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Cultural Context as a Biasing Factor for Language Activation in Bilinguals

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Abstract

Two studies investigated how cultural context and familiarity impact lexical access in Korean-English bilingual and English monolingual adults. ERPs were recorded while participants decided whether a word and picture matched or not. Pictures depicted versions of objects that were prototypically associated with North American or Korean culture and named in either English or Korean, creating culturally congruent and incongruent trials. For bilinguals, culturally congruent trials facilitated responding but ERP results showed that images from both cultures were processed similarly. For monolinguals, culturally incongruent pairs produced longer RTs and larger N400s than congruent items, indicating more effortful processing. Thus, an unfamiliar culture impeded linguistic processing for monolinguals but facilitated it for bilinguals familiar with that culture. Study 2 presented images that were more or less familiar and both groups replicated the pattern for monolinguals in Study 1. Therefore, in Study 1 monolinguals responded to familiarity but bilinguals responded to culture.

Keywords: lexical selection; bilingualism; culture; ERP

Cultural Context as a Biasing Factor for Language Activation in Bilinguals

Substantial research has shown that both languages are constantly active in bilingual minds, even in contexts in which only one is required (see Kroll & Gollan, 2014, for a review). How do bilinguals select the target language and avoid interference from the competing language? Correct lexical selection requires increased activation of the target language relative to the competing language; level of activation is modulated by such factors environmental context (Linck, Kroll, & Sunderman, 2009), and task demands (Lemhöfer & Dijkstra, 2004). Another potential factor in moderating the level of activation of each language is the cultural context in which language use occurs. Knowledge of word meanings may include culture-specific knowledge (Dong, Gui, & MacWhinney, 2005; Pavlenko 2009; Winograd, Cohen, & Barresi, 1976) and this knowledge may also contribute to the selection process. As a result, lexical access will be easier when word meaning is accessed through the language of its associated culture. The current study evaluated this hypothesis by employing Event Related Potentials (ERPs) to investigate how cultural context impacts lexical access for Korean-English bilinguals and English monolinguals. Since language use typically takes place in a rich context, it is important to understand how it is affected by features of that context to create a more complete understanding of language processing and language representation by bilinguals.

Much of the research examining lexical selection in bilinguals has manipulated the overlap between the two languages, showing, for example, faster responses to cognates than to single language control words in such paradigms as picture naming tasks (e.g., Costa, Caramazza, & Sebastián-Gallés, 2000; Kroll, Dijkstra, Janssen, & Schriefers, 2000). These results suggest that the shared features of two activated languages facilitate access by converging on the target lexical item. However, few studies have examined the role of language- or culture-specific information on word retrieval. In picture naming studies, the target images tend to be culturally neutral (e.g., Costa et al., 2000; Gollan, Fennema-Notestine, Montoya, & Jernigan, 2007), yet cultural differences between concepts and images are pervasive: a wedding dress is white in North America but red in China. Therefore, words that are translation equivalents may refer to culturally-distinct concepts that are accessed differently by bilinguals depending on the language and the cultural context.

Following on the idea that concepts are encoded differently in different languages, Malt, Sloman, Gennari, Shi, and Wang (1999) asked English, Chinese, and Spanish monolingual speakers to group a set of objects that included jars, bottles, and containers according to their perceived physical, functional, and overall similarity and then asked them to name each object. They found that categorization based on perceived similarity was highly correlated across language groups, but the groups assigned different labels to many of the objects (e.g., a jar in one language would be a bottle in another). The authors concluded that linguistic category boundaries differ from perceptual categories. Ameel, Storms, Malt, and Sloman (2005) replicated this finding with Dutch and French monolinguals, but also found that Dutch-French bilinguals named objects in a way that reflected an influence of both languages. That is, bilinguals showed a unique naming pattern that was midway between that of each single language group. They suggested that category boundaries for bilinguals are vulnerable to convergence due to permeability of their language representations. Thus, even though a dictionary translates the Dutch word *fles* as *bouteille* in French or *bottle* in English, speakers of these languages may have different concepts of what best represents the word in each language.

Two possibilities exist for how culture might bias language selection. The first possibility is that the connection strengths between culture-specific exemplars and their labels in the language of that culture are stronger than the connections between those concepts and the translation equivalent in the other language. Associative strength to individual words in each language has been demonstrated to be a significant factor for lexical access in that language (Gollan, Montoya, Cera, & Sandoval, 2008). In their shared (distributed) asymmetrical model, Dong et al. (2005) posited that connection strength would be stronger between conceptual elements that are unique to a culture and its language, with weaker connections between these language specific conceptual elements and the other language. Similarly, Pavlenko (2009) suggested that conceptual representations may be completely shared, partially shared, or fully language-specific. An example is that there is no English translation for the Filipino word *gigil* – the closest approximation is “cute aggression”. This perspective predicts that it is easier to access a culture-specific concept through its associated language than from the more weakly associated language due to stronger lexical connections at the level of the individual words. Evidence from Jared, Poh, and Paivio (2013) favours this perspective. In their study, Chinese-English bilinguals who had spent time living in both cultures named the same set of pictures in both Chinese and English. Naming times were faster for culturally-biased pictures named in the corresponding language. That is, Chinese-biased pictures were named faster in Chinese and English-biased pictures were named faster in English. These faster naming times suggest that lexical connection strengths were stronger between the culture and its associated language.

A second possibility for the effect of cultural context on language selection is that cultural-specific elements increase activation of the associated language, creating a sort of cultural priming that becomes involved in the selection process. Grosjean’s (2013) proposal for a continuum from “monolingual mode” to “bilingual mode” implies that the relative activation of each language can be modulated by the context. For example, presenting a block of second language words before performing a first language task increases the impact of L2 on L1 (Jared & Kroll, 2001; Jared & Szucs, 2002) by increasing the activation level of the L2. Immersion programs in a second language can make access to the first language more difficult (Linck, Kroll, & Sunderman, 2009). According to this perspective, faster responses to the congruency between culture-specific concept and label is due to higher modulated activation of the language associated with the culture-specific concept, a congruity that biases a response in that language.

In support of this perspective, Marian and Kaushanskaya (2007) found that Mandarin-English bilinguals gave different answers to the same question depending on the language in which the question was posed. For example, the instruction to "name a statue of someone standing with a raised arm while looking into the distance" elicited the 'Statue of Liberty' when asked in English and the 'Statue of Mao' when asked in Mandarin. Zhang, Morris, Cheng, and Yap (2013) found that exposure to typically Chinese faces and objects (L1 cues) disrupted the fluency of Chinese-English bilinguals when speaking their L2, English. They proposed that the visual context provided by heritage-culture cues influences bilinguals' linguistic access. Taken together, the evidence supports the idea that cultural context affects language activation in bilinguals and changes the speed or efficiency of lexical selection.

The evidence for an effect of cultural context on language processing suggests that culture might be one of the factors that impacts the relative activation of the jointly-activated alternatives and therefore influences the ease or efficiency of selecting the target language for bilinguals. The proposal is that the nonverbal context biases attention towards the word that matches the context, either through strength of the lexical connections or level of overall language activation, leading to cultural priming. This convergence undoubtedly facilitates the correct selection most of the time, but it also leads to selection errors, so it is part of the constellation of factors that determine lexical selection by bilinguals. Monolinguals also need to select between competing alternatives, but the conditions under which those selections are made, the processes underlying the selection, and the electrophysiological correlates of those selections are different for monolinguals and bilinguals (Friesen, Chung-Fat-Yim, & Bialystok, 2016). Experiencing multiple cultures is unique to bilinguals, so understanding the role of cultural context in lexical selection will provide a more complete account of language processing in bilinguals.

To examine the effect of cultural context on language selection, the present study included two novel features. First, in contrast to previous research (e.g., Jared et al., 2013; Marian & Kaushanskaya, 2007; Zhang et al., 2013), a group of monolingual participants was included to control for stimulus effects in the absence of cultural associations and to confirm that group differences could be attributed to cultural knowledge. Participants were Korean-English bilinguals who had resided in both cultures and English monolinguals who were not familiar with Korean culture. Stimuli were culturally-biased towards either Korean or North American culture by presenting prototypical images from each culture (see Figure 1 for examples). Participants saw a picture and simultaneously heard a word; the task was to decide if the word and picture matched. Cultural congruency was defined in terms of the relation between the cultural bias conveyed in the picture and the language in which it was named; a prototypical North American bowl of soup was culturally congruent if the word “soup” was presented in English but culturally incongruent if the word was presented in Korean, even if it was the correct Korean word for soup. Bilinguals performed the task in both English and Korean and English monolinguals performed the task only in English.

