2018-11-01

Second Language Semantic Retrieval in the Bilingual Mind: The Case of Korean-English Expert Bilinguals

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The Case of High-Proficiency Korean-English Bilinguals

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A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Arts

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ABSTRACT

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The present study aims to explore the relationship between proficiency level and semantic retrieval in the second language. A group of Korean bilinguals who speak English with high proficiency performed semantic relatedness judgement tasks of two hundred English word pairs. Unbeknownst to the participants, half of the words in both the related and the unrelated categories contained a "hidden prime"—a common first syllable shared by the two words, if translated into Korean. Each participant's event-related potential (ERP) was recorded while reading the words. While a former study by Thierry and Wu (2007) found that Chinese-English bilinguals were affected by the hidden primes, thus causing a "N400 reduction effect" in their averaged ERP, the bilingual group of the present study was unaffected by the hidden primes. The difference between the bilingual groups' performance between Thierry and Wu's study and the present study is likely caused by the higher English proficiency of the bilingual group in the present study. This provides additional evidence supporting the Revised Hierarchical Model of semantic retrieval proposed by Kroll and Steward (1994), which suggests that increased proficiency leads to reduced reliance on the first language during second language semantic retrieval.

Keywords: Second language semantic retrieval, Bilingualism, Event-related potential (ERP), Electroencephalography (EEG), Cognition, Revised Hierarchical Model, Language access, Semantic priming

ACKNOWLEDGEMENTS

I would like to thank my wonderful thesis committee who are dedicated to academic excellence and who care about my personal and academic growth. It is my honor to work with three wonderful professors and gain knowledge from each of their unique backgrounds.

I would like to thank Dr. Dewey for being my thesis chair, and for your expertise and feedback. Thank you for taking time out of your busy schedule and sabbatical year to help me succeed with my thesis. Thank you for your guidance and support despite the oppositions. I am a stubborn and impatient student, but thank you for staying patient with me. I am grateful that through this experience I learned to be humble and to take the time required to polish my work.

I am also grateful for Dr. Eggington for his encouragement when I was discouraged from drawbacks in my thesis work. Your supportive words meant the world to me. Thank you for helping me see the positive sides.

Last but not least, I am especially grateful for Dr. McPherson from the Communication Disorders Department for being part of my committee. Despite being in a department different from mine, he spent his precious time and effort throughout the past one and a half years to help me shape my thesis. I have admired Dr. McPherson for his sincere care for his students and his living example of a lifelong learner and researcher. Under his mentorship, I was challenged so I could expand and grow under high expectations. I genuinely enjoyed each weekly meeting with him, expanding my knowledge in a related but different field. Without his expertise in EEG and his generous support, I would not have been able to do my thesis on the topic that I am passionate about.

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1 Introduction

While over 50% of the world's population is bilingual (Ansaldo, 2008), how the human brain operates to perform the complicated task of perceiving foreign languages remains a topic of interest. This research topic had inspired a plethora of neuro-linguistic and psycholinguistic research: some suggesting that semantic access in the second language[1] (L2) always involves activation of the first language (L1; Blum-Kulka & Levenston, 1983; Holzen et al., 2014), but others suggesting that direct semantic retrieval of L2 without interference from the L1 is possible (Potter, So, Von Eckardt & Feldmam, 1984; Gerard et al., 1989; Rodriguez-Fornells et al., 2002). Answering this question is essential because it sheds light on how bilinguals process their respective languages in their brains (see Kroll, 2005; Ortega, 2009 and Brenders, 2012 for a review of various hypotheses regarding second language processing). A theory that will be particularly relevant in this study that will be elaborated below is the Revised Hierarchal Model by Kroll and Stewart (1994), which suggests that L1 reliance is reduced as a bilingual develops higher L2 proficiency. This thesis is an attempt to contribute to our understanding of the Revised Hierarchal Model. Furthermore, as we develop an understanding of whether and to what degree L1 affects bilinguals during L2 processing, we can make more informed decisions pedagogically in addition to contributing to theory. For example, if more proficient L2 speakers do not access

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[1] refers to the languages that we learn after the age of three.

their L1 during L2 use, then it might be wise to encourage the use of monolingual dictionaries, as opposed to bilingual dictionaries, in order to facilitate access to information (c.f. Laufer and Hadar, 1997; Chan, 2011). Another example would be for L2 teachers to create a L2-exclusive learning environments for more proficient L2 speakers.

While previous studies have found that competent L2 users unconsciously rely on the L1 to decode in L2 (Morford, J. P., Wilkinson, E., Villwock, A., Pi~nar, P., & Kroll, J. F, 2011; Thierry and Wu, 2007), it is unknown whether L2 users with higher proficiency levels depend on the L1 to the same degree. Additionally, it is unknown whether the results of the previous studies using Chinese-English participants will apply to a different group of subjects, which is Korean-English bilingual speakers in the current study. Utilizing an Electroencephalography (EEG) task that would elicit an effect only if bilingual participants had accessed the L1 during L2 reading, this study aimed to investigate the research question of whether L2 users of high proficiency are able to retrieve meaning in the L2 without involving the L1. My hypothesis is that they would be able to do so.

2 Review of Literature

To help readers understand current research, I will review the concepts of Lexical Representations and the Revised Hierarchal Model. Next, I will explain what EEG is and the reasons for my usage of EEG to investigate my research question. Lastly, I will review major EEG studies concerning L1 lexical representation.

Lexical Representations in the Bilingual Mind

Whether bilingual individuals activate their L1 during L2 comprehension pertains to how the lexical representations are wired in bilingual brains. Empirical studies in the field of psycholinguistics and neurolinguistics provide readers deeper understanding of how the human brain operates.

Some researchers have suggested that direct semantic retrieval of L2 without interference from the L1 is possible (Potter, So, Von Eckardt & Feldmam, 1984; Gerard et al., 1989; Rodriguez-Fornells et al., 2002). The assumption that bilinguals organize their mental lexicon according to different language systems stems from studies adopting tasks that emphasize lexical characteristics of the language, including fill-in-the blanks tasks (asking participants to complete the word f_o_e_r) and lexical decision tasks (asking participants to identify whether a stimulus is a word or a non-word); if a facilitating effect (also called a priming effect) is found within languages and not between languages, then the results support the notion of a separate mental lexicon for bilinguals, and vice versa. For example, Kirsner, Brown, Abrol, Chadha, & Sharma (1980) asserted that lexical representation in bilingual's brains are language-specific because when bilingual participants performed a lexical decision task, participants' reaction time was facilitated when words were repeated in the same language (such as English-English or Hindi-

Hindi); meanwhile, little to no facilitation effect was observed across languages. Along the same line, Scarborough, Gerard, & Cortese (1984) conducted a study that also found that bilinguals are able to process words exclusively in the L2 without interference from their L1. In their study, Spanish-English bilinguals participated in a lexical decision task where they were instructed to react positively only to Spanish words (and not to English words or non-words), and the accuracy results revealed that bilinguals processed real words from the language not targeted (English) as if they were non-words. This shows that bilinguals have the ability to isolate and focus on a language that is in use, minimizing influences from the other languages in the mental lexicon. These studies above suggest that each language is stored separately in the brain and that semantic retrieval is best achieved when only one language is involved.

Other linguists have asserted that the L2 always involves activation of the L1 (Blum-Kulka & Levenston, 1983; Holzen et al., 2014). Studies supporting this notion adopt experimental tasks involving semantic categorization. When a facilitating effect is found from two words that belong to the same semantic category but pertain to different languages, such findings are utilized to support the notion that there is a unitary conceptual storage for both languages in a bilingual brain. Recent studies further suggest that proficient bilinguals utilize their L1 in a subconscious manner when accessing meaning during L2 comprehension. For example, in Thierry and Wu's (2007) study, the researchers adopted a design that would only elicit a response if a participant activated their L1 during L2 comprehension. Even though the participant's electrophysiological response revealed that they did activate their L1 when reading in L2, they claimed that they were unaware of themselves translating the stimuli into their L1. These studies above suggest that the two languages in a bilingual brain are both activated, instead of operating in an isolated manner.

Due to the mixed research findings, a definite answer to the question of whether bilinguals are affected by the L1 during L2 comprehension is yet to be ascertained.

Revised Hierarchical Model

A model that is relevant to the present study is the Revised Hierarchal Model (RHM) by Kroll and Stewart (1994). The RHM provides a way of understanding how words are stored in the bilingual brain and how L2 meaning is accessed. It also explains how proficiency affects the path of L2 meaning access.

Figure 1A shows a fundamental representation of the RHM. The RHM assumes a shared meaning storage for the L1 and L2 and separate lexicons (i.e. sound and/or orthography) for different languages. As shown in Figure 1A, the shared meaning storage is symbolized by a box having a flower symbol. The RHM also assumes that there are separate storages for the lexicon for L1 and L2. As shown in Figure 1A, the separate meaning storage is symbolized by the separate boxes for L1 and for L2. The "lexicon links" in Figure 1A-C stands for lexical-level translation both from the L2 to the L1 (e.g. Flower to 꽃) and from the L1 to the L2 (e.g. 꽃 to flower). As shown in Figure 1A, the arrow from L2 to L1 is represented by a solid line because of the stronger connection while the arrow from L1 to L2 is represented by a dotted line because of the weaker connection.

The RHM suggests that L2 users rely on the L1 in earlier stages of L2 acquisition. Figure 1B shows an application of the RHM for when the L2 user has lower L2 proficiency and has to rely on the L1 to retrieve meaning when an L2 lexical item is presented. From here on in this thesis, the term "translation" will refer to the lexical level translation as shown in Figure 1B. Because the direct link from L2 to the concept is not strong enough, the first step of decoding as seen in Figure 1B is to convert the L2 lexical item into the L1 lexicon through the lexical link.

Once the appropriate L1 lexical item is obtained, then the conceptual link is activated for the L2 user to tap into the meaning. A number of studies show that less proficient L2 speakers are more likely to form lexical links (converting L2 lexicon to L1 lexicon) instead of conceptual links (directly retrieving meaning from the lexical item) (Chan & Leung, 1989; Kroll & Curley, 1988).

The RHM suggests that with increased proficiency in L2, the L2 user would develop a direct path of retrieval between L2 and the concept. Figure 1C shows an application of the RHM when the L2 speaker has higher L2 proficiency. Because a strong link is developed between the L2 lexical item and the concept, reliance on the L1 is unnecessary.

