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Semantic Anomalies in Second Language Processing: An Electrophysiological Study*

Sei-Rang Oh
(Gyeongsang National University)

Oh, Sei-Rang. 2011. Semantic Anomalies in Second Language Processing: An Electrophysiological Study. *Linguistic Research* 28(3), 585-603. How humans' language processing occurs in the brain in real-time has been one of the major issues to clarify in the field. Especially, it is interesting to see related to the issue how bilinguals do in their second language (L2) processing as compared to monolinguals of the language. This study conducts an event-related potential (ERP) study to investigate the temporal neural dynamics of semantic processing in bilinguals. The experiment was done with Korean speakers of English as an L2, divided into two groups depending on their L2 proficiency level. The typical semantic anomaly paradigm was adopted for the material; semantically anomalous sentences end with a word which is not congruent in the sentence context. It was investigated if semantically anomalous stimuli elicit N400, known as meaning-related ERP component since Kutas & Hillyard (1980). Overall, similar pattern of the N400 effect was observed in the high proficiency group, while no significant effect was found in the low proficiency group. Though the results do not show a complete match in every detail, the study suggests that the bilinguals' semantic processing resembles monolinguals' semantic processing to a significant extent. This study also suggests that proficiency has a close correlation with brain responses in semantic processing in L2. **(Gyeongsang National University)**

Key Words event-related potentials, sentence processing, semantic anomaly, semantic congruency, N400, second language

1. Introduction

How semantic information is retrieved during language comprehension and how the normal brain constructs meaning, especially in real-time, have been major concerns in the study of the sentence processing related to meaning. Given that

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behavioral methods and hemodynamic-based brain imaging methods have limitations in capturing the real-time brain processes involved in meaning processing, event-related potentials (ERPs), an electrophysiological method, have been an alternative to overcome such limitations, being a high temporal resolution technique that is both a sensitive measure of real-time language processing and a direct manifestation of brain activity. ERPs are scalp-recorded changes in an electric activity that occur in response to an event. Analyzing changes in the size, timing, polarity (positive or negative) or distribution of the electrical activity over the head across different experimental conditions provides millisecond-level information about sensory, perceptual, cognitive, and motor processing across different brain regions.

ERPs have been adopted in the researches on processing of meaning since Kutas and Hillyard (1980) first observed a meaning-related ERP component, the N400. The N400 is a negative component peaking around 400 ms after stimulus-onset and has been shown to vary systematically with the processing of semantic information. Kutas and Hillyard (1980) first observed it in response to a semantically anomalous(incongruent) word in a sentence context; The amplitude of the N400 increases when a semantically anomalous word is presented in the sentence as compared with the case of semantically normal(congruent) word, shown in the examples below:

(1) a. He spread the warm bread with butter.
    b. He spread the warm bread with socks.
(2) a. He takes cream and sugar in his coffee.
    b. He takes cream and sugar in his afternoon.

In contrast to (1a) and (2a) respectively, the examples in (1b) and (2b) involve semantic anomaly; The last word in each sentence is quite unexpected and therefore, semantically incongruent in the given sentence context. This semantic anomaly increases the amplitude of the negative activity around 400 ms after the stimulus word, showing the N400 effect.

The N400 component is not simply an index of anomaly though. Rather it can be said that it is a part of the brain's normal response to potentially meaningful events (Kutas & Federmeier 2000; Kutas et al. 2000). The amplitude of the N400 is the parameter that is most sensitive to lexical-semantic manipulations. Thus, its

amplitude varies with semantic congruity, cloze probability of words in a context, word repetition, word frequency, and semantic category, among others. Its distribution over the scalp has been found to vary depending on the type of eliciting stimulus.

2. L2 Semantic Processing and ERPs

With the significance and advantages they have in the researches on language processing, ERPs have also been adopted in second language (L2) researches, especially on bilinguals' language processing. The major concerns of ERP-adopted second language studies are, above all, how the findings from first language (L1) ERP studies turn out in an L2, and how the brain works with both languages interrelated when bilinguals process their L2. And L2 studies related to semantic processing share these issues.

Semantic anomalies or incongruities, which was a major object in the ERP semantic studies of L1 inducing the N400 component, can also be considered as a major topic in L2 semantic studies. Most of the other factors which have been considered in L1 researches including cloze probability, word frequency, semantic category are also significantly considered in L2 semantic researches. Some additional factors including bilinguals' biological and cognitive conditions are also found to be relevant in L2 processing (e.g., Kutas & Kluender 1994).