Second, ERPs were recorded to capture the time-sensitive details of processing during lexical selection. Two ERP components are relevant for investigating lexical access: the N400 and LPC. The N400 reflects the integration of lexical and semantic knowledge (Kutas & Hillyard, 1980; Kutas & Federmeier, 2011). It is largest when there is a violation of expectation in linguistic processing and is reduced when semantic integration is more automatic. Moreover, the amplitude of the N400 amplitude is proportional to the degree to which the expectancy has been violated (Kutas & Hillyard, 1984). For example, in a picture matching task, large N400s are elicited when a spoken word and picture do not match and as such cannot be integrated (Desroches, Newman & Joanisse, 2009). The LPC has been implicated in functions such as identification of syntactic violations (Osterhout & Holcomb, 1992), uncertainty in discourse processing (Burkhardt, 2007), updating information (Guo, Misra, Tam, & Kroll, 2012) and reanalysis (see Kolk & Chwilla, 2007, for a review). Brouwer, Fitz, and Hoeks (2012) suggest that the LPC reflects the integration of lexical information with semantic representations to form an updated concept.

To our knowledge, no studies to date have used ERP to examine the effect of cultural context on lexical access in bilinguals but previous studies have pointed to the importance of the N400 and LPC in bilingual processing (Guo & Peng, 2006; Thierry & Wu, 2007; Zhang, van Heuven, & Conklin, 2011). Ellis et al. (2015) asked balanced Welsh-English bilinguals to read passages that were either in English or Welsh, relevant or irrelevant to Welsh culture, and either true or false. True passages elicited smaller N400s than false ones, but there was a three-way interaction between language, cultural relevance, and truth value such that N400 amplitude differences between truth conditions was greatest when passages were written in Welsh and related to Wales. The authors concluded that the language of presentation influenced semantic processing of verifiable, culturally relevant information. Moreno, Federmeier, and Kutas (2002) asked Spanish-English bilinguals to read English sentences in which the final word could be highly expected, a synonym of the expected word, or a Spanish translation equivalent of the expected word. An LPC was present when the final word was a translation equivalent, but not an expected word or synonym. The presence of an LPC when lexical choices did not match language expectations but was appropriate to the meaning of the sentence suggested that further processing was necessary once the language expectations were violated. Consistent with Brouwer et al. (2012), readers needed to integrate the unexpected word into the context to form an updated understanding of the sentence.

It was predicted that cultural congruency would bias lexical selection for bilinguals such that responses to culturally congruent trials would be faster than those to culturally incongruent trials in both the English and Korean tasks. Because the same pictures were used in each language task, the predictions for which items are faster refer to different picture-word pairs and not to different pictures; a picture of Korean soup and the Korean word for soup should be faster than the response to the same picture and the English word for soup. Therefore, results do not depend on specific features of the individual pictures but rather on the relation between the picture and the language of the presented word. Monolinguals should have greater difficulty identifying the less familiar Korean images than the North American images, leading to longer RTs to the Korean items than to the North American items.

The ERPs might provide insight into whether differences can be attributable to differences in associative strength or activation levels of the two languages. Effects on the N400 reflect lexical/semantic processing (Kutas & Federmeier, 2011) so stronger associations between culture specific objects and their label should lead to attenuation in the N400 for culturally congruent trials in both languages. If cultural priming is due to increasing relative activation of the relevant languages, however, then the effect may be expected later in processing on the LPC when information is updated. Since monolinguals have no experience with Korean items, difficulty with lexical access on the culturally incongruent trials should result in larger N400s followed by larger LPCs to integrate the novel concepts.

Lexical selection during spoken word recognition is central to language use and requires bilinguals to constrain processing to the appropriate language. Previous studies have examined the role of language context, language mode, and task demands on these processes, but few have investigated the role of cultural context. Past research has shown that picture naming and concept associations vary with the cultural context, but no study has investigated the underlying processes in real time. The hypothesis for the present study is that cultural context biases lexical selection.

Study 1

Method

Participants

Data were collected from 49 Korean-English bilinguals and 46 English monolinguals. Seven bilingual participants were removed from data analysis due to low English proficiency (n = 3), low Korean proficiency (n = 1), or poor EEG signal quality (n = 3). Seven monolingual participants were excluded from data analysis due to poor EEG signal quality (n = 4) or technical issues (n =3). The final sample consisted of 42 Korean-English bilinguals (27 female; age range 18-28 years, M = 21.0), and 39 native English speakers (23 female, age range 18-30 years, M = 23.9). All participants were right-handed with no known neurological impairments. All bilingual participants had lived in Korea for a minimum of one year. Korean was the first language for all bilinguals. Eleven bilinguals reported higher proficiency in English than in Korean.

Monolinguals reported minimal or no knowledge of Korean culture. Participants received course credit or $20 for their participation. The research was conducted with the approval of the university's Human Participants Review Committee.

Tasks and Instruments

Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997). Measures of receptive vocabulary knowledge were obtained by administering the PPVT in both English (Form-A; bilinguals and monolinguals) and a non-standardised Korean translation (Form-B; bilinguals only). Participants heard a word and chose which of four pictures corresponded to that word. Administration procedures followed instructions in the examiner's manual. Raw scores were used to compute standard scores; the test has a mean of 100 with a standard deviation of 15. Since there is no official Korean version of the PPVT, Form B was translated and used as an estimate of receptive Korean vocabulary knowledge. The English Form-A and Korean Form-B were counterbalanced for presentation order for bilinguals.

Language and Social Background Questionnaire (LSBQ; Anderson, Mak, Keyvani Chahi, & Bialystok, in press). The LSBQ was used to gather information about participants' demographic background, parental education (scale of 1 to 5, where 1 indicates they did not complete high school and 5 they obtained a graduate degree), language use across different contexts, self-rated measures of language proficiency, and self-rated measure of bilingualism. Language use and proficiency were rated so that a score of 100 indicated entirely English usage in that specified scenario, and 100 indicated complete fluency in that language. Self-ratings of bilingualism were similarly scored so that 0 indicated being monolingual and 100 was fluently bilingual.

Cultural Context Task. The stimuli consisted of 111 photographs **(**37 culturally-neutral, 37 North American-biased, and 37 Korean-biased). The culturally-neutral pictures were objects that did not have features that were prototypically Korean or North American (e.g., baseball, pen, and violin are the same across cultures). The culturally-biased pictures included a prototypical example of each object from each culture, as shown in Figure 1.

To confirm the classification into these three categories and the comparability of the pictures as stimuli across categories, 31 participants including 15 non-Korean young adults and 16 Korean-English bilinguals were recruited to rate the 111 pictures. None of these participants were involved in the main study. The participants were asked to rate each picture on four dimensions using a 7-point Likert scale for each, with 7 indicating ‘very’ and 1 indicating ‘not at all’. The dimensions were visual complexity, naming difficulty, familiarity, and relevance to North American culture.

The mean ratings for the four measures are presented in Table 1. Analyses were conducted for each rating measure to compare values across the three picture categories separately by language group; conducting an overall analysis led to interaction effects that could not be interpreted without examining the groups separately. For monolinguals, Korean-biased pictures were rated as more visually complex, $F(2, 108) = 34.55$, $p < .001$, more difficult to name, $F(2, 108) = 41.31$, $p < .001$, less familiar, $F(2, 108) = 53.70$, $p < .001$, and less relevant to North American culture, $F(2, 108) = 83.64$, $p < .001$) than neutral or North American pictures, which did not differ from each other. For bilinguals, ratings revealed no differences between Korean-biased, North American-biased, or neutral pictures in familiarity, $F < 1$, visual complexity, $F(2, 108) = 2.74$, $p > .07$, or difficulty in naming, $F(2, 108) = 1.87$, $p > .16$. However, there was a significant difference between all three picture types on relevance to North

American culture, $F(2, 108) = 222.43$, $p < .001$, in which North American items were viewed as most relevant, neutral items significantly less so, and Korean items significantly less again.

Individual audio files containing 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 North American items to ensure acoustic matching across items (e.g., speaker's tone, pitch, and timbre).

Two factors were manipulated in the design: semantic match and cultural congruency. Semantic match is the relation between the picture and the word irrespective of language; a picture of Korean soup and the word for soup in either English or Korean is a semantic match, but a picture of soup and a word other than "soup" in either language is a semantic mismatch. Cultural congruency is the relation between the cultural bias of the picture and the language of the heard word; a picture of Korean soup and a Korean auditory stimulus (whether or not it is the word for soup) is culturally congruent, whereas a picture of Korean soup and an English word is culturally incongruent. Figure 1 presents examples of the different trial types. The task was to determine whether the picture matched the word irrespective of the cultural bias of the picture.

Bilinguals performed four blocks of trials, and monolinguals performed three blocks because they were not given the Korean condition. Blocks 1 and 4 presented the neutral stimuli with English auditory cues and served as a control. Each picture was presented once with a match and once with a mismatch (74 trials) in each of the two neutral blocks (148 trials). Blocks 2 and 3 presented the culturally-biased pictures with English audio cues or Korean audio cues, with the order of language counterbalanced for the bilinguals. In each block, each picture was presented once with the correct label and once with an incorrect label (148 trials in each block), resulting in 37 each of culturally congruent matches, culturally incongruent matches, culturally congruent mismatches, and culturally incongruent mismatches in each bicultural block.