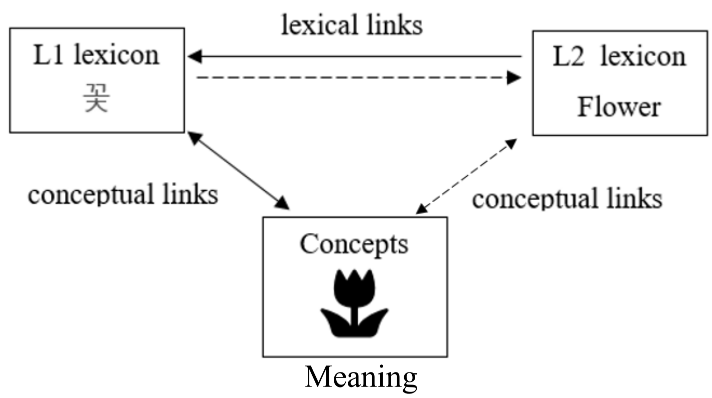

Figure 1A. Representation of the Revised Hierarchal Model

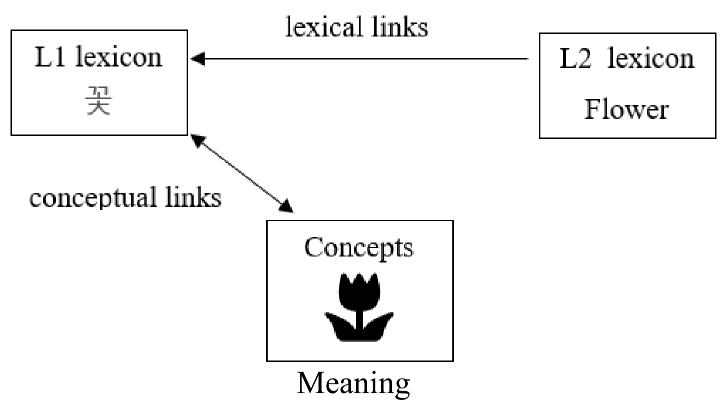

Figure 1B. Representation of the Revised Hierarchal Model's application: low L2 proficiency

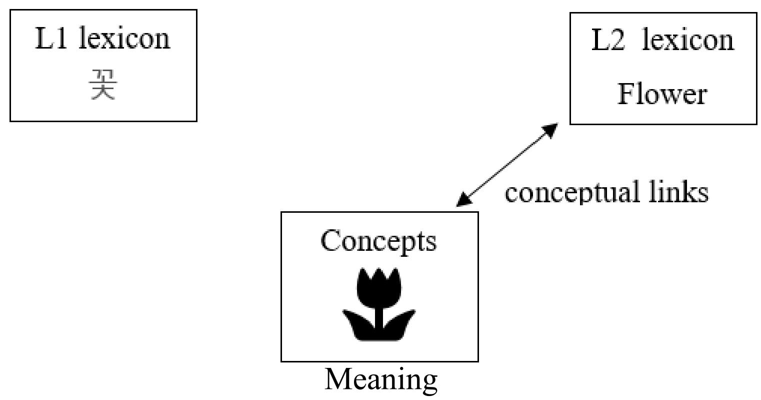

Figure 1C. Representation of the Revised Hierarchal Model's application: high L2 proficiency

The RHM's assumption that an individual's proficiency serves as a function of the strength of L2 connections is supported by several studies (McElree et al, 2000; Dufour & Kroll, 1995, Cheung & Chan, 1998). For instance, McElree et al (2000) designed a study where three groups of participants with different L2 proficiency[2]. The researchers found that bilinguals who are less proficient in the L2 respond more slowly and less accurately when retrieving words from the L2. In McElree et al's study, participants were visually presented pairs of L2 stimuli using a computer program, and were asked to respond by either pressing a button that indicates that the two words are equivalents or a button that indicates that the two words are not equivalents. Four types of pairs were presented (L1-L2, L2-L1, L1-L1, L2-L2), and participants' accuracy and reaction times were recorded and analyzed. As the result of the study show that bilinguals who are more proficient in the L2 respond more quickly and accurately, McElree et al (2000) suggest that L2 users with higher proficiency have developed a stronger and direct path between the L2

[2] The proficiency of the three groups of participants were determined using several factors: age of arrival, length of stay, and self-rated proficiency. The first group had mean proficiency of 8.8/10, the seco nd group 7/10, the third group 9.3/10.

and the concept. RHM was supported by other scholars in different aspects. For example, Kroll, Hell, Tokowicz and Green (2010) posited that word forms (graphic and phonological representations) associated with the L1 and L2 are independently stored in the brain because they found that translation latency from L1 to L2 tended to be longer than translation latency from L2 to L1 for beginner L2 speakers. In other words, L2 required mediation of L1 so as to access meaning in the initial stage of learning L2. In addition, there are other studies that adopt "masked priming," supporting the concept of RHM. Masked priming is a common technique used by researchers to investigate how words are stored in our mental lexicon. A "prime" is a presented stimulus that may facilitate the processing of a subsequent stimulus. "Masked primes" are primes that cannot be overtly seen, such as word pairs that would only contain a common syllable in the word form when translated into a certain language. In studies that adopt "masked priming," participants are asked to consciously respond to targets. Unknown to them, they are also presented with masked primes, and researchers study the influence of the masked primes on the participants' response to the target (e.g. whether a prime facilitates higher response accuracy or shorter response time). In the studies that support the concept of RHM, L1 equivalents serve as "primes" for researchers to investigate whether these L1 primes facilitate the speed/accuracy of L2 decoding. If a facilitation effect is found, it supports the validity of the L2-L1-meaning route. On the other hand, the assumption of RHM is that L2 primes would not facilitate the speed/accuracy of L1 because meaning is thought to be directly retrieved from L1 without L2 mediation. Many studies have shown L1-to-L2 priming shows greater magnitude than L2-to-L1 priming. (Kirsner et al, 1984; Schwanenflugel & Rey, 1986; Frenck & Pynte, 1987; Chen & Ng, 1989; Keatley et al, 1994; Altarriba, 1990). The above observations further supported the RHM.

The Revised Hierarchal Model is only one of many models of L2 word recognition. It is possible that word recognition is influenced by a number of factors. One example is the Orthographic Depth Hypothesis (Frost & Snowling, 2005). The Orthographic Depth Hypothesis (ODH) describes that written forms of languages have differing degrees of transparency between the orthographic symbols and the represented pronunciation. A written form that has close or one-on-one correspondence between the phonology and the orthography, such as Korean, is described as having shallow orthography while a written form that has a more arbitrary relationship between phonology and orthography, such as Chinese, is described as having deep orthography. Orthographic depth has an influence on word recognition, particularly in early L1 and early L2 reading. In languages that have relatively shallow orthography, such as Spanish and Italian, letter-to-sound correspondences are taught in school in merely a few months' time (Seymour, 2006). In contrast, character-to-sound relationships in languages with deeper orthography are more complex to teach and can take one to two years to teach (Frost & Snowling, 2005). It is worth nothing that while English is an alphabetic language, it is the most opaque language among all alphabetic languages because the sound-to-letter forms are very irregular in English (Grabe, 2009).

EEG Research Method

In this section, I will explain what EEG is and the reason that I use EEG in my research. To support my rationale, I will review major EEG studies concerning Lexical representation in bilinguals.

Electroencephalography (EEG) measures electrical activities within the brain reflected on the surface of the scalp during mental processing. It depicts both active and passive processing of the brain and provides quantifiable statistics regarding mental processing. EEG can be applied to different kinds of research, such as diagnosing sleep disorders, depth of anesthesia, and brain death. One of the applications of EEG in cognitive psychology research is the event-related potentials (ERP). Event-related potentials can identify electrophysiological response to a stimulus through signal averaging, which is a process that attenuates background noises and amplifies the brainwave resulting from the presentation of a stimulus. There are different types of ERP that reflect different responses of the brain. One of the types of ERP that is broadly analyzed and well-understood is called the N400. The N400 is a negative amplitude (voltage) ERP component peaking around 400ms after stimulus onset (McPherson & Ballachanda, 2000). An N400 response reflects that a person detected a difference between two stimuli in content. The N400 was discovered by Kutas and Hillyard in 1980. Kutas and Hillyard observed that electrical activity measured on the surface of the brain varied systematically with stimulus features and proposed the N400 as a measure of semantic incongruity for the first time. Since then, over 1000 articles have been published that use the N400 as a dependent measure (Kutas and Febermeier, 2014). A way to examine participants' N400 is to design a study that includes the element of priming. priming is a technique of exposing a participant to a specific stimulus (called "prime") which may influence the participant's response to a subsequent stimulus, without conscious awareness of the effect. When a "prime" is presented prior to the presentation of the stimulus, the presence of priming will reduce the magnitude of N400 amplitude elicited (Brown, Hagoort, & Chwilla, 2000).

The benefit of using EEG, as opposed to measuring response error rate or reaction time (known as behavioral measures), is that it allows researchers to discover the intricate mental processes that are not easily observed from outward behavior. It allows researchers to inspect the time course of the participant's brain activity, identifying activity within the brain even before one provides an external behavioral response. ERP has successfully detected subconscious activities in various research studies about bilingualism (e.g. Kotz, Holcomb, & Osterhout, 2008; Sabourin, 2003). Various studies have shown that EEG reveals information that cannot otherwise be discovered. For example, Thierry and Wu (2007) revealed unconscious mental processing that participants are unaware of according to participant's self-report survey.

Some studies using EEG in their linguistic research have helped enrich our understanding of the RHM, particularly pertaining to the degree of L1 reliance for L2 speakers with different L2 proficiencies. For example, Thierry and Wu's study (2007) and Guo, Misra, Tam, and Kroll's (2012) EEG study provide key findings about intermediate-level L2 speakers' L1 reliance in their L2 decoding; both studies will be expounded below. Thierry and Wu (2007) suggested that operational bilingual speakers exhibit a significant L1 interference in an EEG task. In their study, researchers recruited bilinguals with IELTS level 6. This score, according to IELTS, is interpreted as having "operational command of the language, though with occasional inaccuracies, inappropriacies and misunderstandings in some situations. Generally handles complex language well and understands detailed reasoning" (IELTS, 2017). Thierry and Wu's EEG experiment was structured so that the aforementioned bilingual group would exhibit a significant difference in ERP (as compared with the monolingual group) only if they had consciously or subconsciously translated the L2 words into their L1. More specifically, the research design involved embedding common Chinese words in the translation of certain English words—repetitions that could only be detected if a reader translated the English word pairs into Chinese. The results of the bilingual group demonstrated a significant difference in N400 amplitude between the bilingual and monolingual groups as both groups read the same set of word pairs. By pointing out that the bilingual group had a significantly reduced N400 amplitude and signs of subconscious priming[3], Thierry claimed that the difference was caused by the bilingual group unconsciously translating the words into their native language as they read word pairs in the second language (Thierry & Wu, 2007).

