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Active Filler Effects and Reanalysis: A Study of Japanese *Wh*-scrambling Constructions

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Abstract

This paper presents evidence for the Active Filler Effect (Frazier & Clifton 1989) in Japanese. The experimental results show that Japanese speakers preferentially associate a fronted *wh*-phrase with the first potential scope marker, even when that is contained in an embedded clause. This finding allows us to propose two refinements to the Active Filler Strategy's operation for all languages. We suggest that (i) the Active Filler Strategy results from the parser's rapid attempt to associate an operator with a θ-marked variable position, and that (ii) the parser is able to rescind existing commitments in order to satisfy other constraints. Results from a self-paced reading experiment indicate that a fronted *wh*-phrase is associated with the embedded verb, an association which we argue suggests reanalysis from an initial matrix clause association.

Introduction

The main objective of this paper is to examine the cross-linguistic operation of the Active Filler Strategy first proposed for English by Frazier and Clifton (1989). Many studies have argued that the processing of *wh*-phrases initiates a search for a gap, which is posited at the earliest point allowed by the grammar. This tendency has become known as "The Active Filler Strategy" (henceforth the AFS). Since the AFS is a descriptive statement, we should try to uncover the underlying factors responsible for this generalization. We suggest that *wh*-scope licensing and argument saturation are crucial to an understanding of apparent cross-linguistic variation in Active Filler effects. Based on our experimental results, we find that Japanese readers prefer to associate a fronted *wh*-phrase with an embedded clause. We propose that the reason for the interpretation of the *wh*-phrase in the embedded clause is that active gap filling is driven by other grammatical requirements, specifically *wh*-scope licensing and argument saturation. This, in turn, has implications for theories of reanalysis. In order to associate the *wh*-filler with an embedded clause gap-site, readers must revise their initial matrix question interpretation of the sentence. This forces us to revise claims that reanalysis is always a last-resort operation. We re-interpret the availability of unforced reanalysis in terms of grammatical constraints as well.

Section 1 introduces the main theoretical questions of the paper: whether or not the operation of Active Filler effects is independent of other grammatical requirements, and whether or not unforced reanalysis can take place. Section 2 illustrates Japanese *wh*-scrambling constructions, which are used in the experiment. Section 3 presents the experiment, its results and brief discussion based on the results. Section 4 provides answers to the questions given in Section 1. Section 5 offers concluding remarks.

1 Theoretical questions

An extensive literature on English and other similar languages has claimed that the processing of fronted *wh*-phrases initiates a search for a gap, which is created at the earliest point allowed by the grammar. Fraizer and Clifton (1989: 95) define this hypothesis as follows.

(1) Active Filler Hypothesis
When a filler has been identified, rank the option of assigning it to a gap above all other options.

Several experimental studies provide support for this generalization. For instance, Stowe (1986) observed a Filled-Gap Effect at the direct object position of the embedded verb in (2b), reflected in a slower reading times for the pronoun *us* in the *wh*-extraction condition (2b), relative to a control condition which does not involve *wh*-extraction (2a).[1]

(2) a. My brother wanted to know **if** Ruth will bring **us** home to Mom at Christmas.
b. My brother wanted to know **who** Ruth will bring **us** home to __ at Christmas.

The standard formulation of the AFS presents it as an independent property of the parser, which requires a gap to be posited as soon as possible.[2] An

[1] Additional related findings have been reported in the literature. Tanenhaus et al. (1989) found that the Filled Gap Effect disappeared for preferred-intransitive verbs. Frazier and Clifton (1989) used priming tasks to show facilitation of lexical decisions to words related to a filler at the gap position. Frazier and Flores d'Arcais (1989) showed that Dutch sentences in which a filler proves to be assigned to the first available gap position are read faster than sentences in which the filler is assigned to the second gap position.

[2] The Active Filler Hypothesis has recently been developed in several different ways. For instance, de Vincenzi (1991) proposes that Active Filler effects are a special case of the operation of the Minimal Chain Principle, which avoids postulation of unnecessary chain members at S-structure. Just and Carpenter (1992) and Gibson (1998) explain the processing of *wh*-phrases exclusively in

alternative possibility is that Active Filler effects are consequences of independently motivated grammatical constraints, such as argument-structure saturation and *wh*-scope licensing. Studies based on English-type languages do not easily allow these alternatives to be distinguished, due to the head-initial word order of these languages. In these languages, the first possible gap position is also the first possible position where a thematic role can be assigned (3a). Furthermore, the search for *wh*-scope positions is irrelevant, since in these languages *wh*-scope is typically associated with the surface position of the *wh*-phrase.