Pictures were presented on a Dell 1908 FP Flat Panel monitor located approximately 50 cm in front of the participant, with audio played through two Logitech speakers placed in front of the participant just under the monitor. The monitor and speakers were connected to a Dell computer running E-Prime software. A centrally located fixation cross was presented for a period between 500-1000 ms on a jittered randomization, followed by a picture and auditory word presented simultaneously. Participants responded with one of two keyboard buttons indicating a semantic match or mismatch; the picture remained 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. To minimise ocular artifacts in the EEG recording, 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 randomization of the fixation cross pre-picture and blank screen post-response was included to circumvent anticipatory response effects.

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), referenced to 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 using electrolytic gel to maintain impedances below a maximum of 20 kΩ per electrode. The EEG signal was filtered offline at a .01Hz low cutoff and 80Hz high cutoff with referencing to an average mastoid measurement. The EEG signal was segmented into epochs between -200m (pre-stimulus) to 800ms (post-stimulus) and the waveforms were baseline-corrected using the pre-stimulus timeframe.

All analyses were conducted using the EEGLAB and ERPLAB toolboxes in Matlab software. Trials with extreme voltages (over 400 µV) or drift caused by excessive skin conductance were removed from each participant's recording by visual inspection. Eye blinks and eye movements were modelled using Infomax independent components analysis (ICA) and removed from each participant's EEG recording. Any electrode sites showing high frequency noise were interpolated. Grand average waveforms were created from individual subject ERP data. Mean amplitudes were determined for the N400 (350-500 ms) and the late positive component (LPC, 450-750 ms).

Results

Behavioural Outcomes

Background measures are reported in Table 2. There was no difference between language groups on mother's education level, $t(62) = 1.95$, *n.s.*, but monolinguals scored significantly higher than bilinguals on the English PPVT, $t(79) = 5.00$, $p < .001$ (cf., Bialystok & Luk, 2012). Bilingual participants obtained higher scores on vocabulary in Korean than in English, $t(41) = 7.53$, $p < .001$, a finding that is not surprising since Korean was their first language.

Results of the cultural context task are presented in Table 3 for accuracy and RT. Incorrect trials were excluded from RT analysis, as were trials with RTs 2.5 standard deviations slower than a participant's mean RT for a given condition. This led to the removal of 3.2% of trials for the monolinguals and 3.1% of trials for the bilinguals. All repeated measures ANOVAs 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. Accuracy was near ceiling for all conditions (range 91-99%) with the exception of English monolinguals on incongruent match trials in the English block (85%), indicating that they were not able to identify Korean-biased objects as easily. Thus, accuracy was not analysed further.

Because the blocks included different variables, separate analyses were conducted for each. The neutral blocks served as a baseline condition to compare bilingual and monolingual lexical processing in the absence of cultural bias. There were no RT differences between the first and last neutral block so these were combined for further analyses. A 2-way ANOVA on RTs for semantic match and language group showed no significant effects, all *F*s < 1.3.

Bilingual participants completed the culturally-biased block with English and Korean words in an order that was counterbalanced across participants. An analysis of order of presentation for bilinguals showed no significant of effect in the behavioural or ERP data, *F*s < 1. Therefore, order was not a significant factor and was not considered in subsequent analyses.

Performance on the culturally-biased block with English words was analysed with a 3-way ANOVA for cultural congruency, semantic match, and language group. There was a main effect of language group with faster responses by bilinguals than monolinguals, $F(1, 79) = 6.24$, $p = .015$, $\eta_p^2 = .07$. There was a marginal effect of semantic match, $F(1, 79) = 3.40$, $p = .069$, and a main effect of cultural congruency with faster responses to congruent trials, $F(1, 79) = 113.05$, $p < .001$, $\eta_p^2 = .59$. These effects were modulated by a three way interaction of group, congruency, and semantic match, $F(1, 79) = 10.26$, $p = .002$, $\eta_p^2 = .12$. To explore the interaction, analyses were conducted separately by language group. For the bilingual group, there was an interaction of semantic match and congruency, $F(1, 41) = 4.51$, $p = .04$, $\eta_p^2 = .10$, in which RTs were faster to semantic match than mismatch trials for culturally congruent items, $F(1, 41) = 16.12$, $p < .001$, $\eta_p^2 = .28$, with no difference between match and mismatch trials for culturally incongruent items, $F < 1$. Moreover, these items did not differ from mismatch trials for incongruent items, so match trials to congruent items were faster than all other responses. For the monolingual group, there was also a significant interaction of semantic match and congruency, $F(1, 38) = 39.70$, $p < .001$, $\eta_p^2 = .51$. As with bilinguals, monolinguals responded faster to match than mismatch trials for congruent items, $F(1, 38) = 19.00$, $p < .001$, $\eta_p^2 = .33$, but unlike bilinguals they were slower to respond to match than mismatch trials for incongruent items, $F(1, 38) = 6.86$, $p = .013$, $\eta_p^2 = .15$.

For the Korean word block completed by the bilinguals, a 2-way ANOVA indicated no effect of semantic match, $F < 1$, a marginal effect of cultural congruency, $F(1, 41) = 3.84$, $p = .057$, $\eta_p^2 = .09$, but a significant interaction between them, $F(1, 41) = 10.69$, $p = .002$, $\eta_p^2 = .21$. Simple main effects analysis replicated results found with the English block: match trials were faster than mismatch trials for congruent items, $F(1, 41) = 12.93$, $p = .001$, $\eta_p^2 = .24$, with no difference between match and mismatch trials for incongruent items, $F < 1$. Again, only match trials for congruent items differed from the other three trial types.

ERP Outcomes

ERP analyses were performed on mean amplitudes. A 3x3 electrode region of interest was examined for the N400 (350 ms to 500 ms), extending anteriorly-posteriorly (AP) from fronto-central to central posterior electrodes, and covering a left to right width (LR) of three electrode rows around the midline. The electrodes examined were FC1, FCz, FC2, C1, Cz, C2, CP1, CPz, and CP2. Although the N400 is often found more posteriorly, this central region was selected based on research that suggests a more anterior distribution of the N400 for pictures (McPherson & Holcomb, 1999). To examine the LPC (450 ms to 750 ms), a 2 (AP) x 3 (LR) region centered on the midline was analysed which included the electrodes P1, Pz, P2, PO3, POz, and PO4. The electrode sites indicating AP and LR were included as factors in the analyses, but they did not produce any significant interactions with variables of interest (semantic match, cultural congruency), so for clarity those results are not reported.

As with the behavioural analyses, the blocks were analysed separately because they included different variables and were designed for different purposes. The primary question for the neutral block was whether there were group differences on simple object recognition. The English block evaluated the effect of cultural congruency across language groups and the Korean block compared performance of the bilinguals in the two languages. For all analyses, 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.

For the neutral block, a 4-way repeated measures ANOVA for language group, semantic match, AP site, and LR site was run on each of N400 and LPC mean amplitudes. In the analysis of N400 (Figure 2A and 2B), there was a significant effect of semantic match, $F(1, 79) = 178.39$, $p < .001$, $\eta_p^2 = .69$, in which there was greater negativity for mismatch than for match trials. There were no significant group effects or interactions with group, *F*s < 1. The LPC analysis (Figure 3A and 3B) showed a significant effect of semantic match, $F(1, 79) = 166.58$, $p < .001$, $\eta_p^2 = .68$, with match trials eliciting a late positive deflection and mismatch trials showing a relatively flat waveform. There was no effect of group, $F < 1$, or interaction effects, *p*s > .05. Therefore, in the absence of the cultural manipulation, match trials led to reduced N400 and larger LPC than mismatch trials for both language groups.

For the English block, a 5-way repeated measures ANOVA examining language group, cultural congruency, semantic match, AP site, and LR site was conducted separately for the N400 and LPC. For the N400 (Figure 4A and 4B), there were main effects of cultural congruency, $F(1, 79) = 7.51$, $p = .008$, $\eta_p^2 = .09$, and semantic match, $F(1, 79) = 140.36$, $p <$

.001, $\eta_p^2 = .64$, with no main effect of group, $F < 1$, but a significant interaction between group and congruency, $F(1, 79) = 6.98$, $p = .01$, $\eta_p^2 = .08$. Simple main effects analysis revealed no effect of cultural congruency for bilinguals, $F < 1$, but larger N400 to culturally incongruent than congruent trials for monolinguals, $F(1, 38) = 10.13$, $p = .003$, $\eta_p^2 = .21$. Therefore, bilingual responses to the N400 were affected only by semantic match but monolingual responses were affected by both semantic match and cultural congruency.

The LPC analysis (Figure 5A and 5B) showed main effects of semantic match, $F(1, 79) = 158.03$, $p < .001$, $\eta_p^2 = .67$, and congruency, $F(1, 79) = 8.85$, $p = .004$, $\eta_p^2 = .10$. There was no main effect of group, $F < 1$, but there was an interaction of congruency and group, $F(1, 79) = 13.67$, $p < .001$, $\eta_p^2 = .15$. Simple main effects analysis revealed again no effect of congruency on amplitude for LPC in bilingual participants, $F < 1$, but a significant effect of congruency for monolinguals, $F(1, 79) = 21.47$, $p < .001$, $\eta_p^2 = .21$, with more positive waveforms for culturally congruent than incongruent trials. No other interactions were significant, Fs < 2.7.

Visual inspection of these data suggests that the cultural congruency effect began earlier than the N400 time window, so the P2 component was taken as a potential marker, occurring around 150-250 ms and located at the vertex (Crowley & Colrain, 2004). This window was analysed using the same electrode sites as in the N400 analysis. There was a main effect of congruency, $F(1, 79) = 17.71$, $p < .001$, $\eta_p^2 = .18$, with more positive amplitudes on congruent than incongruent trials, but no main effects of group or lexical match, Fs < 2.3. There was also a significant interaction between lexical match and language group, $F(1, 79) = 8.62$, $p = .004$, $\eta_p^2 = .10$. Simple main effects analysis showed that bilinguals had a more positive P2 for lexical mismatch trials than match trials, $F(1, 79) = 4.18$, $p = .044$, $\eta_p^2 = .05$, while monolinguals had a more positive P2 for lexical match trials than mismatch trials, $F(1, 79) = 4.44$, $p = .038$, $\eta_p^2 =$

.05. No other interactions were significant, *F*s < 2.8.

Responses to the Korean block were examined by 4-way repeated measures ANOVAs for cultural congruency, semantic match, AP site, and LR site for each of the N400 and LPC. For the N400 (Figure 4C), there was a significant main effect of semantic match, $F(1, 41) = 123.45$, $p < .001$, $\eta_p^2 = .75$, with mismatch trials eliciting greater negativity than match trials. There was no effect of cultural congruency, $F < 1.6$, or interaction effects, *F*s < 2.1.

In the LPC analysis (Figure 5C), there was a marginal (but not significant) difference for congruency, $F(1, 41) = 3.05$, $p = .09$, $\eta_p^2 = .07$, but a significant main effect of semantic match, $F(1, 41) = 140.07$, $p < .001$, $\eta_p^2 = .77$. Match trials elicited more positive waveforms than their counterparts. No interactions were significant, *F*s < 1.

Discussion

The purpose of Study 1 was to examine the influence of nonverbal cultural bias on access to lexical alternatives for bilinguals. The key finding was that the relation between the cultural context of the picture and the language in which the word was presented led to differences between the two language groups in both behavioural and ERP outcomes. Bilinguals performed the task faster than monolinguals overall in the difficult culturally-biased condition with English words. The task requires constant monitoring and shifting, processes that have previously been shown to be more efficient in bilinguals (e.g., Costa, Hernandez, Costa-Faidella, & Sebastian-Galles, 2009). Additionally, bilinguals showed facilitation on trials where both the cultural context and the lexical decision converged on a match response. Monolinguals found it difficult to accept the word as a match when it conflicted with the cultural context. Both the faster overall RT by bilinguals and the longer RTs by monolinguals for trials in which there was conflict between cultural context (incongruent) and semantic match (match) values may reflect better executive control by bilinguals in performing this task.

Bilinguals exhibited faster response times to congruent matches in both English and Korean, indicating that the association between the language and the culturally appropriate picture facilitated lexical access. Importantly, the same pictures were employed but appeared in different conditions across language blocks, so RT results cannot be attributed to individual features of the images. Furthermore, bilingual ratings of stimuli indicate that familiarity was consistent across cultural bias whereas monolinguals judged the Korean-biased pictures to be less familiar. If familiarity were the primary factor influencing RTs, then bilinguals would have performed similarly on congruent match and incongruent match trials regardless of language because they were equally familiar. Instead, RT was impacted by the *relation* between the implicit culture depicted in the picture and the language in which the word was presented. This result is consistent with findings reported by Jared et al. (2013) showing that exemplars from a particular culture were named more quickly in the language of that culture. For monolinguals, the Korean-biased pictures were both culturally distinct and less familiar, so the two explanations cannot be separated for that group.

The neutral blocks served as a baseline to isolate the role of cultural bias in performance by removing that variable from the design, and both groups performed equivalently in this condition. Moreover, the ERP data showed the expected pattern in which match trials were associated with smaller N400 and larger LPC than mismatch trials. These results are consistent with those reported by Desroches et al. (2009) for a picture matching task in which mismatch trials yielded larger N400 amplitudes. Similarly, the LPC results are consistent with studies showing positive LPC when retrieving detailed information about a stimulus, including contextual information (Walsh et al., 2016). When the label does not match the picture, the absence of an LPC suggests that additional processing is halted.

Although the P2 component was not initially considered, visual inspection indicating early congruency effects led to an analysis of that time window. The results showed greater P2 amplitude for congruent than incongruent trials. The component is typically associated with visual attention, suggesting more attention on expected items than unexpected items for both language groups. This result is consistent with Federmeier and Kutas (2002) who found that the P2 on pictures is modulated by expectation; greater amplitude was associated with pictures that fit a sentence context, whereas pictures that violated expectations were associated with an attenuated P2. However, there was also an interaction with language group in that the effect of lexical match was different for the two groups. As in the rest of the results, the cultural manipulation affected the groups differently. For monolinguals, the effect of congruency persisted throughout the waveform to the N400 and LPC but for bilinguals the effect of culture appears to have been resolved following this early component. These results are considered suggestive only and have little impact on the overall interpretation, particularly since this pattern was not found for the Korean task.

The ERP results indicated that the effect of a semantic match was similar for all participants and was in the expected direction, namely, smaller N400 and larger LPC. However, only the monolinguals additionally responded to the cultural bias of the picture as an independent factor in the N400 and LPC. That is, monolinguals exhibited attenuation on the N400 and larger LPC for all culturally congruent items, whereas cultural congruency did not impact the N400 or the LPC for the bilinguals; in that case, the effect was found only in the RT. Thus, for bilinguals, objects from both cultures were perceived as being equally appropriate for the provided label. This differentiation between N400 and RT effects is more in line with a level of activation view than with a strength of representation view. If the results reflected greater connection strength between the culture-specific items and their associated labels, one would likely expect an attenuation on the N400 for congruent match trials only. Instead an interaction of semantic match and congruency is not observed until the response time measure. Our interpretation is that the cultural context of the picture preferentially increased activation to the name of the picture in the corresponding language for bilinguals and facilitated their response. This interpretation is speculative but suggests possible ways for distinguishing between the two types of accounts.

Similar results were found for the analyses of LPC. Overall, this component indicated a difference between match and mismatch trials for both groups but additionally reflected cultural congruency for the monolinguals. The presence of larger LPCs to culturally congruent than incongruent items is opposite to our initial prediction, but there was no precedent for predicting how the relation between image and word would affect LPC so the prediction was based on an analogy to word meaning (e.g., Moreno, Federmeier, & Kutas, 2002). However, some studies have posited that the LPC is associated with recollection of old items (e.g., Curran, 2000; Curran & Cleary, 2003), and in this view, the presence of more positive LPCs to culturally familiar items may not be surprising.

In Study 1, all participants benefitted from consistency between the cultural context of a picture and the language in which the word was presented by producing faster RTs for those trials. However, the ERP waveform of bilinguals indicated that the match-mismatch decision was based on comparable processing for congruent and incongruent cultural contexts, although this was not the case for monolinguals. To explore why these results were different for the two language groups and confirm that culture was the relevant factor for bilinguals, Study 2 held culture constant and manipulated familiarity of the stimuli.

Study 2

In Study 1, the relation between the cultural bias of the image and the language in which the word was presented affected performance in a picture-word verification task. Our interpretation was that the relative activation of the competing lexical alternatives for bilinguals is modified by the cultural context, making one alternative more salient. When cultural bias and language converge, responses are faster. Monolinguals showed a different pattern, particularly in the ERP results. However, in addition to being culturally incongruent, the Korean-biased pictures were also less familiar to monolinguals. To examine the effect of familiarity, Study 2 included a block that manipulated familiarity of culturally neutral images. If the results of monolinguals in Study 1 reflect familiarity, then both groups will perform similarly to monolinguals in Study 1 for behavioural and ERP measures. If some other factor were involved, then bilinguals will continue to perform differently from monolinguals even when cultural bias is not manipulated.

Method

Participants

A subset of 20 Korean-English bilingual and 17 English monolingual participants from Study 1 took part in this study. Background measures for this subset did not differ from those of the overall sample.

Familiarity Task

The familiarity block was added at the end of the task for the participants involved in Study 2. Thirty-seven culturally neutral items for which a label could be represented by images that differed in familiarity (e.g., ‘tie’ applies to a common necktie and the less familiar bowtie, ‘rose’ applies to a common red rose and a less familiar blue rose, and ‘peppers’ applies to common bell peppers and less familiar scotch bonnet peppers) were generated.

As in Study 1, a new group of 11 individuals who were not involved in the study rated the pictures for familiarity, visual complexity, and difficulty in naming. These results are shown in Table 1. High familiarity items were rated as more familiar, $F(1, 72) = 84.90$, $p < .001$, visually simpler, $F(1, 72) = 18.68$, $p < .001$, and easier to name, $F(1, 72) = 85.69$, $p < .001$, than low familiarity items. The audio files for the name for each item were recorded by a female monolingual English speaker. This pattern parallels the ratings by monolinguals in Study 1 in which North American and neutral items were rated as more familiar, visually simpler, and easier to name than Korean items.

Results

Behavioural Outcomes

Data analyses were conducted in the same manner as in Study 1, using the same trimming and ANOVA correction procedures. This led to the removal of 2.3% of trials for the monolinguals and 4.6% of trials for the bilinguals. Accuracy data for the familiarity block are presented in Table 3 but not analysed (range 89-99%).

Reaction time data were examined with a three-way ANOVA for group, familiarity, and semantic match. There was a main effect of familiarity, $F(1, 35) = 97.42$, $p < .001$, $\eta_p^2 = .74$, with faster RT for high familiarity than low familiarity trials, and no main effect of semantic match or group, *F*s < 1. There was a three-way interaction between group, familiarity, and semantic match, $F(1, 35) = 6.53$, $p = .015$, $\eta_p^2 = .16$. For bilinguals, there was a significant effect of familiarity, $F(1, 19) = 59.52$, $p < .001$, $\eta_p^2 = .76$, with faster RTs to high familiarity than low familiarity trials, but no effect of match or interaction effect, *F*s < 2.7. For monolinguals, there was an interaction of familiarity and match, $F(1, 16) = 15.34$, $p = .001$, $\eta_p^2 = .49$. Match trials were responded to faster than mismatch trials for high familiarity items, $F(1, 16) = 19.48$, $p <$

.001, $\eta_p^2 = .55$, but match trials were responded to significantly more slowly than mismatch trials for low familiarity items, $F(1, 16) = 5.59$, $p = .031$, $\eta_p^2 = .26$. These results for the monolinguals are similar to their performance for match responses on culturally incongruent trials in the English block in Study 1.

ERP Outcomes

Analyses of EEG were conducted in the same manner as Study 1, examining the same central 3x3 electrode array for N400 and the same 2x3 posterior array for the LPC. Five-way ANOVAs for language group, familiarity, semantic match, AP site, and LR site were conducted separately for each of the N400 and LPC data. For the N400, shown in Figure 6, there was a main effect of familiarity, $F(1, 35) = 13.92$, $p = .001$, $\eta_p^2 = .28$, and a main effect of semantic match, $F(1, 35) = 68.76$, $p < .001$, $\eta_p^2 = .66$. These effects revealed that the N400 was significantly reduced for high familiarity stimuli relative to low familiarity stimuli and for match trials relative to mismatch trials, reflecting greater ease of integration. There was no effect of language group, $F < 1$, and no significant interactions, Fs < 2.4.

In the LPC analysis, shown in Figure 7, there were again main effects of familiarity, $F(1, 35) = 5.70$, $p = .023$, $\eta_p^2 = .14$, and semantic match, $F(1, 35) = 98.84$, $p < .001$, $\eta_p^2 = .74$, with larger positive amplitudes for high familiarity relative to low familiarity and for match trials relative to mismatch trials. An interaction between familiarity and semantic match was significant, $F(1, 35) = 4.71$, $p = .037$, $\eta_p^2 = .12$. Simple effects analysis revealed that high familiarity match trials were significantly more positive than low familiarity match trials, $F(1, 35) = 8.08$, $p = .007$, $\eta_p^2 = .19$, but mismatch trials did not differ in terms of familiarity, $F < 1$. Again, there was no main effect of language group, $F < 1.7$, but there was an interaction between language group and semantic match, $F(1, 35) = 5.61$, $p = .023$, $\eta_p^2 = .14$. Simple effects analysis revealed that the difference between match and mismatch trials was similar for both groups but was greater for bilingual participants, $F(1, 35) = 82.46$, $p < .001$, $\eta_p^2 = .70$, than for monolingual participants, $F(1, 35) = 26.52$, $p < .001$, $\eta_p^2 = .43$. The interaction between familiarity and language group was not significant, $F < 1$.

Discussion

Study 2 examined the effects of familiarity on picture-word verification in the absence of cultural bias. Two features of the behavioural results contribute to the interpretation of Study 1. First, unlike Study 1 where bilinguals showed faster responses to trials in which cultural congruency and semantic match converged on a “yes” response, there was no facilitation found in Study 2 from the high familiarity match items; high familiarity items were responded to faster than low familiarity items regardless of match criteria. This pattern is consistent with the interpretation that the faster RTs to culturally congruent match trials for bilinguals in Study 1 reflected a type of cultural priming rather than familiarity. Second, as in Study 1, monolinguals produced slower reaction times to items for which the picture and word primed different responses; specifically, an unfamiliar picture induces a “no” response but the correct word requires a “yes” response. Although 50% of trials required a “yes” response, the low familiarity items are not immediately seen as matches and thus prime a “no” response, regardless of match status. This conflict did not slow RTs for bilinguals in either study. Bilinguals may be more efficient at dealing with conflicting cues, particularly those involving language and culture.

For both language groups, the ERP data were similar to monolingual results in Study 1. There were no main effects or interactions with group in the analyses of either the N400 or the LPC (with the exception of a difference in effect size for lexical match). The N400 was attenuated for high familiarity items and for match trials indicating that these items were consistent with expectations. In the LPC, there was no deflection in the waveform for mismatch trials, indicating that once a trial was identified as a mismatch, no further processing occurred. High familiarity match trials elicited a more positive deflection on the match trials than low familiarity match trials, suggesting that more information was retrieved about the familiar objects. Thus, in the absence of cultural biases, bilinguals and monolinguals accessed object names in similar ways.

General Discussion

Bilinguals must constantly manage conflict from jointly-activated languages to produce fluent speech in one of them. This ongoing selection from competing alternatives is likely part of the mechanism that leads to enhanced attention and selection processes in bilinguals generally (Bialystok, 2017). Lexical selection is modified by the nature of the linguistic features and the overlap between the two languages such that cognates, for example, facilitate lexical access in both languages (e.g., Friesen, Jared, & Haigh, 2014). The present studies demonstrate that nonverbal cultural context is another factor that biases the selection process by endorsing the lexical term that corresponds to that culture.

The study used a word-picture verification paradigm in which the relation between the word and picture was manipulated. The two main variables were the decision regarding whether the word and picture matched or not, and the cultural bias of the picture regarding whether it corresponded to the language in which the word was presented or not. In Study 1, monolinguals and bilinguals performed equivalently in a neutral condition that did not include cultural bias but bilinguals responded faster than monolinguals overall in the more difficult condition with biased pictures. Bilinguals were particularly fast for match items with culturally congruent pictures in both English and Korean, an effect we attribute to cultural priming. Monolinguals were also faster on culturally congruent match items, but they were slower to respond to culturally incongruent match items. The combination of these results means that the monolinguals were not experiencing cultural priming but rather responding to the dual effects of semantic match and cultural congruency, likely due to their lack of familiarity with the Korean items. The explanation for the slower responses to culturally incongruent match trials was that the two factors created a sort of conflict; this conflict was easily resolved by bilinguals but was problematic for monolinguals. Confirming this explanation, Study 2 manipulated familiarity instead of cultural bias and found that bilinguals were influenced only by familiarity with no facilitation for familiar match as was found for culture but monolinguals again revealed an interaction in which low familiarity match items were particularly difficult. Again, this conflict was not problematic for bilinguals.

The ERP results provided insight into the time-course of this lexical access. Both language groups showed reliable effects of semantic match in reducing the N400 and enhancing the LPC for match trials. These main effects were robust and found in both Study 1 where cultural bias was manipulated and Study 2 where familiarity was manipulated. However, in Study 1, only monolinguals showed an effect of cultural congruency in the ERP signal, an effect found for both the N400 and LPC. Bilinguals processed the pictures equivalently in both culturally congruent and culturally incongruent conditions whereas for monolinguals, the culturally incongruent pictures were more difficult to integrate and judge. The interpretation that monolingual performance reflects differences in familiarity of the culturally congruent and culturally incongruent items is confirmed by the results of Study 2. In this case, all the pictures were culturally neutral but differed in familiarity; the results showed similar performance by monolinguals and bilinguals in which integration was more effortful for the less familiar items, replicating the pattern found for monolinguals in Study 1. Thus, the culturally biased pictures created the possibility of cultural priming and improved access for bilinguals but were interpreted as differences in familiarity for monolinguals.

Our interpretation is that the cultural context of the picture modifies the activation levels of the two languages in the bilingual mind making the congruent label more salient. Therefore, seeing a picture of a bowl of soup raises the activation level of the English word but seeing a picture of a metal pot of soup raises the activation level of the Korean word. An alternative interpretation is that the association between each picture-word pair is stronger for pairs that match on culture than those that do not. Both interpretations are largely consistent with the results but emphasize different aspects – processing in the first case and representation in the second – but several aspects of the results appear to be more consistent with the processing view than the representation view. First, the results depended not on specific items but on the relation between items compared to other pairs. The words were all simple and well-known by all participants, but in specific contexts the culturally congruent labels were more accessible. Second, in the neutral blocks in Study 1 and in the familiarity block in Study 2 there were no differences between monolinguals and bilinguals, suggesting that without cultural variation, the strength of association between concepts and words were similar for participants in both groups. It seems unlikely that these association strengths would be equivalent. Finally, our explanation in terms of changes in activation levels as a function of cultural context is consistent with a study by Wu and Thierry (2013). They showed that bilinguals performed a nonverbal conflict resolution task differently when irrelevant words were flashed creating a monolingual or bilingual context. Performance was better in the bilingual context indicating that processing was modified by the context. Although we cannot rule out the role of strength of association in the representation, we find the explanation in terms of modification of the activation level of each language to be more compelling.

The results from the two studies point to the role of nonverbal cultural context in the ongoing linguistic selection processes by bilinguals. Access to the same lexical item, for example *soup*, can be manipulated by changing the visual features of the bowl of soup and therefore priming the label in either English or Korean. Therefore, bilinguals are constantly assessing information from multiple sources in online linguistic processing. As such, bilinguals are engaging a range of processes while attempting to produce speech in one of their languages, a situation that may lead to differences between monolinguals and bilinguals in nonverbal attention and selection (review in Bialystok, Craik, Green, & Gollan, 2009). There is no doubt that bilingual minds differ from monolingual minds in important ways, but understanding those differences requires documenting with as much precision as possible the processes that define them. The present studies show that the factors involved in lexical selection are one such difference.

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Disclosure

The authors report no conflicts of interest.

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Table 1. Mean rating (out of 7) and standard deviation for stimulus categories by raters for each study.

	Study 1 Korean-English Bilinguals (*n* = 16)			Study 1 Non-Korean Adults (*n* = 15)			Study 2 Young Adults (*n* = 11)	
	North American	Korean	Neutral	North American	Korean	Neutral	High Familiarity	Low Familiarity

Visual Complexity	1.6 (0.5)	1.7 (0.5)	1.4 (0.4)	2.0 (0.6)	2.8 (0.7)	1.8 (0.3)	2.0 (0.4)	2.5 (0.5)
Naming Difficulty	1.5 (0.6)	1.7 (0.6)	1.4 (0.5)	1.7 (0.5)	3.0 (1.1)	1.5 (0.3)	1.6 (0.4)	3.2 (1.0)
Familiarity	6.2 (0.7)	6.3 (0.5)	6.2 (0.6)	6.5 (0.5)	4.8 (1.3)	6.6 (0.3)	6.2 (0.5)	4.2 (1.2)
North-American Bias	5.4 (1.1)	1.6 (07)	4.9 (0.7)	6.0 (0.7)	3.6 (1.4)	6.1 (0.5)	n/a	n/a

Table 2. Demographic and background measures (and standard deviation) by language group in Study 1.

	Bilinguals (n = 42)	Monolinguals (n = 39)
Age	21.2 (2.7)	23.9 (3.2)
Mother's Education	3.7 (1.0)	3.3 (1.0)
Language Use		
Age of Korean Acquisition (in years)	0.6 (1.1)	n/a
Age of English Acquisition**	9.1 (3.7)	0.4 (0.7)
Language Proficiency		
Korean PPVT-B	117 (14.6)	n/a
English PPVT-A**	93 (12.2)	106 (10.3)
Self-Rated Korean Comprehension (out of 100)	92.0 (10.3)	n/a
Self-Rated Korean Speaking	90.2 (14.3)	n/a
Self-Rated English Comprehension**	82.5 (15.1)	99.9 (1.6)
Self-Rated English Speaking**	76.8 (19.6)	99.2 (3.5)
Self-Rated Level of Bilingualism (out of 100)**	83.7 (16.9)	5.0 (9.3)

* $p < .05$; ** $p < .01$;

Table 3. Mean accuracy (and standard deviations) as a function of block, trial type, and language group in Studies 1 and 2.

		Accuracy		Reaction Time	
Block	Trial type	Bilinguals	Monolinguals	Bilinguals	Monolinguals
Study 1					
Neutral combined	Match	0.95 (.04)	0.95 (.04)	721 (79)	743 (133)
	Mismatch	0.99 (.02)	0.98 (.03)	761 (98)	795 (145)
English block	Congruent match	0.95 (.04)	0.96 (.03)	750 (80)	779 (142)
	Congruent mismatch	0.99 (.02)	0.98 (.03)	789 (124)	832 (151)
	Incongruent match	0.92 (.05)	0.85 (.07)	784 (105)	914 (184)
	Incongruent mismatch	0.99 (.02)	0.98 (.03)	792 (96)	869 (164)
Korean block	Congruent match	0.94 (.05)	n/a	766 (82)	n/a
	Congruent mismatch	0.99 (.02)	n/a	796 (104)	n/a
	Incongruent match	0.91 (.07)	n/a	804 (118)	n/a
	Incongruent mismatch	0.98 (.02)	n/a	786 (96)	n/a
Study 2					
Familiarity	High familiarity match	0.93 (.05)	0.96 (.06)	724 (112)	717 (115)
	High familiarity mismatch	0.99 (.03)	0.99 (.02)	748 (98)	760 (130)
	Low familiarity match	0.89 (.06)	0.91 (.05)	802 (109)	854 (196)
	Low familiarity mismatch	0.98 (.03)	0.98 (.03)	801 (111)	801 (144)

Figure Captions

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

Figure 2. N400 at representative electrode FCz in the neutral blocks for (A) bilinguals and (B) monolinguals in Study 1.

Figure 3. LPC at representative electrode POz during neutral blocks for (A) bilinguals and (B) monolinguals in Study 1.

Figure 4. N400 at representative electrode FCz for (A) bilinguals in the English block, (B) monolinguals in the English block, and (C) bilinguals in the Korean block in Study 1.

Figure 5. LPC at representative electrode POz for (A) bilinguals in the English block, (B) monolinguals in the English block, and (C) bilinguals in the Korean block in Study 1.

Figure 6. N400 at representative electrode FCz during the familiarity block for (A) bilinguals and (B) monolinguals in Study 2.

Figure 7. LPC at representative electrode POz during the familiarity block for (A) bilinguals and (B) monolinguals in Study 2.

Fig 1

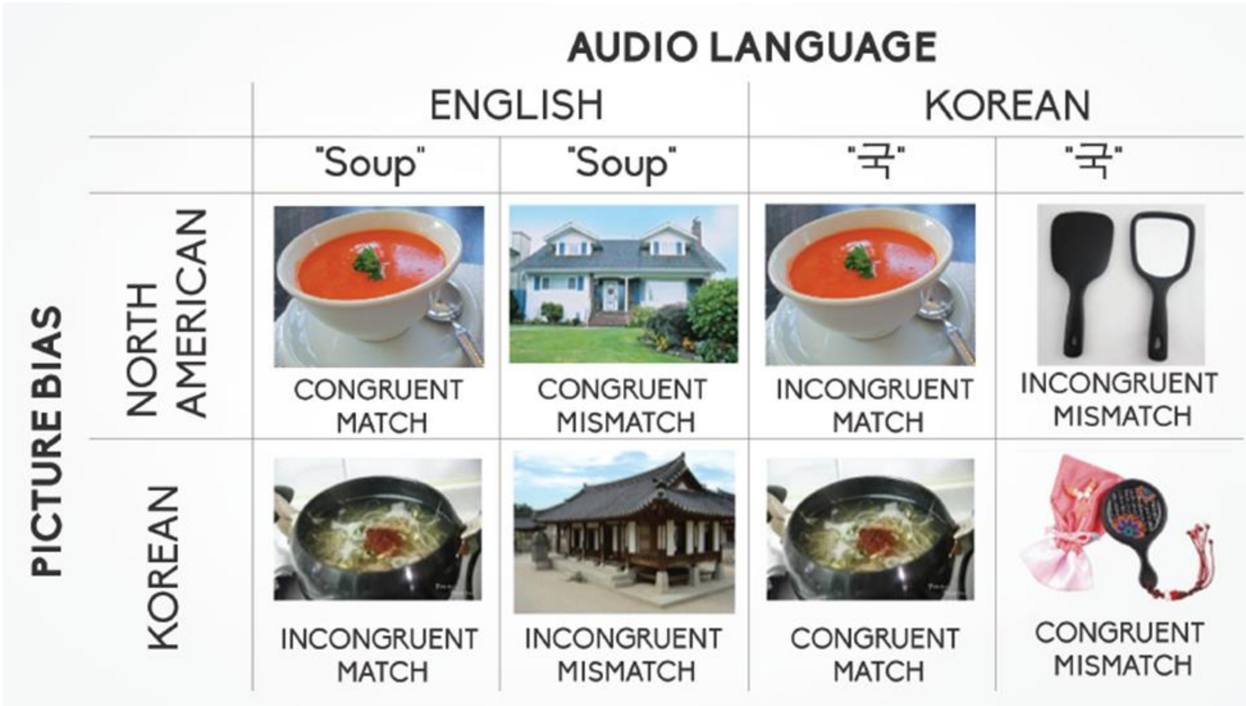

AUDIO LANGUAGE
ENGLISH
KOREAN
"Soup"
"Soup"
"국"
"국"
PICTURE BIAS
NORTH AMERICAN
KOREAN
CONGRUENT MATCH
CONGRUENT MISMATCH
INCONGRUENT MATCH
INCONGRUENT MISMATCH
INCONGRUENT MATCH
INCONGRUENT MISMATCH
CONGRUENT MATCH
CONGRUENT MISMATCH

Fig 2

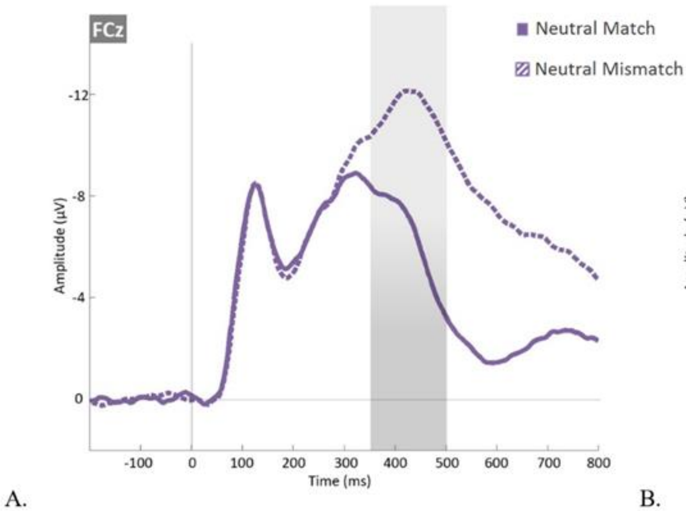
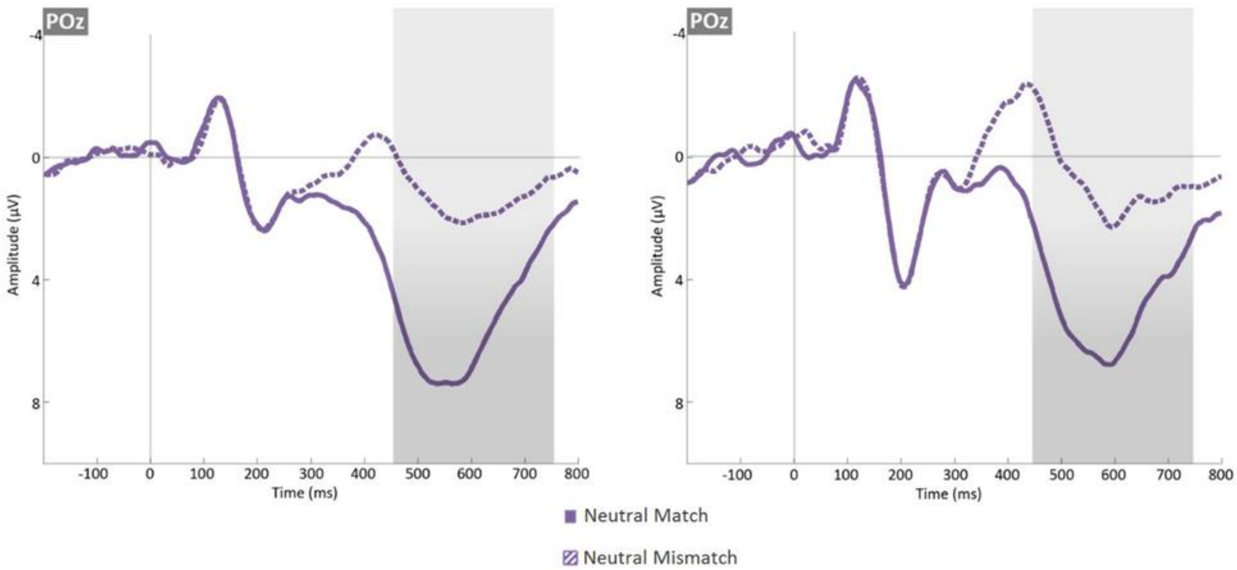

FCz
Neutral Match
Neutral Mismatch
Amplitude (µV)
-12
-8
-4
0
-100
0
100
200
300
400
500
600
700
800
Time (ms)
A.
FCz
Amplitude (µV)
-12
-8
-4
0
-100
0
100
200
300
400
500
600
700
800
Time (ms)
B.

Fig 3


POz
Amplitude (μV)
Time (ms)
POz
Amplitude (μV)
Time (ms)
Neutral Match
Neutral Mismatch

A.

B.

Fig 4

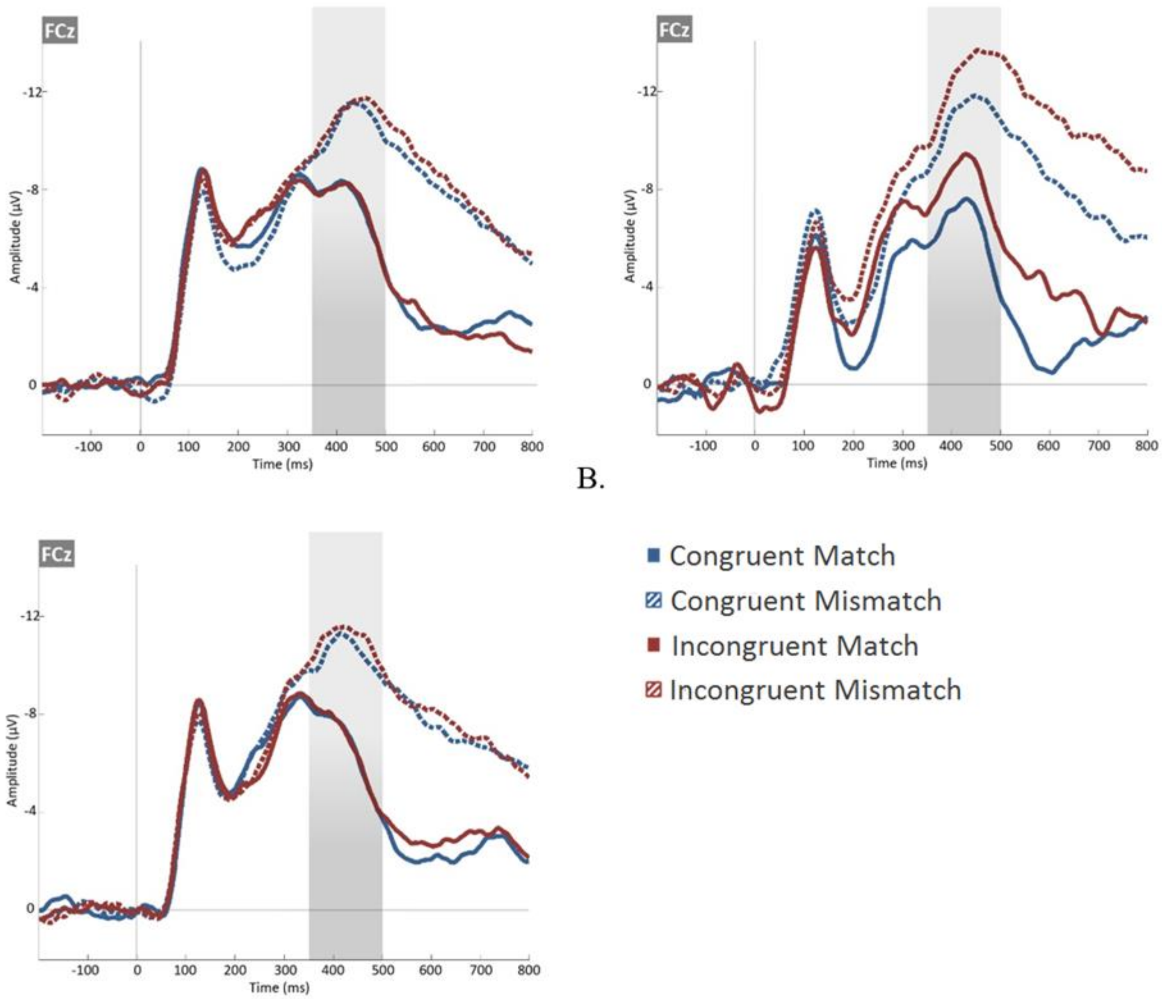

FCz
Amplitude (µV)
Time (ms)
A.
B.
C.
Congruent Match
Congruent Mismatch
Incongruent Match
Incongruent Mismatch