For reference and comparison purposes, the Korean bilingual group means of N400 amplitudes and latencies under various conditions for Thierry and Wu's study (2007) are presented in Table 1.

Table 1

Group Means of N400 for English Monolinguals (EM) and Korean Bilinguals (KB), Thierry and Wu (2007)

Condition	Variable	EM Mean	KB Mean
SR+	MinAmp	0.27	-1.13
SR+	MaxAmp	0.27	-1.13
SR+	MinLat	332.00	375.00
SR+	MaxLat	332.00	375.00
SR-	MinAmp	-1.80	-2.04
SR-	MaxAmp	-1.80	-2.04
SR-	MinLat	415.00	379.00
SR-	MaxLat	415.00	379.00
CS+	MinAmp	-7.78	-1.36
CS+	MaxAmp	-7.78	-1.36
CS+	MinLat	400.00	384.00
CS+	MaxLat	400.00	384.00
CS-	MinAmp	-7.52	-1.87
CS-	MaxAmp	-7.52	-1.87

[3] Subconscious priming is a research design technique where a stimulus influences a response to the stimulus that follows it, without the participant being aware that the former stimulus (called prime) influenced his/her response to the following stimulus.

CS-	MinLat	415.00	371.00
CS-	MaxLat	415.00	371.00

Note. SR- = word pairs are semantically unrelated; SR+ = word pairs are semantically related; CS- = word pairs have no hidden common symbol in Korean; CS+ = word pairs have hidden common symbol in Korean.

In a different study, Guo et al. (2012) also found that intermediate L2 speakers access their L1 during L2 retrieval. The researchers recruited bilinguals with intermediate English proficiency who resided in the university community and who passed a lexical decision task with 60% or above. The research design was similar with Thierry and Wu's study in that researchers recruited Chinese-English bilinguals and adopted ERP measures. The researchers adopted a slightly different experimental setup than Thierry and Wu's study (i.e., a translation recognition task), which served the purpose of providing insights on whether the effects observed by Thierry could be generalized in another experimental task. The behavioral results of this study supported those of Thierry and Wu (2007), suggesting that L1 translation was activated when intermediate bilinguals decoded in L2. Guo et al. further suggested the possibility that the L1 activation shown in the results was caused by back translation (which means translating a word back into the L1 after understanding it in L2) rather than by the L1 serving as a bridge to retrieve L2 meaning. The reason the Guo et al. hypothesized so is because of the long interval of 1,100 ms from the onset of the first word to the onset of the second word, which could allow time for bilinguals to activate the L1 after they understood the meaning of the L1 word. This ambiguity of research design will be resolved and avoided in the present study.

Significance of the Current Study

As seen from literature mentioned above, while there are already studies that adopted EEG methods and priming techniques to investigate L1 usage in bilingual speakers with low to intermediate English proficiency, it is unknown if a different result would be found if the participants had higher English proficiency. In addition, there is value in comparing EEG linguistic studies adopting a similar method but a adopting a group of subjects who speak a different L1.

The present study served to fill the aforementioned research gaps in two major ways—First, my study adopted a group of bilinguals with more advanced English proficiency than the studies listed above. The studies listed above had participants with English proficiencies in IELTS[4] 6 or 6.5, which is interpreted as "competent English users[5]" (IELTS , 2017). My study only included bilinguals with English proficiency equivalent to IELTS 7 or 8, which is interpreted as "Good[6]" or "Very good users[7]" (IELTS , 2017). My hypothesis was that the target bilingual group's reliance on L1 translation would be lower than that of Thierry's study based on the Kroll and Stewart's RHM (1994) because the model suggests that higher proficiency will lead to more direct path of lexical access. Secondly, my study also examined whether the unconscious translation effect as mentioned in previous studies would generalize into a language other than Chinese—which is Korean, for the present study. Chinese and Korean are comparable first languages for the present study because they share comparable English as a second language

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[4] The International English Language Testing System (IELTS) measures "the language proficiency of people who want to study or work where English is used as a language of communication" (IELTS, 2017). It adopts a nine-band scale to differentiate levels of language expertise, from non-user (band score 1) to expert (band score 9).

[5] "Has generally effective command of the language despite some inaccuracies, inappropriacies and misunderstandings. Can use and understand fairly complex language, particularly in familiar situations" (IELTS, 2017).

[6] "Has operational command of the language, though with occasional inaccuracies, inappropriacies and misunderstandings in some situations. Generally handles complex language well and understands detailed reasoning."(IELTS, 2017).

[7] "Has fully operational command of the language with only occasional unsystematic inaccuracies. Misunderstandings occur in unfamiliar situations. Handles complex detailed argumentation as well" (IELTS, 2017).

(ESL) decoding abilities. While Chinese and Korean differ in that Chinese is a logographic language, where each character represents a concept, and Korean is an alphabetic language, where an individual character represent sound only, Koda and Mellon's (1998) study found no difference between the Korean-English bilingual group and the Chinese-English bilingual group in their ability of phonemic awareness (specifically, their perceptual ability to distinguish English phonemes or skills to conduct phonemic analysis). In the study, the researchers recruited a group of Chinese without alphabetic experience and a group of Korean who use non-Roman alphabetic script. Both groups performed decoding tests, such as Word Attack, which consisted of 50 pseudo-English words, and homophone judgement tasks. The results suggest that little difference exist between their ability to distinguish English phonemes (Koda & Mellon, 1998). However, it should be noted that the study above is only one study that supports the notion that Chinese and Korean bilinguals share comparable English decoding ability; thus, it is still possible that bilinguals having different L1 backgrounds process L2 differently from each other. For example, in a more recent study by Wang and Koda (2005)[8], the researchers observed an L1 effect—while both groups performed significantly better in naming frequent words than infrequent words, the Korean students were overall more accurate than were the Chinese students in naming both categories of words. Wang and Koda acknowledge two significant factors in L2 decoding—on the one hand, properties of the L2 writing system affect L2 processing similarly across learners irrespective of L1 backgrounds; on the other hand, systematic differences are seen in L2 processing among learners with alphabetic and nonalphabetic L1 backgrounds. For the present study, we substituted Chinese-English bilinguals for Korean-English bilinguals when

[8] Chinese-English group had an average self-reported TOEFL score of 85, while the Korean-English had an average self-reported TOEFL score of 76

replicating Thierry & Wu's study (2007) that uses Chinese-English bilinguals as subjects. While using Chinese-English bilinguals may reduce ambiguity, we adopted Korean-English bilinguals for the practical reason that Korean-English bilinguals are more accessible in our case.

In the interpretation of my results, a significant reduction in N400 in data analysis would reflect that the participant has subconsciously or consciously tapped into the L1 translation of the word pairs presented. My research question was whether an N400 reduction effect would be elicited in a Korean-English Bilingual group as they read word pairs that contain a hidden "common first syllable in Korean." My hypothesis was that a reduction of N400 amplitude would not be found, and my rationale was that with the bilingual group's higher L2 proficiency, their semantic retrieval process would resemble that of English monolingual speakers in the present study.

3 Method

Overall Procedures

To answer the research question of whether the bilingual group would access their L1 when reading in L2, I examined if a significant "N400 reduction" effect would be elicited using the following set up:

I collected behavioral and EEG data from 15 bilinguals and 15 monolinguals while they performed a semantic relatedness task that was conducted solely in English. In each of the 200 trials, participants read a pair of words and then pressed a button to indicate whether they thought that the words were related in meaning.

Among the stimuli, half of the presented word pairs are related in meaning (SR: +) and half are unrelated (SR: –), hence enabling "semantic relatedness" to be the first controlled factor. While participants are unaware of it, half of the presented word pairs share a common Korean syllable (CS: +) while the other half do not (CS: –). Hence, "repeated first syllable" is the second controlled factor in this study. These two factors form a 2 by 2 factorial design, thereby creating 4 types of word pairs (SR–CS–, SR–CS+, SR+CS–, SR+CS+).

The dependent factors include the amplitude and latency of the N400 component, which were simultaneously recorded by 61 electrodes.

Participants

Screening. Participants were initially recruited by way of posters in major buildings at Brigham Young University. Those who were interested in participating were asked to fill out a self-report online survey. The list of questions can be found in Appendix B. All participants satisfied these criteria: age between 18 to 30, level of education above high school diploma, right-handed, and without allergies to saline gel. In addition, they either spoke English as their only language (control), or were bilingual with Korean as their first language and English as their second language, onset age[9] 4-12 (experimental), reaching a proficiency of IELTS 7-8 or equivalent (self-reported).

Vision testing. The researcher began the experimental routine with the pre-screened volunteers by conducting a Snellen eye test to ensure visual acuity (either natural or corrected vision). Participants were asked to stand 20 feet away from the Snellen chart and read aloud the characters from the top left and to the bottom right to the best of their ability. The smallest row of letters that a participant could read indicated their vision. Any participants with vision below 20/40 would be excluded. All recruited participants passed the vision testing with 20/40 or above.

Experimental group and control group. The experimental group ("the Bilingual group") consisted of 15 Korean-English bilinguals and the control group ("the English Monolingual") was constituted of 15 English monolinguals. The demographic information of the experimental and control groups can be seen in Table 2.

[9] the age that one begins learning the second language

Table 2

Demographic Information of the Control and the Experimental Groups

	Monolingual group	Bilingual group
Number	15 (8 male, 7 female)	15 (7 male, 8 female)
Average age	21.9	23.9
Native Language	English	Korean
L2 onset age	N/A	8.13
Self-reported English proficiency	Native	IELTS average = 7.5 (equivalent to TOEFL average = 98.375)
Handedness	Right-handed	Right-handed
Vision	20/40 or above	20/40 or above

Stimuli Preparation

Stimuli. The stimuli consist of 200 English word pairs to be presented on the computer screen. The list can be found in Appendix A. These word pairs belonged to one of the four types listed in Table 3. There were fifty word pairs in each category, and they were shuffled and presented in a randomized order for each participant.

Table 3

Examples of the Four Types of Stimuli

Stimulus Types	Example word pairs
SR-, CS+	Airport (공항), Tool (공구)
SR+, CS+	Student (학생), Learning (학습)
SR-, CS-	Apple (사과), Linguistics (어학)
SR+, CS-	Husband (남편), Wife (아내)

Note. SR- = word pairs are semantically unrelated; SR+ = word pairs are semantically related; CS- = word pairs have no hidden common symbol in Korean; CS+ = word pairs have hidden common symbol in Korean.