The semantic anomaly sentence paradigm of L1 vs. L2 ERP studies which induces the N400 effect can be distinguished depending on the formation of experiment subject groups. One is between-groups design, which compares an L2 group with an L1 group. The other is within-group design, which focuses on how bilinguals process an L2 as compared to their L1.

One of the observations from previous between-group design studies is that bilinguals are slower in their lexical decisions as compared to native speakers of L2 (e.g., Lehtonen & Laine 2003; Portin & Laine 2001). Ardal et al. (1990) adopted the N400 semantic anomaly paradigm to examine this slowing effect in L2 and found a significant delay in the N400 peak latency (approximately 40ms) for bilinguals in their L2 compared to monolinguals. In this study, bilinguals also showed a delay in the N400 peak latency in their L1 in contrast to monolinguals. Also, it was found

that the N400 tends to peak on the left side of scalp in bilinguals, while it is on the right side in monolinguals. Weber-Fox & Neville (1996) also reported in their between-group study a delay in the N400 peak latency (approximately 20ms) to semantically anomalous sentence endings in Chinese speakers of English as an L2. They divided the speakers depending on the age of acquisition and found out that the peak latency delay was not actually noticeable in the group of speakers who got exposed to their L2 before the age of 11. In this study, however, other parameters reported from the previous studies affecting the N400 component such as amplitude or distribution on scalp were not found to differ between bilinguals and monolinguals. Hahne & Friederici (2001) examined native Japanese speakers who had learned German as an L2 and found with regard to the ERPs to semantic anomalies that the bilinguals showed an N400 effect similar to the one observed in native speakers of German. But the N400 effect lasted about 400ms longer in the L2 group, which may be interpreted as longer engagement in trying to integrate the stimulus word into the prior context.

Kutas & Kluender (1994), who implemented a within-group design to compare the bilinguals' two languages, also found the N400 effect, which peaked later and lasted longer in their L2. It was also found that the average amplitude of the N400 component was smaller in their less proficient language. Proverbio et al. (2002) adopted a within-group design as well as a between-group design, comparing highly fluent Italian-Slovenian bilinguals' ERP responses to semantic anomaly in Italian and Slovenian as well as comparing the bilinguals and Italian monolinguals. For the processing of semantic errors, they report a reversed pattern of N400 lateralization on scalp distribution for the bilinguals compared with the monolinguals. Semantic incongruence resulted in greater response over the left hemisphere than over the right in bilinguals, while the pattern was reversed in the monolinguals. Moreover, the N400 effect was different in the bilinguals' L1 and L2. Moreno & Kutas (2005) examined the N400 effect using English-Spanish bilinguals and found that the effect varies depending on their proficiency level.

What has been observed from the previous L2 studies mentioned above is that the N400 effect is also found in bilinguals' L2, but the pattern does not show a perfect match with L1 in the peak latency, duration, or scalp distribution. In addition, it may be affected by other factors like L2 proficiency level or age of acquisition. With the variant results with different factors involved, however, the

findings do not seem to be quite sufficient to lead to a clear account of the semantic processing in L2. Here the relevant issues are: whether the semantic processing in L2 is done in a different fashion from the one in L1 and if it is, how different the pattern is and what specific factors are involved to cause the pattern. To clarify these critical issues, further studies seem to be in need. Moreover, little is known about how Korean L2 speakers process the semantic information in their L2 compared to the native speakers of the language. Would they show the N400 effect in their English semantic processing? Given this, a new investigation of Korean-English bilinguals' semantic processing needs to be done to see how the findings from the previous studies above would turn out in Korean bilinguals. To provide more findings on such issues, this study runs an experimental study adopting the electrophysiological method ERP. The main relevant issues we eventually desire to clarify are listed below:

(3) a. Do bilinguals show the same ERP pattern in their L2 compared to the native speakers of the language?
b. What factors may affect the ERP pattern of bilinguals?
c. Are there any limitations on the linguistic components L2 speakers can acquire? (e.g. Clashen & Felser 2006)

Related to these fundamental issues, the current study specifically deals with the following questions:

(4) a. Do Korean L2 speakers of English show the same ERP responses to the semantic stimuli as observed from English native speakers and others?
b. What factors may affect Korean bilinguals' ERP pattern as compared to English monolinguals'?
c. Are there any components of English full mastering of which by Korean L2 speakers is significantly restricted?

