Backward Antecedent Search of the Null Subject Pronominal (*pro*) in Korean: An ERP Study*

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Park, Myung-Kwan, Cho, Euiyon, and Chung, Wonil. (2015). Backward Antecedent Search of the Null Subject Pronominal (*pro*) in Korean: An ERP Study. *Language Research*, 51.3, 537-568.

Departing from Mazuka (1991) and Kwon and Sturt (2013), we examine how Korean native speakers comprehend the zero/null subject pronominal (*pro*) in Korean in the course of sentence processing. Instead of the forward antecedent search design that the two previous studies adopted, we used the backward one to construct sentences where *pro* finds its antecedent in a preceding discourse. The results of the Event-related Potentials (ERPs)-based two experiments with the two sets of materials are three-folded. First, Korean native speakers process *pro* in a parallel fashion to overt subjects, which is evidenced by the fact that the *pro* subject and the overt subject conditions are ERPs-wise indistinguishable. Second, the use of the honorific marker *-si-* on a verb/adjective with a respectful and a non-respectful subject elicits different ERP components; with the former, N400 that reflects a repair of contextual meaning, but with the latter, LAN followed by anterior P600 that reflects a grammatical abnormalcy. Third, we also examine the exact (ERP-wise, temporal & spatial) locus of the difference between a respectful and a non-respectful subject, finding that the misuse of the honorific marker with a respectful *pro* subject relative to its overt counterpart registers a negativity at the anterior region at the 320-420 ms interval.

Keywords: zero/null subject pronominal (*pro*) in Korean, honorific marker *-si-*, respectful vs. non-respectful subject, Event-related potentials (ERPs). left anterior negativity (LAN), N400, anterior P600

* We are grateful to the three anonymous reviewers of this journal for their helpful comments and suggestions. All the remaining errors are, of course, ours. This work was supported, in part, by the National Research Foundation Grant (NRF-2013S1A5A2A03044783).

1. Introduction

In the first type of languages like English as in (1) and (2) the use of a pronoun in a subject or object position is necessary whenever it is called for, as in (1) and (2):

(1) a. $John_1$ thinks that *(he_1) is smart.
b. A: Who did Bill1 see?
B: *(He_1) saw John.
B': I think that *(he_1) saw John,

(2) a. $Mary_1$'s teacher praised *(her_1) in class.
b. A: Who saw $John_1$.
B: Bill saw *(him_1).
B': I think that Bill saw *(him_1),

In the second type of languages like Italian as in (3) and (4) the use of a pronoun is necessary in an object position, but its use in a subject position is phonologically suppressed, being realized as a zero/null pronoun or *pro*.

(3) José sabe [que [e]/*pro* ha sido visto por María]
know that has been seen by
'José knows thats he has been seen by María.'

(4) *José sabe [que María *(l')ha visto].
know that María him-has seen
'José knows that María has seen [him]'

In the third type of languages like Korean as in (5) and (6) the use of a pronoun is optional either in a subject or object position, as shown below:

(5) a. con_1-un [(ku_1-ka) ttokttokha-tako] sayngkakha-y.
John-Top he-Nom smart-Comp think-Informal
'John thinks *(he) is smart.'
b. A: pil_1-i nwukwu-lul manna-ass-ni.
Bill-Nom who-Acc see-Past-Q
'Who did Bill see?'
B: (ku_1-ka) con-ul manna-ass-e.
he-Nom John-Acc see-Past-Informal
'*(He) saw John.'
B': na-nun (ku_1-ka) con-ul manna-ass-tako sayngkakha-y.
I-Top he-Nom John-Acc see-Past-Comp think-Informal
'I think *(he) saw John.'

(6) a. $meyli_1$-uy sensayngnim-i swuep-eyse ($kunye_1$-lul) chingchanha-yss-e.
Mary-Gen teacher-Nom class-in she-Acc praise-Past-Informal
'Mary's teacher praised *(her) in class.'
b. A: nwu-ka con_1-ul mann-ass-ni?
who-Nom John-Acc see-Past-Q
'Who saw John?'
B: pil-i (ku_1-lul) manna-ass-e.
Bill-Nom he-Acc see-Past-Informal
'Bill saw *(him).'
B': na-nun pil-i (ku_1-lul) manna-ass-tako sayngkakha-y.
I-Top Bill-Nom he-Acc see-Past-Comp think-Informal
'I think that Bill saw *(him).'

Considering these cross-linguistic different realizations of overt and null pronouns, Huang (1984) characterizes languages into three groups, "hot", "medium-hot", and "cool" with respect to the possibility of omitting pronouns in a subject or object position of a sentence. English, which falls into the "hot" group, does not allow for omission of pronouns in a sentence. In other words, for an English sentence to convey its information, pronouns must be overtly encoded whenever they are needed. The second group of languages like Italian, on the other hand, which Huang (1984) dubs "medium-hot", do allow a phonologically suppressed or zero pronoun in the subject position of a (tensed) sentence, but they do not permit it in an object position of a sentence. The third group of languages like

Korean, which Huang (1984) calls "cool", do not have to overtly encode a pronoun in a subject or object position of a sentence, thus freely allowing a zero/null pronoun there.

In the course of sentence processing of either an overt or a zero/null pronoun, it is obvious that the grammatical/syntactic features such as person, number, or gender on an overt pronoun in "hot" or overt-pronoun-encoding languages help identify its antecedent in a certain discourse context. In "medium-hot" languages, on the other hand, the overt pronoun itself is phonologically suppressed in a subject position, but the verb that a zero/null pronoun subject agrees with carries the corresponding grammatical features, which in turn play the role of recovering its antecedent.

Since "cool" languages lack an overt pronoun or a realization of grammatical features on a verb, it presumably poses a great challenge to the users of these languages when they engage in sentence processing of a zero/null pronoun. "Cool" languages are in other words characterized as "discourse-oriented" languages, where discourse properties are known to play more central roles than grammatical/syntactic properties. In fact, there were two notable previous studies on a zero/null subject in "cool" languages which concentrate on discourse properties that come into play in interpreting such a subject during sentence processing.

First, Mazuka (1991) claims that inserting and interpreting an empty category (EC) or *pro* in Japanese does not cause any processing difficulties:

(7) Yuuzin-ga [**EC/*pro*** moochoo de nyuuin site ita toki]
friend-nom appendicitis by hospitalized was when
mimai ni kite kureta.
see to coming gave
"When I was hospitalized with appendicitis, a friend came to visit me."

The sentence in (7) has an empty pronoun as a subject of the temporal adjunct clause. Mazuka observes no effect of processing the empty pronoun on overall reading time per character in this type of sentences, compared to a control sentences. From this observation, she concludes that the postulation of an empty pronoun in Japanese is cost-free during sentence processing.

Kwon and Sturt (2013) claim, on the other hand, that Korean null pronouns assigned to a discourse topic are not reanalyzed even if the parse encounters a potential intra-sentential cataphoric antecedent. They use a 2×2 design that cross (i) presence vs. absence of context (providing a discourse referent for *pro*) as in (8a) and (ii) presence vs. absence of *caki* 'self', a reflexive-like element (that provides a morpho-syntactic cue for *pro*) as a pre-nominal modifier of the object expression in the adverbial clause of (8b).

