternate viewpoint to how lexical selection and cultural congruency interacted to influence linguistic activation. Two components of interest were readily visible through inspection: the N400 and an LPC. The N400 and LPC waveforms were prominent at frontal to centro-parietal sites, and at parietal right electrodes, respectively.

The N400 was most negative along the midline and frontal electrodes, but was elicited in both left and right hemispheres and at more posterior sites as well. These results are in line with prior research involving pictures or auditory stimuli (e.g., Guo & Peng, 2006; Kutas & Van Petten, 1994). The frontal prominence, in addition to the prolonged length of the waveform, suggest that the auditory stimuli strongly influenced the N400.

In every block, the N400 was influenced most strongly by lexical match manipulations. Match trials in the neutral blocks, as well as both congruent and incongruent match trials in the English and Korean blocks, showed an attenuated N400. The difference in amplitudes between match and mismatch trials was large: -2.87 μV in the English block, -4.32 μV in the Korean block, and -4.75 μV in the neutral blocks. The design was manipulated in such a fashion to elicit the largest waveforms during the Korean block; the block in which language of presentation is most familiar, yet most unexpected. The switch to Korean audio after two blocks of hearing English should have made any differences attributed to language more pronounced. To some extent, this manipulation worked if we compare the English block and Korean block. However, the largest difference was seen in the neutral blocks. There are some possible explanations for these observed N400s.

Monocultural picture stimuli were repeated in the neutral blocks, as were bicultural picture stimuli in the English and Korean blocks. Repeated exposure to these stimuli would have increased participants' levels of familiarity with the objects, and thus increased ease of naming as the experiment progressed. Match trials would have required less effortful processing as the label became more strongly attached, causing greater attenuation of the N400. Conversely, mismatch labels would have been more readily identified as incorrect, increasing the amplitude of the N400.

Another possibility is that object labels in English were less strongly attached than labels in Korean. Although participants scored similarly to monolingual English participants on a test of receptive vocabulary (within one standard deviation of the mean on the PPVT Form A), participants had learned Korean at an earlier age (M = 1.0) than English (M = 9.4), suggesting greater exposure to, and experience with, Korean labels for objects than for English. It seems that the weaker labels in English were less readily activated than Korean labels in order to establish match criteria. This would especially be true when labeling Korean bicultural items in English, as these items would generally be present within the context of family or social life, situations in which English labels would rarely be necessary. This weaker activation could account for less attenuation of the N400 during match trials in the English block as compared to during the Korean block. The weaker association between English labels and objects, as well as repeated exposure to stimuli, would account for the increasing amplitude differences between the N400s elicited by match and mismatch trials throughout the blocks.

Weak associations between English labels and objects also help to explain N400 differences between the blocks, but do not fully account for the behavioural data. In the English block there were no differences between the N400s elicited by culturally congruent and incongruent trials, yet participants responded to culturally congruent match trials with the fastest RTs, a difference not reflected in the N400 data.

Because responses occurred on average approximately 800ms after stimulus onset, the second component of interest was the LPC (550-750 ms). Early research found that the P600 was sensitive to syntactic violations (e.g. Osterhout & Holcomb, 1992), but more recent findings implicate the P600 in code switching in bilinguals (e.g. Moreno et al., 2002), uncertainty in discourse processing (e.g. Burkhardt, 2007), and reanalysis of information processing to resolve response uncertainty (e.g. see Kolk & Chwilla, 2007, for a review). In the current study, an LPC was prominent in posterior regions which is consistent with findings in the aforementioned literature.

Mismatch trials across all blocks failed to elicit an LPC. This is consistent with other LPC findings, such as Moreno et al. (2002) who used a sentence reading task in conjunction with EEG to examine conflict processing. English-Spanish bilinguals read English sentences presented one word at a time in which the final word was highly expected, a lexical switch (a synonym of the expected word), or a translation of the word into Spanish. The results showed that both lexical and linguistic switches (also called code switches) elicited large N400s, but only code switches caused by translation final words elicited an LPC. This suggested that the costs of making a code switch occur predominantly at later stages of processing, following the idea that the LPC is involved with reprocessing of information. The absence of an LPC when lexical choices did not match expectations suggested that no further processing occurred once these expectations were violated.

These findings are consistent with a recent theory posited by Brouwer et al. (2012), and help to explain the ERP results found in the current study. Brouwer et al.

(2012) argue that N400 amplitude reflects retrieval of the meaning of a word from long-term memory, while amplitude of the LPC reflects the integration of lexical information with semantic representations into an updated concept. In the current study, culturally incongruent match trials elicited a larger LPC than culturally congruent match trials in the English block. This increased amplitude implies that participants had greater difficulty in processing bicultural Korean items than English items when hearing English labels. When viewing Korean bicultural items, if participants do indeed activate Korean labels, the increased amplitude of the LPC to incongruent match trials is indicative of costs due to code switching. Participants activate Korean labels despite hearing the labels in English, and would then need to recheck this translation before responding. This extra cost in integrating lexical information with semantic representations would account for the larger LPC, a finding present in other research as well (e.g. Guo et al., 2012). English bicultural items would activate English labels, and thus when hearing English, processing costs to make a decision are reduced as reflected in a smaller LPC. Brouwer et al.’s (2012) explanation of the N400 also accounts for why both congruent and incongruent match trials show similar N400 amplitudes. Despite activating different languages based upon the cultural bias of the item, participants retrieved the same semantic information from long-term memory. Applying this semantic knowledge into the integration of a linguistic and lexical framework occurred at a later stage of processing, evidenced by different amplitudes of the LPC. The assumption that context influences linguistic activation is then supported by the results from both Moreno et al. (2002) and Brouwer et al. (2012).

ERP results from the Korean block are not as easily explained. Analyses showed that the LPC was not significantly different for culturally congruent and incongruent match trials as was the case for the English block. Results from the English block, along with the main hypothesis, predict that congruent match trials in the Korean block would have elicited smaller amplitudes of the LPC than incongruent match trials, but this was not seen. When presented in conjunction with Korean labels, both Korean and English bicultural pictures did not elicit different amplitudes of the LPC. Why would these stimuli, when paired with English labels, elicit differences in implicit processing, but not when paired with Korean labels? One strong possibility is that levels of experience in Korean and English influenced how participants activated labels. During the English block, participants showed evidence of activating Korean labels when viewing Korean bicultural items. As previously mentioned, it is possible that these items have only been present within Korean contexts in the past, and thus English labels were only weakly attached. Every participant learned Korean before English, and participants showed greater proficiency in Korean than English. It would therefore be reasonable to assume that applying Korean labels to objects is simpler, and more readily occurs, than applying English labels. Bowls of tomato soup or Korean '국' may vary with respect to the ingredients that comprise each, but they are both examples of a common archetype, 'soup'. Bilinguals would learn to apply their L1 labels to a wide range of examples of these archetypes before learning L2 equivalents. Additionally, participants knew that Korean was the only language needed to make accurate responses during this block. According to one supporter of global inhibition, Paradis (1994) posited that when bilinguals intend to speak in one language only, the non-target language is sufficiently inhibited to prevent interference. In the English block, suppression of the much stronger L1 was not fully possible and is why interference effects were reflected in RT and ERP data. However, in the Korean block, it is possible that participants were able to globally inhibit their weaker L2, even in the presence of bicultural English items. Korean labels would be strongly activated as participants would have greater experience applying these labels to a larger range of objects, while simultaneously inhibiting English selection. This idea would explain both the presence of the LPC, as well as the lack of amplitude differences between culturally congruent and incongruent trials. Resolving the lexical information with the semantic meaning elicited the LPC, but no code switching costs were incurred as participants applied Korean labels to every object. However, the slower RTs to culturally incongruent match trials in the Korean block do not show any trace in the ERP data, and are currently unexplainable using ERP results.

The pattern of results suggests that the cultural context of objects does influence how bilinguals both explicitly and implicitly process information. Culturally neutral objects presented with English labels elicited faster RTs when the label lexically matched the object compared to a lexical mismatch, an attenuated N400 for lexical matches, and the presence of an LPC for match, but not mismatch, trials. When objects were manipulated to represent exemplars from either North American or Korean culture, and presented with English or Korean labels, a different pattern of results emerged. RT data indicated that participants were processing culturally congruent match trials faster than all other trial types. This suggests that participants were activating object labels in the language congruent with the cultural bias of the object. If the label correctly identified the object but was presented in a language incongruent with the cultural bias, participants showed language switching costs reflected in slower RTs. ERP data also showed that participants were implicitly processing these culturally biased items differently, reflected in an LPC. Participants seemed to activate Korean labels even when listening to English labels, but the LPC did not suggest that weaker English labels were activated in the presence of Korean labels.