This study investigates the above issues in an experiment with Korean L2 speakers of English. Specifically we will adopt the typical semantic anomaly paradigm to find out their semantic processing pattern.

3. The Semantic Congruency Effect

In the current experimental study, we mainly deal with the so-called semantic congruency effect mentioned above as observed in Kutas & Hillyard (1980). The effect is also called the N400 effect since the negative deflection peaking at around 400 ms after stimulus onset reveals more negativity to semantically anomalous words which are incongruent in the given context as compared to semantically congruent words. The N400 component was originally presented in the following configuration in Kutas & Hillyard (1980).

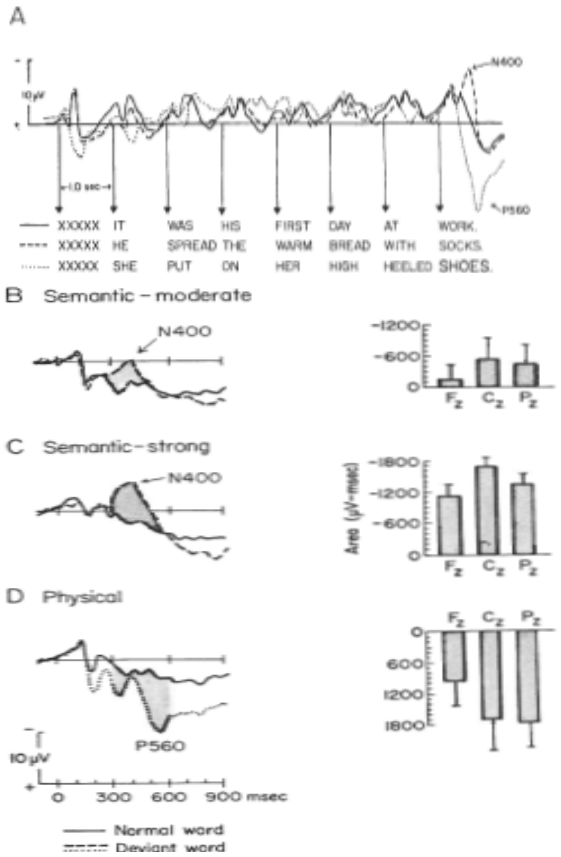

Figure 1. ERP Responses in Kutas and Hillyard (1980)

In their study, they tested the effects in three different sentence types: sentences

ending with a semantically moderately incongruous word (*He took a sip from the waterfall*.), a strongly incongruous word (*He took a sip from the transmitter*), or a physically peculiar word (e.g. in letter size). As shown in the above results, the main effects were observed at Fz, Cz, Pz, and the N400 effect was more significant for the strong incongruity case. Basically adopting the research paradigm related to the semantic congruency effect of their study, but focusing on rather strong semantic incongruency, the current study runs an experiment to investigate the effect in Korean-English bilinguals. Especially we look into the paradigm comparing different L2 proficiency groups. In the following section, we present the details of the experiment.

4. Experiment

4.1 Participants

Two groups of Korean-English bilinguals whose first language is Korean participated in the present experiment. They were all late-learners of English as an L2 and did not have any experience of living in an English native country. All participants were undergraduate college students, right-handed and had normal or corrected to normal vision. None of them had experienced a psychiatric or neurological disease. The group with high English proficiency consisted of 19 advanced L2 speakers of English (12 men; mean age 22.2) who had very high scores on the TOEIC Test (mean 900.5/990, range 855–970). The other group of participants consisted of 15 intermediate L2 learners of English (9 men; mean age 23.9) whose English proficiency was significantly lower than that of High group[1] (mean TOEIC score 556/990, range 475–665). Participants gave consent for participation and were paid 20,000 Won for their participation.

4.2 Material

A total of 110 pairs of stimulus sentences consisting of basic English words were

[1] Hereafter we will refer to the participants' group with high English proficiency as High group and the other with low proficiency as Low group.

devised. Paired sentences shared the sentence frame and all the words except one word at the end. With the semantic congruity condition, one sentence in each pair was semantically anomalous by virtue of one word and the other was semantically congruous. The critical words always appeared in a sentence-final position. The sentences were 7 to 12 words long with the mean length of 8.5 words. The sentences are illustrated in Table 1. Two lists of 110 sentences were created; each list contained one sentence from each of the 110 sentence pairs. One list was presented to a half of the participants and the other list to the other half. Thus, each subject read 110 sentences consisting of 55 congruous and 55 incongruous sentences. These sentences were presented in a random order.