(3) a. Verb-initial configuration:
[$_{CP}$ Wh [$_{IP}$ NP-subj [$_{VP}$ V <gap> …]]]
b. Verb-final configuration:
[$_{CP}$ Wh [$_{IP}$ NP-subj [$_{VP}$ <gap> … [$_{CP}$ [$_{IP}$ NP-subj [$_{VP}$ <gap> … V]]] V]]]

A head-final language such as Japanese provides a useful testing ground for alternative interpretations of Active Filler effects. Consider (3b). Once the *wh*-phrase is identified, according to the Active Filler Hypothesis, a search for a gap is initiated, and the gap position should be created as soon as possible. Given the assumption that a head-final language parser incrementally builds a connected tree (Fodor & Inoue 1995), the parser builds a verb phrase tree immediately after it identifies the subject NP. At this point, the parser could potentially posit a gap position in the verb phrase. If Active Filler effects are the result of an independent requirement to create gap sites as early as possible, the parser would select this verb phrase as the site of the gap, even though the head of the verb phrase has not been processed yet at this point. On the other hand, if Active Filler effects are due to the need to satisfy argument structure requirements as early as possible, its effects may unfold differently in Japanese. A gap site may be posited as soon as the matrix VP is created, but this will not allow thematic role assignment until the main verb is encountered. If, however, the parser encounters an embedded clause subject, then it will also construct an embedded VP structure, and the first opportunity to satisfy the thematic requirements of the *wh*-phrase will occur at the embedded clause verb. If, however, Active Filler effects are not sensitive to argument structure saturation, the parser would not consider this embedded clause gap position, since an earlier potential gap site will already have been created in the matrix clause.

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terms of working-memory resources. The relevance to our results of these elaborations of the AFS is discussed further in Section 4.1 below.

To sum up, our question is whether Active Filler effects are due to an independent parsing constraint, specifically designed for fronted phrases, or whether they result from independently motivated grammatical requirements such as thematic role assignment and *wh*-scope licensing. Head-initial languages such as English do not allow these alternatives to be distinguished, since the position of the first verb and the first gap coincide. In contrast, by using head-final languages such as Japanese, the question can be addressed. Due to head-final word order, the parser does not encounter verbs before possible gap positions. In multi-clause sentences, the first gap and the gap associated with the first verb are two quite different positions.

If Active Filler effects result from the need to satisfy grammatical constraints as early as possible, the parser must cancel existing structural commitments in order to satisfy those constraints. In other words, reanalysis takes place. If so, we should consider how the parser can abandon its first commitment and why unforced reanalysis is preferred in a particular structure. In addition, we must explain the apparent availability of reanalysis, as opposed to previous studies and findings which show that reanalysis is avoided if at all possible (Kamide & Mitchell 1999, Sturt, Pickering, Scheepers & Crocker 2001, and Schneider & Phillips, 2001).

This paper argues that Active Filler effects are driven by argument saturation and *wh*-scope licensing requirements, based upon experimental evidence from Japanese *wh*-scrambling constructions. It will be shown that Japanese readers create a gap position in an embedded clause, and preferentially associate a fronted *wh*-phrase with an argument position of the embedded clause, as predicted by the account that treats Active Filler effects as epiphenomena of other grammatical requirements. Furthermore, the results show that unforced reanalysis must be allowed and we give an account of these facts that unifies the range of cases. This will indicate that reanalysis can take place to satisfy requirements such as argument saturation and *wh*-scope licensing.

2 *Wh*-scrambling constructions in Japanese

This section discusses Japanese *wh*-scrambling in constructions like (3b), repeated as (4). These constructions form the basis of our study of Active Filler effects in Japanese.

(4) $[_{CP}$ Wh $[_{IP}$ NP-subj $[_{VP}$ $[_{CP}$ $[_{IP}$ NP-subj $[_{VP}$ … t_{wh} … V]]] V]]]

Japanese *wh*-interrogatives do not require the *wh*-phrase to be fronted to a clause-initial scope position, unlike their English counterparts. Instead, *wh*-scope needs to be indicated by a scope marker such as the question particles (Q-particle), *ka* (embedded or matrix clauses[3]) and *no* (matrix clauses). These particles appear as verbal suffixes, and they are considered to be complementizers. Given this requirement, (5a) is grammatical whereas (5b) is ungrammatical. The former licenses the *wh*-scope relation between the *wh*-phrase, *dare-ni* and the scope marker, *no*, while the latter does not, due to the lack of a question particle as a scope marker.[4]

(5) a. Mary-wa dare-ni sono hon-o ageta-no?
Mary-top whom-dat that book-acc gave-QP
'Who did Mary give that book to?'
b. *Mary-wa dare-ni sono hon-o ageta.
Mary-top whom-dat that book-acc gave
(Lit.) 'Who did Mary give that book to?'