The current study lends support to the theory that bilinguals show constant joint activation of their two languages by revealing that the cultural context of objects influences linguistic activation in specific ways. Culturally biased objects increase activation of lexical labels in line with the language associated with the culture. When Korean-English bilinguals viewed Korean items, Korean labels were activated, and likewise when viewing North American items, English labels were activated. However, levels of activation were modulated by the expected language of response. Relative levels of activation were also influenced by levels of experience and proficiency in each language. These results have important implications for how bilinguals interact within an L1 or L2 environment, particularly in unbalanced bilinguals who may be weaker in their L2. When in an L2 environment with L2 contextual cues, bilinguals seem to access the appropriate lexicon for the environment. However, introducing a cue associated with a bilingual's L1 culture actually disrupts L2 access and production. A similar finding was also recently discussed by Zhang, Cheng, Morris, and Yap (2013). In a series of studies with Chinese-English bilinguals, Zhang et al. (2013) asked participants to perform a variety of tasks including holding conversation in English, describing objects, narrating stories, and picture naming. Tasks were preceded by priming participants with either Chinese cultural faces or objects (e.g. The Great Wall), or American faces or objects (e.g. Mount Rushmore). Despite different task demands, the effects of priming were consistent: exposure to Chinese cultural objects before a task hindered English speech production and fluency, while exposure to American cultural objects did not elicit any effect on English processing.

The results of the current study, as well as Zhang et al. (2013), highlight the automaticity of processing language in the presence of nonverbal cultural context cues. However, the results indicate that for bilinguals, contextual cues are not equivalent in influencing linguistic activation. Zhang et al. (2013) found that American cues do not facilitate English processing, but Chinese cues hinder English processing. To expand this concept more broadly, L2 culture cues do not facilitate L2 access, but L1 cues will disrupt L2 processing. The current study found electrophysiological evidence to support the claim that L1 culture cues interfere with L2 processing, but L2 cues do not interfere with implicit L1 processing. One possibility to explain this dissociation was mentioned earlier – though participants in both studies were relatively fluent in English, they lacked equal experience in their two respective cultures. The significance of L2 stimuli may not have been sufficient to elicit the same level of familiarity as L1 stimuli, and thus would not influence linguistic activation as prominently as L1 stimuli did. As well, L2 facilitatory effects in Zhang et al.'s (2013) study may not have been seen because participants were already in an L2 context. Instructions were in English and the environment was American

– levels of English may have already been in a state of heightened activation. It is feasible to predict that, in the context of an L1 environment, subsequent exposure to L2 cultural cues would facilitate L2 processing and possibly interfere with L1 production. Future studies that investigate the role of cultural context on bilinguals' linguistic activation should aim to create stimuli that are equal in saliency for both cultures, as well as investigate how the context that participants are placed in prior to testing affects linguistic processing.

With the rise in global transnationalism and subsequent bilingualism, the findings of the current study and in the literature provide a note of caution. Reasonably, bilinguals would feel comfortable in settings that utilise their L1, and tend to dispose themselves towards those situations. These situations could be visiting a restaurant that serves food associated with their L1 culture, or only associating with peers of a similar cultural background. The simple exposure to L1 cultural cues in these contexts limits L2 production, a potential issue for those attempting to assimilate themselves into other cultures such as new immigrants or students studying abroad. Future research from this sociocultural perspective will aid in understanding and recommending how bilinguals can best interact within their current setting – even if it just involves ordering a bowl of soup.

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Table 1.

Block design by stimuli and audio presentations.

Block	Stimuli	Audio Presentation	No. Match Trials†	No. Mismatch Trials†
Neutral 1	Monocultural	English	37	37
English	Bicultural	English	74‡	74‡
Korean	Bicultural	Korean	74‡	74‡
Neutral 2	Monocultural	English	37	37

† English and Korean blocks have both congruent and incongruent trials, whereas the monocultural blocks do not have these distinctions.
‡ 37 trials are congruent and 37 incongruent.

Table 2.

Accuracies (and standard deviations) of responses as a ratio per trial type.

Block	Trial type	Accuracy
Neutral 1	Match	0.94 (.05)
	Mismatch	0.99 (.01)
Neutral 2	Match	0.96 (.03)
	Mismatch	0.99 (.02)
English	Congruent match	0.95 (.04)
	Congruent mismatch	0.99 (.02)
	Incongruent match	0.92 (.05)
	Incongruent mismatch	0.99 (.02)
Korean	Congruent match	0.91 (.05)
	Congruent mismatch	1.00 (.01)
	Incongruent match	0.96 (.03)
	Incongruent mismatch	0.99 (.02)

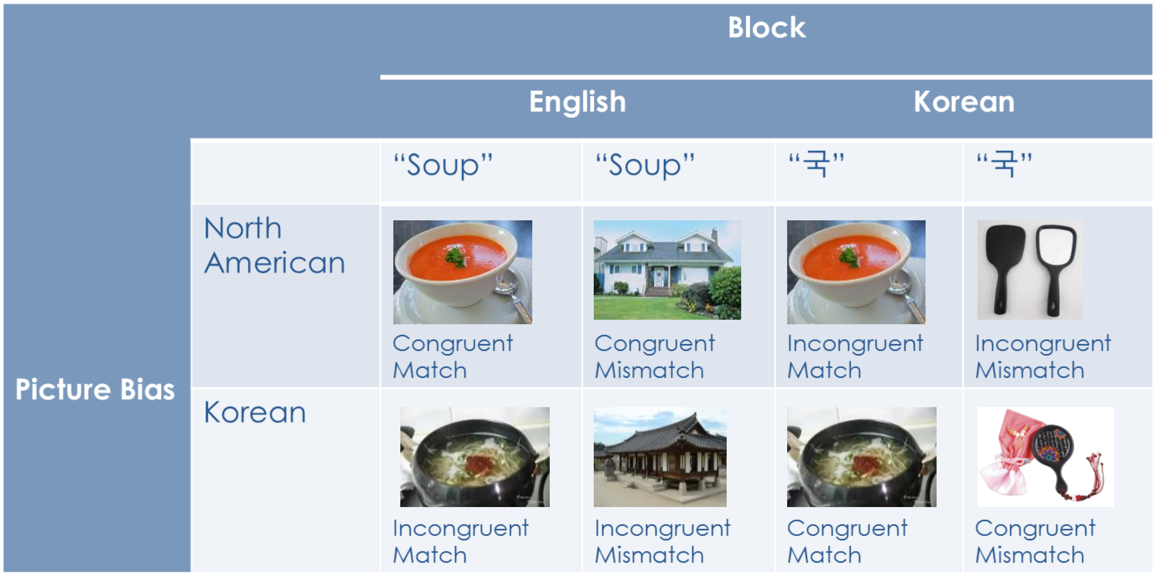


Figure 1. Trial types based upon bias of picture (English or Korean) and audio presentation (English or Korean, match or mismatch) for the English block and Korean block with examples.

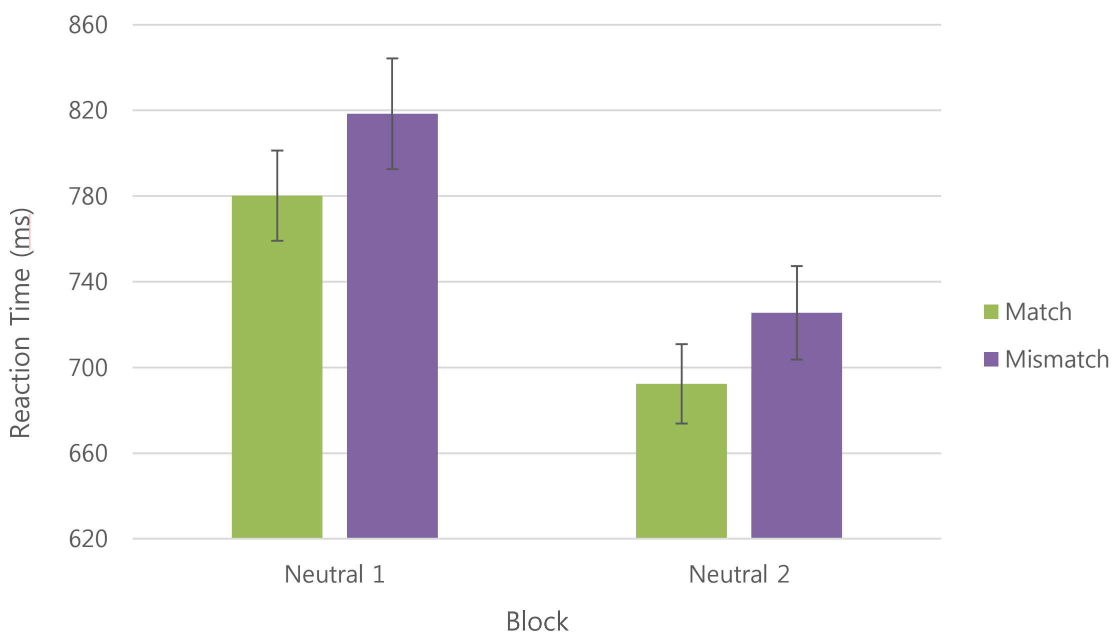


Figure 2. Reaction times (ms) per trial type in neutral block 1 and neutral block 2.