Table 1. Semantically Congruous Sentences vs. Semantically Anomalous Sentences

Semantically congruous	Semantically anomalous
He spread his warm bread with butter.	He spread his warm bread with socks.
He took a sip from the cup.	He took a sip from the transmitter.
He shaved off his mustache and beard.	He shaved off his mustache and city.
She put on her high heeled shoes.	He put on her high heeled cups.
It was his first day at work.	It was his first day at apple.
Captain Smith wanted to stay with the sinking ship.	Captain Smith wanted to stay with the sinking leaf.
I take coffee with cream and sugar.	I take coffee with cream and gloves.
He keeps his refrigerator stocked with oranges.	He keeps his refrigerator stocked with passion.
The broker hoped to sell the stock.	The broker hoped to sell the hope.
The scientist criticized Max's proof of the theorem.	The scientist criticized Max's proof of the napkin.

Since this study wants to see if the semantic congruency effect is also observed in Korean L2 speakers of English as it was in native English speakers, the stimulus sentences were mostly modeled on the stimulus sentences used in the previous researches related to the semantic congruency effect and other semantic processing effects (Kutas & Hillyard 1980, Kutas & Federmeier 2000, Kutas & Kluender 1994,

Coulson et al. 2005, among others), but they were often modified to produce a matching pair of semantically congruous and incongruous sentence. The length of stimulus sentences was also controlled to the extent that is usually adopted in other previous researches, so that the processing load for a single sentence can be at a relatively optimal level.[2] While following the patterns of the stimulus sentences of other related previous researches, we did not control the syntactic structure (limiting to some specific uniform kind of sentence structure) as far as it does not affect our target construction of semantic congruity vs. incongruity, just as in other semantic processing researches. All the stimulus sentences were finalized after they were reviewed by Korean L2 speakers of English with basic proficiency to sort out any unnecessarily difficult words. The stimulus sentences were also proof-read by a native speaker of English to confirm their validity.

4.3 Procedure

During the experiment, participants sat in a sound-attenuating, dimly-lit, electrically shielded recording room. Stimuli were presented on a computer screen approximately 100 cm distant in front of the participants. Sentences were displayed in word by word manner in black Courier New font size 23 on white screen. An initial fixation (XXXX) was presented for 300ms and replaced by first word of the sentence. Each word was presented at the center of the screen for 300ms, followed by a blank screen for 300ms.[3] In about one-third of the trials (42 trials) a comprehension question was presented two seconds after the last word of the sentence. The following sentence was initiated with pressing button either to answer the comprehension question or to terminate empty blank. A 10-trial practice session preceded the experimental run. The entire session, including electrode application and removal, lasted about 2 hours.

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[2] As in other related ERP researches, the actual slight difference of the length among the stimulus sentences should not be a problem in our experimental design since the responses are measured during the time course after the presentation of the stimulus word (last word of each sentence) and the responses to stimulus sentences get averaged for the statistical results.

[3] This follows the typical experimental setting in the relevant researches, which usually falls in between 200 ms and 400 ms.

4.4 EEG Recordings

Electroencephalograms (EEGs) were recorded from thirty-two electrodes mounted in an electrode cap (Neuroscan Quikcap). An additional electrode was placed below the right eye to monitor eye blinks. Each electrode was referred to linked mastoids. The EEG recordings were amplified by NeuroScan amplifiers, sampled at 250 Hz, and filtered with a band-pass of 0.1 - 30 Hz. Electrode impedances were kept below 10 kΩ.

4.5 Data Analysis

Three participants were excluded from analysis because of recording error, so a total of 31 participants (16 participants in High group and 15 participants in Low group) were included in the statistical analysis. ERPs were averaged for each individual participant over 1000 ms epoch for the critical words in all conditions, relative to a 200 ms pre-stimulus baseline. Trials with excessive eye-blinks or movements and ones with electrode drift were screened, and contaminated trials were not included in the statistical analysis. Epochs with an elector-oculogram (EOG) response exceeding 100 mv were discarded.