When a *wh*-interrogative structure such as (5a) is embedded into another clause, two types of questions can be derived. (6a) is interpreted as an indirect question, where the *wh*-dependency is local in that the *wh*-phrase and its scope marker are in the same clause. (6b) is a direct question, where the *wh*-dependency is not local in that the *wh*-phrase is in the embedded clause and its scope marker is in the matrix clause.

(6) a. John-wa [Mary-ga dare-ni sono hon-o ageta-ka] itta.
John-top Mary-nom whom-dat that book-acc gave-QP said
'John said who Mary gave that book to.'
b. 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-QP
'Who did John say Mary gave that book to?'

Japanese allows *wh*-phrases to be either in their base argument positions (i.e. *wh*-in-situ), or in fronted positions (i.e. *wh*-scrambled). For instance, (7b) is a *wh*-scrambling example, in which the *wh*-in-situ phrase in (7a) is fronted from the embedded clause to the matrix clause.

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[3] The Q-particle, - *ka* naturally appears in matrix clauses when the matrix verb is expressed with a morpheme indicating politeness. The acceptability of verbs without a politeness morpheme differs across speakers and styles of speech. For instance,

(i) John-wa Mary-ga naita to itta-$^{??}$ka / ii-masita-ka.
John-top Mary-nom cried that said-QP / said-polite-QP
'Did John say that Mary cried?'

[4] Note that (5b) becomes acceptable if there is a rising intonation at the end of sentence. This prosody-based method of question formation can be observed in particular in colloquial speech.

(7) a. John-wa [Mary-ga dare-ni sono hon-o ageta-ka] itta.
John-top Mary-nom whom-dat that book-acc gave-QP said
'John said to whom Mary gave that book.'

b. Dare-ni John-wa [Mary-ga $t_{\text{dare-ni}}$ sono hon-o ageta-ka]
whom-dat John-top Mary-nom that book-acc gave-QP
itta.
said
'John said to whom Mary gave that book.'

This type of *wh*-scrambling construction is the same as *wh*-interrogatives in English with respect to the fronting of a *wh*-phrase. However, it is crucially different from those in English in that verbs appear in the final position of their clause, and also because the surface position of the fronted *wh*-phrase in Japanese does not determine the scope of the question.

3 Experiment

3.1 Diagnostics of Active Gap Filling

Miyamoto and Takahashi (2000, 2001) propose that the processing of in-situ *wh*-phrases in Japanese is similar to the processing of fronted *wh*-phrases in English. They show that readers expect a question particle to occur in the first available position (8a), marking the scope of the *wh*-phase. This expectation is demonstrated by a slowdown that is observed when that expectation is violated, as in (8b), in which the position is occupied by a declarative complementizer (DeclC), relative to reading times for a verb marked with a Q-particle. They call this the Typing Mismatch Effect (henceforth, the TME).

(8) a. … [… **wh** … Verb-**QP**] … Verb.
b. … [… **wh** … Verb-<u>**DeclC**</u>] … Verb-QP.
Slowdown: Typing Mismatch Effect

In our experiment, we use the TME as a diagnostic of active gap filling in sentences in which *wh*-phrases are scrambled to sentence-initial position. Then, there are two possible predictions. First, consider (9) and (10). If the gap position is created immediately after the first subject (NP-subj), and stays there, then the gap position is related to the highest verb, i.e. the matrix verb. Readers will then expect the entire sentence to be a direct question, since the scope position of a *wh*-phrase must always be higher than its thematic position. If this is the case, then a slowdown should be observed at the embedded verb position that has a Q-particle in (10a), relative to the embedded verb with a declarative complementizer in (10b). This is so because, under this scenario, readers keep the *wh*-phrase in the top clause and wait for the scope marker to come with the matrix verb. They should be surprised to see the Q-particle as a scope marker in the embedded position in the case of (10a).

(9) **Wh** [NP-subj [$_{\text{VP}}$ **<gap>** [$_{\text{CP}}$ NP-subj … Verb] … V-**QP**]]]
(10) a. **Wh** … [… Verb-**QP**] … Verb.
Slowdown: Typing Mismatch Effect
b. **Wh** … [… Verb-**DeclC**] … Verb-QP.

The alternative prediction is illustrated in (11) and (12). If gap creation is driven by the requirements of argument saturation and *wh*-scope licensing, the gap must be posited in the embedded clause in which readers will see the first verb, This also means, as shown in (11), that the parser must cancel the first gap position created, in order to create a gap position in the embedded clause where the first verb occurs. The results would then be opposite to those just discussed. The condition that has a declarative complementizer in the embedded clause (12b) should show the TME (slowdown) in that position, relative to an embedded verb in the same position marked with a Q-particle (12a). This is because the gap is inside the embedded clause, so that the readers expect a Q-particle to be affixed to the embedded verb. When they see a declarative complementizer, they will be surprised.