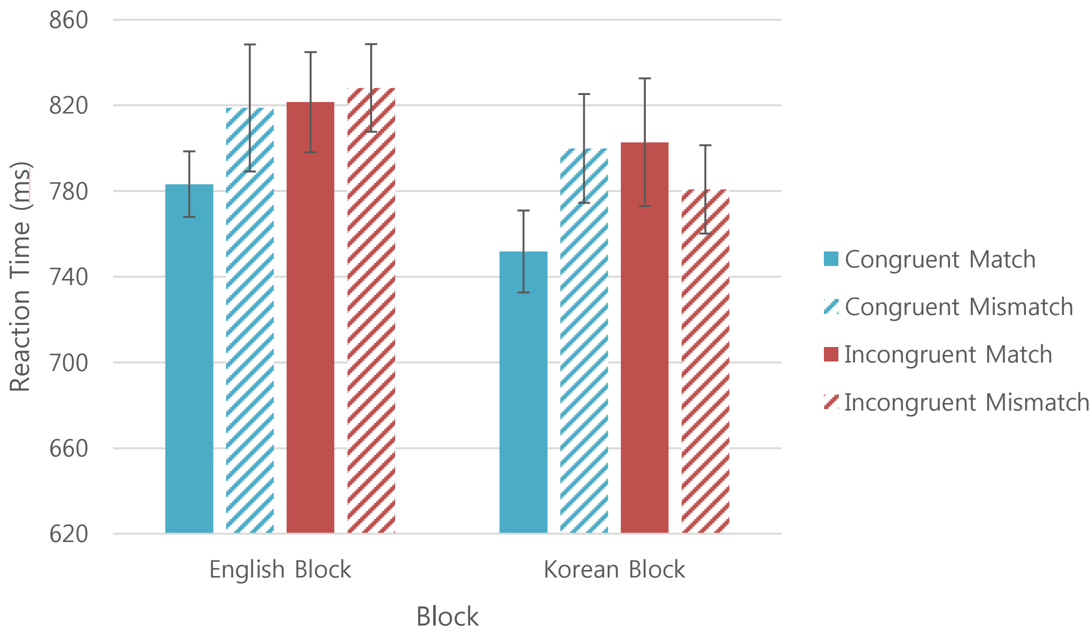
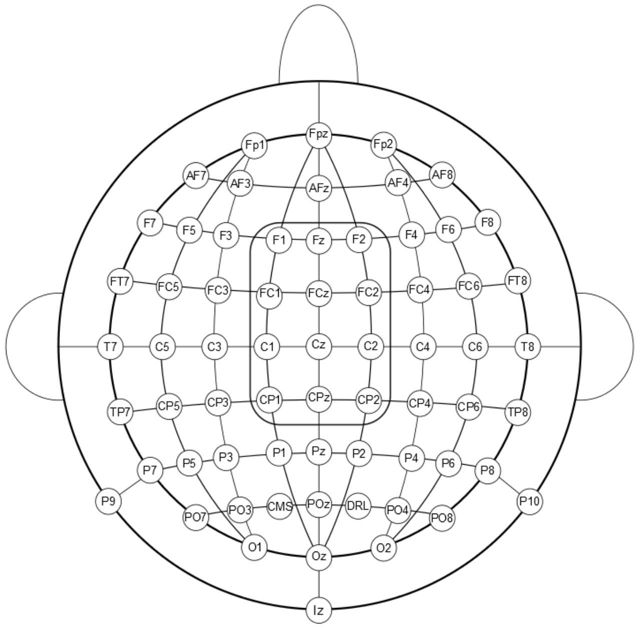


Figure 3. Reaction times (ms) per trial type in the English block and Korean block.

a)



b)

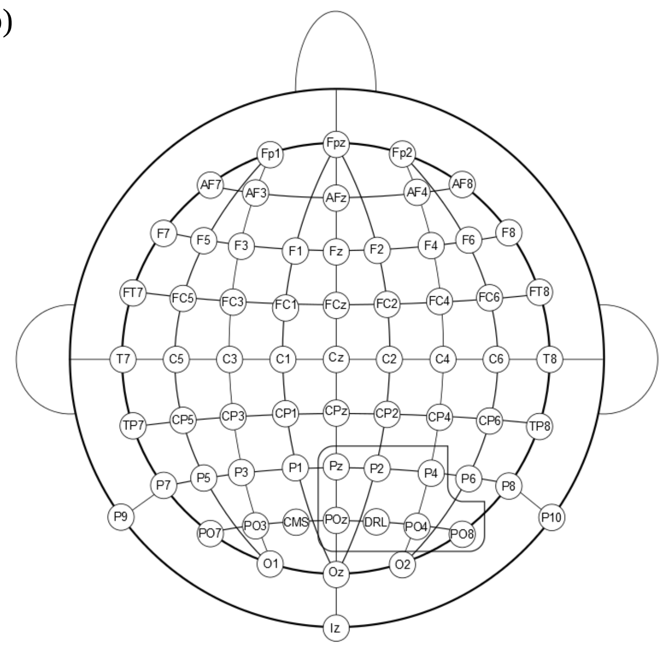
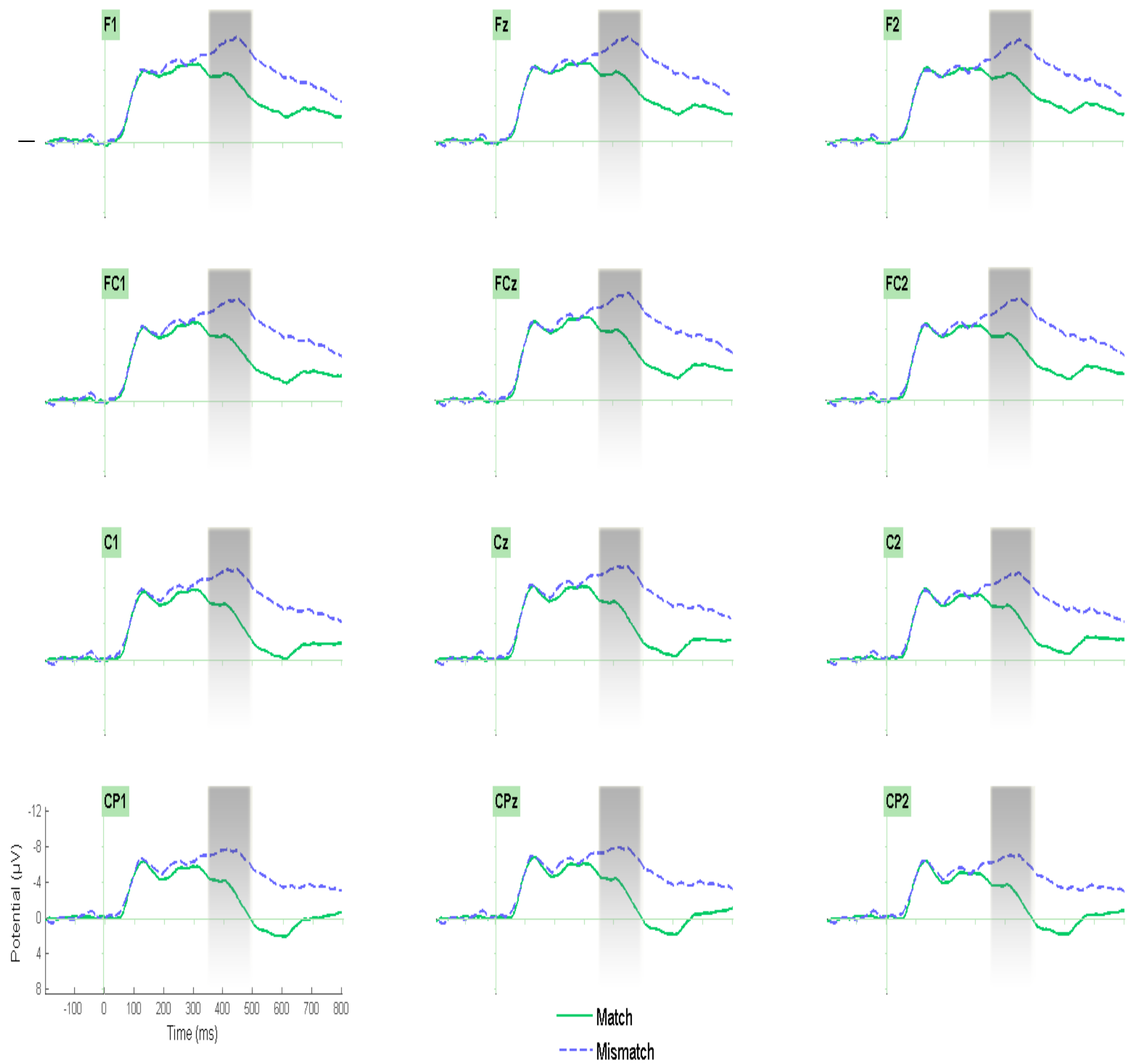