Repeated measures analyses of variance (ANOVAs) were performed on the mean amplitude of the ERPs during the two ranges of 300 - 460 ms and 620 – 800 ms, to capture the N400 and P600 component respectively. One ANOVA was conducted for midline sites Fz, Cz, Pz, and Oz only (midline analysis) and one was done comparing electrode sites over left and right hemispheres at different levels of anteriority (scalp topography analysis). The scalp topography analysis also included the factors of hemisphere (left or right) and anteriority (three levels: anterior, central, and posterior, going from the front to the back of the head), which created six regions: left-frontal (F3, F7, FC3), right-frontal (F4, F8, FC4), left-central (C3, CP3, T7), right-central (C4, CP4, T8), left-posterior (P3, P7) and right-posterior (P4, P8). Three separate ANOVAs were executed to compare electrode sites over left and right hemisphere at each of frontal, cental, and posterior regions.

4.6 Results

The difference ERP waves over selected Fz, Cz, & Pz are shown in Fig 2 and 3. Results from ANOVAs that included factors of High group and Low group are presented in Table 2.

Table 2. Statistics for the N400 & P600 Time Window in High Group and Low Group

	df	High		df	Low	
		F	*p*		*F*	*p*
300 - 460 ms						
Midline analysis						
Main effect	1,15	3.33	.08	1,14	.00	.95
X electrode	3,45	3.50	.02	3,42	1.04	.38
Scalp topography						
Main effect	1,15	5.31	.03	1,14	.01	.94
X Hemisphere	1,15	4.06	.06	1,14	.13	.72
X Anteriority	2,30	2.12	.13	2,28	.68	.51
X Hemi X Ant	2,30	.70	.50	2,28	.36	.69
620 - 800 ms						
Midline analysis						
Main effect	1,15	.99	.33	1,14	.31	.58
X electrode	3,45	.59	.62	3,42	1.41	.25
Scalp topography						
Main effect	1,15	.38	.54	1,14	1.06	.32
X Hemisphere	1,15	.52	.48	1,14	.17	.68
X Anteriority	2,30	.53	.59	2,28	.82	.45
X Hemi X Ant	2,30	1.49	.24	2,28	.30	.74

N400 (300 - 460 ms)

High group. The overall effect of semantic congruency was significant in both the midline and topography analyses. At the midline sites, the condition main effects (congruous vs. anomalous) were marginally significant only in Fz [F(1,15)=3.56,

p=.079] and Cz [F(1,15)=3.79, p=.071)] in High group. There were also significant interactions with electrode in the midline analysis and marginally significant interactions with hemisphere in the scalp topography analysis. More information on the N400 component in High group is shown in Table 3.

Low group. No significant effects were found in both the midline and scalp topography analysis in Low group.

Table 3. N400 Component in High Group

		onset(ms)	amp(μV)	peak(ms)	amp(μV)
CZ	anomalous	342	-1.26	404	-2.60
	congruent	360	0.46	412	-0.32
FZ	anomalous	360	-1.91	408	-2.9
	congruent	360	0.44	412	0.32
PZ	anomalous	348	0.82	408	-0.57
	congruent	352	1.55	424	0.35

P600 or LPC (620 - 800 ms)

High group. The LPC time-window did not show an overall effect of semantic congruency in the midline and scalp topography analyses. Also, no interactions were found for the effects of semantic congruency in either the midline or scalp topography analyses. However, there was a significant effect in Pz (F(1, 15)=4.45, p=.05).

Low group. No significant effects were found in both the midline and scalp topography analyses including interaction effects.