(11) **Wh** [NP-subj [$_{\text{VP}}$ ~~**<gap>**~~ [$_{\text{CP}}$ NP-subj **<gap>** …Verb-**QP**] …Verb]]
(12) a. **Wh** … [… Verb-**QP**] … Verb.
b. **Wh** … [… Verb-**DeclC**] … Verb-QP.
Slowdown: Typing Mismatch Effect

Furthermore, if the second prediction is correct, we also predict that there should be a significant parallelism between the *wh*-insitu and the *wh*-scrambled structures in terms of the difference in reading time patterns at the embedded verb. In both structures, readers will take a longer time to read the embedded verbs affixed by a declarative complementizer than to read those affixed by a Q-particle.

3.2 Method

3.2.1 Participants Seventy-three native speakers of Japanese participated in the experiment. All of them were students either at the University of Maryland, Shizuoka University or Shizuoka Sangyo University. They were paid $5.00 for their participation in the experiment, which lasted about 30 minutes.

3.2.2 Materials and design Twenty-four sets of sentences with four conditions each were constructed. (13) shows one set of conditions used in the experiment. Conditions were organized in a 2 X 2 factorial design, manipulating the position of the *wh*-phrase (in-situ vs. scrambled) and the distribution of complementizer particles (Q-particle vs. Declarative complementizer on embedded verb). The twenty four sets of items were distributed in a Latin Square design, creating four lists. Each subject saw exactly one of the lists intermixed with forty-eight unrelated items in a random order.

(13) a. Wh-Scrambled & Declarative Complementizer:
Wh-dat / NP-top / NP-nom / NP-acc / V-DeclC / Adverb / NP-dat / V-QP
Dono-seito-ni tannin-wa koocyoo-ga hon-o
which student-dat class teacher-top principal-nom book-acc
yonda-to tosyositu-de sisyo-ni iimasita-ka?
read-DeclC library-at librarian-dat told-QP
'Which student did the class teacher tell the librarian at the library that the principal read a book for?'

b. Wh-Insitu & Declarative Complementizer:
NP-top / NP-nom / Wh-dat / NP-acc / V-DeclC / Adverb / NP-dat / V-QP
Tannin-wa koocyoo-ga dono-seito-ni hon-o
class teacher-top principal-nom which student-dat book-acc
yonda-to tosyositu-de sisyo-ni iimasita-ka?
read-DeclC library-at librarian-dat told-QP
'Which student did the class teacher tell the librarian at the library that the principal read a book for?'

c. Wh-Scrambled & Question Particle:
Wh-dat / NP-top / NP-nom / NP-acc / V-QP / Adverb / NP-dat / V
Dono-seito-ni tannin-wa koocyoo-ga hon-o
which student-dat class teacher-top principal-nom book-acc
yonda-ka tosyositu-de sisyo-ni iimasita
read-QP library-at librarian-dat told
'The class teacher told the librarian at the library which student the principal read a book for.'

d. Wh-Insitu & Question Particle:
NP-top / NP-nom / Wh-dat / NP-acc / V-QP / Adverb / NP-dat / V
Tannin-wa koocyoo-ga dono-seito-ni hon-o
class teacher-top principal-nom which student-dat book-acc
yonda-ka tosyositu-de sisyo-ni iimasita.
read-QP library-at librarian-dat told

'The class teacher told the librarian at the library which student the principal read a book for.'

We will now explain the derivation of the sentences. (14) illustrates schematically the canonical unscrambled word order for all conditions. The matrix verb is a type of report verb that takes both a dative object and a clausal complement.[5] The Q-particle *ka*, which takes the role of scope marker, is suffixed either to the matrix verb or to the embedded verb.

(14) NP-top adverb NP-dat [NP-nom Wh-dat NP-acc verb-DeclC/QP] verb-QP/.

From (14), the sentential complement is scrambled to the post-subject position (15), deriving *wh*-in-situ structures as in (13b) and (13d).

(15) NP-top [NP-nom Wh-dat NP-acc verb-DeclC/QP]$_i$ adverb NP-dat t_i verb-QP/.

To derive the *wh*-fronted cases as in (13a) and (13c), the *wh*-dative phrase is furthermore scrambled out of the sentential complement, and fronted to the pre-subject position (16). The scrambled word orders shown in (15) and (16) are both entirely natural in Japanese.