Figure 4. ERP scalp map of region of interest for a) the N400 and b) the LPC.

a) Neutral block 1



b) Neutral block 2

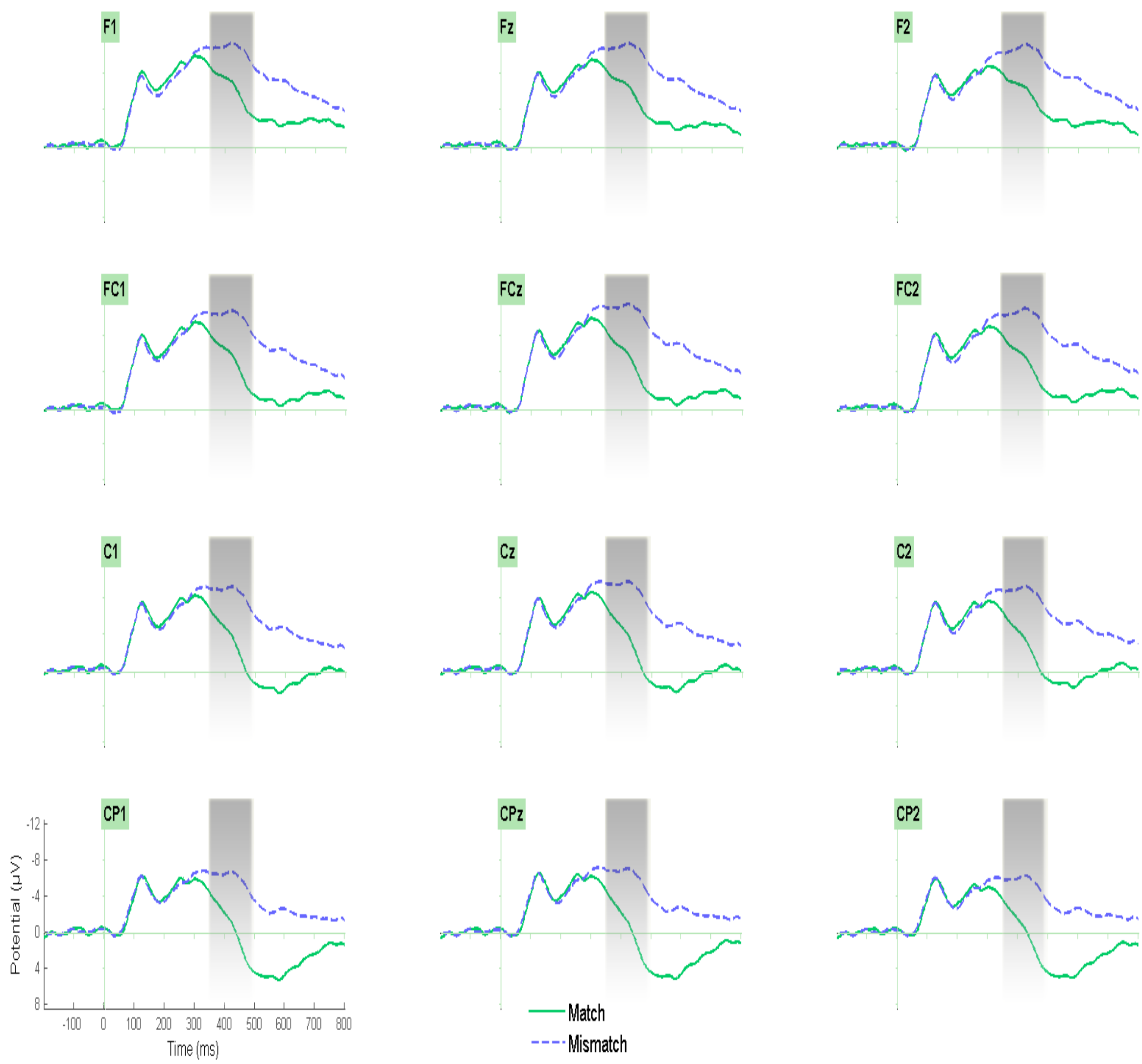
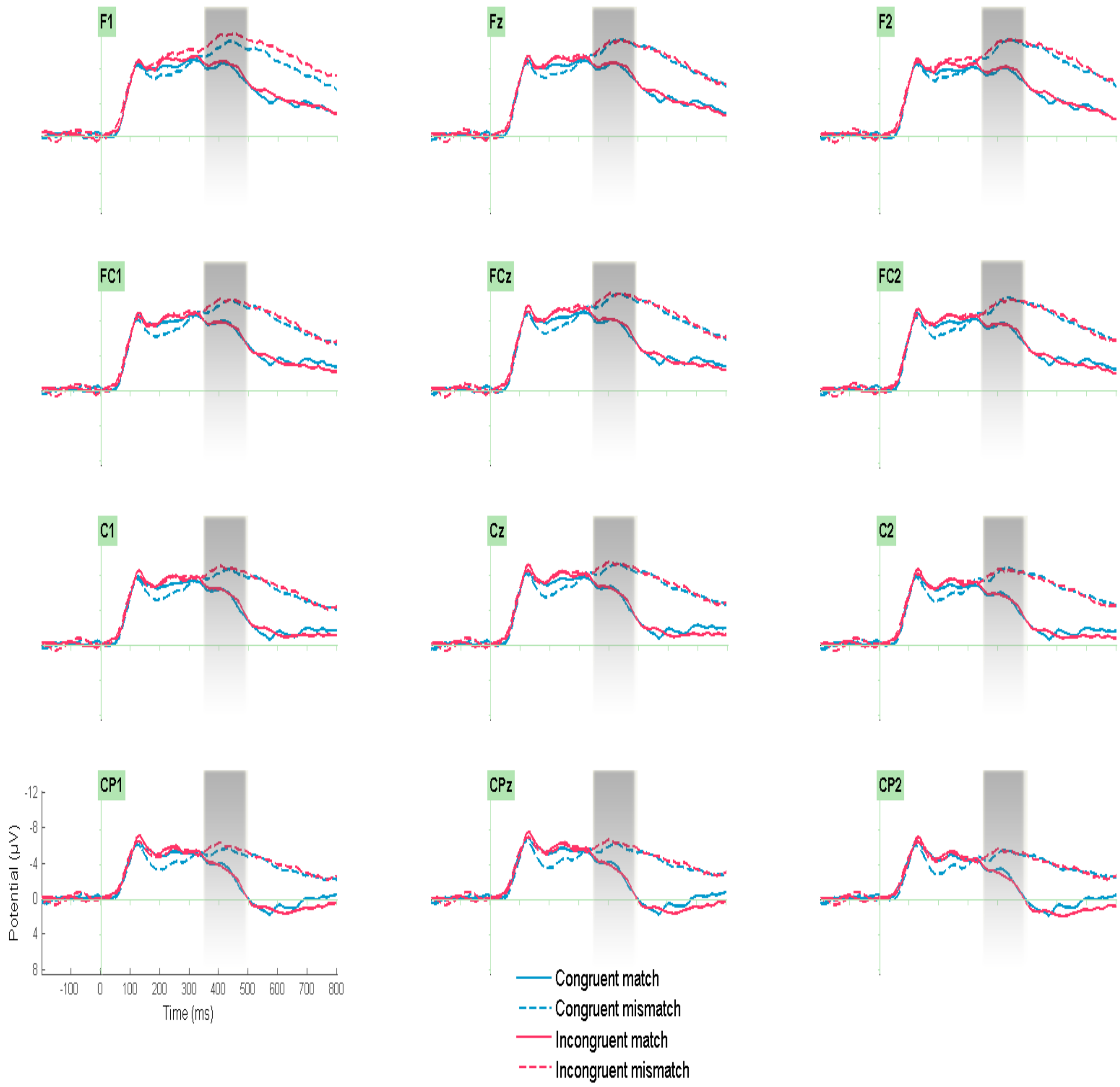