SR- CS+ stimuli are word pairs that are unrelated semantically yet share a syllable when translated into Korean. SR+ CS+ stimuli are word pairs that are semantically related in English and share a syllable in Korean. SR- CS- stimuli are word pairs that are unrelated semantically and do not share a syllable in Korean. SR+ CS- stimuli are word pairs that are semantically related, but do not share a syllable in Korean.

Priming. This study adopts the masked priming paradigm (MPP) research design. The masked primes are the "common syllables in L1 translation" which are implicitly presented only in SR+ stimuli. For example, participants were asked to rate the two words, "airport" and "tool," in terms of semantic relatedness. The prime that was masked within is the "공 ([goʊŋ])" syllable in the Korean translation of the two words, 공항 ([goʊŋ hang]; meaning: airport) and 공구 ([goʊŋ gʊ]; meaning: tool). This masked prime could only be "unmasked," or decoded, if participants had accessed their L1 while decoding the L2 word pairs.

Instrument to measure the semantic relatedness of word pairs. As I collected semantically related and unrelated word pairs as stimuli, I adopted a computational program to confirm my judgements of semantic relatedness. I adopted ClaC Laboratory's semantic relatedness software[10] (ClaC Laboratory, 2013) which derives a "semantic relatedness score" using natural language processing technology. As I chose stimuli for my study, the word pairs that were considered semantically related had scored 70% or above as measured by the instrument. The word pairs that were considered semantically unrelated had scored 46% or below as measured by the instrument. A list of all word pairs and their corresponding scores can be found in Appendix A.

Electroencephalography (EEG) Data Collection

Data Acquisition. A Compumedics Neuroscan EEG data acquisition and analysis system, Curry 8 software, was used to collect and analyze the raw EEG. Streaming EEG was collected with a low pass filter set to 10 KHz using a 64 channel Synpase2 Compumedics amplifier. A Compumedics Quick Cap with 64 electrodes was placed on the scalp of each participant. The electrodes were injected with Sigma Gel and electrode impedance were at or below 50 kΩs. Also, eye movement artifact was monitored with a set of bipolar electrodes placed above and below the right eye for eye blink monitoring, and another set of bipolar electrodes placed on the outer canthi of each eye to monitor movement. Epochs[11] ranged from 100ms before the onset of the presentation of the second word to 1000 ms after. Stimulus and

[10] The validity of this program is demonstrated in Siblini and Kosseim (2013). Researchers found that their approach outperforms many other lexicon-based methods in semantic relatedness measurement, particularly so on the TOEFL synonym test, achieving an accuracy of 91.25% (Siblini and Kosseim, 2013).

[11] an epoch is a specific time-window that is extracted from a continuous EEG signal. It is usually time-locked to begin after a visual stimulus is presented.

response types were recorded on the streaming EEG for post hoc analysis. Behavioral data (i.e., reaction time and error rate) was collected simultaneously with EEG data. The bipolar eye monitoring electrodes were used for post hoc artifact removal and reduction. A two-interval forced choice button push response for each stimulus presented was collected. The raw data was stored on a PC running the Compumedics software.

Stimulus presentation. The visual stimuli were presented using ePrime® 3.0 software. The stimulus was presented binocularly with a visual angle of 0 degrees. A LED computer monitor with a 24" screen placed 1 meter from the participant's forehead was used as the viewing platform. Two sessions of 100-word pairs each were presented as visual stimuli in pseudorandomized order. The order of presentation was as follows: 200ms pre-stimulus interval, 500ms first-word presentation, 500ms inter-stimulus interval, 500ms second-word presentation, participant respond by pressing button, repeat to first step.

Data Analysis

EEG data. The raw EEG recordings were filtered between 0.01 Hz and 10 Hz and processed for artifact removal. Following the initial processing of the raw recordings, latency & amplitude peaks of the N400 component in each sample were extracted manually within the timeframe of 300 to 500 ms after stimulus onset. The data were then subject to repeated measures analysis of variance (ANOVA) with semantic relatedness (related/unrelated) and syllable repetition (repeated/ unrepeated) as a within-subject factors. Between-group comparisons were indicated by the main effects (semantically unrelated–semantically related and no character repetition–character repetition). When a significant group difference was found ($p < 0.05$), post-hoc pairwise comparisons were obtained to determine under which conditions the difference occurred.

4 Results

The main aim of the current study was to determine how results for a higher English proficiency group of the target bilinguals would differ from a lower English proficiency group in Thierry and Wu's study (2007) in terms of reliance on L1 translation. Reliance on L1 translation was measured by an N400 reduction effect, particularly on whether an N400 reduction effect would be elicited from a Korean-English bilingual group as they read word pairs that contained a hidden common first syllable. According to the data and results presented in this chapter, the bilingual group (IELTS 7-8) in the present study did not show evidence accessing the L1 translation when reading word pairs with semantic relatedness (SR+) or common syllables (CS+) or without (SR-, CS-). This result contrasts with the Thierry and Wu's finding (2007) that a bilingual group with lower English proficiency accessed the L1 translation when reading words with a hidden common first syllable.

Descriptive Data

The English monolingual and Korean bilingual group means of N400 (See p.6 for an explanation of N400) amplitudes and latencies under various conditions (SR+, SR-, CS+, CS-) for the present study are listed in Table 4.

Table 4

Group Means, Standard Deviation, and Minimum and Maximum Values of N400 under Various Conditions

Condition	Variable	EM Mean	EM SD	EM Min	EM Max	KB Mean	KB SD	KB Min	KB Max
SR+	MinAmp	-1.38	0.56	-2.11	-0.39	-1.40	0.88	-3.11	-0.26
SR+	MaxAmp	0.15	0.60	-0.59	1.38	-0.29	0.61	-1.36	0.79
SR+	MinLat	396.53	53.71	284.00	458.00	406.33	42.05	338.00	466.00
SR+	MaxLat	413.33	84.53	277.00	531.00	397.47	71.44	294.00	520.00
SR-	MinAmp	-2.11	.56	-3.09	-1.04	-1.81	0.84	-3.46	-0.21
SR-	MaxAmp	.03	.79	-1.86	1.47	-0.12	0.57	-1.25	.67
SR-	MinLat	415.40	37.63	318.00	451.00	408.73	39.51	351.00	478.00
SR-	MaxLat	401.20	169.05	258.00	910.00	383.80	82.31	298.00	529.00
CS+	MinAmp	-1.81	.42	-2.48	-1.09	-1.55	0.90	-3.43	-.32
CS+	MaxAmp	.11	.59	-.60	1.37	-0.18	0.48	-1.09	.45
CS+	MinLat	405.07	35.81	333.00	445.00	406.27	38.51	339.00	459.00
CS+	MaxLat	435.93	72.65	332.00	518.00	393.40	88.09	285.00	507.00
CS-	MinAmp	-1.71	.58	-2.89	-.74	-1.58	0.87	-3.07	-0.14
CS-	MaxAmp	-.08	.64	-1.39	1.23	-0.18	0.73	-1.63	0.86
CS-	MinLat	415.40	35.03	338.00	457.00	398.00	50.57	302.00	489.00
CS-	MaxLat	397.13	84.65	279.00	516.00	354.60	58.21	282.00	507.00

Note. EM = English monolingual group; KB = Korean bilingual group; SR+ = word pair is semantically related; SR- = word pair is not semantically related; CS+ = word pair has a common first Korean syllable; CS- = word pair does not have a common first Korean syllable.

Comparative Data

After the initial data collection from the current study, differences between the KB and EM groups were examined through repeated-measures ANOVA (see Table 5). Repeated measures ANOVA in Table 5 show no significant overall differences between the KB and EM groups in terms of maximum amplitude ($p = 0.23$) or maximum latency ($p = 0.169$).

Table 5

Tests of Between-Subject Effects According to Repeated Measures ANOVA

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Group	MinAmp	47.04	1	47.04	2.39	.13
	MaxAmp	32.17	1	32.17	1.48	.23
	MinLat	200,384.34	1	200,384.34	1.07	.31
	MaxLat	474,692.46	1	474,692.46	2.00	.17

As seen in Table 6 below, between-subject effects were tested by pairwise comparisons. Pairwise comparisons show that the two groups did not differ significantly in maximum amplitude ($p = 1.00$) or maximum latency ($p = 0.34$) when word pairs had a hidden common first syllable (CS+) as compared to word pairs without the common first syllable (CS-). However, significant difference ($p = 0.002$) was found between condition SR+ (word pairs are semantically related) and SR- (word pairs are not semantically related).

Table 6

Tests of Between-Subject Effects: Pairwise Comparisons

Measure	Cond-ition	Cond-ition	Mean Difference	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
MaxAmp	SR+	SR-	-.273*	.066	.002*	-.460	-.086
		CS+	-.097	.058	.638	-.262	.068
		CS-	-.123	.055	.205	-.280	.034
	SR-	SR+	.273*	.066	.002*	.086	.460
		CS+	.176	.065	.071	-.010	.362
		CS-	.150	.062	.132	-.026	.325
	CS+	SR+	.097	.058	.638	-.068	.262
		SR-	-.176	.065	.071	-.362	.010
		CS-	-.026	.056	1.000	-.185	.132
	CS-	SR+	.123	.055	.205	-.034	.280
		SR-	-.150	.062	.132	-.325	.026
		CS+	.026	.056	1.000	-.132	.185
MaxLat	SR+	SR-	-21.469	14.786	.946	-63.445	20.506
		CS+	-16.128	7.540	.248	-37.533	5.276
		CS-	-4.122	8.164	1.000	-27.299	19.055
	SR-	SR+	21.469	14.786	.946	-20.506	63.445
		CS+	5.341	16.641	1.000	-41.903	52.585
		CS-	17.348	16.153	1.000	-28.510	63.205
	CS+	SR+	16.128	7.540	.248	-5.276	37.533
		SR-	-5.341	16.641	1.000	-52.585	41.903
		CS-	12.007	6.046	.341	-5.156	29.170
	CS-	SR+	4.122	8.164	1.000	-19.055	27.299
		SR-	-17.348	16.153	1.000	-63.205	28.510
		CS+	-12.007	6.046	.341	-29.170	5.156

Note: Based on estimated marginal means. * $p < .05$; [b] indicates adjustment for multiple comparisons: Bonferroni.

Figure 2 and Figure 3 show the visual representations of the between-group comparisons of maximum amplitude and maximum latency across conditions. Figure 2 shows a significant group difference between semantic relatedness conditions (SR- and SR+). The group difference between reading condition CS+ and CS- indicates that the bilingual group was not affected by the concealed Korean primes.