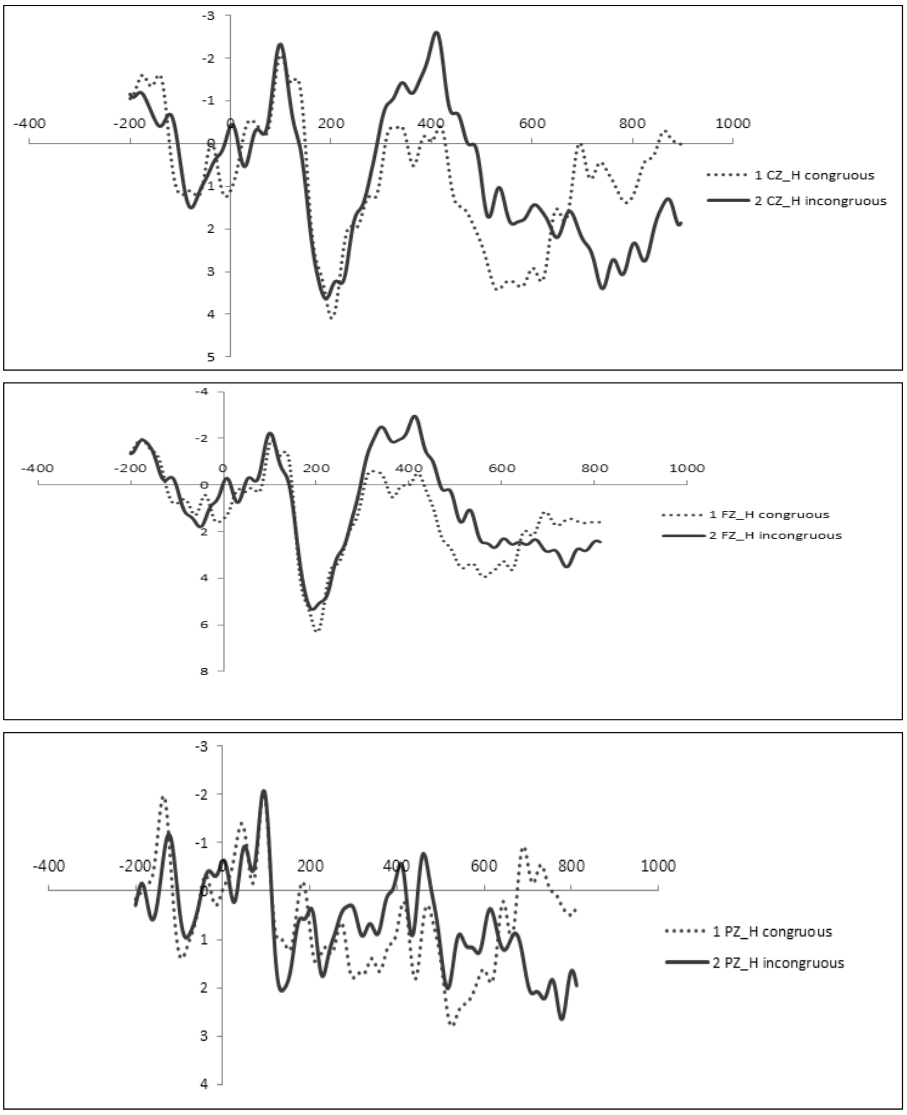

Figure 2. Grand-average ERP Waveforms for Semantically Congruous and Incongruous Words at Cz, Fz and Pz in High Group

