Processing Scrambled Wh-Constructions in Head-Final Languages: Dependency Resolution and Feature Checking

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Hye-ryeong Hahn, Seungjin Hong. 2014. Processing Scrambled Wh-Constructions in Head-Final Languages: Dependency Resolution and Feature Checking. *Language and Information 18.2*, 59–79. This paper aims at exploring the processing mechanism of filler-gap dependency resolution and feature checking in Korean *wh*-constructions. Based on their findings on Japanese sentence processing, Aoshima *et al.* (2004) have argued that the parser posits a gap in the embedded clause in head-final languages, unlike in head-initial languages, where the parser posits a gap in the matrix clause. In order to verify their findings in the Korean context, and to further explore the mechanisms involved in processing Korean *wh*-constructions, the present study replicated the study done by Aoshima *et al.*, with some modifications of problematic areas in their original design. Sixty-four Korean native speakers were presented Korean sentences containing a *wh*-phrase in four conditions, with word order and complementizer type as the two main factors. The participants read sentences segment-by-segment, and the reading times at each segment were measured. The reading time analysis showed that there was no such slowdown at the embedded verb in the scrambled conditions as observed in Aoshima *et al.* Instead, there was a clear indication of the *wh*-feature checking process in terms of a major slowdown at the relevant region. (**Seowon University & University at Buffalo, SUNY**)

Key words: filler-gap dependency, *wh*-feature licensing, scrambled *wh*-constructions, Korean, head-final language, active filler, thematic role

1. Introduction

One of the major difficulties in sentence processing concerns the resolution of long-distance filler-gap dependency, that is, the relationship between a displaced element

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and the original thematic position out of which the element has been moved (Fodor, 1978). In the following example, a filler-gap dependency exists between the fronted element *who* (the filler) and the gap after the verb *arrest*; the interpretation of the filler *who* is critically dependent on the gap's position.

(1) Who does Tom believe that the detective arrested ___ on the train?

Researchers have attempted to understand how the human parser resolves such filler-gap dependencies, especially when the filler and the gap are in a long-distance relationship. A particular focus of investigation is how and where the parser posits a gap upon encountering a *wh*-filler. Some researchers have proposed that the parser's search for a gap is driven by the filler's need to resolve its dependency as early as possible (Frazier & Clifton, 1989). Others have claimed that the parser's search for a gap is driven by the thematic requirements of sentence elements, especially the verb (Garnsey, Tanenhaus, & Chapman, 1989; Traxler & Pickering, 1996). Psycholinguistic experiments have provided supporting evidence for each of these processing models, and the controversy has long remained unsettled, the main reason being that the majority of studies have investigated head-initial languages such as English. In head-initial languages, the two competing accounts tend to converge in their predictions as to where the parser will look for a gap.

Meanwhile, little research had discussed how the parser processes head-final languages with scrambling, until Aoshima, Phillips, and Weinberg (2004) conducted a pioneering study on long-distance filler-gap dependency resolution in Japanese. Capitalizing on the head-final nature of Japanese, Aoshima *et al.* designed a series of experiments that allowed different processing models to make diverging predictions. By demonstrating that a gap can be created around the embedded verb, instead of the matrix verb, the researchers argued that the parser's search for a gap is driven by the need to satisfy thematic requirements rather than the need to reach the earliest possible gap creation for the filler.

Aoshima *et al.*'s work with Japanese has allowed us to take a fresh look at language processing by incorporating a head-final language into the study of filler-gap dependency. Yet their findings have not been tested with other head-final languages that allow scrambling, and thus require verification through experiments with such languages. Furthermore, the experimental designs adopted by Aoshima *et al.* (2004) seem to be flawed by several factors, such as the use of sentences with too many lexical-NP arguments, which could have created an excessive burden on their participants' working memory. More seriously, they heavily rely on assumptions that themselves require further verification, which makes their findings controversial.

This study uses a modified version of Aoshima *et al.*'s (2004) experiments in the Korean context. By investigating the time course of the processing of sentences with scrambled *wh*-phrases, we aim at investigating how the parser assigns a gap when processing *wh*-questions in head-final languages, and further exploring other key processes involved in interpreting scrambled *wh*-elements in head-final languages.

2. Theoretical Background

2.1 Filler-Gap Dependencies

Syntactic operations in English such as *wh*-question formation, relativization, and topicalization involve the movement of an argument NP, creating a gap (or a "trace") in the original thematic position, as in (2–4).

(2) *What* do you want to see ___?

(3) That is the girl *whom* I met ___ yesterday.

(4) *Action movies*, I don't want to see ___.

The moved element in each example is referred to as a "filler," and the empty position in the constituent structure representation is referred to as a "gap" (Frazier, 1987, p. 578). In order to reach an interpretation, the filler must be associated with its gap. This relation between the filler and the gap is called "filler-gap dependency."

Researchers in psycholinguistics have investigated the mechanisms that allow the parser to resolve filler-gap dependencies in real-time, incremental sentence processing. One of the most frequently mentioned processing strategies is the Active Filler Strategy (AFS henceforth; Frazier & Clifton, 1989, p. 95):

> Active Filler Strategy:
> When a filler has been identified, rank the option of assigning it to a gap above all other options.

The AFS states that once a filler is identified, the parser actively predicts a gap. Rather than waiting until the actual empty argument position is encountered, the parser seeks the earliest grammatically possible gap position. When it finds the earliest permissible position, it assigns a gap in that position. In English, this earliest possible gap coincides with the highest possible gap position in terms of a tree structure, because English is a head-initial language, where elements in a higher position in the sentence hierarchy are located to the leftward in the sentence. Evidence for the AFS is shown most dramatically when the AFS leads to misanalysis. Sentence (5) below, a much-cited example (Aoshima, Phillips, & Weinberg, 2004; Crain & Fodor, 1985; Stowe, 1986), involves a filler-gap dependency.

(5) My brother wanted to know who Ruth will bring us home to ___ at Christmas. (Stowe, 1986)

While the dependency is between *who* and the gap that follows *to*, the AFS predicts that the parser will posit a gap in the earliest possible position, that is, the object position after *bring*. This initial attempt at dependency resolution soon proves wrong as the parser finds the object position filled by an overt pronoun *us*. The initial analysis thus has to be discarded, as the parser resumes a reanalysis. The initial misanalysis and resulting reanalysis is known to cause slowdown in reading times around the region immediately following the verb ("us" in the above example), which is also called a "surprisal" effect (Crain & Fodor, 1985; Stowe, 1986).