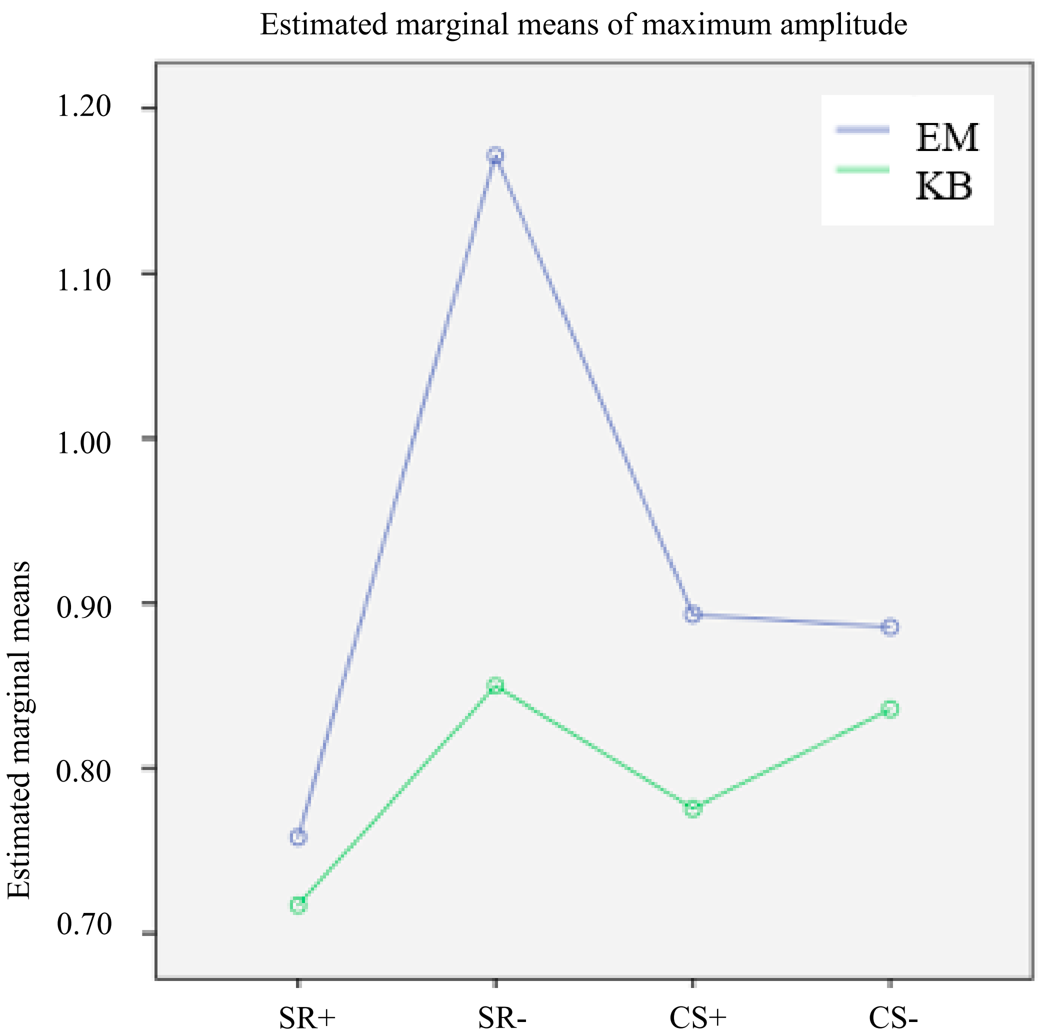

Figure 2. Profile plot of estimated marginal means of maximum amplitude of N400 for both groups and all stimulus conditions.

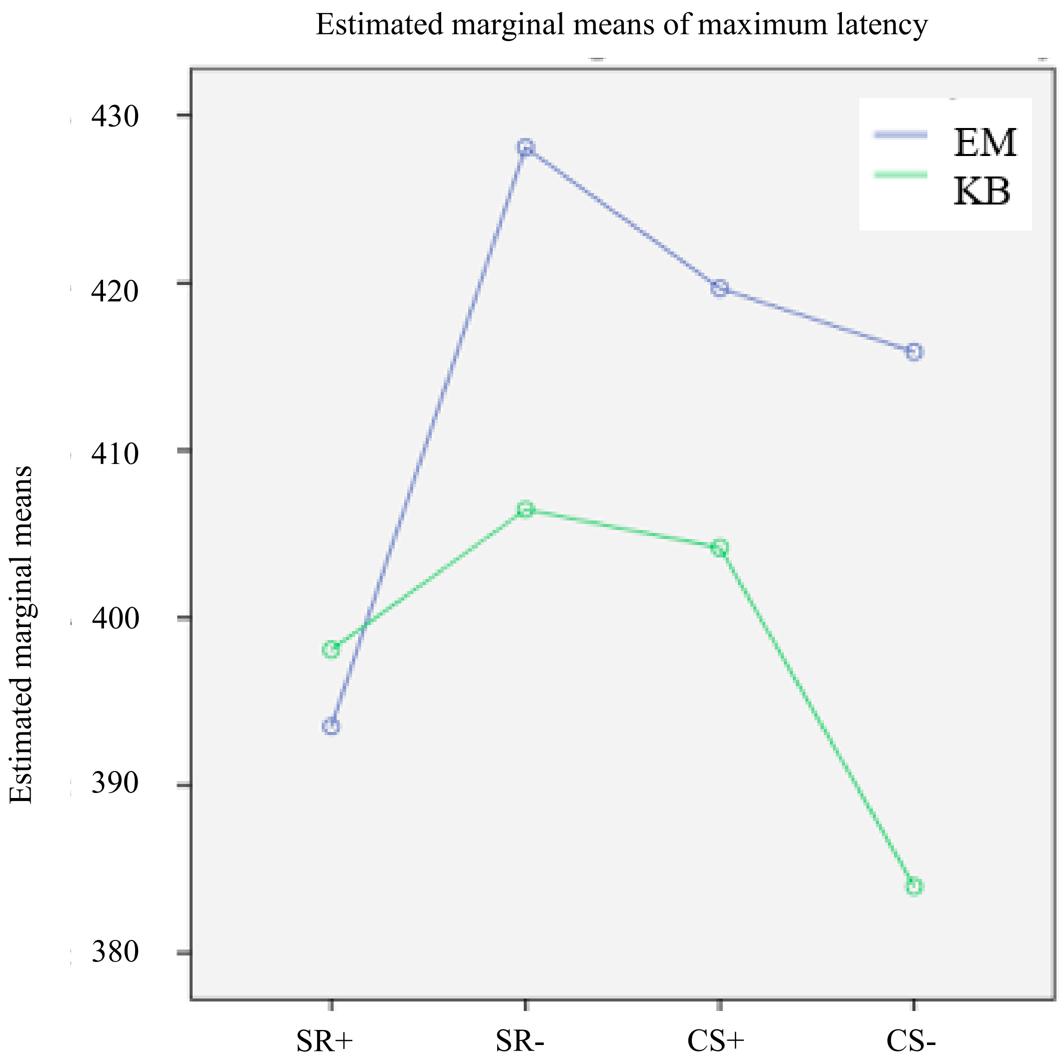

Figure 3. Profile plot of estimated marginal means of maximum latency of N400 for both groups and all stimulus conditions.

Source Localization

Source localization maps electrical activity on the surface of the brain. The resulting reconstruction of brain activity can be represented as a graphical display of spatial distribution. The advantage of such a topography is that it allows researchers to identify the areas of the brain most sensitive and reactive to N400, thus providing a more effective analysis. Figure 4 displays the activated brain regions when participants read the word pairs under the different conditions (CS-, CS+, SR+, SR-).

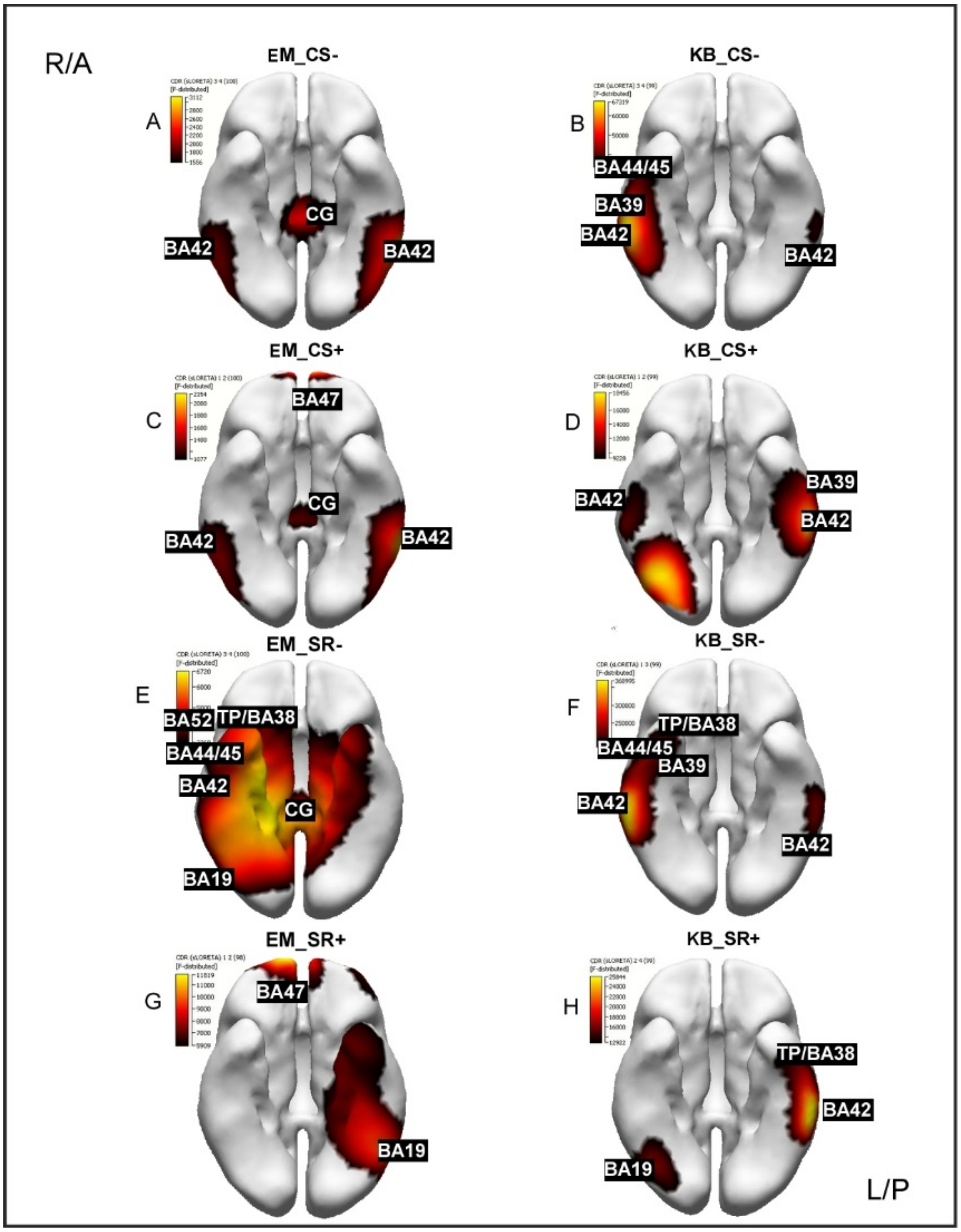

Figure 4. Source localization (BA, Brodmann's area; CG, Cingulate Gyrus; TP, Temporal-Parietal lobe; orientation is radiological).