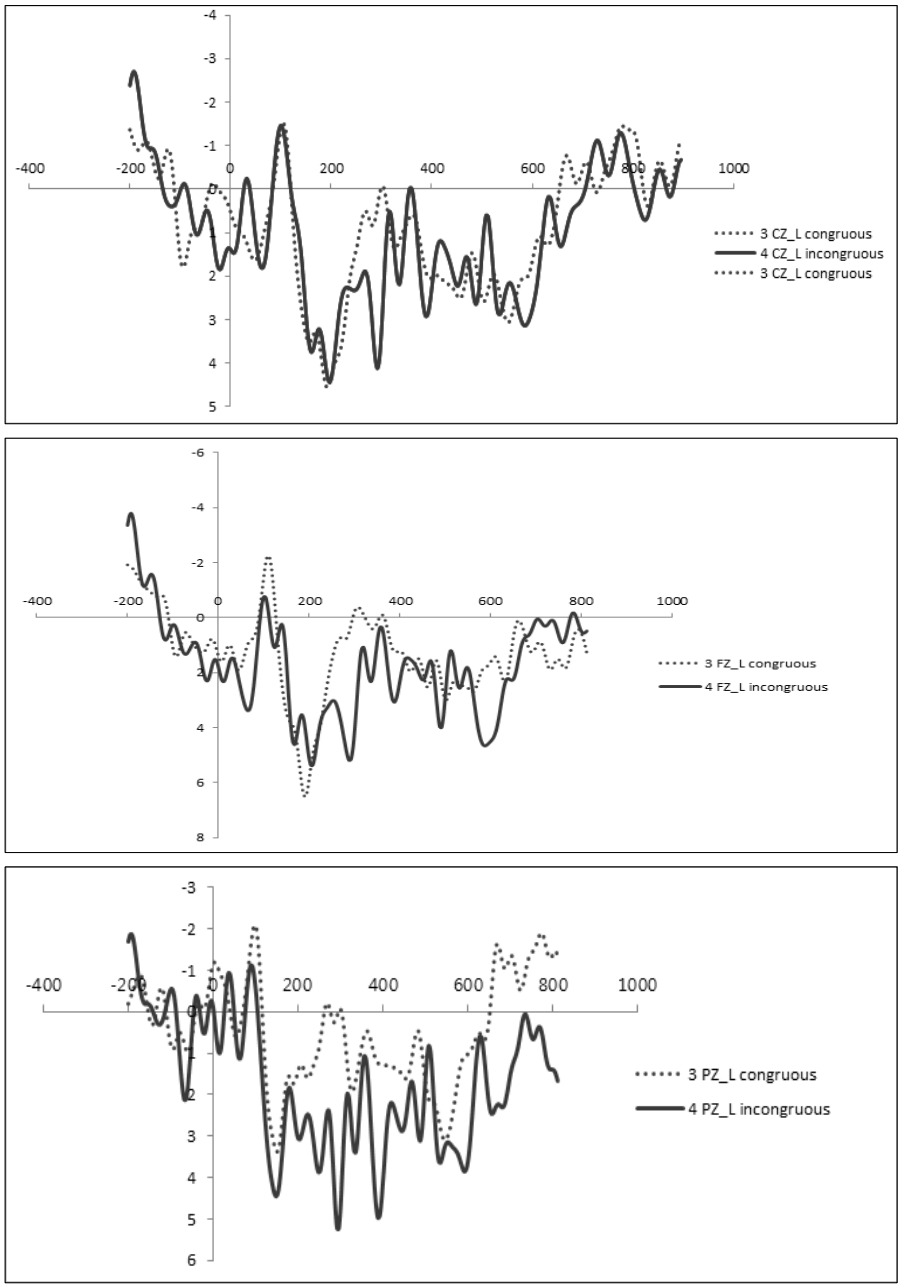

Figure 3. Grand-average ERP Waveforms for Semantically Congruous and Incongruous Words at Fz and Cz in Low Group

5. Discussion

The current study investigates the meaning-related ERP component in Korean-English bilinguals to see how the L2 speakers of English deal with semantic anomaly in processing and if they show a similar pattern in the ERP responses to the ones shown in English monolinguals. We adopted the basic semantic anomaly paradigm and tested on two different L2 proficiency groups. The results of the experiment show that the semantic congruency effect is also found in Korean bilinguals' ERP responses. That is, the N400 effect was observed with ERPs having more negativity around 400 ms after semantically anomalous stimuli. This result, however, was limited to the high proficiency group and not observed in the low proficiency group.

As for the amplitude of the N400 component observed in High group, it was not significantly different from the numbers observed in other N400-related researches (e.g., Moreno & Kutas 2005, Zhou et al. 2010).[4] It was often found in L2 ERP researches, the peak latency of the N400 component shows a delay. But no significant delay in the peak latency was observed in the N400 of High group in this study.

As shown in the midline analysis above, major significant effects of the N400 component were observed at Fz and Cz, where the N400 effect was also found in Kutas & Hillyard's (1980) original research. Though it was not found significant in the analysis, the N400 component at Pz also seems to be in line with the general pattern with a slight increase in the negativity. The data analysis presented in the previous section suggests that the ERP results interact with hemispheres. In this study, the congruency effect was bilaterally asymmetric; it was observed more actively in the left hemisphere. This result is in parallel with the pattern observed in Ardal et al. (1990) but contrasted with Moreno & Kutas (2005), who observed a bilaterally symmetric congruency effect in Spanish-English bilinguals.

The current study also suggests that proficiency plays an important role in L2 processing. The semantic congruency effect was found in the N400 component in

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[4] The amplitude of the N400 component observed in Kutas & Hillyard (1980) seems to be substantially higher than that of the current study and other contemporary researches. Since the ERP technique was newly emerging at the time of their study and the field was at the initial stage, we speculate there might have been some inefficiency in dealing with the responses and analyzing the data.

high proficiency group only; the N400 effect was not found in low proficiency group. And the effect was consistently observed in all the participants in High group. Given this, bilinguals with high L2 proficiency seem to have the capacity to comprehend the words in the given sentence appropriately and notice the semantic anomaly involving excessive load of processing. On the other hand, the low proficiency group does not show any significant congruency effect and their ERP responses to semantic anomaly do not show the pattern observed in L1 English speakers. All the participants of the current experiment were late-learners of English as an L2 and have never been put in an emersion setting of English. However, the high proficiency group showed a pattern consistent with L1 speakers of English. This confirms that proficiency is a significant factor affecting semantic processing in L2.