An alternative approach to sentence processing is the Thematic Role-Driven model (TD henceforth), which states that dependency resolution relies on the lexico-thematic relationship between the moved element and the verb. According to this account, the parser's dependency resolution is driven by the need to satisfy the thematic requirements of the sentence elements, in line with the Theta Criterion (Altmann, 1999; Garnsey, Tanenhaus, & Chapman, 1989; Gibson, 1991; Traxler & Pickering, 1996). In one version of this approach, the need is claimed to be solely driven by the verb's requirement to have its thematic roles saturated. Thus, the search for a gap in (5) is initiated when the parser encounters the verb *bring*, and the parser will assign a gap in the earliest possible position, that is, the direct object position. Another version of the TD claims that filler-gap dependency resolution is driven by the thematic requirements of both the filler and the predicate (Aoshima *et al.*, 2004). In this model, the filler *who* triggers a search for the earliest possible gap in order to receive its thematic interpretation. The verb also initiates a search for a gap that will satisfy its thematic requirement as early as possible. Therefore, this latter version of the TD also predicts that the gap will be posited right after the earliest verb (e.g., *bring* in [5]). When the initial gap assignment proves wrong upon encountering *us*, the parser is forced to seek another position for the gap. This initial misanalysis and later reanalysis creates processing difficulty. As a result, both versions of the TD make the same prediction as the AFS: There will be a slowdown at a region next to the verb *bring* in (5). In this paper, we will not distinguish these two versions, referring to them both as the TD.

So far, we have seen that while these processing models propose different parsing mechanisms, they all come to make the same prediction as to where the gap is posited — right after the earliest verb — making it hard to determine which mechanism is at work. The AFS predicts latency immediately after the verb because it is the earliest permissible gap position, whereas the TD predicts latency in the same region because it is the first thematic position of a verb.

Aoshima *et al.* (2004) attempted to tease apart the effects of the different mechanisms by approaching the question from a new angle. They noted that the controversy between the AFS and the TD had remained unsolved because the studies had been focused on head-initial languages, in which the earliest possible gap position coincides with the highest argument position, which is around the matrix verb. Aoshima *et al.* capitalized on the fact that in head-final languages, the earliest possible gap position is not necessarily around the matrix verb because the embedded verb "provides the first opportunity in the sentence to construct a *wh*-dependency" (Aoshima *et al.*, 2004, p. 33). This allows the competing models to make different predictions. In order to better understand the ideas employed by Aoshima *et al.*, let us first look at how filler-gap dependency in *wh*-questions can be created in head-final languages such as Japanese and Korean.

2.2 Head-Final Languages and Long-Distance *Wh*-Scrambling

In head-final languages such as Korean and Japanese, the verb follows its complement. When the sentence takes an embedded clause as a verb complement, the main verb follows the embedded clause, as in the following Japanese example, juxtaposed with its Korean equivalent (All Japanese examples in this section are from

Aoshima *et al.*, 2004).

(6) John-wa [Mary-ga sono hon-o nakusita-to] omotteiru.
John-un [Mary-ka ku chayk-ul ilepeliessta-ko] sayngkakhanta.
John-top [Mary-nom that book-acc lost-Comp] thinks
'John thinks that Mary lost that book'

In addition, these languages allow NP arguments within an embedded clause to appear in a fronted position across the local clause boundary, via scrambling.

(7) Sono hon-o John-wa [Mary-ga ___ nakusita-to] omotteiru.
Ku chayk-ul John-un [Mary-ka ___ ilepeliessta-ko] sayngkakhanta.
that book-acc John-top [Mary-nom ___ lost-Comp] thinks
'John thinks that Mary lost that book'

Scrambling applies to *wh*-arguments as well. The following sentences contain a dative *wh*-argument whose thematic position is within the embedded clause. While Korean and Japanese word order allows *wh*-phrases *in-situ* as in (8), the *wh*-expression can move up to the sentence initial position via scrambling (Beck & Kim, 1997; Ko, 2006; Park, 2010; Saito, 1985; Sohn, 1995; Watanabe, 1992; Yoon, 2013), as in (9).

(8) *Wh*-phrase *in-situ*

John-wa [Mary-ga dare-ni sono hon-o ageta-to]
John-un [Mary-ga nuwkuw-eykey ku chaik-ul cuwessta-ko]
John-top [Mary-nom whom-dat that book-acc gave-Comp]
itta-no?
malhayss-ni?
said-Q

'Who did John say Mary gave that book to?'

(9) Scrambled *wh*-phrase

Dare-ni John-wa [Mary-ga ___ sono hon-o ageta-to]
Nuwkuw-eykey John-un [Mary-ga ___ ku chayk-ul cuwessta-ko]
whom-dat John-top [Mary-nom ___ that book-acc gave-Comp]
itta-no?
malhayss-ni?
said-Q

'Whom did John say Mary gave that book to?'

These scrambled *wh*-constructions were what Aoshima *et al.* (2004) utilized in their experiments in order to have different processing models yield divergent predictions.

2.3 Wh-Questions and Scope Marking

It is important to note at this point that the scope of *wh*-questions in languages such as Korean and Japanese is determined differently than in head-initial languages such as English. In English, the scope of a question is indicated by the position of a *wh*-expression. So in the following English *wh*-question, (10) is a direct question because *who* has been extracted to the sentence-initial position, whereas (11) exemplifies an indirect question as *who* has been moved to the initial position of the embedded clause.

(10) Who did he say [Mary read that book to ___]? (Direct Question)

(11) He told me [who Mary read that book to ___]. (Indirect Question)

By contrast, the scope of a Japanese question is determined by the location of a question marking affix (Q-particle, henceforth) such as *-ka* or *-no* (Nishigauchi, 1990; Saito, 1985; Watanabe, 1992). In the following Japanese direct question, the Q-particle *-no* is attached to the sentence-final matrix verb, indicating that the question is a direct question. On the other hand, when the question is an indirect question, the Q-particle *-ka* is attached to the embedded verb.