(16) Wh-dat NP-top [NP-nom $t_{wh\text{-}dat}$ NP-acc verb-DeclC/QP] adverb NP-dat verb-QP/.

Note also that the embedded verbs are restricted to those which do not obligatorily subcategorize a dative NP, but which nevertheless readily allow a dative NP to be interpreted as a benefactive phrase.[6] Consequently, the *wh*-dative phrase is always interpreted as a benefactor of the event of the embedded clause. For instance,

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[5] Six report verbs were used as a matrix verb: *tutaeta* ‘told’, *itta* ‘said’, *siraseta* ‘informed’, *osieta* ‘taught’, *setumeisita* ‘explained’, and *hookokusita* ‘reported’.

[6] All the verbs used as embedded verbs are listed as below.

(i) *yonda* ‘read’, *utatta* ‘sang’, *yaita* ‘baked’, *taita* ‘cooked (rice)’, *katta* ‘bought’, *eranda* ‘chose’, *kaita* ‘sketched’, *tukutta* ‘fixed’, *tonaeta* ‘chanted’, *yonda* ‘recited’, *koonyuusita*‘purchased’, *mituketa* ‘found’, *sakkyokusita* ‘composed (music)’, *tutta* ‘caught (fish)’, *totta* ‘caught’, *otta* ‘folded’, *tunda* ‘picked up’, *aketa* ‘opened’, *hiita* ‘played (a musical instrument)’, *yatotta* ‘hired’, *sakuseisita* ‘made (a document)’, *itameta* ‘fried’, and *kumitateta* ‘assembled’

(17)	John-ga	(dono kodomo-ni)	ehon-o	yonda	no?
	John-nom	*which child-dat*	*a picture book-acc*	*read*	*QP*
	'(For which child) did John read a picture book?'				

This choice of embedded verbs is crucial, because it ensures that any preference to associate the *wh*-phrase with the embedded verb cannot be derived from satisfaction of the lexical requirements of the embedded verb. Since the dative *wh*-phrase does not frequently co-occur with 'optionally' benefactive verbs used as embedded verbs, an expectation for the indirect question reading in (13) cannot be attributed to lexical constraints imposed by the verb.

3.2.3 Procedure The experiment was conducted on G3 Macintosh computers running the `mw-run` software for Macintosh developed at MIT. Participants were timed in a phrase-by-phrase self-paced non-cumulative moving-window reading task (Just, Carpenter, & Wooley, 1982). All sentences, including the forty-eight filler items, were presented on a single line. The segmentation indicated with spaces in (13) was the actual segmentation used in the presentation. The embedded complementizer or question particle was presented together with the embedded verb since both the complementizer and the question particle are bound morphemes in Japanese.

Sentences were presented using Japanese characters with the uniform-width font Osaka 14. Stimulus segments initially appeared with dots, and participants pressed the space bar of the keyboard to reveal each subsequent region of the sentences.

After each sentence, in order to verify comprehension, a verb followed by two Agent NPs (Topic-marked NP and Nominative-marked NP) was presented on a new screen and participants decided which NP was the subject of the verb in the sentence just read by pressing one of the two keys of the keyboard. The task was adopted by Nagata (1993), and was the same task used in the studies by Miyamoto and Takahashi (2000, 2001). This task was used instead of a standard yes/no comprehension question, due to the fact that some of the target sentences were themselves questions. Visual feedback indicated whether the answer given was incorrect. Corresponding data points were eliminated from further analyses if the participant did not answer the comprehension task appropriately.

The experimental trials followed two screens of instructions and five practice trials.

3.4 Data Analysis

Analyses were conducted on comprehension task response accuracy, item accuracy and reading times. All data of subjects whose comprehension task accuracy was less than 70% in the target sentences and 75% in total were discarded (n=26). Items whose accuracy among the remaining subjects was less than 60% were also excluded (n=6). Reading times longer than 2500ms were discarded. This procedure affected 4.3% of trials. The means and analyses presented below are based on the remaining trials.

3.5 Results

3.5.1. Comprehension Task Accuracy Among the subjects included in the analysis, average comprehension accuracy was 79.89%. The average correct response percentage did not differ significantly across the four conditions. In addition, there was no significant difference in the comprehension task accuracy between the subjects who live in Shizuoka, Japan (80%) and those who live in Maryland, USA (79%). A higher percentage of subjects tested in Japan (37.5%) were excluded than subjects tested in the United States (24%).

3.5.2 Reading Times The reading time analysis provided the following results. Reading times for *wh*-insitu conditions and regions are shown in Figure 1, and those for *wh*-scrambled conditions are in Figure 2.

At all regions prior to the fifth region, there were no significant differences between reading times in the Declarative Complementizer and Q-particle conditions. Comparisons between the in-situ and scrambled conditions are inappropriate for these regions, since the lexical material differed across conditions.