The primary areas of the brain used by one or both groups in the current study are designated using Brodmann's classification (Bernal & Perdomo, 2008). Also, the Cingulate Gyrus (CG) is noted as a major contributing source (see Figure 4). In the present study, the most active area in different groups and conditions was BA42, which is responsible for early processing of auditory information in the primary auditory cortex of the temporal lobe; it was activated in the KB group in all conditions and when the EM group read in CS+ and SR- conditions. Other BA areas, including BA19, BA38, BA39, BA42, BA44, BA47, were also activated as follows: BA19, associated with visual memory recognition and naming, was activated when KB read in SR+ condition and when EM read in the SR+ and SR- conditions; BA 38, associated with word retrieval for specific entities and emotional responses, was activated when EM read in the SR- condition; BA 39, playing a role in semantic processing and reading, was activated when EM read in the SR- condition; and BA44, motor speech production in Broca's area in the inferior frontal lobe, was activated when KB read in the CS- condition and when EM read in the SR- condition; BA 47, associated with language and memory, was activated when EM read in the CS+ condition and when EM read in the SR- condition. In the present study, the CG was activated only when English Monolinguals read word pairs in the SR-, CS+, and CS- conditions.

According to source localization data, the most brain activity was found when English monolinguals read semantically unrelated word pairs (See Figure 4E). In the right hemisphere, high activity was found in the right temporal lobe, anterior occipital lobe, and posterior frontal lobe. In the left hemisphere, broad activation was found in the central part of the temporal and parietal lobes. The cingulate gyrus, part of the limbic system active when the brain processes conflicting stimuli, also shows activity. This activity contrasts with that of the Korean bilingual group (See Figure 4F), where activity was found in the right temporal lobe. The difference in active brain areas indicates that the English monolingual participants were having more difficulty and expending more processing resources in the semantically unrelated condition (SR-) than the

Korean bilingual participants. Moreover, it should be noted that when both groups were reading semantically unrelated word pairs, neither group appeared to be accessing Wernicke's area in the left temporal lobe, suggesting that language processing was not accessed.

The semantically related condition (SR+) shows that both groups were accessing language areas over the right hemisphere, with the English monolingual participants also accessing area 47 where syntactic decoding takes place. It should be noted that area 47 was also accessed when the English monolingual group read SR+ word pairs. This was not seen in any other condition for either group.

ERP Waveforms

Figure 5 shows the grand-average ERP waveforms of 61 electrodes for the English monolingual and Korean bilingual groups under the different conditions (CS+, CS-, SR+, SR-). Gray areas highlight regions of interest—the time area that N400 takes place. Figure 5A shows the ERP for the English monolingual group when they read word pairs with and without a common syllable. Figure 5B shows the ERP for the English monolingual group when they read word pairs with and without a common syllable. Figure 5C shows the ERP for the Korean bilingual group when they read word pairs with and without semantic relatedness. Figure 5D shows the ERP for the Korean bilingual group when they read word pairs with and without a common syllable. Please note that Figure 2 and 3 are N400 amplitude and latency values derived from the ERP waveform below. The interpretation of Figure 2 and 3 can also be applied into Figure 5 correspondingly.

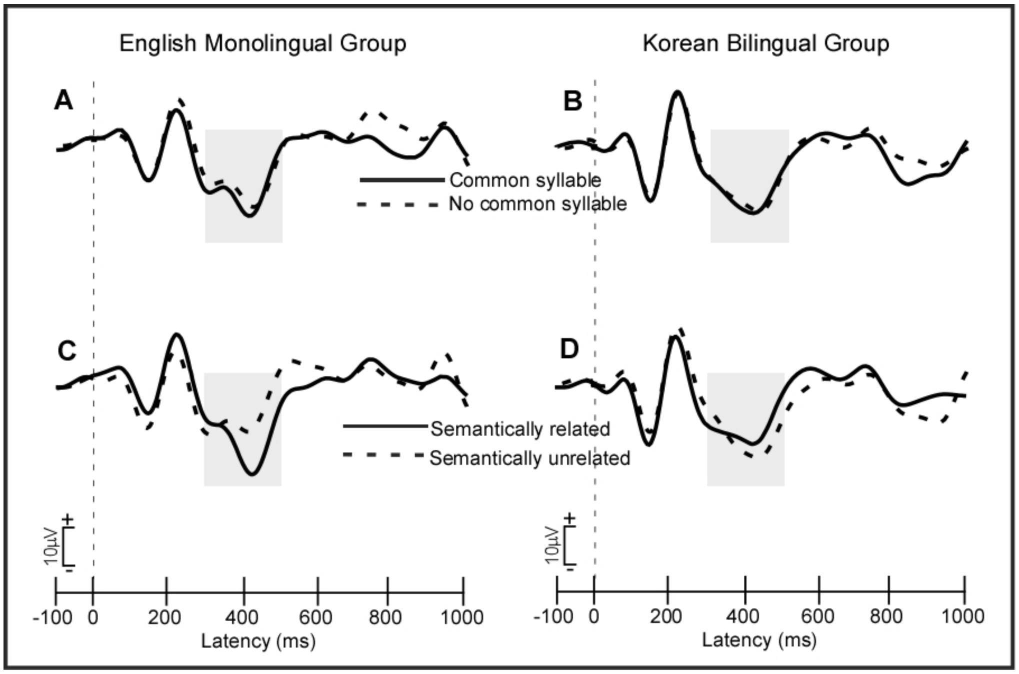

Figure 5. ERP waveforms for both EM and KB groups (A-D*).*

In sum, the results of the present study found that the Korean bilingual group were unaffected by the hidden primes embedded in the stimuli as indicated by the absence of a reduction in N400. This was indicated by the observation that there were no significant differences observed between the monolingual and bilingual groups.

5 Discussion

The present study was designed to investigate whether an N400 reduction effect would be elicited in a Korean-English bilingual group (KB group) as they read word pairs with a hidden common first syllable in Korean compared to word pairs that do not. The presence of N400 in the present research design signifies activation of native language translations. For the present study, I hypothesized that higher English proficiency of participants would diminish the amplitude reduction effects. In accordance with my hypothesis, the results of the present study showed that there are no significant between-group differences under common syllable conditions (CS+, CS-; refer to Table 5 for the results of the pairwise comparisons and description of each condition), and thus the N400 reduction effect was not found. A plausible explanation of the results is that these highly proficient bilinguals retrieved meaning directly from the L2 without relying on their L1, which is Korean. The results might not be surprising since the bilingual group members are undergraduate students immersed in the English language; their path of semantic retrieval turns out to resemble that of native speakers of English (i.e., the control group in the present study).

The present study indicates that the bilingual participants decoded L2 in a way comparable to the way monolingual participants decoded in L1. In Figure 4, the P1 waveforms[12] are well developed and clearly seen for both participant groups across all four conditions, suggesting that the participants perceived the stimuli in approximately the same manner, supporting that the bilingual participants decoded L2 in a way similar to the way monolingual

[12] P1 (also called P100) is a first positive-going component of ERP that peaks at around 100ms. It represents acoustic processing of the stimulus.

participants decoded in L1. Also, according to Figure 4, a difference in N400 processing was not found between the two groups when they read stimuli in the CS+ condition, meaning that the Korean bilingual group was unaffected by the hidden primes that would only affect them if they translated the stimuli into their L1, Korean.

Regarding the effect of common syllable conditions, according to source localization data, the Korean bilingual and the English monolingual groups appear to process the conditions in approximately the same manner, supporting the notion that Korean bilinguals accessed their L2 without accessing the L1. The only difference found between the groups is that the EM group accessed the cingulate gyrus, particularly in the CS- condition, suggesting that greater emotional activity was involved in the decision-making process (Hart & Kraut, 2007). Both groups in the CS+ condition accessed the primary auditory cortex over the left hemisphere. From the wide activity shown in Figure 3E, it can be postulated that the English monolingual group was using more resources in an attempt to categorize the incongruent information of the common syllable word pairs into a recognizable category. The activation of the cingulate gyrus would suggest that emotional content was involved in the linguistic decision (Bernal & Perdomo, 2008).

An interesting finding was that the Cingulate Gyrus (CG) was activated only when English Monolinguals read word pairs in the SR-, CS+ and CS- conditions. The CG is part of the limbic system and is active during conflict resolution and receives input from the thalamus (Bernal & Perdomo, 2008). From the source localization results, the CG was not activated when English Monolinguals read SR+ word pairs, nor when Korean Bilinguals read in any of the four conditions. It is predictable that English Monolinguals do not activate their CG when reading SR+ conditions—information is coherent and no conflict resolution is triggered (Kutas and Febermeier, 2014). The interesting finding from the source localization results is that none of the word pairs triggered activation of CG in Korean Bilinguals—even SR- word pairs, which are most likely to trigger a response in the brain for conflict resolution. A possible interpretation of this is that, while the findings of this study seems to show that the Korean Bilinguals have high enough English proficiency to not access their first language when retrieving meaning, the depth of processing between English Monolinguals and Korean Bilinguals are still different. The non-activation of CG in Korean Bilinguals may signify that less resources were used by their brains when resolving differences in meaning between unrelated word pairs.