(12)	John-wa	[Mary-ga	dare-ni	sono	hon-o	ageta-to]	itta-no?
	John-top	Mary-nom	whom-dat	that	book-acc	gave-Comp	said-Q

(Direct Question)

(13)	John-wa	[Mary-ga	dare-ni	sono	hon-o	ageta-ka]	itta. (Indirect
	John-top	Mary-nom	whom-dat	that	book-acc	gave-Q	said

Question)

Thus, although a *wh*-phrase is fronted to the sentence-initial position in both (14) and (15) below, (14) is a direct question because it has a Q-particle on the matrix verb, while (15) is an indirect question because it has a Q-particle on the embedded verb.

(14)	Dare-ni	John-wa	[Mary-ga		sono	hon-o	ageta-to]	itta-no?
	whom-dat	John-top	[Mary-nom	___	that	book-acc	gave-Comp]	said-Q

(Direct Question)

'To whom did John say that Mary gave that book?'

(15)	Dare-ni	John-wa	[Mary-ga		sono	hon-o	ageta-ka]	itta.
	whom-dat	John-top	[Mary-nom	___	that	book-acc	gave-Q]	said

'John said to whom Mary gave that book.'

The same is true of Korean direct and indirect questions (Beck & Kim, 1997; Choe, 1987; Chung, 1996; Yoon, 2001). For a direct question, a Q-particle such as *-ni* affixed to the matrix verb indicates that the question is a direct question; and for an indirect question, the Q-marker *-nunci* on the embedded verb signals that the scope of the question is the embedded sentence.[1]

(16) Nuwkuw-eykey John-un [Mary-ka ku chayk-ul chuwessta-ko]
whom-dat John-top [Mary-nom ___ that book-acc gave-Comp]
malhayss-ni? (Direct Question)
said-Q

(17) Nwukuw-eykey John-un [Mary-ka ku chayk-ul chuwess-nunci]
whom-dat John-top [Mary-nom ___ that book-acc gave-Q]
malhayss-ta. (Indirect Question)
said

Now, the *wh*-element has two features to be checked: a theta-feature and a *wh*-feature. While the theta-feature is checked in its thematic position, the *wh*-feature must be licensed by Q in the CP-head (Chomsky, 1995; Miyamoto & Takahashi, 2003; Ko, 2006). In order to have its *wh*-feature licensed, English requires a *wh*-element to move leftward. On the other hand, in languages that allow *in-situ wh*-phrases such as Korean and Japanese, the *wh*-feature must be licensed by the Q particle marked on the verb. Therefore, once a *wh*-filler is identified, the parser immediately engages in a search for its thematic position (i.e., the gap) on the one hand, and for the scope-marker (i.e., the Q-particle) on the other. As the Q-marker is not necessarily affixed to the verb with which the *wh*-argument is thematically related, it is highly likely that the processes of filler-gap association and *wh*-feature checking can be separately observed in the time course of sentence processing. Although Aoshima *et al.* (2004) did not touch upon this issue of *wh*-feature checking at the Q-marked position, we will take it as one of our research questions.

2.4 Aoshima et al. (2004): The Experimental Design and Its Problems

The way in which Aoshima *et al.* (2004) created "Japanese counterparts of so-called filler-gap dependencies in *wh*-questions" (p. 23) is quite complex. A clear understanding of Aoshima *et al.*'s study is necessary for understanding our own study, and therefore we explain their assumptions and experimental design in some detail in this section. Aoshima *et al.* adopted two major assumptions about Japanese and its processing. The first assumption concerns the canonical order of the verb phrase with a dative NP. Based on previous research findings (Kitagawa, 1994; Takano, 1998; Yatsushiro, 1999), Aoshima *et al.* assumed that (i) the canonical order of a dative construction is Nominative-Dative-Accusative, and (ii) "when a verb takes a clausal complement and a dative argument (e.g., *tutaeru* 'tell'), the canonical position of the dative argument is before the clausal complement" (Tsujimura, 1996, cited by Aoshima *et al.*, 2004). Therefore, the position for a dative *wh*-phrase in situ is immediately before the clausal complement, as in (18). In this paper, we assume that Korean and Japanese share the same canonical order for dative constructions (Im, 2009; Nam & Hong, 2013).

[1] Note that sentence (16) is ambiguous: nuwkuw-eykey can be interpreted as originating either from inside the embedded clause or from the dative NP position of the matrix sentence.

(18)

John-ga	dare-ni	[Mary-ga	sono	hon-o	nakusita-to]	iimasita-ka?
John-nom	whom-dat	[Mary-nom	that	book-acc	lost-Comp]	said-Q

'To whom did John say that Mary lost that book?'

The second major assumption made by Aoshima *et al.* concerns the parser's scope fixing, namely, the "Typing Mismatch Effect" proposed by Miyamoto and Takahashi (2003). The Typing Mismatch Effect (TME) refers to a slowdown observed in the processing of Japanese sentences with a *wh*-phrase in situ. According to Miyamoto and Takahashi, Japanese speakers expect to encounter a Q-particle in the same clause that contains the thematic position of a *wh*-phrase. Therefore, when the parser encounters a declarative complementizer on the embedded verb instead of a Q-particle, processing will be disrupted, which will then be realized in the form of a slowdown at the embedded verb.[2]

Aoshima *et al.* (2004) extended the TME to the study of sentences with scrambled *wh*-phrases. In terms of a scrambled *wh*-question, the TME is interpreted as follows: If a gap of a *wh*-filler is posited somewhere in an embedded clause, the parser will expect to encounter a Q-particle in the same embedded clause. However, the TME is only a hypothesis that is subject to further verification. No independent studies on the TME in the scrambled *wh*-context exist, and there is little investigation on the TME in the Korean context; hence, we will not take the TME as a given fact. Instead, the viability of the TME in processing Korean *wh*-constructions will be one of our queries.

Now let us move to Aoshima *et al.*'s (2004) experimental design and test sentences, and discuss how the AFS and the TD will make different predictions as to where the difficulty will arise. Their experiment employed scrambled "dative" *wh*-phrases, as in the direct question in (19) and the indirect question in (20).