In region 5 (embedded verb suffixed by a declarative complementizer for Declarative Comp conditions, and verb suffixed by a question particle for Q-particle conditions), there was a significant main effect of complementizer type, i.e. between Declarative Comp conditions and Q-particle conditions ($F1(1,47)=12.88$, $MSe=1911377$, $p<.001$; $F2(1,18)=8.89$, $MSe=1951773$, $p<.001$). Embedded verbs with declarative complementizers were read 106.2 milliseconds slower than embedded verbs with Q-particles. In the analysis of word order type, i.e. the comparison of *wh*-insitu conditions and *wh*-scrambled conditions, *wh*-insitu conditions were marginally slower than the *wh*-scrambled conditions ($F1(1,47)= 2.18$, $MSe=323777$, $p=.14$ $F2(1,18)=2.87$, $MSe=630267$, $p=.09$). Pairwise comparisons within each level of the word order manipulation yielded the following results. In the Decl/Q-particle comparison for the *wh*-insitu conditions, the declarative condition was read significantly slower than the question condition ($F1(1,47)=5.52$, $MSe=862663$, $p<.05$; $F2(1,18)=2.82$, $MSe=675989$, $p=.09$). In the Decl/Q-particle comparison for the *wh*-scrambled conditions, the Declarative Comp condition was also read significantly slower than the Q-particle condition ($F1(1,47)=8.25$, $MSe=803005$, $p<.05$; $F2(1,18)=5.56$, $MSe=1099580$, $p<.05$).

In region 6 (matrix clause adverb phrase in all conditions), there was a main effect of complementizer type, which was significant in the subject analysis but not in the item analysis (F1(1,47)=5.34, MSe=503256, p<.05; F2(1,18)=0.82, MSe=105216, p=.37). There was no significant main effect of word order (all Fs<1). Pairwise comparisons within each level of the word order manipulation yielded the following results. In the Decl/Q-particle comparison for the *wh*-insitu conditions, the declarative condition was read significantly slower than the question condition in the subject analysis (F1(1,47)=4.0, MSe=329060, p<.05), but the item analysis merely showed a non-significant tendency in the same direction (F2(1,18)=1.7, MSe=191637, p=.19). In the Decl/Q-particle comparison for the *wh*-scrambled conditions, on the other hand, there was no significant difference between the Declarative Comp condition and the Q-particle condition (F1(1,47)=1.34, MSe=149608, p=.25; F2(1,18)=1.7, MSe=246448, p=.19), although there was again a tendency for slower reading times in the declarative conditions.

In region 7 (matrix clause dative NP in all conditions), there was a main effect of complementizer type (F1(1,47)=9.64, MSe=768349, p<.01; F2(1,18)=4.78, MSe=596488, p<.05). The main effect of word order was marginally significant in the subject analysis (F1(1,47)=3.52, MSe=768349, p=.06), due to longer reading times for the Declarative Comp condition, and showed a non-significant tendency in the same direction in the item analysis (F2(1,18)=1.9, MSe=237286, p=.17). Pairwise comparisons within each level of the word order manipulation yielded the following results. In the Decl/Q-particle comparison for the *wh*-insitu conditions, the declarative condition was read marginally slower than the question condition (F1(1,47)=3.84, MSe=231789, p=.05; F2(1,18)=1.53, MSe=146793, p=.22). In the Decl/Q-particle comparison for the *wh*-scrambled conditions, the Declarative Comp condition was read significantly slower than the Q-particle condition in the subject analysis (F1(1,47)=6.54, MSe=618626, p<.05), and marginally slower in the item analysis (F2(1,18)=3.24, MSe=507159, p=.07).

In region 8 (matrix verb with a Q-particle for Declarative Comp conditions, and matrix verb without a suffix for Q-particle conditions), there was a main effect of complementizer type (F1(1,47)=8.82, MSe=1203472, p<.01; F2(1,18)=6.1, MSe=1178804, p<.05). The main effect of word order was marginally significant in the subject analysis (F1(1,47)=3.04, MSe=414784, p=.08; F2(1,18)=0.89, MSe=172631, p=.34). There was no significant interaction of complementizer type and word order (F1(1,47)=2.21, MSe=301898, p=.14; F2(1,18)=2.0, MSe=387278, p=.16). Pairwise comparisons within each level of the word order manipulation yielded the following results. In the Decl/Q-particle comparison for the *wh*-insitu conditions, there was no significant difference between the declarative condition and the question condition (F1(1,47)=1.38, MSe=166941, p=.24; F2(1,18)=0.4, MSe=69411.8, p=.53). In the Decl/Q-particle comparison for the *wh*-scrambled conditions, the Declarative Comp condition was read significantly slower than the Q-particle condition (F1(1,47)=8.61, MSe=1276472, p<.005; F2(1,18)=7.46, MSe=1583691, p<.01).