As the figures indicate, the only significant group difference in N400 maximum amplitude was found under condition SR- (word pairs semantically unrelated) which can be seen in both Figure 1 (showing group differences in maximum amplitude of N400) and Figure 4 (showing a comprehensive ERP of the N400 component). As can be seen in Figure 1, only in condition SR- did the monolingual group exhibit a significantly higher maximum amplitude than the bilingual group. Likewise, it can be seen in Figure 4C and 4D that while the two groups perform similarly when reading in the SR+ condition, the two groups perform differently when reading in the SR- condition. It can be seen from Figure 4D that whether Korean Bilinguals read semantically related or unrelated word pairs, there is not a big difference in the N400 triggered. However, when English Monolinguals read semantically unrelated word pairs, an obvious "dip" can be observed compared to when English Monolinguals read semantically related word pairs. The bigger "dip (stronger N400)" signifies a greater depth of conflict resolution. Such a finding concurs with findings in previous literature (e.g. Hahne, 2001) which describes the observation that English Monolinguals exhibit a higher magnitude in N400 compared to Chinese-English bilinguals. Hahne (2001) suggested such an effect shows that monolinguals are relatively more efficient in lexical access in their first language. While this finding is unrelated to the research question of the present study (i.e. whether bilinguals access their L1 when reading in L2), this finding provides the insight that there is still a difference in the manner English Monolinguals and Korean Bilinguals process language in English.

The current study—combined with the findings of Thierry and Wu (2007), Guo et al. (2012), Morford et al. (2011), and Zhang et al. (2011)—provides a more comprehensive view about L1 access in bilingual minds. The findings of these studies constitute evidence that the more proficient bilinguals are in the second language, the less likely they are to rely on the L1 when retrieving meaning in the L2.

The study findings have two main implications for both second language acquisition theory and L2 instruction. First, the present data provides additional and unique evidence toward the selective access theory. While most studies were done using behavioral measures such as translation tasks, the present study provides additional evidence for selective access using EEG measures, which provide insights about participants' subconscious reactions—reactions that cannot be observed using behavioral measures. Second, in terms of L2 acquisition and teaching, the results of this study suggest less L1 interference for advanced learners than was seen for less advanced. Teachers concerned about L1 interference and complications related to L1 background in their classroom (see Derakhshan & Karimi, 2015, for more information) might be less concerned for the more advanced English learners—fewer adjustments and less instruction aimed at cross-linguistic influence may be needed as proficiency increases. The present study suggests that bilingual participant whose English proficiency level reaches IELTS 7 do not rely on L1 when reading in L2.

The present study has several limitations. First, it lacks behavioral measures (i.e., research that involves observing outward actions or reaction and analyzing them, such as measuring reaction time or error rate) or auditory modules (i.e., presenting the stimulus using sounds instead of printed word) to support its findings. While the current study found no L1 lexical representation on L2 reading, additional insights may be found if the stimulus was also presented in the auditory module. Due to the fact that the present study focuses on the overt aspects of cognition, the behavioral aspects and auditory modules were not considered. In the future, researchers could consider conducting a study that includes behavioral aspects and auditory modules. Secondly, while the word pairs were verified for their relatedness using computational methods, the frequency or commonness of words were not controlled. The frequency of words may influence semantic access patterns of readers. Thirdly, this study is limited in sample size. While the total number of participants in the present study is the same as Thierry and Wu's (2007) and more than Guo et al.'s (2012), using 15 bilinguals to represent the vast Chinese-English highly-proficient bilingual population is still insufficient. Fourthly, the study has limited ecological validity, because the rapid presentation of words without context is not typical in the lives of bilinguals. An experimental setting that has greater resemblance to real life encounters would be to present words in sentential contexts. Fifthly, it should be noted that Chinese-English participants and Korean-English participants may not be equivalents, so comparing the results of my study and Thierry and Wu's study (2007) may not be completely valid. In order to reduce ambiguity in replicating Thierry and Wu's study (2007), Chinese-English bilingual participants instead of Korean-English participants should be adopted in a future replication study.

To conclude, the electrophysiological results of the present study did not show a significant N400 reduction effect that would indicate that the bilingual group accessed their native language while decoding word pairs in their second language. Despite the fact that the cortical areas of two languages in highly-proficient bilingual brains show common or partial overlaps (Kovelman, 2008), this finding demonstrates that bilinguals are able to retrieve meaning directly from the L2 orthography and supports the notion that that the mental lexicon of two languages can operate independently of each other. The present study also provides additional evidence to the Revised Hierarchical Model of semantic retrieval proposed by Kroll and Steward (1994)—that increased proficiency level will reduce the L1 reliance in L2 semantic retrieval. The results of the present study imply that advanced L2 learners may be capable of using L2 monolingual dictionaries, as opposed to bilingual dictionaries, in order to facilitate access to information (c.f. Laufer and Hadar, 1997; Chan, 2011); in addition, for applications in the classroom setting for more advanced learners, it may facilitate L2 semantic retrieval to use L2 exclusively used in the classroom instead of including their L1.

6 Conclusion

Utilizing an implicit priming paradigm, this study investigated whether Korean-English bilinguals would unconsciously access Korean translations when reading English word pairs. The hypothesis that the high-proficiency Korean-English bilingual group would not be affected by primes embedded within the Korean translation of English word pairs was correct. This was indicated by the observation that there were no significant differences observed between the monolingual and bilingual groups (i.e., differences failed to reach significance).

The result of my study found that bilingual students with higher English proficiency (IELTS 7 or 8) did not experience L1 translation effect when they participated in a L2 relatedness task. That supports the notion that an increased English proficiency strengthens direct semantic retrieval between L2 and meaning, thus reducing L1 lexical representation. This provides additional evidence supporting the Revised Hierarchical Model of semantic retrieval proposed by Kroll and Steward (1994), which suggests that increased proficiency leads to reduced reliance on L1 during L2 semantic retrieval.

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Appendix A

Practice word pairs

1. Police – Thank
2. Grateful – Ungrateful
3. Pots - Pans
4. Yesterday – Basement
5. Window – Biology

The 4 types of items in the semantic relatedness task	
SR- CS+	1. Sky 하늘 - Hippo 하마 [36%] 2. Cradle 요람 -Summary 요강 [33%] 3. Milk 우유 - Depression 우울 [36%] 4. Yacht 요트 -Cooking 요리 [41%] 5. Chair 의자 - Opinion 의견 [41%] 6. Journalist 기자 - Foundation 기초 [32%] 7. Airport 공항 - Tool 공구 [33% related] 8. Watermelon 수박 - Surgery 수술 [40%] 9. Pizza 피자- Fatigue 피곤 [33%] 10. Fool 바보 - Ocean 바다 [41%] 11. Hat 모자 - Contradictions 모순[33%] 12. Scripture 경전- Police 경찰 [41%] 13. Scissors 가위 - Family 가정 [41%] 14. Cucumber 오이 - Pollution 오염 [41%] 15. Internally 내부 - Tomorrow 내일 [33%] 16. Name 이름 - Lice 이 [41%] 17. Lion 사자 - Apple 사과 [33%] 18. Librarian 사서 - Apology 사과하다 [33%] 19. Sugar 설탕 - Diarrhea 설사 [44%] 20. Eraser 지우개 - Support 지원 [33%] 21. Ring 반지 - Reflect 반사 [30%] 22. Scissors 가위 - Patriarch 가장 [41%] 23. Chair 의자 - Opinion 의견 [41%] 24. Injection 주사 - Address 주소 [45%] 25. Exaggeration 과장 - Snacks 과자 [41%] 26. Leopard 표범 - Expression 표현 [33%] 27. Pants 바지 - Rock 바위 [33%] 28. Crispy 바싹 - Floor 바닥 [41%]

	29. Prayer 기도 - Souvenir 기념품 [33%] 30. Verb 동사 - Zoo 동물원 [41%] 31. Service 봉사 - Seal 봉인 [30%] 32. Telephone 전화 – Abalone 전복 [35%] 33. Grade 성적 - Personality 성격 [44%] 34. Fruit 과일 - Tutoring 과외 [33%] 35. Purchase 사다 - Accident 사고 [42%] 36. Deer 사슴 - Truth 사실 [41%] 37. Rain 비 - Soap 비누 [42%] 38. Engineering 공학 - Daydream 공상 [29%] 39. Factory 공장 - Study 공부 [41%] 40. Introduction 소개 - Sauce 소스 [42%] 41. Refund 환급 - Patient 환자 [46%] 42. Humidity 습도 - Habit 습관 [33%] 43. Idioms **관용어** - Sightseeing 관광 [33%] 44. Irrigation 관개 - Tariff 관세 [46%] 45. Soysauce 간장- Nurse 간호사 46. Value 가치 - Autumn 가을 [41%] 47. Economy 경제 - Slope 경사 37[%] 48. Mathematics 수학 - Nuns 수녀 [37%] 49. Yawn **하품하다** - Sky 하늘 [46%] 50. Appreciation 감사 - Potato 감자 [33%]
SR+ CS+	1. Student 학생 -Learning 학습 [75% related] 2. Meal 식사 - Tableware 식기 [75% related] 3. Semester 학기 - School 학교[83%] 4. Appetite 식욕 - Meals 식사 [75%] 5. Professor 교수 - Teacher 교사 [75%] 6. Color 색깔 - Pigment 색소 [91%] 7. Art 미술 - Beauty 미모 [75%] 8. Home 가정 - Family 가족 [98%] 9. Japanese 일본어 - Japan 일본 [91%] 10. Instrument 악기 - Sheet-music 악보 [83%] 11. Monitoring 감시하다 - Supervising 감독하다 [92%] 12. Germany 독일 - German 독일어 [99%] 13. Consciousness 의식 - Will 의지 [71%] 14. Task 과업 - Assignment 과제 [91%] 15. Suspicion 의혹 - Doubt 의문 [91%] 16. Ocean 해양 - Seabed 해저 [92%] 17. Map 지도 - Area 지역 [75%] 18. Passion 열정 - Enthusiasm 열중 [75%] 19. Growth 성장 - Maturity 성숙