(19)

Dono-seito-ni	tannin-wa	[koochuu-ga	hon-o	yonda-to]
which student-dat	teacher-top	[principal-nom	book-acc	read-DeclC]

tosyositu-de	sisyo-ni	iimasita-ka?
library-at	librarian-dat	said-Q

(20)

Dono-seito-ni	tannin-wa	[koochuu-ga	hon-o	yonda-ka]
which student-dat	teacher-top	[principal-nom	book-acc	read-Q]

tosyositu-de	sisyo-ni	iimasita.
library-at	librarian-dat	said

In addition to the scrambled sentences, Aoshima *et al.* added corresponding constructions with a dative *wh*-phrase *in-situ*, in order to secure baseline data that would confirm that the Typing Mismatch Effect is indeed observed when *wh*-phrases are placed in situ in the embedded clause. Both *in-situ* and scrambled *wh*-questions were constructed in two conditions: (a) direct questions with the Q-particle on the matrix verb and (b) indirect questions with the Q-particle on the embedded verb. This yielded four conditions as demonstrated in the sample set in Figure 1, taken from Aoshima *et al.* (2004, p. 30).

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[2] The tendency to locate a Q-particle in the same clause is allegedly a locality bias because it reflects the parser's preference for a local scope marker (Leiberman, Aoshima, & Phillips, 2006,

Sample set of experimental conditions for Experiment 1

1	2	3	4	5	6	7	8
a. Scrambled, Declarative Complementizer							
Dono-seito-ni	tannin-wa	koocyoo-ga	hon-o	yonda-to	tosyositu-de	sisyo-ni	iimasita-ka?
which student-dat	*class teacher-top*	*principal-nom*	*book-acc*	*read-DeclC*	*library-at*	*librarian-dat*	*said-Q*
b. In situ, Declarative Complementizer							
Tannin-wa	koocyoo-ga	dono-seito-ni	hon-o	yonda-to	tosyositu-de	sisyo-ni	iimasita-ka?
class teacher-top	*principal-nom*	*which student-dat*	*book-acc*	*read-DeclC*	*library-at*	*librarian-dat*	*said-Q*
'Which student did the class teacher say to the librarian at the library that the principal read a book for?'							
c. Scrambled, Question Particle							
Dono-seito-ni	tannin-wa	koocyoo-ga	hon-o	yonda-ka	tosyositu-de	sisyo-ni	iimasita.
which student-dat	*class teacher-top*	*principal-nom*	*book-acc*	*read-Q*	*library-at*	*librarian-dat*	*said*
d. In situ, Question Particle							
Tannin-wa	koocyoo-ga	dono-seito-ni	hon-o	yonda-ka	tosyositu-de	sisyo-ni	iimasita.
class teacher-top	*principal-nom*	*which student-dat*	*book-acc*	*read-Q*	*library-at*	*librarian-dat*	*said*
'The class teacher said to the librarian at the library which student the principal read a book for.'							

[Figure 1] Aoshima *et al.*'s sample set of experimental conditions (Taken from Aoshima *et al.*, 2004:30)

Note: Aoshima *et al.* used a region-by-region self-paced reading task to measure the time taken in each region of the sentences. The numbers 1–8 across the top row of the table stand for the different regions.

A close look at the scrambled sentences (a) and (b) in Figure 1 allows us to see how the prediction made by the AFS will diverge from that made by the TD. The AFS will predict a gap in the earliest available gap position, which is right after the main-clause subject *tannin-wa* (i.e., right after Region 2), because a dative NP is canonically ordered right after the subject NP and before the embedded clause. In other words, the gap for the dative *wh*-filler will be posited in the main clause. So, when the parser encounters a lexically filled main-clause dative NP (*sysyo-ni*) at Region 7, difficulty will arise, which will cause a slowdown in reading time.

On the other hand, the TD will posit a gap in a position where the thematic role of the *wh*-phrase can be assigned by the earliest possible verb, which is the embedded verb *yonda* (Region 5). In other words, the TD predicts that the filler is associated with a gap in the embedded clause. If that is the case, according to Aoshima *et al.*, Japanese speakers will expect to encounter a Q-particle on the embedded verb due to the TME. If they encounter a declarative complementizer instead of a Q-particle on the embedded verb, they will be surprised, which will lead to a slowdown in reading time.

In order to test these differing predictions, Aoshima *et al.* examined where in the sentence such slowdowns occur, by observing the time course of sentence processing. They segmented each test sentence into eight regions, as in Figure 1, and presented them region-by-region on the computer screen in a self-paced reading experiment. The participants read sentences at their own pace, proceeding from segment to segment by pressing the space bar, and the amount of time the

p. 429).

participants took to read the different regions was measured automatically.

Aoshima *et al.*'s findings can be summarized as follows:

First, in the *in-situ* conditions, there was a slowdown as the readers encountered a declarative complementizer, but the slowdown occurred in Region 6, one region later than Region 5 (which is the critical region). As slowdowns that "spill over into regions immediately downstream of a point of difficulty" (Grodner & Gibson, 2005, p. 269) are often reported in self-paced reading experiments, Aoshima *et al.* concluded that the slowdown in Region 6 was due to the surprisal effect (i.e., the TME) experienced at the previous region (Region 5).

Second, in the scrambled conditions, there was a slowdown in Region 5, at the embedded verb with a declarative particle. Again, the authors attributed the slowdown to the TME. Aoshima *et al.* interpreted these results as evidence that the Japanese readers posited a gap in the embedded clause. The authors thus concluded that filler-gap dependency is thematically driven.

So far, we have seen that the TME played a critical role in Aoshima *et al.*'s claim that dependency resolution occurs at the embedded verb. However, the TME is an effect observed at an embedded verb whose *wh*-argument is in its thematic position. No independent study has proved that the effect extends to scrambled *wh*-constructions. In other words, the slowdown at Region 5 in the scrambled conditions might be attributable to factors other than the TME. Moreover, if the TME does exist in Japanese, the same mechanism must be observed in Korean as well. Therefore, in this study, we will examine whether the TME appears in the *wh-in-situ* conditions first, and then see if the same kind of latency is observed in the scrambled-wh conditions. If a slowdown is observed in both the *in-situ* and scrambled conditions, it will serve as evidence that dependency is resolved in the embedded clause in Korean as well.