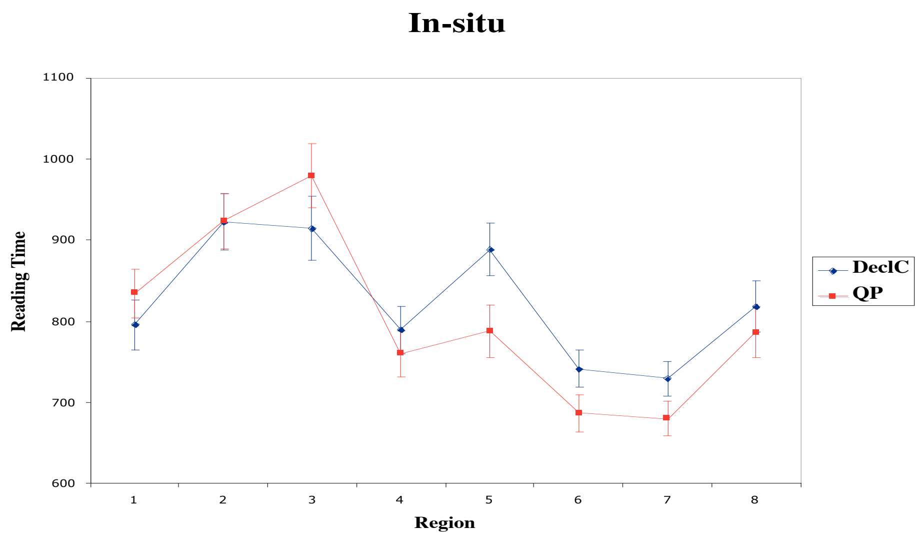

Figure 1: Reading times per region for the wh-insitu conditions.

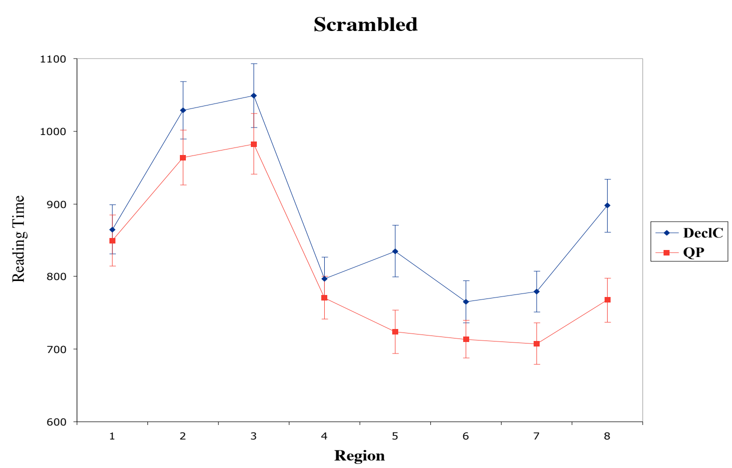

Figure 2: Reading times per region for the *wh*-scrambled conditions.

3.6 Discussion

The main result of this experiment is that Typing Mismatch Effects are observed at the embedded verb that is marked with a declarative complementizer, both in the *wh*-insitu (Figure 1) and the *wh*-scrambled conditions (Figure 2). The TME in the *wh*-insitu conditions at the embedded verb region (Figure 1) shows that the experiment replicated Miyamoto and Takahashi's results for the processing of *wh*-phrases. The TME is observed because readers expect to encounter a Q-particle as soon as possible after the thematic position of a *wh*-phrase. The parallel observation of a TME at the embedded verb region in the *wh*-scrambled conditions (Figure 2) indicates that subjects expected to encounter a Q-particle in the embedded clause. This expectation could only arise if subjects had created a gap-site in the embedded clause, given the grammatical requirement that *wh*-scope positions c-command thematic positions. This in turn indicates that readers associate a fronted *wh*-phrase with the first verb that they encounter, rather than with the structurally highest verb, contained inside the initially constructed VP tree. This also suggests that readers ultimately interpret fronted *wh*-phrases as indirect questions.

Figure 3 illustrates the parallelism in patterns of reading time slowdown at the embedded verb.