Fig 5

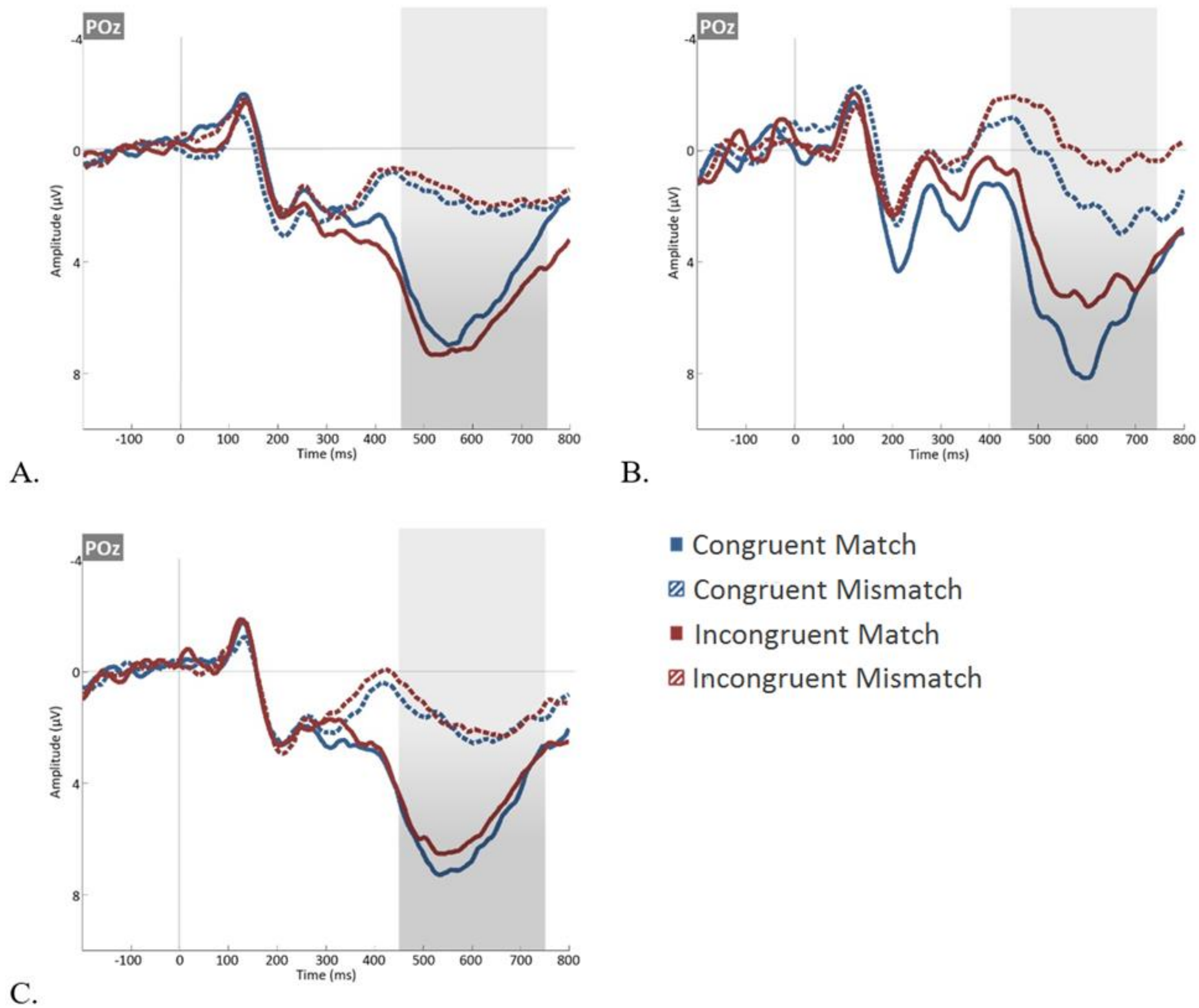
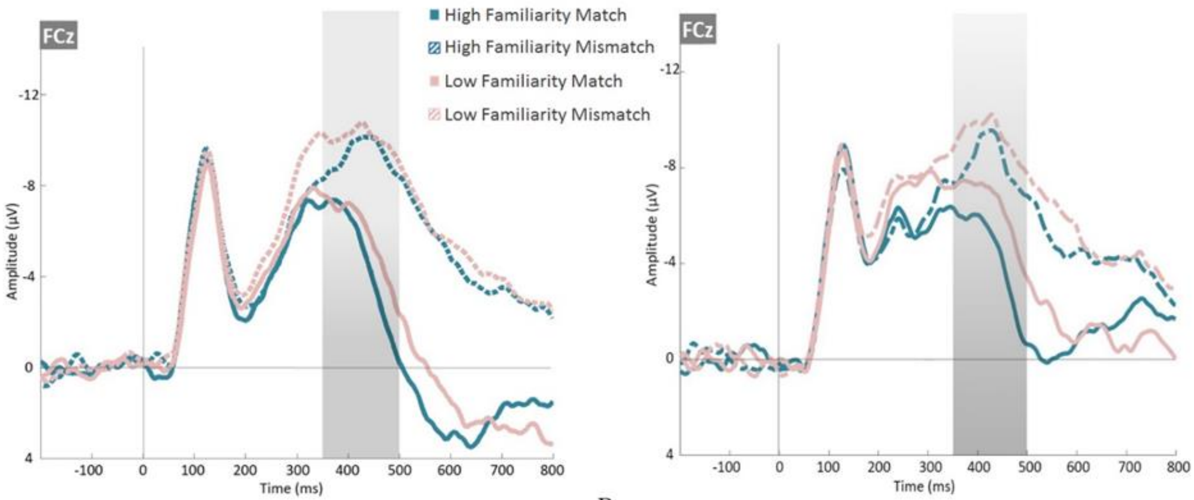
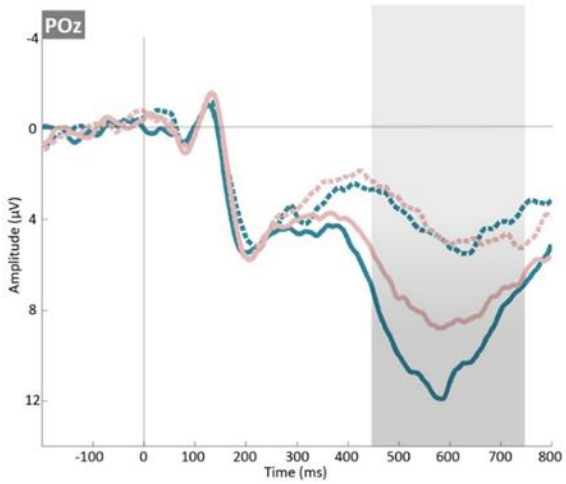

POz
Amplitude (µV)
-4
0
4
8
-100
0
100
200
300
400
500
600
700
800
Time (ms)
A.
B.
C.
Congruent Match
Congruent Mismatch
Incongruent Match
Incongruent Mismatch

Fig 6

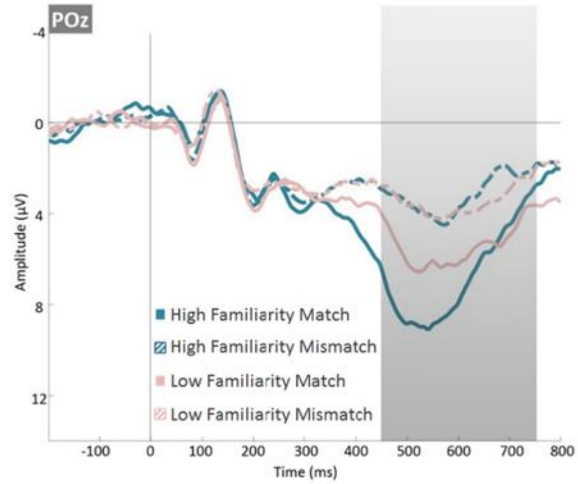

FCz
High Familiarity Match
High Familiarity Mismatch
Low Familiarity Match
Low Familiarity Mismatch
Amplitude (µV)
Time (ms)
FCz
Amplitude (µV)
Time (ms)

A. B.

Fig 7


POz
-4
0
4
8
12
Amplitude (µV)
-100
0
100
200
300
400
500
600
700
800
Time (ms)

A.


POz
-4
0
4
8
12
Amplitude (µV)
High Familiarity Match
High Familiarity Mismatch
Low Familiarity Match
Low Familiarity Mismatch
-100
0
100
200
300
400
500
600
700
800
Time (ms)

B.