2.5 The Current Study

The present study is a near-replication of Aoshima *et al.*'s (2004) study, in the Korean context. The first question is whether Korean readers create a gap in the main clause or in the embedded clause. If a gap is found to be posited in the main clause, it will support the AFS. By contrast, if a gap is found to be posited in the embedded clause, it will support the TD. We assume, with Aoshima *et al.*, that the scope for the interpretation of a *wh*-phrase in head-final languages with scrambling such as Korean and Japanese is determined by the location of a Q-particle rather than the location of a *wh*-expression. We do not assume, however, that the Typing Mismatch Effect as proposed by Miyamoto and Takahashi (2001, 2003) or Aoshima *et al.* (2004) is at work in Korean as well. In fact, the effect has hardly been discussed in the literature on Korean *wh*-questions. If the TME occurs in Korean sentences at all, it should be found in sentences where the *wh*-phrase is in situ in the embedded clause. Only then can we test whether the effect extends to sentences with scrambled *wh*-phrases. So, the viability of the TME in Korean will constitute our second question. Our final question concerns whether the parser engages in a *wh*-feature licensing operation at the Q-marked position. As mentioned, this third question was beyond the scope of Aoshima *et al.*'s study, but we predict that the parser will slowdown at a Q-particle if a feature licensing operation occurs in real time.

3. Method

3.1 Research Questions

The three research questions are:

1. Do Korean speakers resolve a long-distance filler-gap dependency created by *wh*-scrambling in the main clause or in the embedded clause?
2. Does the Typing Mismatch Effect affect Korean speakers' processing of *wh*-questions?
3. Does the *wh*-feature checking requirement affect Korean speakers' processing of *wh*-questions?

3.2 Participants

Sixty-four native speakers of Korean participated in the experiment. All of them were undergraduate students or college graduates in their twenties. They were paid 5000 won ($5.00, approximately) for their participation in the experiment. The experiment was conducted individually in a quiet place.

3.3 Materials and Design

Twenty-four sets of test items in four conditions were constructed in Korean, using a 2*2 factorial design, following Aoshima *et al.* (2004). The first factor was whether the *wh*-phrase was *in-situ* in the embedded clause or fronted to the sentence-initial position (*in-situ* vs. scrambled). The second factor was whether the embedded clause had a declarative complementizer or a Q-particle on the embedded verb (DeclComp vs. Q-particle). The four conditions with sample sentences are presented in Figure 2 (for all test items, see Appendix). The 24 test items were interspersed with 36 filler items and presented in a random order for each trial. In order to ensure that each participant encountered an item in only one of the four conditions, four lists were constructed using a Latin-Square design.

Note that our main interest lies in Condition 1 (Scrambled/DeclComp) and Condition 3 (Scrambled/Q), where long-distance filler-gap dependencies need to be resolved. Also note that the critical regions are Region 5 through Region 8, where the AFS and the TD make different predictions about the regions where surprisal effects and accompanying slowdowns in reading time will occur, as summarized in Table 1.

While some of the test items were a near-translation of Aoshima *et al.*'s original test items, we made some major changes in constructing the Korean experimental items. First, the original dative *wh*-phrases in Aoshima *et al.*'s Japanese experiment were composed of *which* + N + Datative (e.g., *dono seito-ni* 'to which student'). However, we found that the meaning of the Korean equivalents of *dono* (e.g., *etten* or *enu*) is ambiguous between 'which' and 'a certain'. On the other hand, the one word *wh*-pronoun *nuwkuw* 'who' is strongly biased toward a *wh*-interpretation. To ensure that *nuwkuw* has a stronger tendency toward a *wh*-interpretation than *etten*

	Region							
Conditions	1	2	3	4	5	6	7	8
1 Scrambled/ DeclComp	nuwkwu-eykey *who-dat*	tamim-un *teacher-top*	[kyocang-i *principal-nom*	chayk-ul *book-acc*	ilkecuwess-tako] *read-DeclC*	ecey *yesterday*	sase-eykey *librarian-dat*	malhayss-ni? *said-Q*
2 In-situ/ DeclComp	tamim-un *teacher-top*	[kyocang-i *principal-nom*	nuwkwu-eykey *who-dat*	chayk-ul *book-acc*	ilkecuwess-tako] *read-DeclC*	ecey *yesterday*	sase-eykey *librarian-dat*	malhayss-ni? *said-Q*
3 Scrambled/ Q-particle	nuwkwu-eykey *who-dat*	tamim-un *teacher-top*	[kyocang-i *principal-nom*	chayk-ul *book-acc*	ilkecuwess-nunci] *read-Q*	ecey *yesterday*	sase-eykey *librarian-dat*	malhayss-ta *said-Decl*
4 In-situ/ Q-particle	tamim-un *teacher-top*	[kyocang-i *principal-nom*	nuwkwu-eykey *who-dat*	chayk-ul *book-acc*	ilkecuwess-nunci] *read-Q*	ecey *yesterday*	sase-eykey *librarian-dat*	malhayss-ta. *said-Decl*

[Figure 2] Sample set of experimental conditions

Conditions	□	Regions			
		5	6	7	8
Scrambled/	AFS	-	-	slowdown	(spillover)
DeclComp	TD	slowdown (TME)	(spillover)	no slowdown	-
Scrambled/	AFS	-	-	-	-
Q-particle	TD	-	-	-	-

[Table 1] Differing predictions about slowdown in the scrambled conditions: The AFS vs. the TD

+ N, we conducted a pilot study using a sentence completion task. In the task, we asked 40 adult native Korean speakers in their twenties (all university students) to complete sentences beginning with *nuwkuw-eykey* 'to whom' or *etten saram-eykey* 'to which person'. While the sentence in the *nuwkuw-eykey* condition elicited interrogatives 85% of the time, the sentence in the *etten saram-eykey* condition elicited interrogatives only 20% of the time. Therefore, while both *etten* + N and *nuwkuw* are ambiguous between a *wh*-interpretation and an indefinite/existential interpretation, we can safely say that *nuwkuw* is strongly biased toward a *wh*-interpretation, and is thus far more likely to prompt an active search for a gap. Another benefit of using *nuwkuw* instead of *etten* N-*eykey* is that replacing the full NP (*etten* N) with a pronoun (*nuwkuw*) will reduce any processing burden due to handling too many lexical nouns.