It has been pointed out that there is some contextual effect in eliciting different amplitude of the N400 component. Here the context may include individual words, sentences, or the entire discourse. Such context sensitivity of the N400 has been shown with the so-called semantic priming effect and also cloze probability test. The semantic priming effect is that prior occurrences of an associatively related item (e.g. *bee*) or a semantically related item (e.g. *sugar*) reduces the N400 amplitude to a given word (e.g. *honey*) (e.g., Van Petten & Luka 2006). It has also been noted that the amplitude of the N400 is an inverse function of the word's rated 'cloze probability'- the proportion of individuals who provide that particular word as the most likely completion for that sentence fragment in a paper and pencil test (e.g., Kutas & Hillyard 1984). Furthermore, van Berkum et al. (1999) found that words that were equally acceptable (and elicited equivalent N400s) in an isolated sentence (e.g. *The mouse quickly/slowly returned to its hole.*) elicited an even smaller N400 if they were coherent (*quickly*) as opposed to incoherent (*slowly*) with extant discourse level constraints (e.g. *The cat entered the room suddenly, starling a mouse which had found a bit of cheese in the corner.*). In this respect, it can be said that the N400 effect reflects constraints arising from several levels of context and the N400 component reflects this contextual integration. Given that the high proficiency L2 group showed a comparable ERP pattern to the L1 speakers,' we can say the current study also confirms the bilinguals' capacity of contextual integration involved in normal semantic processing. This might provide some implications on the issue brought up in Slabakova (2006) whether there exists a critical period for semantics, since the results from the current experiment suggest that proficiency plays a crucial

role in acquiring the semantic components rather than the age of acquisition of L2, though an advanced research seems to be in need to confirm it further.

6. Conclusion

In this paper, we presented an experimental study examining event-related potentials in bilinguals. To see how semantic processing occurs in bilinguals' brain in real-time, we tested the typical semantic anomaly paradigm with Korean L2 speakers of English. The experiment was done in a between-group design to see if semantic anomaly elicits a different ERP pattern depending on the bilingual's L2 proficiency level. While the meaning-related ERP component N400 was not evoked in Low group, it was rather significantly found in High group. High group's ERPs did not show a big discrepancy with monolingual's usual pattern of N400.[5] Given that Korean bilinguals' ERP responses to semantic anomaly reveal a similar neurodynamic pattern to English monolinguals' at major points over the scalp as observed in other researches, though scalp topography did not show a complete match, the study suggests that the bilinguals' semantic processing resembles monolinguals' semantic processing to a significant extent. The study also strongly suggests that proficiency has a close correlation with brain responses in semantic processing. Although there still remain issues to be resolved further, especially what exactly prevents the elicitation of N400 in Low group, whether semantic aspects other than congruency can also elicit N400 in Korean bilinguals' L2 as in monolinguals' L1, and what exactly is involved in observed differences in distribution of the effect (e.g., no significant effect at Pz in High group), this study illuminates the neural dynamics of

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[5] One of the anonymous reviewers pointed out that English native speakers should also have been tested with the same experimental material in the current research so that a direct comparison could be possible, and not having the results from native English speakers could undermine the validity of the findings of this study. I admit that results from native speakers with the same material would ideally lead to a closer comparison between the two groups. However, it should be pointed out that the N400 effect related to semantic anomaly has been known as a very typical, robust response; It has been typically observed as to semantic anomaly among native speakers of English in the previous researches mentioned in this paper. Given that the main purpose of this paper is to see if Korean speakers of English also show the N400 effect with semantic anomaly and that the experimental material in the current research is modeled on the material which has been typically used in the previous studies, not including English native speakers in the current experiment should not be considered undermining the validity of the current research.

semantic processing in Korea-English bilinguals and shows how ERPs can be implemented to answer the theoretical questions brought up in the field of L2 research.

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Sei-Rang Oh
Department of English Language & Literature
Gyeongsang National University
900 Gajwa-dong, Jinju
600-701, Korea
Tel: (055) 772-1130
E-mail: seirangoh@gnu.ac.kr

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