Figure 5. ERPs in the region of interest highlighting the N400 in a) neutral block 1 and b) neutral block 2.

a) English block



b) Korean block

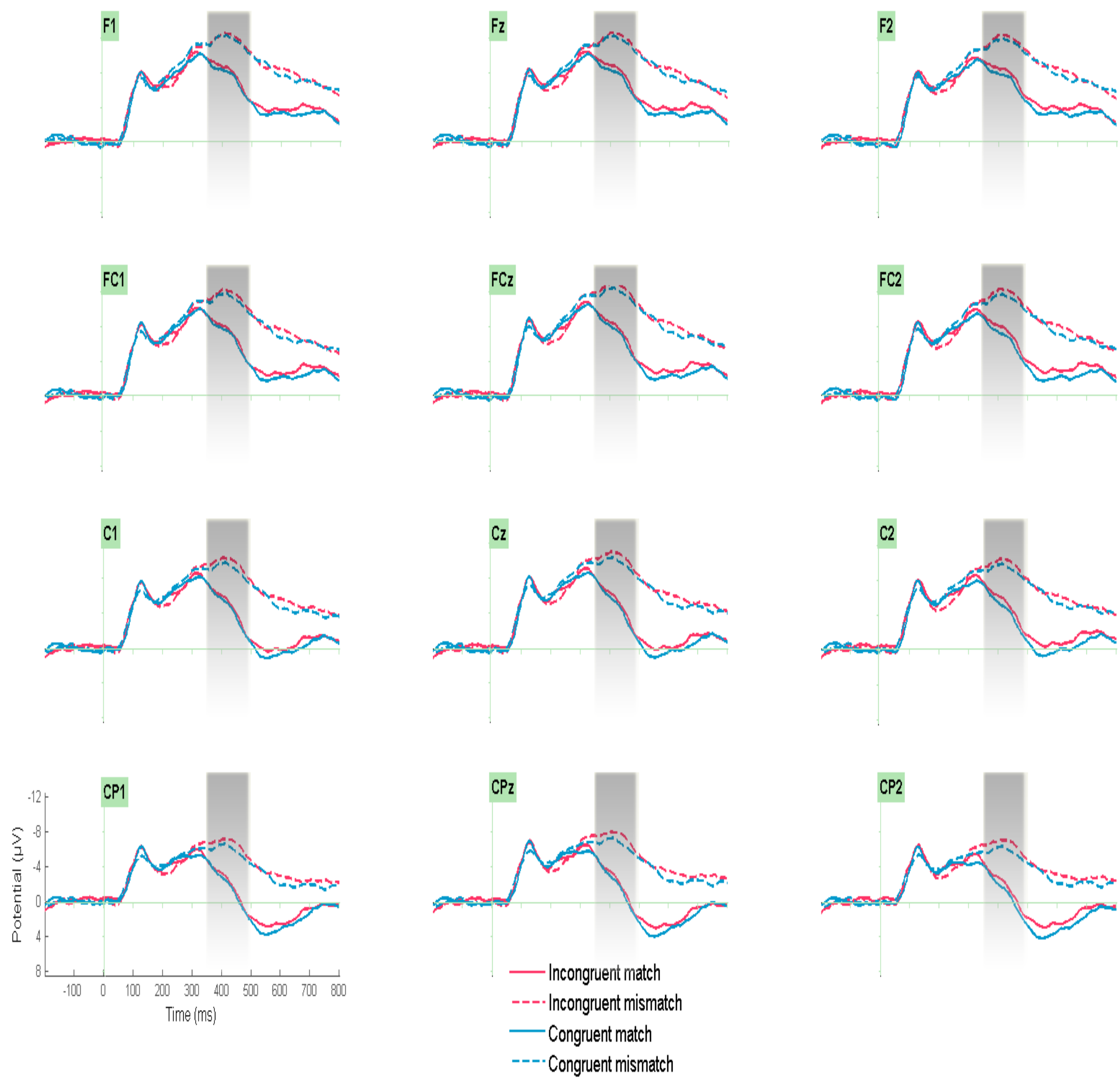
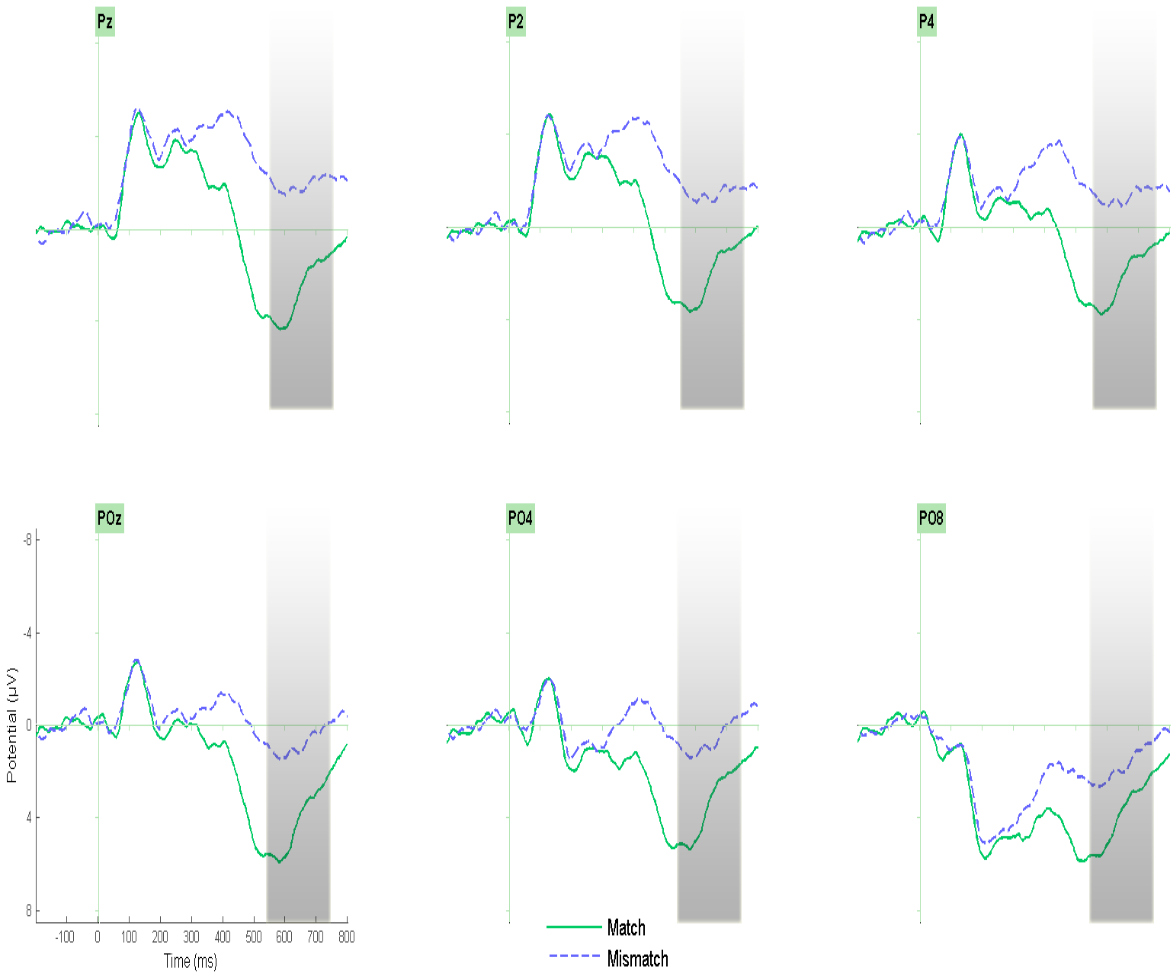


Figure 6. ERPs in the region of interest highlighting the N400 in a) the English block and b) the Korean block.

a) Neutral block 1



b) Neutral block 2

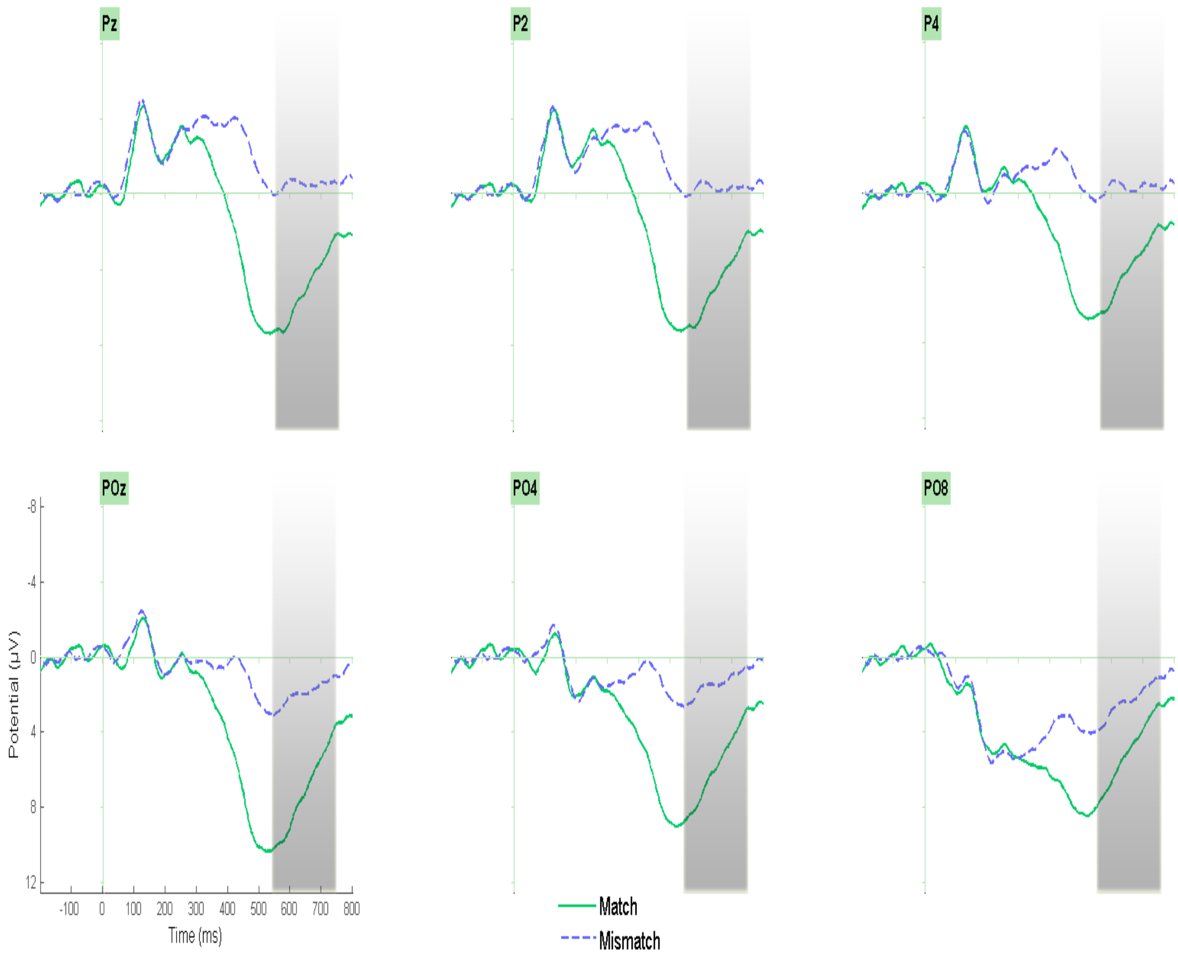
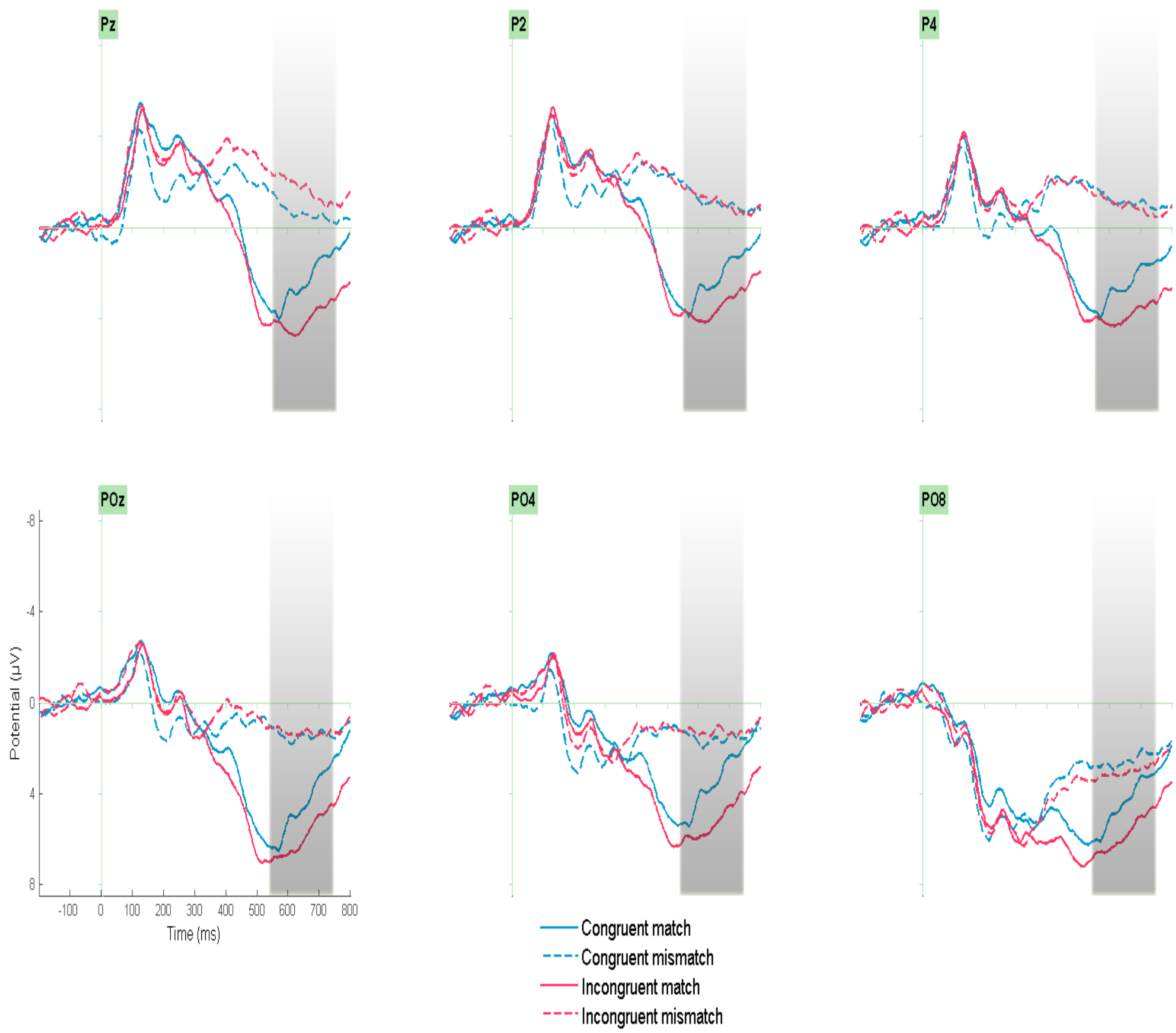


Figure 7. ERPs in the region of interest highlighting the LPC in a) neutral block 1 and b) neutral block 2.

a) English block



b) Korean block

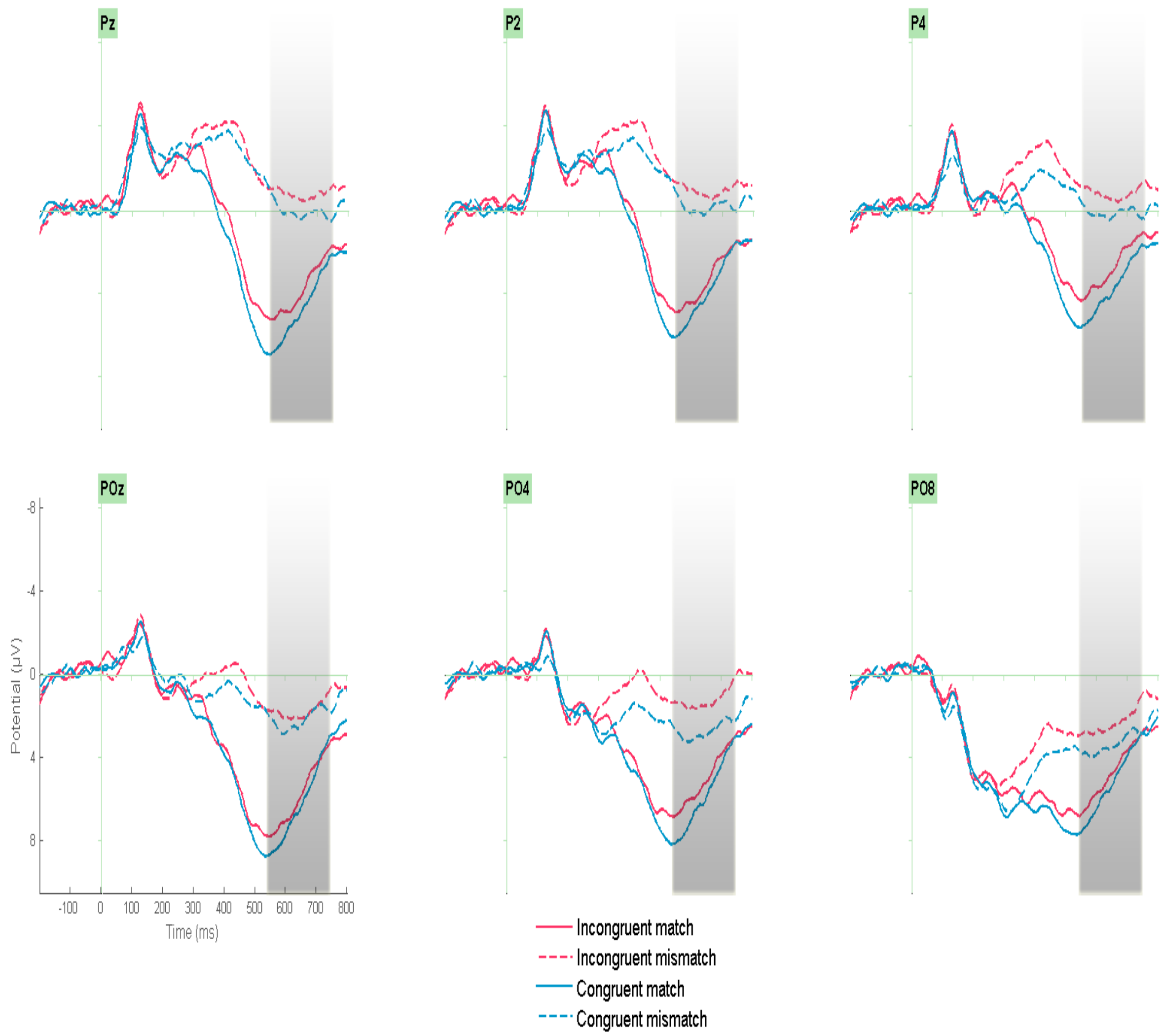


Figure 8. ERPs in the region of interest highlighting the LPC in a) the English block and b) the Korean block.

Appendices

A. Stimuli list
B. Consent form
C. LSBQ

<u>Monocultural stimuli</u>[2]

Name	Familiarity	Complexity	Difficulty	NA-ness[3]	Log Frequency	Syllable Length
apple	6.9	1.6	1.4	6.3	11.10	2
balloons	6.5	1.7	1.8	6.1	7.02	2
baseball	6.5	1.1	1.3	6.7	9.82	2
bat	6.2	2.2	1.4	5.4	8.78	1
beaver	6.3	2.2	1.9	6.5	7.45	2
blender	6.8	1.9	1.3	6.5	6.88	2
book	6.6	1.4	1.2	6.1	12.16	1
cactus	6.1	1.9	1.5	6.1	7.10	2
cake	6.9	1.9	1.3	6.5	8.74	1
cannon	6.2	2.0	2.5	5.7	8.93	2
canoe	6.3	1.7	1.7	6.4	7.45	2
cat	6.5	2.0	1.4	6.2	10.56	1
coffee	6.9	2.0	1.4	6.5	9.82	2
desk	6.9	1.7	1.4	6.3	9.52	1
diamond	6.7	2.5	1.2	6.3	9.81	3
doctor	6.8	2.5	1.6	6.4	10.37	2
fish	6.3	2.0	2.1	4.7	10.33	1
fountain	6.1	1.8	1.9	5.5	8.37	2
goose	6.5	1.7	2.1	6.9	7.49	1
guitar	6.6	2.0	1.2	6.4	10.12	2
helmet	6.7	1.5	1.3	6.2	8.66	2
horse	6.5	1.5	1.1	5.8	10.08	1
jacket	6.5	2.0	1.7	6.4	9.23	2
jeans	7.0	1.1	1.2	6.3	8.35	1
knife	6.9	1.3	1.5	5.6	8.87	1
lamp	7.0	1.9	1.4	6.5	8.80	1
mittens	6.7	1.3	1.3	6.7	5.59	2
pen	6.7	1.5	1.5	5.9	8.98	1
phone	7.0	1.7	1.6	6.6	11.86	1
piano	6.4	2.3	1.3	5.7	9.14	3
rabbit	6.7	1.7	1.6	6.2	8.66	2
sandwich	6.9	1.9	1.2	6.7	7.75	2
scarf	6.8	1.3	1.5	6.1	6.72	1
scooter	6.1	1.7	1.9	4.7	6.61	2
toque	6.3	1.9	2.1	6.1	4.49	1
tractor	5.9	2.4	1.8	6.3	7.38	2
violin	6.4	2.0	1.4	5.3	7.86	3
Mean	6.58	1.81	1.54	6.12	8.67	1.68

2. Numbers indicate mean ratings out of 7, obtained from 15 participants
3. Colloquial term used during testing, indicating relevance to North American culture, or ‘North American-ness’

<u>English Bicultural pairs</u>

Name	**Familiarity**	**Complexity**	**Difficulty**	**NA-ness**	**Log Frequency**	**Syllable Length**
airplane	6.9	1.6	1.0	6.4	8.46	2
alcohol	6.2	2.7	1.7	5.8	9.56	3
bookmark	6.3	2.6	2.3	5.6	7.45	2
bridge	6.5	2.2	1.8	6.5	9.87	1
candy	6.7	2.9	1.5	6.0	8.49	2
car	6.8	1.3	1.4	6.7	11.37	1
coin	6.7	1.9	1.7	6.5	8.76	1
dog	6.9	1.3	1.1	6.5	10.97	1
drums	5.8	2.2	1.9	5.5	8.72	1
farmer	6.6	1.9	1.2	6.6	8.52	2
flag	7.0	1.2	1.1	6.9	9.64	1
fridge	6.9	1.1	1.1	6.5	7.38	1
house	7.0	2.3	1.5	6.3	11.55	1
jersey	6.7	1.6	1.5	6.5	9.64	2
mailbox	6.9	1.3	1.3	7.0	9.08	2
mask	6.0	1.6	1.7	4.7	9.42	1
mirror	6.5	1.5	1.5	5.6	10.21	2
money	7.0	1.3	1.1	7.0	12.25	2
noodles	6.5	1.5	1.3	4.8	7.07	2
outlet	7.0	1.6	1.3	6.4	8.21	2
pears	6.9	1.5	1.2	6.1	5.73	1
playground	6.9	3.3	2.3	6.2	7.22	2
police	6.3	2.3	2.3	6.6	10.78	2
porridge	5.4	2.4	2.9	5.1	5.48	2
ribs	6.5	1.6	1.6	6.3	7.52	1
sauna	5.7	2.1	2.5	5.3	6.32	2
snacks	6.9	2.7	1.6	6.7	6.87	1
sneakers	6.7	2.1	1.1	6.6	6.77	2
soup	6.1	2.1	2.1	5.3	8.71	1
statue	5.7	2.9	2.0	5.7	8.96	2
table	6.6	1.2	1.2	6.2	10.94	2
teapot	6.5	1.7	1.7	5.1	5.78	2
tower	5.0	3.0	3.1	4.4	10.08	1
train	6.4	2.3	1.7	6.7	10.06	1
tree	7.0	2.3	2.1	6.7	10.21	1
vendor	6.0	2.4	2.1	5.7	9.43	2
yams	6.0	1.3	2.3	4.5	4.76	1
Mean	6.47	1.97	1.70	6.02	8.71	1.57

Korean Bicultural pairs[4]

Name	Familiarity	Complexity	Difficulty	NA-ness
밥상	5.6	2.9	3.2	3.4
배	4.2	2.9	4.1	3.8
차주전자	5.1	3.0	2.4	3.5
유니폼	6.5	2.2	1.7	5.5
동상	4.2	3.9	3.5	2.9
갈비	5.7	1.7	1.9	4.5
기차	6.4	2.3	1.7	5.1
고구마	4.7	2.3	2.8	4.4
고무신	4.4	2.9	4.0	1.9
국	5.4	2.1	2.7	3.5
과자	4.1	3.6	3.4	1.9
경찰	4.3	2.5	3.6	1.8
집	3.7	3.2	3.7	1.5
콘센트	4.7	2.4	2.7	3.0
놀이터	6.7	2.4	1.7	5.7
포장마차	3.6	4.3	4.6	2.9
소나무	5.6	2.6	2.6	4.1
탑	4.5	3.1	3.3	4.6
비행기	6.9	2.5	1.2	6.5
차	7.0	2.0	1.2	6.4
책갈피	3.6	4.1	3.9	4.0
다리	6.1	3.1	1.9	5.8
돈	4.0	3.0	3.1	2.5
동전	3.4	2.1	2.2	2.0
장구	4.6	4.1	3.7	3.7
죽	4.8	2.9	3.0	3.3
냉장고	3.0	3.7	5.1	3.7
농부	5.0	2.5	3.1	2.3
라면	5.1	2.9	2.9	3.3
사탕	1.8	3.8	6.0	2.0
손거울	2.6	4.1	4.7	2.1
술	4.5	2.3	2.9	2.7
태극기	6.3	1.5	1.8	2.0
탈	4.3	2.5	1.9	2.6
우편함	5.9	2.4	2.3	3.9
개	7.0	1.9	1.5	6.3
찜질방	2.9	3.3	4.5	2.9
Mean	4.8	2.8	3.0	3.6

4. No log frequencies were able to be obtained, but assumed to be equal between languages. Syllable length could not be matched to English based upon conceptual and interlinguistic differences.

INFORMED CONSENT
Korean-English Bilingual Study

Sponsor: York University
This research has been approved by the Human Participants Review Subcommittee (HPRC) of York University for compliance with York University Senate Ethics policy.

Purpose of the Study
The purpose of the study is to better understand the effect of visual context on object identification. We will study Korean-English bilingual adults from the York University URPP.

What You will be Asked to Do in the Study
You will be asked to complete a background questionnaire, as well as computer based tasks, such as:

- Tests of vocabulary
- Naming objects while wearing an EEG cap
- Classifying objects according to culture and familiarity

We will provide you with clear instructions and examples at the beginning of each task so that you will know what to do. We will provide you with breaks throughout the testing time if you wish to take them, and we will answer any questions that you may have. The study will take about 2 hours. You will receive course credit for the time you spent with the researcher.

Voluntary Participation
Participation in this study is completely voluntary. The decision to participate is entirely up to you.

Risks and Discomforts
We do not expect the study to cause any risks or discomforts for you. However, if you feel uncomfortable or become tired, you can take a break whenever you want.

Withdrawal from Study: You can stop participating in the study any time you want, for any reason you want. If you decide to withdraw, you do not need to give a reason, and it will not prejudice your future relations with me, with this university, or any part of this university. If you decide to stop participating for any reason, you will still be eligible to receive the promised pay (URPP credits) for agreeing to be in the project. Should you withdraw from the study all of your data generated will be destroyed.

Confidentiality
The information (data) we get from you during the study will be kept confidential. Your name will never be used in connection with any of the data we collect. Your signature below indicates that you are willing for the *information* we got from you to be used in an article or lecture as long as your name is not revealed. Your data will be safely stored in a locked file cabinet and only my

 Participant's Initial's: ___

supervisor and I will have access to this information. Your confidentiality will be maintained to the extent allowed by law.

Benefits
You will not receive direct benefit from being in this study. However, your participation will facilitate our understanding the role of language on various cognitive processes involved in object identification.

Questions
If you have any questions about the research in general or about your role in the study, please feel free to contact the principal investigator, Dr. Ellen Bialystok, either by phone at (416) 736-2100 x 66109 or by e-mail (ellenb@yorku.ca).

Ellen Bialystok, Ph.D.
Principal Investigator

Legal Rights and Signatures
You will receive a copy of this informed consent. You are not waiving any of your legal rights by signing this form. Your signature below indicates that you agree to participate in this study.

This research has been reviewed by the Human Participants in Research Committee, York University's Ethics Review Board and approved the protocol for compliance with Senate ethics policy. If you have any questions about this process, or about your rights as a participant in the study, please contact the Manager of Research Ethics for York University at the Office of Research Ethics, 309 York Lanes, York University (telephone 416-736-5914).

Name of Participant (Print): _________________________ Birth date: ____________________

Signature of Participant: ___________________________ Today's Date: ________________

Signature of Experimenter:___________________________ Today's Date: ________________

Cognition and Development Lab

Ellen Bialystok Ph.D, Principal Investigator
Department of Psychology, York University

Language & Social Background Questionnaire

1. Today's date (D/M/Y):________________ 4. Occupation/University

Major:_______________

2. Sex: M F 5. Date of Birth (D/M/Y):-

____

3. Handedness: L R

6. What is the highest year of school you have completed?______________________________

7. What is the highest degree you have earned?_______________________________________

8. On average, how many hours do you use a computer per week?________________________

9. On average, how many hours do you play video/computer games per week? ______________

10. Do you have hearing problems? Yes No

If Yes, do you wear a hearing aid? Yes No

11. Do you have vision problems? Yes No

If Yes, do you wear glasses/contacts? Yes No

Is your vision corrected to 20/20 with glasses/contacts? Yes No

12. Are you colour blind? Yes No

If Yes, what type? _______________________

13. Do you have any known neurological impairments? Yes No

Have you ever had a head injury? Yes No

Are you currently taking any psychoactive medications? Yes No

Please indicate the highest level of education for each parent:

14. **Mother**

1._____No high school diploma

2. _____High school graduate

3. _____Some college or college diploma

4. _____Bachelor's Degree

5. _____Graduate or professional degree

Native language: ___________________

Second language: ___________________

15. **Father**

1. _____No high school diploma

2. _____High school graduate

3. ____Some college or college diploma

4. _____Bachelor's Degree

5. _____Graduate or professional degree

Native language: ___________________

Second language: ___________________

16. Were you born in Canada? Yes No

If No, where were you born? ____________________________________

When did you move to Canada? ____________________________

Have you ever lived in a place where English is not the dominant communicating language? Yes No

If Yes, where & for how long?	1	____________	From:	________	To:	________
	2	____________	From:	________	To:	________
	3	____________	From:	________	To:	________

17. ***Language Background***

List all the languages and dialects you can speak including English, *in order of fluency*:

Language	**Where did you learn it? (Home, School, Community)**	**Where do you use it? (Home, School, Friends, Travel, Other)**	**At what age did you learn it?**
1.			

2.			
3.			
4.			
5.			

Do you have any knowledge of another language, even though you are not fluent? Yes No

If Yes, please explain____

Did you study any other languages during high school? Yes No

If Yes, which language and for how many years?_________________________________

On each of the following scales, indicate the proportion of use for English and your other language in **daily life**. On one end, 0 indicates that the activity in that environment is carried out in ALL ENGLISH. On the other end, 100 indicates that only the other language(s) is used. You can mark anywhere on the scale, so please be as precise as possible.

All English ... No English
0 25 50 75 100

1. Language spoken to family members
2. Language spoken to friends
3. Language for watching watched TV/video
4. Language for reading books/magazines, etc
5. Language written (e.g. shopping list, notes)
6. Language used in the community and cultural activities.

Relative to a native speaker's performance, rate your proficiency level in a scale of 0 – 100 for the following activities conducted in English and your other language.

English

No Proficiency — Native-like

0 — 25 — 50 — 75 — 100

Speaking

Understanding (Comprehension)

Reading

Writing

Other Language: ______________________ (please indicate)

No Proficiency — Native-like

0 — 25 — 50 — 75 — 100

Speaking

Understanding (Comprehension)

Reading

Writing

Global self-assessment:

Overall, how would you describe your level of bilingualism?

Not bilingual Non-fluent bilingual Fluent bilingual

1 2 3 4 5

1 – speak predominantly one language – only know a few vocabulary in the other language. 2 – weak bilingual – know enough to carry out some conversation to a very limited extent (use key words with not much grammar) – need to listen to sentences more than once before understanding. 3 – unbalanced bilingual – able to carry out basic conversation with minor grammatical errors – without the other speaker repeating the sentence – has difficulty producing a fluent conversation. 4 – practical bilingual – can carry out conversation fluently – does not use the second language everyday 5 – fluent bilingual – able to converse fluently and actively use two languages everyday – lived abroad in a community that has English as the dominant language

Experimenter's judgment: __________