(8) a. Context sentence
I kanhosa-nun maywu chincelhata
This nurse-Top very be.kind
'This nurse is very kind'
b. **[EC/*pro*$_i$** enjeyna caki$_i$/aphun hwancatul-ul cengsengsulepkey kanhohay-se**]**
always self/sick patients-Acc with.care took.care-as
[**na-nun** **[**ipen sisangsikeyse **kanhosa-ka** choywuswu cikwonsang-ul
I-Top this ceremony-at nurse-Nom best worker award-Acc pata-ya hantako**]** cwucanghayssta
awarded should.be claimed
'Because (she$_i$) took care of self$_i$'s/sick patients with much care, I claimed that the nursei should be awarded the best employee award at this ceremony'.

The result showed that without (8a) given, namely when there was no preceding discourse referent for *pro*, the *Caki* condition took longer to read than the No-*Caki* condition at the words after the matrix subject *na-nun* 'I-Top.' Kown and Sturt take the slowdown of the No-Context *Caki* condition to indicate that the parser engages in an active forward search for the antecedent of *caki* but confronts processing difficulties when it mismatches with the matrix subject with respect to person feature because in Korean *caki* cannot take a first-person antecedent. In contrast, when (8a) was followed by (8b), namely when there was a preceding discourse referent for *pro*, the *Caki* condition didn't display corresponding slowdown effects. Kwon and Sturt take a lack of the slowdown in the Yes-Context *Caki* condition to indicate that when *pro* had a preceding discourse referent, the former was immediately linked to the latter, rendering the forward antecedent search unnecessary. They suggest that the asymmetry between the Yes-Context and the No-Context *Caki* conditions with respect to a forward search for the antecedent of *pro* renders conclusive evidence showing that, as has been argued elsewhere, Korean is a discourse-oriented language.

Departing from these two previous analyses, we investigate the interpretation of a zero/null pronoun subject *pro* in a backward antecedent search setting. It is admittedly a moot point whether *pro* is more frequently used in a forward or in a backward antecedent search context, but we presumably more often use a pronoun or its null counterpart when its antecedent is given in a preceding discourse. We thus differ from Mazuka (1991) and Kwon and Sturt (2013) by placing *pro* in an embedded subject, whose antecedent is given in a sentence-initial adverbial clause. The goals of the two experiments with *pro* are two folded. One is to investigate whether there is a difference between an overt subject and a covert *pro* subject given the discourse where the parser will easily recover its antecedent in a preceding clause. The second is to examine and compare the effects of (the presence vs. absence of) the honorific marker *-si-*[1] on the verb/adjective that an overt or *pro* subject element syntactically relates with.

2. Experiment

2.1. Participants

Twenty-one (male: 15) native Korean speakers (mean age: 23.4 years, SD: 2.3) without immersion education in the L2 environment before the puberty (corresponding to 12 years old) participated in the present experiment. All the participants were undergraduate students, had normal or corrected to normal vision, and were right-handed. They gave written informed consent to their participation and were paid ₩20,000 for their participation.

1) The honorific maker is known to provide information on the relative hierarchical status of the subject in relation to the speaker, regardless of person or number.

2.2. Materials

The experimental sentences for the ERP study are given in Table 1. There were two experiments with the two sets of the four conditions, constructed in a 2×2 factorial design, manipulating the two factors: (i) subject status, i.e., overt/covert-ness of a subject element (overt vs. *pro* subject) and (ii) match (match vs. mismatch in (non-)honorific marking).

In experiment 1 (EXP1), we manipulated match/mismatch by (not) inflecting the embedded verb/adjective with the honorific marker *-si-*. In (A) of the control match condition, the embedded subject (*chelswu*) is a non-respectful person that calls for the form of embedded verb/adjective without the honorific *-si-*. In (B) of the control mismatch condition, the embedded subject is also a non-respectful person, but the embedded verb/adjective it agrees with is erroneously inflected with the honorific marker. In (C) of the *pro* match condition, the embedded null subject *pro* is supposed to take as its antecedent the non-respectful subject (*chelswu*) of the preceding adverbial clause, thus calling for the form of embedded verb/adjective without the honorific marker. In (D) of the *pro* mismatch condition, the embedded subject is also supposed to take as its antecedent the non-respectful subject (*chelswu*) of the preceding adverbial clause, but the embedded verb/adjective it agrees with is erroneously inflected with the honorific marker.

In experiment 2 (EXP2), we likewise manipulated match/mismatch by (not) inflecting the embedded verb/adjective with the honorific marker *-si-*. In (A) of the control match condition of EXP2, the embedded subject (*sensayng-nim*) is not a non-respectful person but a respectful one, thus calling for the honorific-marked form of embedded verb/adjective. In (B) of the control mismatch condition, the embedded subject is also a respectful person, but the embedded verb/adjective it agrees with is erroneously not inflected with the honorific marker. In (C) of the *pro* match condition, the embedded null subject *pro* is supposed to take as its antecedent the respectful subject (*sensayng-nim*) of the preceding adverbial clause, thus calling for the honorific-marked form of embedded verb/adjective. In (D) of the *pro* mismatch condition, the embedded subject is also supposed to take as its antecedent the subject (*sensayng-nim*) of the preceding adverbial clause, but the embedded verb/adjective it agrees with is erroneously not inflected with the honorific marker.

Table 1. Design of Stimulus Materials. Critical Words are Highlighted

EXP1

A control match

철수가 약속을 지키는 것을 보고서, 선생님은 철수가
chelswu-ga yaksok-ul cikhi-nun kes-ul pok-ose, sensayngnim-un chelswu-ga
Chelswu-Nom promise-Acc keep-Mod thing-Acc see-after teacher-Top Chelswu-Nom
아주 **성실하다고** 생각했다.
acwu **sengsilha-ta-ko** sayngkakhayssta.
quite sincere-Decl-Sub thought
'After seeing Chelswu keep a promise, the teacher thought Chelswu was sincere.'

B control mismatch

철수가 약속을 지키는 것을 보고서, 선생님은 철수가
chelswu-ga yaksok-ul cikhi-nun kes-ul pok-ose, sensayngnim-un chelswu-ga
Chelswu-Nom promise-Acc keep-Mod thing-Acc see-after teacher-Top Chelswu-Nom
아주 **성실하시다고** 생각했다.
acwu **sengsilha-si-ta-ko** sayngkakhayssta.
quite sincere-Decl-Sub thought
'After seeing Chelswu keep a promise, the teacher thought Chelswu was sincere.'

C *pro* match

철수가 약속을 지키는 것을 보고서, 선생님은 *pro*
chelswu-ga yaksok-ul cikhi-nun kes-ul pok-ose, sensayngnim-un *pro*
Chelswu-Nom promise-Acc keep-Mod thing-Acc see-after teacher-Top *pro*
아주 **성실하다고** 생각했다.
acwu **sengsilha-ta-ko** sayngkakhayssta.
quite sincere-Decl-Sub thought
'After seeing Chelswu keep a promise, the teacher thought *pro* was sincere.'

D *pro* mismatch

철수가 약속을 지키는 것을 보고서, 선생님은 *pro*
chelswu-ga yaksok-ul cikhi-nun kes-ul pok-ose, sensayngnim-un *pro*
Chelswu-Nom promise-Acc keep-Mod thing-Acc see-after teacher-Top *pro*
아주 **성실하시다고** 생각했다.
acwu **sengsilha-si-ta-ko** sayngkakhayssta.
quite sincere-Decl-Sub thought
'After seeing Chelswu keep a promise, the teacher thought pro was sincere.'

EXP2

A control match

선생님이 수학을 가르치시는 것을 보고서, 철수는 선생님이
sensayngnim-i swuhak-ul kaluchi-si-nun kes-ul po-kose, chelswu-nun sensayngnim-i
teacher-Nom math-Acc teach-Hon-Mod thing-Acc see-after Chelswu-Top teacher-Nom/pro
매우 **열정적이시다고** 생각했다.
maywu **yelcengcek-i-si-la-ko** sayngkakhayssta.
very passionate-Cop-Hon-Decl-Sub thought
'After seeing the teacher teaching math, Chelswu thought the teacher was passionate.'

B control mismatch

선생님이 수학을 가르치시는 것을 보고서, 철수는 선생님이
sensayngnim-i swuhak-ul kaluchi-si-nun kes-ul po-kose, chelswu-nun sensayngnim-i
teacher-Nom math-Acc teach-Hon-Mod thing-Acc see-after Chelswu-Top teacher-Nom/pro
매우 **열정적이라고** 생각했다.
maywu **yelcengceki-la-ko** sayngkakhayssta.
very passionate-Hon-Decl-Sub thought
'After seeing the teacher teaching math, Chelswu thought the teacher was passionate.'

C *pro* match

선생님이 수학을 가르치시는 것을 보고서, 철수는 *pro*
sensayngnim-i swuhak-ul kaluchi-si-nun kes-ul po-kose, chelswu-nun *pro*
teacher-Nom math-Acc teach-Hon-Mod thing-Acc see-after Chelswu-Top *pro*
매우 **열정적이시라고** 생각했다.
maywu **yelcengcek-i-si-la-ko** sayngkakhayssta.
very passionate-Cop-Hon-Decl-Sub thought
'After seeing the teacher teaching math, Chelswu thought the *pro* was passionate.'

D *pro* mismatch

선생님이 수학을 가르치시는 것을 보고서, 철수는 *pro*
sensayngnim-i swuhak-ul kaluchi-si-nun kes-ul po-kose, chelswu-nun *pro*
teacher-Nom math-Acc teach-Hon-Mod thing-Acc see-after Chelswu-Top *pro*
매우 **열정적이라고** 생각했다.
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very passionate-Cop-Hon-Decl-Sub thought
'After seeing the teacher teaching math, Chelswu thought the *pro* was passionate.'

In each of the two experiments, the target materials of the 120 sets of 4 sentences were distributed among four lists in a Latin Square design, such that each list contained 30 sentences of each experimental condition but only one item from each set. Each participant read the target sentences from one of the four lists, distributed with 120 fillers in pseudorandom order in order to make it difficult for the participants to detect the target structures or to develop special strategies. Thus, each list contained 240 sentences in total. Each list was split into two blocks.

2.3. Procedure

The participants sat in a comfortable chair in a dimly-lit testing room, with a computer monitor in front of them. As shown in Figure 1, each trial began with the presentation of a fixation point at the center of the screen.

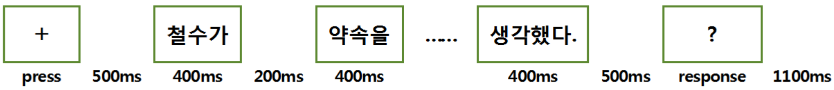


Figure 1. The procedure of stimulus presentation.

After pressing the button, the participants were presented with sentences in a word-by-word manner, with each word appearing at the center of the screen for 400 ms, using an SOA (stimulus onset asynchrony) of 600 ms (400 ms for a word, followed by a 200 ms interstimulus interval). After the final word of each sentence and a 500-ms blank screen interval, a yes/no comprehension question ensued. The participants pressed one of the two buttons ("Yes" or "No") on the response box to decide whether the previous sentence they read was an "acceptable" or "unacceptable" sentence. Before the actual experiment, the participants read a practice block with eight items. The stimuli were presented in Courier New 23-pt black letters on a white background, using E-prime (Psychology software tools Inc.).

The experimental lists were divided into two blocks of 120 items, each of which lasted for 30 minutes in each experiment. The order of the two blocks were counterbalanced across the participants to prevent any possible order-related effects. The participants had a short break between the blocks.

2.4. EEG recordings

Electroencephalograms (EEGs) were recorded from 30 Ag/AgCl electrodes, mounted in an electrode cap (Neuroscan Quikcap, USA): midline (Fz, FCz, Cz, CPz, Pz, Oz), lateral (FP1/2, F3/4, F7/8, FC3/4, FT7/8,

C3/4, T7/8, CP3/4, TP7/8, P4/5, P7/8, O1/2), and referenced to linked mastoids. Additional electrodes were placed above and below the left eye as well as on the left and right outer canthi to monitor eye movements. The EEG recordings were amplified by a SynAmps2 EEG amplifier, by using a band-pass from 0.3 to 100 Hz with a sampling rate of 1 kHz. The electrode impedances were kept below 5 ㏀.

2.5. Data analysis

The trials with excessive eye-blink or movement artifacts were removed on the basis of visual screening prior to any subsequent analysis. After artifact-eliminating procedures, 88% in EXP1 and 90% in EXP2 of the initial total number of trials were saved for the subsequent analysis. Averaging ERPs were based on 1100 ms intervals, consisting of a 100 ms pre-stimulus baseline and a 1,000 ms post-stimulus interval. Grand average waveforms were filtered at a low-pass of 30 Hz.

For the statistical analyses, nine regions of interest (ROIs) were used in the ANOVAs, consisting of groups of two electrodes at each ROI: left anterior (LA: F3, FC3), anterior midline (MA: FZ, FCZ), right anterior (RA: F4, FC4), left center (LC: C3, CP3), central midline (MC: CZ, CPZ), right center (RC: C4, CP4), left posterior (LP: P3, O1), posterior midline (MP: PZ, OZ), and right posterior (RP: P4, O2) in Figure 2.

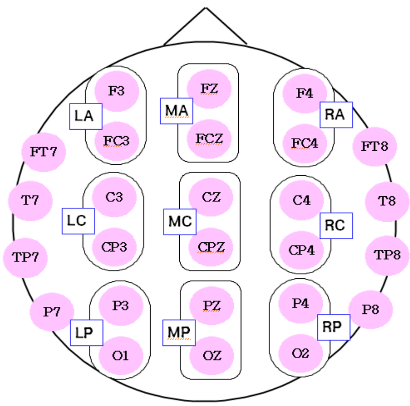


Figure 2. Nine regions of interest (ROIs).

These regions were organized into the two topographic factors: laterality (left, midline, right) and region (anterior, posterior). Therefore, we performed repeated-measures ANOVAs with three within-subject factors: sentence type, laterality (left, midline, right) and region (anterior, posterior). For significant effects, the Greenhouse-Geisser correction was applied (Greenhouse and Geisser (1959)), and the uncorrected degrees of freedom and corrected *p*-values were reported. At the critical verbs/adjectives, ANOVA was calculated on the basis of mean voltages within the N400 window (320-420 ms) and the P600 window (580-680 ms).

For the additional analysis, the difference between waves was also computed for each of the *pro* match condition minus the control match condition. In the analysis of the degree of amplitude, the difference of mean amplitude measures at each region were calculated for each experiment, and the two experiments were compared in regard of it.

3. Results

3.1. Off-line Task: Sensicality Judgment

For the sensicality judgment task after the ERP experiment, the participants were asked to rate one version of the experimental sentences different from what they read during the ERP experiments. As shown in Figure 3, in EXP1 with the embedded subject being non-respectful, the control match condition made the most sense, and then the *pro* match condition made more sense than the other control and *pro* mismatch conditions. There were a significant main effect of the subject-status factor, $F_{(1,20)}$=11.38, p<0.01, a significant main effect of the match factor, $F_{(1,20)}$=72.58, p<0.001, and a significant subject-status*match interaction, $F_{(1,20)}$=11.56, p<0.01.

In EXP2 with the embedded subject being respectful, the control match condition also made the most sense, and then the *pro* match condition made more sense than the other mismatch conditions, which notably made more sense than their counterpart conditions in EXP1. There were a significant main effect of the subject-status factor, $F_{(1,20)}$=10.34, p<0.01, a significant main effect of the match factor, $F_{(1,20)}=F_{(1,20)}=21.73$, $p<0.001$, and a significant subject-status*match interaction, $F_{(1,20)}=11.56$, $p<0.05$.

Figure 3. Mean sensicality judgments (not at all acceptable=1, not acceptable=2, acceptable=3, definitely acceptable=4) for control match, control mismatch, *pro* match, and *pro* mismatch. Standard deviation indicates dispersion from the mean.

3.2. On-line Task: Acceptability Judgment

The participants' judgment of acceptability on the target sentences during the online sentence comprehension yielded the following results, as shown in Figure 4 (The match conditions were expected to be rated as acceptable, but the other mismatch conditions were expected to be rated as unacceptable). In the EXP1 with the conditions containing non-respectful subjects, the participants made 93% acceptable responses to the control match condition, 93.0% unacceptable responses to the control mismatch condition, and 83% acceptable responses to the *pro* match condition, and 91% unacceptable responses to the *pro* mismatch condition. In regard to acceptability ratings of these conditions in EXP1, there was a significant main effect of the subject-status factor, $F_{(1,20)}=4.34$, $p=0.05$.

In the EXP2 with the conditions containing respectful subjects, on the other hand, the participants made 95% acceptable responses to the control match condition, 51% unacceptable responses to the control mismatch condition, 85% acceptable responses to the *pro* match condition, and 46% unacceptable responses to the *pro* mismatch condition. In regard to acceptability ratings for these conditions in EXP2, there was a significant main effect of the subject-status factor, $F_{(1,20)}=4.50$, $p<0.05$, and a significant main effect of the match factor, $F_{(1,20)}=20.29$, $p<0.001$.

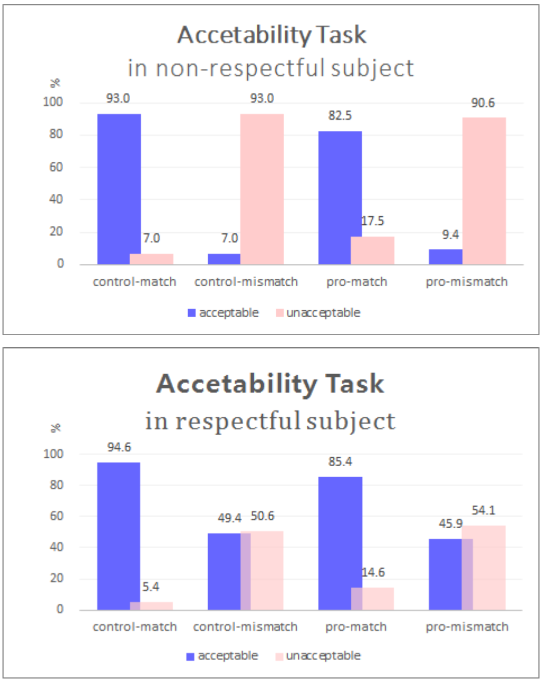
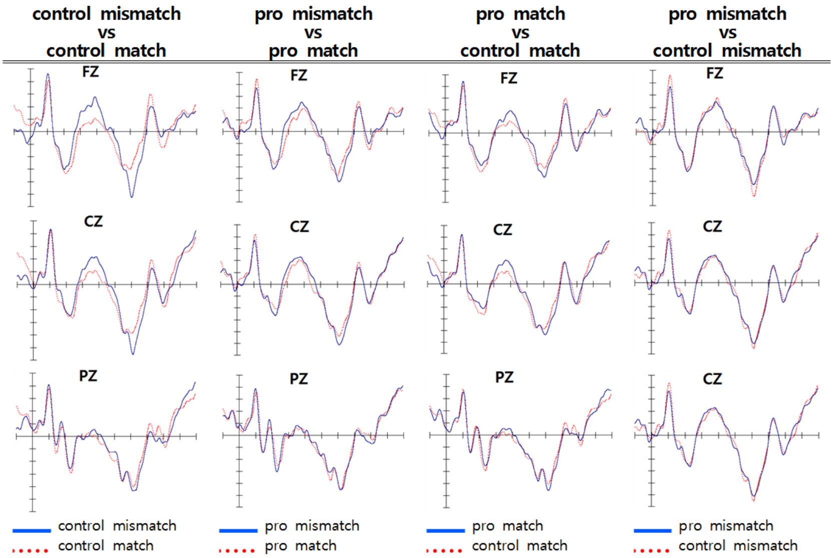


Figure 4. Mean acceptability judgment.

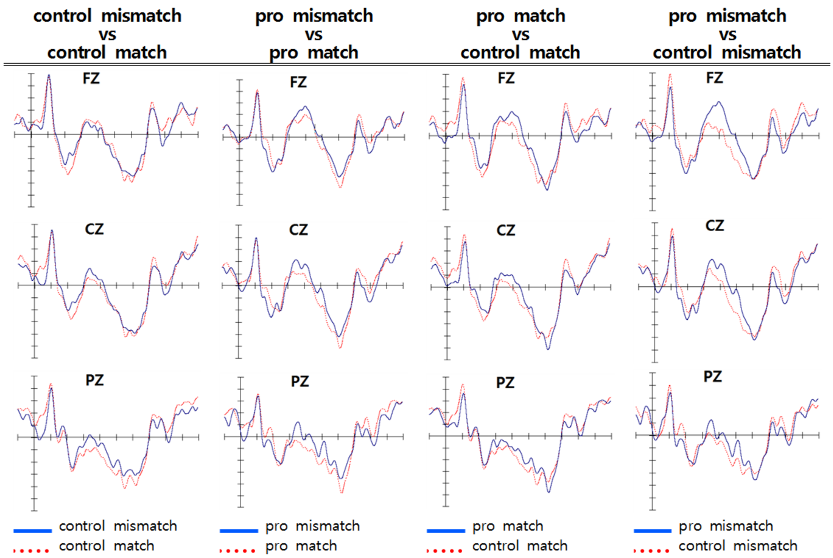
3.3. Event-related potentials

Both grand average waveforms and topographic maps (displaying the difference between the *pro* and the control conditions, and between the mismatch and the match conditions) for the critical verb/adjective (e.g., *sengsilha-* 'sincere'/ *yelcengcekita* 'passionate') are shown in Figure 5.

[A] EXP1



[B] EXP2



[C]

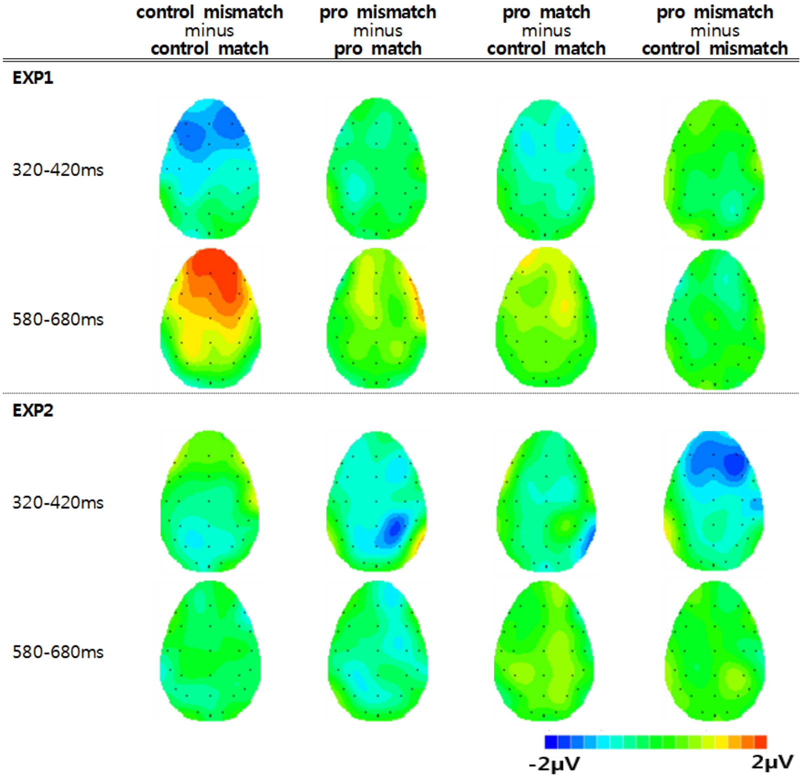


Figure 5. [A] The grand average ERP responses to the critical verbs/adjectives in the four conditions at the electrodes such as FZ, CZ, and PZ in EXP1 and EXP2. The onset of each critical verb/adjective is indicated by the vertical bar. Each interval represents 100 ms of activity. The positive voltage is plotted down. [B] The topographic scalp voltage maps that compare the responses to the critical verbs/adjectives in the four conditions, by subtracting each base condition from each target condition.

3.2.1. EXP1

The visual inspection of grand average waveforms at the critical verb/adjective in the control mismatch condition relative to the control match condition revealed a negativity at the anterior region in the 320-420 ms interval, with the timing profile characteristic of an LAN response. Besides, the control mismatch condition registered a positivity at the anterior region in the 580-680ms interval, which is interpreted as a characteristic of the anterior P600 component, since it deviates from the well-known, general type of P600 elicited at posterior regions. Furthermore, the *pro* match condition recorded a negativity at the anterior region relative to the control match condition in the 320-420 ms interval.

For the statistical analysis, the overall ANOVA were first performed, and the pairwise comparisons were then carried out between the control mismatch vs. the control match conditions and between the *pro* mismatch vs. the *pro* match conditions in order to identify the effects of the match factor, and between the *pro* match vs. the control match conditions and between the *pro* mismatch vs. the control mismatch conditions in order to identify the effects of the subject-status factor. The mean amplitudes of the four experimental conditions were entered into a 2×2 repeated measures ANOVA with the subject-status (control and *pro* conditions), the match (match and mismatch), laterality (left, midline, and right), and an-pos (anterior, central and posterior) factors, as shown in Table 2.

Table 2. Comparison of Overall ANOVA *F*-values at the Critical Verb/adjective in EXP1

time window / factor	320-420 ms	580-680 ms
subject-status (1,20)	3.14*	-
match (1,20)	6.80**	3.52*
lat (2,40)	8.78***	29.40****
an-pos (2,40)	16.60***	7.88***
*pro**match (1,20)	-	-

* p<0.1; ** p<0.05; *** p<0.01; **** p<0.001

The significant main effect of the match factor was found at the 320-420 ms interval, $F_{(1,20)}=6.80$, $p<0.05$. Furthermore, there was a marginally significant effect of the subject-status factor at the 320-420 ms interval, $F_{(1,20)}=3.14$, $p=0.09$, and of the match factor at the 580-680 ms interval, $F_{(1,20)}=3.52$, $p=0.08$. The laterality factor was also significant both at the 320-420 ms interval, $F_{(2,40)}=8.78$, $p<0.01$, and at the 580-680 ms interval,

$F_{(2,40)}$=29.4, p<0.001. Likewise, the anterior-posterior factor was significant at the 320-420 ms interval, $F_{(2,40)}$=16.6, p<0.01, and at the 580-680 ms interval, $F_{(2,40)}$=7.88, p<0.01. The results of these effects will lead us to below perform additional analyses of the topographic distributions of the ERP effects.

Pairwise comparisons were now carried out in order to identify a difference between the conditions involving the subject-status and the match factors, which is summarized in Table 3.

Table 3. Pairwise Comparison for ERP Data at the Critical Verb/adjective in EXP1

pair / time window	control mismatch vs control match		pro mismatch vs pro match		pro match vs control match		pro mismatch vs control mismatch	
factor	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms
type(match/ subject-status)	11.36***	7.01**			7.86**			
lat	12.03****	25.26****	5.51**	28.31****	8.52***	21.55****	6.84***	28.35****
an-pos	15.33****	9.52***		5.53**	11.15**	4.12**	19.75****	12.78***
type*lat* an-pos		3.91**						

* p<0.1; ** p<0.05; *** p<0.01; **** p<0.001

The control mismatch condition relative to the control match condition yielded a significant effect at the 320-420 ms interval, $F_{(1,20)}$=11.36, p<0.01, being more negative at the anterior than the control match condition, which is understood as (Left) Anterior Negativity or (L)AN. Subsequently, the control mismatch condition was found more positive than the control match condition, giving rise to a significant effect at the 580-680 ms interval, $F_{(1,20)}$=7.01, p<0.05, which is understood as "anterior P600". On the other hand, the *pro* match condition was more negative than the control match condition, yielding a significant effect at the 320-420 ms interval, $F_{(1,20)}$=7.88, p<0.05, being more negative at the anterior than at the posterior, which is reasonably characterized as an LAN response.

Additional comparisons within individual ROIs were also conducted to better understand clear topographic differences. The significant results of ANOVA are listed in Table 4.

Table 4. Comparison of Overall ANOVA *F*-values at 9 Regions in EXP1

pair / time window / factor	control mismatch vs control match		pro mismatch vs pro match		pro match vs control match		pro mismatch vs control mismatch	
	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms
LA	11.96***	10.36***	-	-	5.57**	-	-	-
LC	9.91***	5.53**	-	-	3.05*	-	-	-
LP	-	-	-	-	-	-	-	-
MA	16.33****	12.76***	-	-	6.36**	-	-	-
MC	8.15***	6.01**	-	-	8.47***	-	-	-
MP	-	-	-	-	-	-	-	-
RA	17.88****	16.41****	-	-	10.95***	-	-	-
RC	7.37**	8.84***	-	-	11.68***	-	-	-
RP	-	-	-	-	3.07*	-	-	-

* p<0.1; ** p<0.05; *** p<0.01; **** p<0.001

Recording a broad negativity, the control mismatch condition relative to the control match condition yielded a significant effect at the 320-420 ms interval at the anterior regions (LA; $F_{(1,20)}$=11.96, p<0.01; LC; $F_{(1,20)}$=9.91, p<0.01; MA; $F_{(1,20)}$=16.33, p<0.001; MC; $F_{(1,20)}$=8.15, p<0.01; RA; $F_{(1,20)}$=17.86, p<0.01; RC: $F_{(1,22)}$=17.88, p<0.001), which is understood as LAN. Furthermore, the control mismatch condition relative to the control match condition yielded a significant effect at the 580-680 ms interval at the anterior regions (LA; $F_{(1,20)}$=10.36, p<0.01; LC; $F_{(1,20)}$=5.53, p<0.01; MA; $F_{(1,20)}$=12.76, p<0.01; MC; $F_{(1,20)}$=6.01, p<0.05; RA; $F_{(1,20)}$=6.01, p<0.05; RC: $F_{(1,22)}$=8.84, p<0.01), which is understood as "anterior P600." On the other hand, the *pro* match condition relative to the control match condition also produced a significant effect at the 320-420 ms interval at the anterior regions (LA; $F_{(1,20)}$=5.57, p<0.05; MA; $F_{(1,20)}$=6.36, p<0.05; MC; $F_{(1,20)}$=8.47, p<0.01; RA; $F_{(1,20)}$=10.95, p<0.01), which is understood as LAN.

3.2.2. EXP2

The visual inspection of grand average waveforms at the critical verb/adjective in the control mismatch condition relative to the control match condition revealed a negativity at the posterior region in the 320-420 ms interval, with the timing profile characteristic of an N400 response. Besides, the *pro* mismatch condition showed a negativity at the posterior region in the 320-420 ms interval, which is interpreted as a characteristic of N400 component. Furthermore, the *pro* mismatch condition recorded a sustained negativity at the anterior region relative to the control mismatch condition, beginning at around 320 ms and lasting to around 600 ms.

In the same fashion as EXP1, for the statistical analysis, the overall ANOVA were first performed, and then the pairwise comparisons were carried out between the control mismatch vs. the control match conditions and between the *pro* mismatch vs. *pro* match conditions in order to identify the effects of the match factor, and between the *pro* match vs. the control match conditions and between the *pro* mismatch vs. the control mismatch conditions in order to identify the effects of the subject-status factor. The mean amplitudes of the four experimental conditions were entered into a 2×2 repeated measures ANOVA with the *pro* (control and *pro* conditions), the match (match and mismatch), laterality (left, midline, and right), and an-pos (anterior, central and posterior) factors, as shown in Table 5.

Table 5. Comparison of Overall ANOVA *F*-values at the Critical Verb/adjective in EXP2

time window / factor	320-420 ms	580-680 ms
subject-status (1,20)	4.51**	
match (1,20)	5.26**	
lat (2,40)	4.04**	23.55****
an-pos (2,40)	33.40****	7.11**
*pro**match (1,20)	-	-

* p<0.1; ** p<0.05; *** p<0.01; **** p<0.001

There was a significant main effect of the subject-status factor at the 320-420 ms interval, $F_{(1,20)}=4.51$, $p<0.05$, and also a significant effect of the match factor at the 320-420 ms interval, $F_{(1,20)}=5.26$, $p<0.05$. In contrast, there was no effect at the 580-680 ms interval. The laterality factor was also significant both at the 320-420 ms interval, $F_{(2,40)}$=4.04, p<0.05, and at the 580-680 ms interval, $F_{(2,40)}$=23.55, p<0.001. Likewise, the anterior-posterior factor was significant at the 320-420 ms interval, $F_{(2,40)}$=34.40, p<0.001, and at the 580-680 ms interval, $F_{(2,40)}$=7.11, p<0.05. The results of these effects led us to below perform additional analyses of the topographic distributions of the ERP effects.

Pairwise comparisons were carried out in order to identify a difference between the conditions involving the subject-status and match factors, which is summarized in Table 6.

Table 6. Pairwise Comparison for ERP Data at the Critical Verb/adjective in EXP2

pair / time window / factor	control mismatch vs control match		pro mismatch vs pro match		pro match vs control match		pro mismatch vs control mismatch	
	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms
type(match/ subject-status)			4.45**				4.76**	
lat		19.91****	5.35**	20.97****		19.16****	5.72**	24.10****
an-pos	23.22****	8.60***	33.72****	5.55**	25.69****	6.46**	36.31****	7.06**
type*lat* an-pos								

* p<0.1; ** p<0.05; *** p<0.01; **** p<0.001

The *pro* mismatch condition relative to the *pro* match condition yielded a significant effect at the 320-420 ms interval, $F_{(1,20)}$=4.45, p<0.05, being more negative at the posterior than at the *pro* match condition, which is understood as N400. The *pro* mismatch condition was more negative than the control mismatch condition, yielding a significant effect at the 320-420 ms interval, $F_{(1,20)}$=4.76, p<0.05, being more negative at the anterior than at the posterior, which is characterized as an LAN response. In contrast, there was no effect at the 580-680 ms.

Additional comparisons within individual ROIs were also conducted to better understand topographic differences. The significant results of ANOVA are listed in Table 7.

Table 7. Comparison of Overall ANOVA *F*-values at 9 Regions in EXP2

pair / time window / factor	control mismatch vs control match		pro mismatch vs pro match		pro match vs control match		pro mismatch vs control mismatch	
	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms	320-420 ms	580-680 ms
LA	-	-	3.21*	-	-	-	5.80**	-
LC	-	-	-	-	-	-	-	-
LP	7.70**	-	-	3.36*	4.18*	-	-	-
MA	-	-	-	-	-	-	5.94**	-
MC	-	-	4.62**	-	-	-	-	-
MP	8.34***	-	6.29**	-	3.71*	-	-	-
RA	-	3.09*	-	-	-	-	8.64***	-
RC	-	-	6.06**	3.33*	-	-	5.71**	-
RP	3.03*	-	4.17*	-	3.57*	-	-	-

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; **** $p<0.001$

The control mismatch condition relative to the control match condition yielded a significant effect at the 320-420 ms interval, displaying a negativity at the posterior regions (LP; $F_{(1,20)}=7.70$, $p<0.05$; MP; $F_{(1,20)}=8.34$, $p<0.01$), which is understood as N400. Furthermore, the *pro* mismatch condition relative to the *pro* match condition yielded a significant effect at the 320-420 ms interval at the posterior regions (MC; $F_{(1,20)}=4.62$, $p<0.05$; MP; $F_{(1,20)}=6.29$, $p<0.05$; RC; $F_{(1,20)}=6.06$, $p<0.05$), which is called N400. At the 580-680 ms, there was a marginally significant effect (LP; $F_{(1,20)}=3.36$, $p=0.08$; RC; $F_{(1,20)}=3.33$, $p=0.08$), which is attributed to the fact that the *pro* mismatch condition was more negative than the *pro* match condition, thereby with the characteristic of sustained negativity beginning at the 320-420 ms interval, as shown in Figure 5.

The *pro* match condition relative to the control match condition produced marginally significant effects at the 320-420 ms at the posterior regions (LP; $F_{(1,20)}=4.18$, $p=0.05$; MP; $F_{(1,20)}=3.71$, $p=0.07$; RP; $F_{(1,20)}=3.57$, $p=0.07$), but there was no effect at the 580-680 ms.

The *pro* mismatch condition relative to the control mismatch condition produced a significant effect at the 320-420 ms at the anterior regions (LA; $F_{(1,20)}=5.80$, $p<0.05$; MA; $F_{(1,20)}=5.94$, $p<0.05$; RA; $F_{(1,20)}=8.64$, $p<0.01$; RC; $F_{(1,20)}=5.71$, $p<0.05$), which is called as LAN, but there was no effect at the 580-680 ms.

3.2.3. Comparison between EXP1 and EXP2

We performed an additional analysis to compare the differences between the effects of non-respectful subjects in EXP1 and those of respectful subjects in EXP2. To this purpose, we used the differences either in a match/mismatch factor between the overt and the covert subject conditions to compare the results of EXP1 and those of EXP2. The result of this analysis is given as shown in Table 8.

Table 8. Effects of the Between-overt-and-covert Conditions in EXP1 and EXP2

overt/covert	condition	320-420 ms		580-680 ms	
		EXP1	EXP2	EXP1	EXP2
between overt and covert	*pro* match vs. control match	**	*		
	pro mismatch vs. control mismatch		**		

* p<0.1; ** p<0.05; *** p<0.01; **** p<0.001

Note that at the 320-420 ms interval, there was a significant difference between EXP1 and EXP2.

Second, we went on to conduct statistical pairwise and ROI analyses to compare difference between the overt and the covert conditions. The results of these analyses are given in Table 9:

Table 9. Compare Difference Between the Covert and Overt Conditions at the Critical Verb/adjective in Difference Between EXP1 and EXP2, Using Pairwise and ROI Analyses

pair / time window / factor/region	***pro* match vs. control match**		***pro* mismatch vs. control mismatch**	
	320-420 ms	580-680 ms	320-420 ms	580-680 ms
subject-status	-	-	-	-
lat	-	-	-	-

time window / factor/region (pair)	**pro match vs. control match**		**pro mismatch vs. control mismatch**	
	320-420 ms	580-680 ms	320-420 ms	580-680 ms
an-pos	3.14*	2.92*	-	-
subject-status*an-pos	-	-	4.11**	-
LA	-	-	4.84**	-
LC	-	-	-	-
LP	-	-	-	-
MA	-	-	3.97*	-
MC	-	-	-	-
MP	-	-	-	-
RA	-	-	5.09**	-
RC	-	-	-	-
RP	-	-	-	-

* p<0.1; ** p<0.05; *** p<0.01; **** p<0.001a

As for the *pro* mismatch vs. the overt mismatch conditions, at the 320-420 ms interval there was a significant subject-status*an-pos interaction effect, $F_{(2,40)}$=4.11, p=0.05, particularly recording significant effects at the anterior region (LA: $F_{(1,20)}$=4.84, p<0.05; RA: $F_{(1,20)}$=5.09, p<0.05; MA: $F_{(1,20)}$=3.97, p=0.06). However, there was no effect at the 580-680 ms interval. As for the *pro* match vs. the overt match conditions, there was a marginally significant an-pos effect at the 320-420 ms interval, $F_{(2,40)}$=3.14, p=0.07, and there was also a marginally significant an-pos effect at the 580-680 ms interval, $F_{(2,40)}$=2.92, p=0.09.

4. Discussion

The first question that was examined in the experiments with the materials designed was whether Korean native speakers differentiate overt and *pro* subjects in the course of sentence processing. More specifically, the question was whether long-distance agreement of the honorific-(un)marked predicate with null subjects (or *pro*'s) that take a non-local antecedent are distinguished in sentence processing from short-distance/local agreement of the honorific-(un)marked predicate with overt subjects that do not take a non-local antecedent. The experimental results bearing on this first question are summarized below:

Table 10. Comparison Effects Between Overt-and-covert Conditions at 320-420 ms in EXP1 and EXP2

comparison	**EXP1**	**EXP2**
pro match vs. overt match	significant effect (p<0.05) at anterior region	marginal effect (p<0.1) at posterior region
pro mismatch vs. overt mismatch		significant effect (p<0.05) at anterior region

The comparison between overt and covert *pro* subject conditions registered a negativity at the 320-420 ms interval either at anterior or posterior regions, except for the comparison between the overt and the covert *pro* subject mismatch conditions in EXP1.2) We first take the absence of an ERP effect in the latter comparison to indicate that Korean native speakers are able to parse the null subject *pro* in the embedded subject position, and process overt and covert *pro* subjects in the same manner in the case of the conditions involving the most obvious misuse of the honorific marker. Note that if, as argued by Aoshima et al. (2004), instead of the embedded *pro* subject the matrix subject in the covert *pro* subject mismatch

2) As for the ERP-based previous studies on the processing of subject-verb agreement in English and other languages, they usually focus on features such as number (e.g., Kutas and Hillyard (1983); Hagoort et al. (1993); Osterhout and Mobley (1995); Kaan (2002); De Vincenzi et al. (2003); Roehm et al. (2005); Silva-Pereyra and Carreiras (2007); Zawiszewski et al. (2015) and person (e.g., Munte and Heinze (1994); Hinojosa et al. (2003); Silva-Pereyra and Carreiras (2007); Mancini et al. (2011); Shen et al. (2013); Zawiszewski et al. (2015)). These studies have shown such specific components responsive to incorrect agreement patterns as an anterior negativity that is often left-lateralized (LAN) and peaks between 300 and 500 ms after the mismatch onset and/or a late posterior positivity (P600) peaking around 600ms after the mismatch onset.

condition of EXP1 had been incorrectly analyzed as the embedded subject, the comparison of the comparison with the overt subject mismatch condition in EXP1 would have elicited an ERP effect, contrary to fact. This comparison renders compelling evidence showing that Korean speakers are able to parse the embedded *pro* subject where it is needed, instead of parsing the overt matrix subject as the embedded subject incorrectly.

Some comments are in order on the other three comparisons. The conditions in these comparisons are sentences where the honorific marker does not occur (the match conditions of EXP1) or it is not absolutely required (all the conditions of EXP2)[3]. Acknowledging again that the presence of a negativity in the early time course of an ERP processing at the 320-420 ms interval points to a more demanding cost of processing, we take the record of a negativity in this interval of the three comparisons to indicate that the *pro* subject conditions in EXP1 and EXP2 are more taxing than the overt subject conditions. Since the null pronoun *pro* subject is supposed to take a non-local subject as its antecedent and engage in semantic integration with a verb/adjective it relates with, it presumably calls for more processing efforts, which in turn result in inducing a 320-420 ms-interval negativity in the *pro* subject conditions relative to the overt subject conditions.

We now turn to the second question of whether there was a difference between honorific agreement satisfaction and honorific agreement violation. The experimental results bearing on this second question are summarized below:

Table 11. Comparison Effects Within Overt Conditions and Within Covert Conditions at 320-420 ms and 580-680 ms Intervals in EXP1 and EXP2

comparison	320-420 ms		580-680 ms	
	EXP1	**EXP2**	**EXP1**	**EXP2**
overt mismatch vs. overt match	significant effect ($p<0.01$) at anterior region	marginal effect ($p<0.1$) at posterior region	significant effect ($p<0.05$) anterior	

3) The use of the honorific marker in EXP2 will be returned to shortly below.

comparison	320-420 ms		580-680 ms	
	EXP1	**EXP2**	**EXP1**	**EXP2**
pro mismatch vs. *pro* match		significant effect ($p<0.05$) at central posterior region		

The comparison between match and mismatch conditions containing either an overt or a covert *pro* subject recorded LAN followed by anterior P600 for the overt subject condition of EXP1, and a centro-posterior negativity or N400 for the covert *pro* subject condition of EXP2 (in addition to a posterior negativity or N400 for the covert *pro* subject condition of EXP2).

Recall that the materials of EXP1 involve a non-respectful embedded subject. But the overt mismatch condition of EXP1 contains the illegal honorific marker. Since LAN followed by anterior P600 is known as an index of a syntactic/grammatical violation, the starkly erroneous use of the honorific marker in the overt mismatch condition of EXP1 in fact is an instance of a syntactic/grammatical violation. In other words, the embedded verb/adjective in the overt mismatch condition of EXP1 is illegally inflected with the honorific marker, which in turn induces bi-phasic ERP components, i.e., LAN followed by anterior P600.

In contrast, the materials of EXP2 involve a respectful embedded subject. It is well acknowledged in Korean grammar that a respectful subject element does not require the presence of the honorific marker on a verb/adjective it relates with. Particularly, young Korean speakers tend to omit the use of the honorific marker. We suggest that the use of the honorific marker is not a syntactic/grammatical requirement, but pragmatically oriented. This suggestion gains more validity, as the omission of the honorific marker where it is called for induces N400, which is known as a signature of contextual meaning processing (cf. Lau et al. (2008)).

We finally turn to the third question of whether there was a difference between mismatch of a respectful null subject with a non-honorific marked predicate form and mismatch of a non-respectful null subject with a honorific-marked predicate form. The experimental results relating to this third question are summarized below:

Table 12. Comparison Effects Between Overt-and Covert Conditions in Difference Between EXP1 and EXP2 at 320-420 ms and 580-680 ms Intervals

between [EXP1]-[EXP2]	320-420 ms	580-680 ms
pro match vs. overt match	marginal an-pos effect (p<0.1)	marginal an-pos effect (p<0.1)
pro mismatch vs. overt mismatch	subject-status*an-pos interaction effect (p=0.05) at the anterior	

The comparison in match/mismatch between the overt and the covert subject conditions in EXP1 and EXP2 revealed that there was a significant subject-status*an-pos interaction effect in the *pro* vs. the overt subject mismatch conditions, specifically at the anterior region. There was, on the other hand, no effect at the 320-420 ms nor at the 580-680 ms interval in the *pro* vs. the overt subject match conditions. To understand this result, we once again assume that the presence of a negativity in the early time course of an ERP processing at the 320-420 ms interval is a signature of a more flagrant abnormalcy that in turn needs a more demanding processing cost to repair it. Note that the use of the honorific marker on a verb/adjective with the non-respectful subject in EXP1 is blatantly ruled out, but its absence on a verb/adjective with the respectful subject in EXP2 incurs only a minor penalty. This difference in mismatch conditions between EXP1 and EXP2 yielded the afore-mentioned ERP results. In EXP1 the *pro* and the overt subject mismatch conditions are both equally irreparable, hence the difference between them being insignificant. In EXP2, on the other hand, the *pro* and the overt subject mismatch conditions are both unstable in (un)acceptability, but the presence of *pro* in the former *pro* subject mismatch condition calls for a more processing cost to identify it, and subsequently search for and engage in semantic integration with its antecedent. In other words, as pointed out above, the effects of *pro* subjects relative to those of overt subjects come into full force unless the use of the honorific marker is completely banned. All in all, there is a difference between EXP1 and EXP2 in a difference between *pro* and overt subject mismatch conditions, which is attributed to the different roles that the respectful and the non-respectful subject expressions play in sentence processing in Korean.

5. Conclusion

In conclusion, our ERPs-based experiments with the materials involving the two factors such as subject-status and match have yielded three results. First, Korean native speakers detect *pro* subjects in a parallel way to overt subjects, particularly in the mismatch conditions illegally containing the honorific marker. In the other conditions where the honorific marker is legal or its use is not obligatory, *pro* subjects are differentiated from overt subjects, in that the former are processing-wise costlier and thus more negative in ERP waveforms than the latter at the 320-430 ms interval.

Second, the use of the honorific marker elicits different ERP components in EXP1 and EXP2. In the former EXP1, where the honorific marker is illegal with the non-respectful subject, the overt mismatch condition relative to its overt match condition registers a bi-phasic LAN followed by anterior P600, which we take as a reflection of a grammatical abnormality. In EXP2, however, where the use of the honorific marker with the respectful is not strongly enforced, the overt mismatch condition relative to its overt match condition records an N400, which we take as a reflection of contextual meaning adjustment. Thus, the honorific marker as a cue for the detection of a subject expression yields different processing responses, depending on whether the subject expression is a respectful or a non-respectful person.

Third, the comparison between EXP1 and EXP2 reveals different aspects of the interaction between the two factors: subject-status and match in the materials in our design. Recall that the use of the honorific marker on a verb/adjective with the non-respectful subject in EXP1 is completely ruled out, but its absence on a verb/adjective with the respectful subject in EXP2 is permissible. Thus, in EXP1 the *pro* and the overt subject mismatch conditions are both equally irreparable, hence the difference between them being only meager. In EXP2, on the other hand, the *pro* and the overt subject mismatch conditions are both repairable, but the presence of *pro* in the former *pro* subject mismatch condition needs a more processing cost to undergo interpretational resolution.

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Received: November 5, 2015
Revised version received: December 17, 2015
Accepted: December 21, 2015