	20. Contract 계약 - Deposit 계약금 21. Life 생명 - Living 생활 [100%] 22. Merchandise 상품 - Store 상가 [75%] 23. Vacation 휴가 - Holiday 휴일 [100%] 24. Time 시간 - Era 시대 [91%] 25. Division 분리 - Split 분열 [90%] 26. Male 남성 - Boys 남자 [75%] 27. Permission 허가 - Permit 허용 [99%] 28. Military 군대 - Warrior 군사 [87%] 29. International 국제 - National 국가 [92%] 30. Rally 집회 - Gathering 집합 [92%] 31. Aid 지원 - Support 지지 [92%] 32. Protection 보호 - Security 보안 [91%] 33. Honesty 정직 - Justice 정의 [71%] 34. Faith 신앙 - Trust 신뢰 [99%] 35. Clock 시계 - Hour 시간 [75%] 36. Creating 창조 - Creation 창작 [75%] 37. Released 출고 - Publish 출판 [99%] 38. Sort 종류 - Species 종 [91%] 39. Birth 출산 - Origin 출처 [75%] 40. Menu 식단 - Restaurant 식당 [92%] 41. Taboo 금기 - Prohibited 금지 [79%] 42. Passport 여권 - Travels 여행 [91%] 43. Pig - pork 44. Freeze 냉동 - Refrigerate 냉장 [78%] 45. Military 군대- Soldier 군인 [92%] 46. Singer 가수 - Song 가요[75%] 47. Decide 결정하다 - Determination 결심 [70%] 48. Educate 교육 - Enlighten 교화하다 [71%] 49. Failure 실패 - Mistake 실수 [82%] 50. Literate 문명 - Illiterate 문맹 [96%]
SR- CS-	1. Apple(사과)- Linguistics(어학) [33% related] 2. Stove 난로 - Bookstore 서점 [41%] 3. Gentleman 신사 - Mirror 거울 [37%] 4. Sofa 쇼파 - Wind 바람 [33%] 5. Nail 손톱 - Chair 의자 [41%] 6. Noodle 면 - Church 교회 [42%] 7. Notebook 공책 - Puzzle 퍼즐 [3%] 8. Clock 시계 - Water 물 [42%] 9. Salt 소금 - Rent 방세 [39%] 10. Engine 엔진 - dessert 디져트 [20%]

	11. Lips 입술 - printer 인쇄기 [25%] 12. Pillow 베개 - Needle 바늘 [29%] 13. Milk 우유 - President 회장 [36%] 14. Treasure 보물 - Train 기차 [43%] 15. Status 상태 - Butter 버터 [41%] 16. Geography 지리 - Receipt 영수증 [33%] 17. Tissue 휴지 - Retirement 은퇴 [36%] 18. Song 가요 - Cup 컵 [33%] 19. Deer 사슴 - Gift 선물 [37%] 20. Website 사이트 - Vitamin 비타민 [33%] 21. Jellyfish 해파리- Temple 성전 [41%] 22. Slope 경사 - Calendar 달력 [41%] 23. Reference 참조 - Pill 알약 [40%] 24. Valley 계곡 - Loyalty 충성 [33%] 25. Magnet 자석 - Jeans 바지 [39%] 26. Soybean 대두 - Lid 뚜껑 [33%] 27. War 전쟁 - Fish 생선 [41%] 28. Toothpick 이쑤지게 - Wedding 결혼식[46%] 29. Ketchup 케찹 - Oxygen 산소 [32%] 30. Shampoo 샴푸 - Magic 마술 [40%] 31. Meat 고기 - Shoes 마술 [37%] 32. Photography 사진학 - Lettuce 상추 [33%] 33. Singer 가수 - Oil 기름 [33%] 34. Hair 머리카락 - Fridge 냉장고 [41%] 35. Stone 바위 - Trip 여행 [41%] 36. Square 사방 - Tears 눈물 [40%] 37. Mirror 거울 - Employee 고용인 [37%] 38. Door 문 - Butterfly 나비 [39%] 39. Boat 배 - Translate 번역 [39%] NO 40. Football 축구 - Pharmacist 약사 [33%] 41. Pot 냄비 - Zipper 지퍼 [33%] 42. Elephant 코끼리 - Angel 천사 [33%] 43. Pills 알약 - Novel 소설 [45%] 44. Tourist 여행자 - Pepper 후추 [39%] 45. Gym 운동 - Pollution 오염 [25%] 46. Bookmark 서표 - Face 얼굴 [33%] 47. Protein 단백질- Phone 전화 [41%] 48. Maid 시녀 - Ocean 바다 [33%] 49. Scissors 가위- Hour 시간 [33%] 50. Lipstick 립스틱 - Flour 밀카루
SR- CS+	1. Husband(남편) - Wife(아내) [96%]

2. Brother(형제) - Sister(자매) [96%]
3. Mother (어머니) - Father (아버지) [100%]
4. Family (가족) - Relative (친척) [91%]
5. Bed (침대) - Pillow (베개) [75%]
6. School 학교 - Work 직장 [75%]
7. Food 음식 - Water 물 [90%]
8. Start 시작 - End 끝 [95%]
9. False 가짜 - True 참됨 [92%]
10. Bird 새 - Feather 깃털 [75%]
11. Deficit 결핍 - Lack 부족 [91%]
12. Change 변화 - Transformation 변형 [91%]
13. Book 책- Page 페이지 [75%]
14. Snow 눈 - Ice 얼음 [92%]
15. Smile 웃음 - Happy 행복 [83%]
16. Bread 빵 - Flour 밀가루 [83%]
17. Width 가로 - Length 길이 [74%]
18. Color 색깔 - Yellow 노란색 [92%]
19. Music 음악 - Piano 피아노 [92%]
20. Shoes 신발 - Heels 발굽 [75%]
21. Teacher 선생 - Student 학생 [75%]
22. Employer 고용주 - Employee 종업원 [96%]
23. Concerned 근심 - Worry 걱정 [99%]
24. Phone 전화 - Charger 충전기 [72%]
25. Football 미식축구 - Soccer 축구 [92%]
26. Drink 마시다 - Cup 컵 [82%]
27. Toast 토스트 - Bread 빵 [92%]
28. Pen 펜 - Pencil 연필 [75%]
29. Table 탁자 - Desk 책상 [91%]
30. Star 별 - Moon 달 [83%]
31. Shampoo 샴푸 - Conditioner 컨디셔너 [75%]
32. Sense 감각 - Feeling 느낌 [78%]
33. Money 돈 - Wallet 지갑 [92%]
34. Exercise 운동 - Sports 스포츠 [70%]
35. Lemon 레몬 - Lime 라임 [75%]
36. Father 아빠 - Grandfather 할아버지 [92%]
37. Day 낮 - Night 밤 [95%]
38. Running 달리기 - Jogging 조깅 [92%]
39. Boy 소년 - Girl 소녀 [95%]
40. Rocks 바위 - Stones 돌 [100%]
41. Vision 력 - Eyes 안구 [79%]
42. Agree 동의 - Disagree 비동의 [96%]

	43. Name 이름 - Nickname 별명 [92%] 44. Play 놀다 - Game 게임 [91%] 45. House 집 - Apartment 아파트 [75%] 46. Lunch 점심 - Dinner 저녁 [75%] 47. Salmon 연어- Fish 물고기 [75%] 48. Environment 환경 - Circumstances 상황 [91%] 49. Fork 포크 - Spoon 숟가락 [90%] 50. Flower 꽃 - Rose 장미 [75%]

Appendix B: Pre-Study Survey

Last name:

First name:

Email address:

Phone number:

Age:

Level of education obtained so far:

First language (the language you learned before age 3):

Second language (any language you learned after age 3):

Second language proficiency score (IELTs or TOEFL or ACTFL):

How old were you when you started learning the second language:

Handedness (Right/ Left)?

Have you had allergic reactions to saline gel in the past?

Appendix C: Consent Documents

Introduction

This research study is being conducted by master's student in Linguistics, Janice Lam, at Brigham Young University under mentorship of Professor Dewey, Professor McPherson and Professor Bourgerie to investigate how the brain gets the meaning when you read English words. Things to consider before coming in:

· Please come to Room 110 of Taylor Building (TLRB) at the scheduled time. It is located opposite to the Creamery on 9th.

· The total time commitment will be 90 minutes. Please allow enough time in your schedule to complete the study.

· During the study, you will wear a cap as shown below, and a gel will be applied to your hair through each of the electrodes. After you take off the head, you may rinse the gel off in the bathroom and a blow dryer will be provided to you. You may also prefer to go home immediately after to freshen up.

· You may be asked to brush your hair before putting on the cap. You can skip this if you do it at home before coming to the facility.

Image retrieved from http://bild.la.psu.edu/

Procedures

If you agree to participate in this research study, the following will occur:

· When you come in, you will first sign this consent form to confirm that you agree to participate.

· EEG set up (40 minutes): Researchers will ask you to brush your hair. If you have long hair, you will be asked to tie up your hair into a low ponytail. When you are ready, researchers will place an electrode cap that will fit tightly on your head and wrapped around your jaw. Additional electrodes will be placed on various places around your face. The areas where these electrodes will be taped on will first be cleansed using a gentle abrasive gel. Each of the 72 electrodes will be injected with a gel using a syringe with blunt-tipped needles which is safe but can be uncomfortable.

· EEG recording (40 minutes): You will enter into a soundproof room and be seated comfortably in front of a computer. In this task, you will see 200 rounds of word pairs in total. In each round, the first word in the pair will be presented for 1 second followed by an interval of 0.7 second, and then will be presented with the second word. By pressing buttons, you will indicate whether the second word was related in meaning to the first, in a scale of 1 to 5. The higher the number, the more related they are.

The first 8 pairs will be a demonstration and researcher will explain to you how to do it.

· When the task is complete, you may remove the cap under assistance of the lab attendant. A sink, paper towels, and hair dryer will be available for you to remove any remaining gel on your hair.

Risks/Discomforts

You will be required wear an electrode cap that has to fit tightly on your scalp, which may be uncomfortable. Also, when using blunt-tipped syringes to inject gel into each of the 72 electrodes, the gentle pressure applied may cause a slight degree of discomfort. As a remedy, the researcher will pay special attention about the amount of pressure applied on the participant's scalp when injecting the gel, and will frequently check with you to ensure your wellness. If you indicates that the discomfort is unbearable, you are welcome to withdraw at any time.

Coming in for a total of 1.5 hour can potentially bore you. I will ensure that you can take breaks or stop participating at any time.

Benefits

There will be no direct benefits to you. It is hoped, however, that through your participation researchers may learn more about Korean linguistics.

Confidentiality

At the start of the study, you will get an ID code. Data from this study will be marked with your ID code and not with your name or any information about you. The research data will be kept on password protected computer and in the researcher's google account, and only the researchers will be able to see it. When the results of this study are published, no identifying information about you will be included. Only averaged data or, if necessary, ID codes will be published. The data will be stored for 10 years.

Compensation

You will receive a $15 cash or gift card for your participation; compensation will not be prorated.

Participation

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participating entirely without jeopardy to your class status, grade, or standing with the university.

Questions about the Research

If you have questions regarding this study, you may contact Janice Lam at janicesl@go.byuh.edu or phone (801)979-9323 or Dr. Bourgerie dana_bourgerie@byu.edu for further information.

Questions about Your Rights as Research Participants

If you have questions regarding your rights as a research participant contact IRB Administrator at (801) 422-1461; A-285 ASB, Brigham Young University, Provo, UT 84602; irb@byu.edu.

Statement of Consent

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

Name (Printed): Signature Date: