Processing Asymmetries of Subject and Object *pro* in Korean

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Previous studies have shown that object relative clauses incur a heavier processing load than subject relative clauses. The processing advantage of subject relative clauses has been taken to support various processing accounts based on memory resources (Gibson, 1998; Lewis & Vasishth 2005) or linguistic analyses (O'Grady, 1997; Keenan & Comrie, 1977). In this paper, we aim to test these accounts using the construction that has not been previously examined, namely the noun complement construction with subject and object *pro* (~*the fact that __pro threatened the editor vs. ~the fact the editor threatened __pro*). Self-paced reading results showed that the processing advantage of subject gap was also found for the noun complement construction with *pro*. The results are taken to support processing accounts based on linguistic analyses (O'Grady 1997; Keenan & Comrie 1977).

Keywords: *pro*, null argument, subject/object asymmetry, noun complement clauses, Korean

1. Introduction

Processing of long-distance dependencies has been an important topic in the studies of sentence processing. For example, previous studies have shown that object relatives (2) elicited more processing difficulty than subject relatives (1) (in English: King & Just 1991; King & Kutas 1995; Stromswold et al. 1996; Caplan et al. 2001; Traxler et al. 2002; in Korean: Kwon et al. 2006; Kwon et al. 2010; Kwon et al. 2013). This asymmetry has provided a good testing ground for various processing models based on working memory resources (Gibson, 1998; Lewis & Vasishth 2005) or linguistic analyses (O'Grady 1997; Keenan & Comrie 1977) (see below

for details of these models).

   (1) Subject relative clauses
      The reporter who attacked the senator admitted the error.

   (2) Object relative clauses
      The reporter who the senator attacked admitted the error.

However, processing of long-distance dependencies has been mainly discussed in the context of relative clauses and there have been very few studies that examined the processing of different constructions (cf. Kwon 2008). Thus, in this study, we aim to fill this gap by examining the processing of long-distance dependencies involving *pro* (i.e., argument drop) in Korean.

   In fact, analyses of Korean relative clauses have been controversial. In one analysis, relative clauses are analyzed to involve *wh*-operator movement (Han 1992; Han & Kim 2004; D. W. Yang 1987; H. K. Yang 1990 among others) and the trace is bound by this null relative operator. On the other hand, in the argument-drop analysis (Y. Kang 1986; Sohn 1980), relative clauses are analyzed as embedded clauses with argument drop (see Kwon 2008 for a review). However, despite the ambiguity in the nature of the gap in relative clauses, relative clauses and the target sentences with *pro* used in the current study are similar in that they both involve a dependency between a gap and a sentential-internal element; they should be associated. Thus, it is an empirical question to investigate whether a potentially different dependency type is subject to similar processing constraints. Given this, in this study we aim to investigate the processing of a referential dependency with *pro* and compare the results with those with relative clauses. Specifically, we investigate the processing of noun complement clauses with subject and object *pro,* as illustrated in (3) and (4) in English.

   (3) Noun complement clause with subject *pro*
      The fact that __*pro* threatened the senator was revealed.

(4) Noun complement clause with object *pro*
   The fact that the senator threatened __*pro* was revealed.

An example of the target sentences in Korean is in Table 1. Apart from the gap type, we also manipulated the preceding context in this study. This is because Korean has impoverished verbal agreement, and thus discourse context is crucial in the interpretation of pro (Huang 1984; Kwon & Sturt 2013). Thus, the experimental sentences varied with regard to the presence/absence of preceding context.

Table 1. Example Experimental Item

| **Context sentences for subject *pro*** |
| 총장이 편집장을 왜 협박했는지 지금까지 의문이었다. |
| 'It has not been clear so far why the chancellor threatened the editor.' |

| **Context sentences for object *pro*** |
| 편집장이 총장을 왜 협박했는지 지금까지 의문이었다. |
| 'It has not been clear so far why the editor threatened the chancellor.' |

W1	W2	W3	W4	W5	W6	W7	W8
지난	달	편집장-을/이	뇌물	수수	혐의-로	협박한	사실-이
Last	month	editor-ACC/NOM	bribe	receiving	suspicion-with	threaten-ADN	fact-NOM

W9	W10	W11	W12	W13
밝혀지-자	총장-은	즉각	기자회견-을	열었다.
was.revealed-AS	chancellor-TOP	immediately	press.conference-ACC	held

Subject *pro*: 'The chancellor*i* immediately held a press conference as the fact that (he*i*) threatened the editor for taking a bribe last month was revealed.'
Object *pro*: 'The chancellor*i* immediately held a press conference as the fact that the editor threatened (him*i*) for taking a bribe last month was revealed.'

Given the different requirements on the interpretation of a gap within a relative clause (i.e., syntactic in nature) and *pro* (i.e., referential in nature) (for different syntactic analyses of a gap within relative clauses from those of *pro* in Korean, see Han 1992; Han & Kim 2004; D. W. Yang 1987; H. K. Yang 1990 among others; cf. Y. Kang 1986; Sohn 1980), the investigation of the processing of noun complement clauses with a gap should further the understanding of cognitive mechanisms underlying long-dis-

tance dependencies.

In the next section, we present an overview of the processing models
that have been proposed to account for the processing asymmetry between
subject and object relative clauses. We also present predictions for the
target constructions made by these models.

1.1. Accounts based on working memory resources
(Gibson 1998, 2000; Lewis & Vasishth 2005; Lewis et al. 2006)

In memory-based processing theories, processing difficulty is accounted
for in terms of memory activation and subsequent decay in working memo-
ry stores. While theories vary as to how to characterize memory decay,
either susceptible to new discourse referents (e.g., Gibson 1998, 2000;
Warren & Gibson 2002) or time (Lewis & Vasishth 2005; Lewis et al.
2006), in the context of the processing of relative clauses in English, this
suggests that filler-gap dependencies are more difficult to process over
longer distance due to more memory decay. When applied to the compar-
ison of subject and object relative clauses, the accounts predict that object
relative clauses (5)-(b) will be more difficult to process than subject relative
clauses (5)-(a), as the former has longer linear/temporal distance between
a filler and its gap than the latter.

(5) Linear distance between filler and gap
    (a) Object relative clause:
        The reporter$_i$ [who$_i$ the senator attacked __$_i$] disliked the editor.

    (b) Subject relative clause:
        The reporter$_i$ [who$_i$ __$_i$ attacked the senator] disliked the editor.

For the target sentences in Korean, however, the memory-based processing
theories predict that subject *pro* sentences will be more difficult than object
pro sentences. The target sentences involve a gap-antecedent ordering in
which a gap occurs before its antecedent. As a gap does not have any
phonetic value of its own, the presence of a gap can be only indirectly

signaled based on other cues available. For subject *pro* sentences, the non-canonical sentence-initial NP-ACC could signal a presence of a missing argument. For object *pro* sentences, the argument structure of the embedded verb will signal a missing argument. Thus, on this view, subject *pro* sentences have longer linear/temporal distance between a gap and its coindexed argument than object *pro* sentences, as shown in (6) and (7). This predicts a processing advantage of object *pro* sentences compared to subject *pro* sentences at the coindexed argument.

(6) editor-ACC threaten-ADN fact-NOM was.revealed-AS chancellor-TOP ⋯
    Subject *pro* 'The chancellor$_i$ ~ as the fact that (he$_i$) threatened the editor was revealed.'

(7) editor-NOM threaten-ADN fact-NOM was.revealed-AS chancellor-TOP ⋯
    Object *pro* 'The chancellor$_i$ ~ as the fact that the editor threatened (him$_i$) was revealed.'

1.2. Theories based on linguistic analyses (O'Grady 1997; Keenan & Comrie 1977)

Theories based on linguistic analyses account for the processing asymmetry between subject and object relative clauses in terms of inherent properties associated with these structures. For example, O'Grady explains the processing asymmetry between subject and object relative clauses in terms of the different structural distance between a gap and its filler. To be specific, the assumption is that structural complexity increases when there are more number of XP categories between a gap and its associated filler. Thus, subject relative clauses are predicted to be easier to process than object relative clauses, as the object gap is more deeply embedded than the subject gap, and the subject gap is structurally closer to the head noun than the object gap.

On the other hand, the Accessibility hierarchy (Keenan & Comrie 1977) is based on the assumption that the accessibility to relative clause formation also reflects '*the psychological ease of comprehension*'. Under this account,

the subject position is more likely to allow relativization than any other grammatical positions across languages, and subject relative clauses are easier to process than any other types of relative clause. Accordingly, these linguistically motivated accounts predict a universal parsing pattern for all configurational languages; subject relative clauses will be easier to process than object relative clauses.

Subject *pro* sentences have fewer number of intervening XP categories between *pro* and its antecedent than object *pro* sentences. Thus, the processing account based on structural distance predicts that object *pro* sentences will be more difficult to process than subject *pro* sentences. Likewise, the Accessibility hierarchy also predicts that object *pro* sentences will be more difficult to process than subject *pro* sentences, if we assume that the hierarchy can be extended to sentences with *pro*.[1] The gap type effect is predicted at the coindexed argument position.

In summary, accounts based on working memory resources predict the processing advantage of object *pro* sentences. On the other hand, linguistically motivated accounts predict the processing advantage of subject *pro* sentences over object *pro* sentences. In relation to context, we predict that the presence of preceding context will facilitate the overall processing of the sentences. We also predict that *pro* resolution will get easier with a preceding context sentence.

2. Experiment

2.1. Materials and experimental design

The experiment had four conditions, using a 2×2 design, crossing (i) presence vs. absence of preceding context (providing referential information for *pro*) and (ii) subject vs. object *pro* (see Table 1 for an example). The stimuli were adopted from Kwon (2008) in which subject vs. object gap sentences were controlled for plausibility ($t(36) = 2.94$, $p < .1$).

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1) Although Comrie (personal communication) suggested a possibility that the Accessibility hierarchy could be extended to sentences with *pro*, it is an empirical question that needs to be further investigated.

2.2. Participants

Forty native speakers of Korean participated in the experiment, receiving KRW5000. At the time of the experiment, they were undergraduate students at a university in Korea. All had normal or corrected-to-normal vision.

2.3. Procedure

There were 40 sets of experimental sentences. Four lists were created according to a Latin square design. There were 112 filler sentences of similar length and of compatible structural complexity. These were experimental sentences for three unrelated experiments on pronoun resolution and number agreement. The experiment was run individually on a laptop running *Linger* (Doug Rohde, MIT) in a quiet room. Stimulus presentation was self-paced, word-by-word and non-cumulative. Every word in the sentence was masked with dashes, with spaces left unmarked. The time between each button-press was recorded as reading time measures. Participants answered a yes/no comprehension question after each sentence. Half of the comprehension questions targeted the content of the embedded clause and the other half the content of the main clause. Presentation order was pseudo-randomized such that no two experimental sentences were appeared in a row. The experiment lasted approximately 30 minutes.

2.4. Analysis

Reading times were first trimmed by removing individual data points that fell beyond 2 standard deviations from the overall mean for each word position. Reading times were then analyzed using a commercially available statistical package (JMP IN). An omnibus ANOVA was performed with context and gap type as independent factors and comprehension accuracy and reading times of each word position as the dependent variables. Data from one participant were removed due to low comprehension performance (65%).

3. Results

Mean comprehension accuracy is presented in Table 2, mean reading times for each word in Table 3, and statistical analyses results in Table 4. The comprehension accuracy scores were significantly higher for the Context condition than for the No-context condition. There was no gap type effect for comprehension accuracy.

Table 2. Mean Comprehension Accuracy

	subject *pro*	object *pro*
context	92%	93%
no context	85%	81%

Table 3. Mean Reading Times (ms)

	Context		No-Context	
	Subj. *pro*	Obj. *pro*	Subj. *pro*	Obj. *pro*
W1	505	491	418	417
W2	380	402	393	385
W3 editor-ACC/NOM	363	377	417	420
W4	373	374	516	457
W5	359	348	455	433
W6	342	351	418	417
W7	366	359	420	423
W8 fact-NOM	358	368	430	456
W9 was.revealed-AS	347	370	411	444
W10 chancellor-TOP	345	360	409	413
W11	360	368	417	420
W12	369	366	399	397
W13	424	434	448	464

Table 4. Statistical Analysis Results

		F1(1, 38)	p	F2(1, 39)	p
Answer accuracy	Context	23.7	***	10.08	*
	Gap type	< 1	n.s.	< 1	n.s.
	Cxt × Gp	< 3	n.s.	< 3	n.s.
W1	Context	26.84	***	95.95	***
W2	Context	< 1	n.s.	< 1	n.s.
W3 editor-ACC/NOM	Context	23.93	***	41.53	***
	Gap type	< 3	n.s.	< 3	n.s.
	Cxt × Gp	< 1	n.s.	< 1	n.s.
W4	Context	57.74	***	90.87	***
	Gap type	4.9	*	6.05	*
	Cxt × Gp	7.4	**	8.75	**
W5	Context	79.41	***	138.17	***
	Gap type	10.17	**	5.26	*
	Cxt × Gp	< 2	n.s.	< 2	n.s.
W6	Context	81.16	***	122.56	***
	Gap type	< 1	n.s.	< 1	n.s.
	Cxt × Gp	< 1	n.s.	< 1	n.s.
W7	Context	47.13	***	179.13	***
	Gap type	< 1	n.s.	< 1	n.s.
	Cxt × Gp	< 1	n.s.	< 1	n.s.
W8 fact-NOM	Context	66.64	***	138.8	***
	Gap type	8.35	**	9.116	**
	Cxt × Gp	< 2	n.s.	< 2	n.s.
W9 be.revealed-AS	Context	90.89	***	149.64	***
	Gap type	18.35	***	15.89	**
	Cxt × Gp	< 2	n.s.	< 2	n.s.
W10 chancellor-TOP	Context	79.32	***	223.3	***
	Gap type	< 3	n.s.	< 3	n.s.
	Cxt × Gp	< 1	n.s.	< 1	n.s.
W11	Context	101.34	***	113.21	***
	Gap type	< 2	n.s.	< 2	n.s.
	Cxt × Gp	< 1	n.s.	< 1	n.s.
W12	Context	41.57	***	58.8	***
	Gap type	< 1	n.s.	< 1	n.s.
	Cxt × Gp	< 1	n.s.	< 1	n.s.
W13	Context	5.56	*	12.46	**
	Gap type	< 2	n.s.	< 2	n.s.
	Cxt × Gp	< 1	n.s.	< 1	n.s.

* < .01, ** < .001, *** < .0001

There was a main effect of context at all the word positions except for W2. Reading times were significantly shorter when there was preceding context. A main effect of gap type was found at W4, W5, W8 and W9. At W4 and W5, reading times were significantly longer for subject *pro* than for object *pro*. At W8 and W9, however, object *pro* sentences took longer to read than subject *pro* sentences. Finally, there was an interaction of context and gap type at W4, suggesting that the gap type effect was modulated by the presence of context. Post-hoc pairwise comparisons at W4 showed that the interaction was due to the fact that in the No-Context conditions , subject *pro* sentences took significantly longer to read than object *pro* sentences (p < .05) but no such asymmetry was found in the Context conditions.

There was no other word position with a significant interaction of context and gap type. However, given the strong context effects at various word positions, we further ran pairwise comparisons between subject and object *pro* sentences at the other three word positions (W5, W8 and W9) at which the gap type effect was significant. In the Context conditions, the object *pro* sentences took significantly longer to read than subject *pro* sentences at W9 ($p < .003$). On the other hand, at W5 and W8 subject and object *pro* sentences did not significantly differ from each other (W5: $t(38) = -1.47$, n.s.; W8: $t(38) = 1.32$, n.s.). In contrast, in the No-Context conditions, the gap type effect remained significant (or marginally significant) for all these word positions (W4: $t(38) = -2.89$, $p < .004$; W5: $t(38) = -1.81$, $p < .069$; W8: $t(38) = 2.04$, $p < .05$; W9: $t(38) = 2.776$, $p < .006$).

4. Discussion and Conclusion

The results showed a main effect of context for comprehension accuracy and reading times at all word positions except for W2. In addition, there was a main effect of gap type at W4, W5, W8 and W9 and an interaction between a gap type and context at W4. Below, we discuss these effects in turn.

Overall, the results showed a strong effect of context on sentence processing. The experimental sentences were read faster and comprehended better when there was preceding context than when sentences were presented in isolation. Given that preceding context provided readers with discourse context for the target sentences, the facilitatory effects of context found in this study is not so surprising (see Kwon et al. 2010 for similar results with eye-tracking with relative clause sentences). More importantly, the experimental results are consistent with the claim that context is crucial for the interpretation of *pro* in Korean (Huang 1984; Kwon & Sturt 2013). That is, it is possible that the processing of the target sentences was overall facilitated, as preceding context provided informative cues for the interpretation of *pro* of the target sentences.

For the gap type effect, the overall experimental results showed rather complicated patterns. Although the main effect of the gap type was found at four word positions, the direction of effect was different at these word positions; at W4 & W5, the subject *pro* sentences took longer to read, but at W8 & W9, it was the object *pro* sentences that took longer to read. Furthermore, the pairwise comparison results at these word positions suggested that the effect of gap type was modulated by the presence/absence of preceding context. That is, in the No-context conditions, the subject and object *pro* asymmetry was observed in all the word positions with a main effect of gap type (W4, W5, W8 and W9), in the Context conditions, the processing asymmetry was only observed at W9 with significantly longer reading times for object than subject *pro* sentences. These complicated patterns of the results are difficult to interpret but it is possible that they are due to particular processing strategies involved in the interpretation of the target sentences. For example, as mentioned above, interpretation of *pro* requires various processing strategies. In particular, given that Korean is a discourse-oriented language (Huang 1984), sentence comprehenders should crucially utilize discourse information for the *pro* resolution (Kwon & Sturt 2013). This suggests that the gap type effects found for the No-context condition could have been confounded with the general processing difficulty of sentences with *pro* due to the lack of discourse context. In fact, this hypothesis is supported by the overall reading time

patterns. In subject *pro* sentences, W4 immediately followed the non-can-
onical sentence-initial NP-ACC. Thus W4 was the first position that sen-
tence comprehenders could realize that the subject was missing in these
sentences. Likewise, in object *pro* sentences, W8 was the first position
that the sentence comprehenders could realize that the object is missing,
as W8 immediately followed the embedded verb, whose argument struc-
ture would signal the missing objects. This means that the processing
disadvantage of subject *pro* sentences at W4 & W5 and the processing
disadvantage of object *pro* sentences at W8 &W9 could be due to the
missing arguments in these sentences without preceding discourse context.
On the other hand, the reading time results of the Context conditions
are not confounded with the interpretational requirements of *pro.* Instead,
the processing disadvantage of object *pro* sentences at W9 in the Context
condition could reflect genuine processing asymmetry due to the gap type.
Under this analysis, the results support the processing accounts based
on linguistic analyses such as the structural distance (O'Grady 1997) or
the Accessibility hierarchy (Keenan & Comrie 1977).

One problem, however, remains: the processing difficulty was not found
at W10, the position that *pro* should be associated with its antecedent
but one word before. This is different from the previous experimental
results with relative clauses that the processing asymmetry was the most
evident at the gap-filler integration position (Kwon et al. 2010, 2013).
These different results might suggest different parsing strategies for senten-
ces with *pro* and for relative clause sentences. One possibility is that the
earlier gap type effect at W9 in the Context condition is related to predictive
processing. That is, based on previous discourse context, sentence compre-
henders could have actively predicted an upcoming word and this is why
the gap type effect was detected at an earlier word position. The earlier
effect is in line with previous research on predictive processing (DeLong,
Urbach & Kutas 2005). However, future research is required to investigate
the possibility.

This study did not directly compare the processing of relative clause
sentences and noun complement sentences involving *pro.* Nevertheless,
overall results suggest that there is certain similarity as well as dissimilarity

between these two types of long-distance dependencies. The apparent similarity is that both constructions are best compatible with the processing accounts based on linguistic analyses, suggesting that underlying sentence structure is a critical factor in the processing of long-distance dependencies. On the other hand, the results suggest that the processing of *pro* sentences is potentially more susceptible to the presence/absence of contextual sentences than the processing of relative clauses (cf. Kwon et al. 2010), which is consistent with the previous observation that *pro* interpretation is strongly governed by discourse context in Korean (Kwon & Sturt 2013).

In the study, we investigated the processing of noun complement sentences with subject and object *pro*. The results showed that the processing advantage of subject gap is also found for sentences involving *pro,* supporting the accounts based on linguistic analyses. In contrast, the results do not support the processing accounts based on memory resources.

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