Another major change we made was to remove locative NPs (Region 6 in Figure 1) such as *toseokwan-eyse* 'library-at', and replace them with highly frequent time adverbials such as *ecey* 'yesterday' or *akka* 'a while ago'. Note that the test items used in Aoshima *et al.* were all loaded with as many as six full NPs. We found that these sentences sounded hardly processible when translated into Korean. More importantly, storing multiple NP arguments in memory while processing a sentence can be expected to create a heavy load on working memory (Caplan & Waters, 1999, 2001), preventing the parser from engaging in normal sentence processing. In order to avoid these potential problems, we reduced the total number of full NP arguments from six to four (i) by replacing the first dative phrase (*etten* N-*eykey*) with a simpler expression *nuwkuw-eykey*, and (ii) by replacing the locative NP with a highly frequent time adverb with a low semantic weight (e.g., *ecey* 'yesterday').[3]

3.4 Procedure

The experiment was conducted on Windows 7 running E-Prime software. Sentences were presented on the computer screen, in a region-by-region self-paced non-cumulative reading mode (Just, Carpenter, & Woolley, 1982). Stimulus regions initially appeared as dashes. The participants were asked to press the space bar to have the first region appear, and then to proceed to the next region of the sentence. The E-prime software automatically measured the time taken at each region.

In addition to the self-paced reading task, we administered a comprehension task to ensure that the participants were attending to the meaning of the sentences. After each self-paced reading trial, the participants were presented a subject-matching question similar to those used by Aoshima *et al.* (2004, p. 30), where the participants were asked to match a main or embedded verb with its matching subject.

3.5 Data Analysis

The reading times at individual regions were recorded. The reading times were then entered into a repeated measures ANOVA, with two main factors (i.e., the word order and the complement type). Before the main analysis, the data were trimmed following the criteria used by Aoshima *et al.* (2004). First, individuals whose accuracy in the subject-matching task was below 70% in the test items and below 80% in total were excluded from the analysis. Thirty-eight participants' data remained for the analysis. Among the remaining data, items with accuracy below 65% were excluded (N = 4). In addition, reading times beyond 2.5 standard deviations in each region were also discarded. The reading times of the remaining data were compared region-by-region, across the four conditions.

[3] The final modification we made concerns the verbs used in the original test items in Aoshima *et al.*'s experiment. We found that many of the embedded verbs in their test items, if translated directly into Korean, require a benefactive verbal affix *-cuw* as in *haksayng-eykey chaik-ul ilke-cuw-essta* 'read a book to the student', which might bias the parser to posit a gap upon encountering the dative (ditransitive) verb. To avoid this unintended clue for dependency resolution, we selected monotransitives that do not require an extra benefactive verbal affix and used them as the embedded verbs for half of the experimental items (12 items). The other half of the items (12 items) were constructed using verbs that require *-cuw*, for comparison's sake. However, the analysis did not yield a significant difference between them, and we will not discuss it in detail.

4. Results

4.1 Comprehension Task

After the data trimming, the mean accuracy of the remaining 38 participants for the test items was 86.2%. The difference between the scrambled conditions and the *in-situ* conditions was marginally significant (84.2% in the scrambled conditions and 88.2% in the declarative conditions), with a marginally significant main effect of word order (F = 3.103, p = .086).

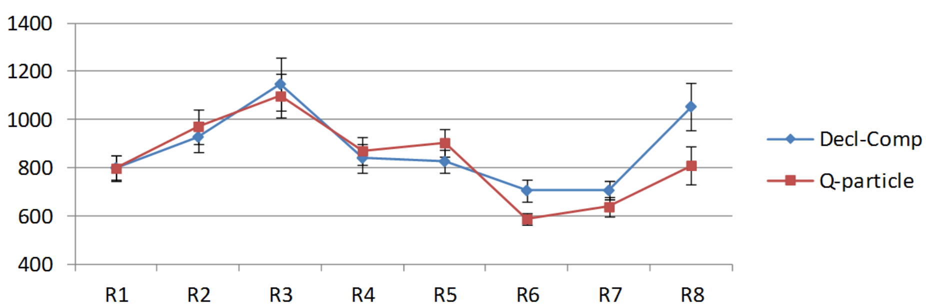
4.2 Self-paced Reading

The analyses of reading times for each region in the four conditions yielded the following results.

Conditions	□	R1	R2	R3	R4	R5	R6	R7	R8
Scrambled/ DeclComp	Mean	664.02	832.45	1370.04	970.50	830.70	612.33	667.60	946.84
	(SD)	(239.80)	(355.49)	(579.39)	(342.68)	(349.36)	(196.96)	(249.38)	(588.63)
Scrambled/Q	Mean	748.97	864.02	1226.06	986.20	982.97	647.62	644.43	848.35
	(SD)	(330.76)	(378.61)	(658.79)	(378.02)	(420.34)	(177.80)	(214.07)	(413.68)
InSitu/DeclC	Mean	799.38	927.63	1146.86	840.51	826.13	705.18	705.61	1053.59
	(SD)	(305.35)	(389.03)	(684.80)	(368.26)	(295.97)	(275.12)	(231.03)	(617.54)
InSitu/Q	Mean	797.58	971.65	1097.70	870.22	903.88	587.89	638.11	809.79
	(SD)	(312.28)	(439.27)	(557.95)	(364.28)	(362.44)	(146.63)	(243.27)	(482.13)

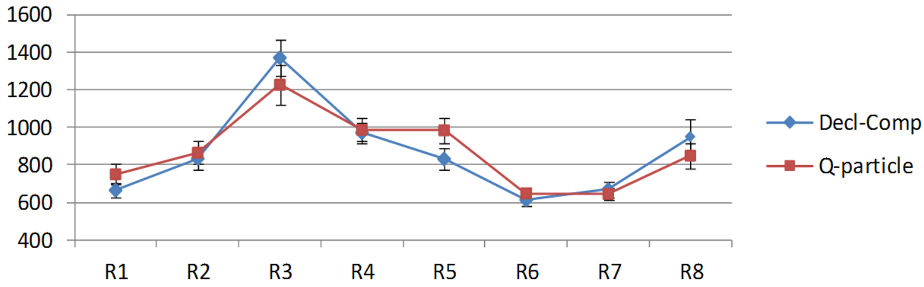
[Table 2] Reading times per region (ms)

Like Aoshima *et al.* (2004), we present the reading times for the *in-situ* conditions and those for the scrambled conditions separately, in Figure 3 and Figure 4, as the lexical contents differed between the *in-situ* conditions and the scrambled conditions up to Region 3.



[Figure 3] Reading times per region for the *in-situ* conditions

From Region 1 to Region 4, word order was found to affect the reading time, unlike in Aoshima *et al.*'s (2004) study, where no significant differences were found in the declarative complementizer and question particle conditions. The main effect



[Figure 4] Reading times per region for the scrambled conditions

of word order at Region 1 was significant in the subject analysis ($F1(1, 37) = 13.310$, $p = .001$) and marginally significant in the item analysis ($F2(1, 19) = 3.304$, $p = .085$). At Region 2, the main effect of word order was significant in the subject analysis ($F1(1, 37) = 7.476$, $p = .010$), but not in the item analysis ($F2(1, 19) = 2.500$, $p = .130$). The main effect of word order was significant in Region 3 in the subject analysis ($F1(1, 37) = 7.008$, $p = .012$) as well as in the item analysis ($F2(1, 19) = 5.425$, $p = .031$). At Region 4, where the participants encountered the embedded object in all four conditions, there was a significant main effect of word order ($F1(1, 37) = 5.167$, $p < .05$; $F2(1, 19) = 7.876$, $p = .011$), presumably due to the spillover effect of the diverging word order in the previous regions. The main effect of complementizer type was not significant in any of the first four regions, as the complementizer did not appear until Region 5.

Our main concern, however, lies in the regions that follow (Regions 5–8), where the lexical content of the materials is the same across the four conditions. At Region 5 (the embedded verb region), there was a slowdown in reading time in the Q-particle conditions in both the *in-situ* and scrambled conditions. There was a significant main effect of complementizer type in both the subject analysis and the item analysis ($F1(1, 37) = 5.879$, $p = .020$; $F2(1, 19) = 6.531$, $p = .019$). On the other hand, the main effect of word order was not significant ($F1(1, 37) = .994$, $p = .325$; $F2(1, 19) = .878$, $p = .361$), and there was no significant interaction between word order and complementizer type ($F1(1, 37) = 1.153$, $p = .290$; $F2(1, 19) = .156\ 1$, $p = .698$). The lack of a complementizer type effect in our study would be unexpected from Aoshima *et al.*'s (2004) point of view. Recall that in Aoshima *et al.*'s study, Region 5 is where the Typing Mismatch Effect occurs in the form of a slowdown in reading time in the DeclComp conditions. The researchers attributed this slowdown in the DeclComp condition to the unexpected encounter with a declarative affix on the embedded verb. However, no such effect was found either in the *in-situ* *wh*-conditions or in the scrambled *wh*-conditions in our experiment. What we found instead was a significantly slower reading time at embedded verbs with a Q-particle. Given that the position of the Q-particle is where the *wh*-feature is checked in Korean, the *wh*-licensing operation seems to be responsible for the slowdown.

The Typing Mismatch Effect seemed to appear at Region 6, one region after the critical region (Region 5). However, the TME as measured by a slowdown in reading time was observed only in the In-Situ/DeclComp condition. While there was no significant main effect of word order (*F1*(1, 37) = .516, p = .477; *F2*(1, 19) = .226, p = .640) or complementizer type (*F1*(1, 37) = 2.687, p = .110; *F2*(1, 19) = 2.393, p = .138), the interaction between word order and complementizer type was significant in the subject analysis (*F1*(1, 37) = 10.248, p = .003), and marginally significant in the item analysis (*F2*(1, 19) = 3.731, p = .068). Pairwise comparisons revealed that the difference between the DeclComp and the Q-particle conditions was significant only within the *in-situ* conditions (*F1*(1,37) = 8.025, p = .007; *F2*(1, 19) = 4.967, p = .038), suggesting that the TME is a local effect that works when the *wh*-phrase is within its clausal boundary.

Region 7 is where the dative NP of the matrix sentence is encountered. According to the AFS, Region 7 should be read significantly more slowly in the DeclComp conditions than in the Q-particle conditions within the scrambled conditions, because the parser would have already posited a gap for the matrix dative NP at Region 3 and would be surprised by finding a lexically realized matrix dative NP at Region 7. However, there was no slowdown in reading time in the DeclComp condition. The main effect of word order was not significant (*F1*(1, 37) = .665, p = .424; *F2*(1, 19) = .729, p = .404). The main effect of complementizer type was marginally significant in the subject analysis but not significant in the item analysis (*F1*(1, 37) = 4.015, p = .052; *F2*(1, 19) = 1.716, p = .206). The interaction between word order and complementizer type was not significant (*F1*(1, 37) = 1.003, p = .323; *F2*(1, 19) = .003, p = .957). The lack of surprisal effect in the Scrambled/DeclComp conditions provides weak support for the TD, which predicts that the gap will be posited around the embedded verb (Region 5) but not at the matrix dative NP (Region 7).

The final region, Region 8, is where the matrix sentence type is determined by the presence/absence of the Q-particle -*ni*. The matrix verbs with a Q-particle were read more slowly than those with a declarative complementizer. There was a significant main effect of complementizer type (*F1*(1, 37) = 9.350, p = .004; *F2*(1, 19) = 5.727, p = .027). The main effect of word order was not significant (*F1*(1, 37) = .344, p = .561; *F2*(1, 19) = .003, p = .955). The interaction between the two factors was not significant (*F1*(1, 37) = 1.304, p = .261; *F2*(1, 19) = .290, p = .596). The slowdown at the sentence-final Q-particle again indicates that the *wh*-feature licensing by the Q-particle required an extra processing cost of the readers. Recall that there was a slowdown in reading time at Region 5 in the Q-particle conditions. The slowdown at the verbs with a Q-particle was consistently observed, regardless of whether the *wh*-phrase was moved to the sentence-initial position or stayed in situ, or whether the Q-particle was marked on the embedded verb or on the main verb. This pattern strongly suggests that *wh*-feature licensing at the Q-particle is psychologically real.

5. Discussion

Our findings do not exactly replicate Aoshima *et al.*'s (2004) results. First, while Aoshima *et al.* observed a slowdown around the embedded verb with a declarative complementizer, both in the *in-situ* and scrambled conditions, we observed a similar kind of slowdown only in the *in-situ* conditions with a declarative complementizer. Our finding confirms the findings of the original study of Miyamoto and Takahashi (2001, 2003), given that this slowdown is the effect of the TME.

As for Aoshima *et al.*'s alleged TME in the scrambled conditions, we did not find a similar effect in the declarative complementizer condition, suggesting that the TME might be a local effect restricted to *in-situ wh*-phrases. What we found instead was a slowdown at the embedded verb region in the Q-particle condition. Given that the slowdown at the embedded verb with a declarative complementizer is Aoshima *et al.*'s diagnostic for the embedded clause dependency resolution, our data do not provide support for the TD approach. It is not within our scope to identify the source of the slowdown observed in Aoshima *et al.*'s study. But unless there is some independent evidence that the TME is an effect that goes beyond the clausal boundary, and that the filled gap plays the same role as a *wh*-phrase in situ in causing the TME, Aoshima *et al.*'s alleged TME in the scrambled condition seems to be no more than one potential source of the slowdown.

On the other hand, the lack of a surprisal effect at the matrix dative NP region (Region 7) in the DeclComp conditions fails to support the AFS. Conversely, the same lack of surprisal effect at this region is in accordance with the prediction by the TD, and thus constitutes evidence for the TD. In sum, while our data do not confirm the TME at the embedded verb when the *wh*-phrase is scrambled, the lack of slowdown at the matrix time adverbial constitutes counterevidence to the AFS, while lending weak support to the TD.

Our one clear finding, which has not been reported elsewhere in the literature, is that there was a significant slowdown in reading time at the verbs with a Q-particle, in both the *in-situ* conditions and the scrambled conditions, whether the Q-particle was on the main verb or the embedded verb. Unlike in head-initial languages, *wh*-scrambling in a head-final language involves three places in a sentence: (i) the position of the moved *wh*-phrase, (ii) the thematic position of the *wh*-phrase, and (iii) the position of the verb with a Q-marker, where the scope is fixed and the *wh*-feature is licensed. In the studies on head-initial languages, only two positions matter — (i) the surface position of the *wh*-phrase and (ii) its gap (i.e., its thematic position) — because the surface *wh*-position is where *wh*-feature checking occurs. Because the surface *wh*-position is where the feature-checking occurs, it is not possible to observe the time course of *wh*-feature licensing in head-initial languages. In our study, the *wh*-feature fixing process and its location are demonstrated in terms of a slowdown in reading time at the Q-particle.

6. Conclusion

Our experiment, as a partial replication of Aoshima *et al.*'s (2004), was an attempt to explore the processing of dependency resolution in the Korean context. As another head-final language, Korean shares many syntactic properties with Japanese. However, our findings from Korean processing data do not replicate those from Japanese processing obtained by Aoshima *et al.* We did not find consistent evidence of the TME, on which Aoshima and colleagues heavily relied to support the TD.

On the other hand, we did not find evidence for the AFS either, because we found no surprisal effect at the main clause dative NP (Region 7). This suggests that the Korean participants did not posit a gap for the dative *wh*-NP earlier in the sentence, before they encountered the embedded subject. The lack of surprisal effect around Region 7, in turn, provides partial support for the TD.

Our clearest finding is that there is a consistent slowdown at the verb with a Q-particle. The slowdown at the verb in the Q-particle conditions reveals the psychological reality of *wh*-feature licensing, which has remained a theoretical construct in theoretical linguistics (Chung, 1996; Ko, 2006; Saito, 1985; Watanabe, 1992). Our inquiry into *wh*-feature checking has been limited to dative *wh*-constructions. Future research on the *wh*-feature licensing operation with other types of *in-situ* and scrambled *wh*-arguments should be conducted to further confirm its psychological reality.

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Appendix: Test Items (List 1)

1. 담임은 교장이 누구에게 영어책을 읽어주었다고 사서에게 말했니?
2. 코치는 중년여인이 누구에게 초상화를 그려주었는지 감독에게 말했다.
3. 누구에게 사회자는 뮤지션이 노래를 불러주었다고 청중에게 설명했니?
4. 누구에게 이모는 엄마가 케익을 구워주었는지 가정부에게 알려주었다.
5. 부장은 사장이 누구에게 새 차를 사주었다고 상무에게 알렸니?
6. 간호사는 목사가 누구에게 찬송을 불러주었는지 의사에게 보고했다.
7. 누구에게 할머니는 할아버지가 아파트를 사주었다고 아버지에게 알려주었니?
8. 누구에게 지휘자는 작곡가가 오페라를 작곡해주었는지 가수에게 얘기했다.
9. 할아버지는 삼촌이 누구에게 물고기를 잡아주었다고 할머니에게 알려주었니?
10. 원장은 보조교사가 누구에게 종이접기를 해주었는지 부모에게 말했다.

11. 누구에게 감독은 탤런트가 기타를 연주해주었다고 기자에게 설명했니?
12. 누구에게 점장은 요리사가 샐러드를 만들어주었는지 웨이터에게 알려주었다.
13. 담당자는 지원자가 누구에게 합격했다는 소식을 알렸다고 학장에게 말했니?
14. 기자는 물리학자가 누구에게 신이론을 설명했는지 동료에게 일러주었다.
15. 누구에게 대통령은 장관이 회의결과를 발표했다고 비서에게 알려주었니?
16. 누구에게 정부관계자는 외교관이 비밀을 누설했는지 측근에게 말했다.
17. 과사무원은 채점자가 누구에게 시험결과를 통보했다고 교수에게 말했니?
18. 박물관장은 조각가가 누구에게 작업실을 공개했는지 큐레이터에게 말했다.
19. 누구에게 비서는 홍보팀장이 신상품을 소개했다고 사장에게 보고했니?
20. 누구에게 팀장은 전화 상담원이 사용법을 안내했는지 부사장에게 말했다.
21. 경찰은 김밥할머니가 누구에게 1억원을 기부했다고 기자에게 알려주었니?
22. 경비원은 택배원이 누구에게 화환을 배달했는지 집주인에게 말했다.
23. 누구에게 아버지는 할아버지가 일생을 헌신했다고 아이들에게 말했니?
24. 누구에게 보조작가는 담당피디가 대본을 배부했는지 매니저에게 말했다.

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