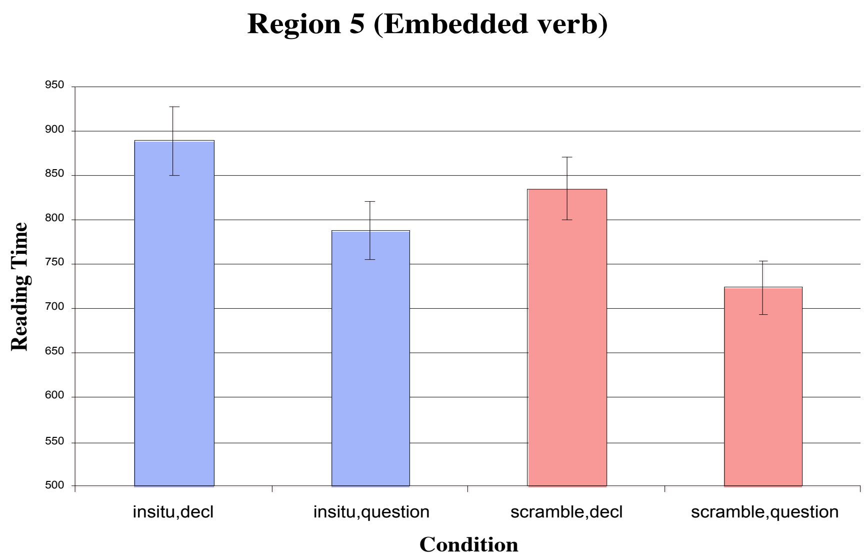

Figure 3: Reading times at the embedded verb region

We assume that the slower reading times in the declarative-complementizer conditions at regions 6-8 reflect the continued cost of the disruption caused at the embedded verb in region 5. Recall that the dative-marked NP in region 7 was included as an additional means of testing whether readers interpret the fronted dative *wh*-phrase in the matrix clause or the embedded clause. If they interpret the fronted dative *wh*-phrase in the matrix clause, then they should be surprised to encounter a second dative-marked NP in region 7 in the declarative-scrambled condition, but in no other conditions. There should be no slowdown in the insitu conditions, since readers know at region 3 that the thematic role of the *wh*-phrase is assigned in the embedded clause; there should be no slowdown in the Q-particle/scrambled condition, since readers know at region 5 that the scope of the *wh*-phrase is in the embedded clause. However, since the results show a slowdown in both declarative-complementizer conditions, relative to their respective Q-particle conditions, we consider it more likely that the slowdowns at region 7 reflect a spillover from region 5, rather than any effect of interpreting the fronted *wh*-phrase in the matrix clause.

4 Consequences

Recall that we addressed two questions in Section 1. They are summarized as follows.

(18) What is the mechanism underlying Active Filler effects? Is its operation independent of other requirements of the grammar, or is it the result of requirements of scope-discharge and/or argument-saturation?

(19) If Active Filler effects are driven by independently-motivated grammatical requirements, can the parser undertake unforced reanalyses in order to satisfy those requirements as soon as possible? If so, how can the parser reanalyze its first commitment and why?

The findings presented in the previous section lead us to answers for these questions. Section 4.1 gives an answer to the first question in (18), and Section 4.2 discusses the second question in (19), in particular comparing our results with previous studies regarding unforced reanalysis.

4.1 Operation of Active Filler effects

As discussed in Section 3.6, the findings show that readers create a gap in the embedded clause, and hence prefer to associate a fronted *wh*-phrase with an embedded clause. This is illustrated in (20) below.

(20) $[_{CP}$ **Wh** $[_{IP}$ NP-subj $[_{VP}$ $[_{CP}$ $[_{IP}$ NP-subj $[_{VP}$ **<gap>** … **Verb**]]] Verb]]]

The *wh*-phrase is related not to the structurally highest verb with which the first possible gap position would be associated (i.e. the matrix VP in (20)), but instead to the first verb that readers encounter (i.e. the embedded verb in (20)). Crucially, the embedded verb is the predicate that provides the first opportunity in the linear order of the sentence to assign the scope and thematic status of the *wh*-phrase. This suggests that the operation of Active Filler effects is not independent of other requirements of the grammar, but rather is driven by requirements for thematic interpretation and *wh*-scope licensing.[7]

This answer leads us to revise the definition of the Active Filler Hypothesis. The original definition of the hypothesis is as follows (repeated from (1)).

(21) Active Filler Hypothesis (Fraizer & Clifton, 1989: 95)
When a filler has been identified, rank the option of assigning it to a gap above all other options.

This hypothesis predicts that the gap for a *wh*-phrase should be created in the matrix VP structure because the gap should be created as soon as the parser builds the VP structure. This definition, however, would make the wrong prediction that the filler should always be related to the matrix verb (as in fact is the case in English-type languages). This is not what the experimental results show, as illustrated in (20). The results indicate that the *wh*-phrase is associated with the embedded verb, and we have shown how this is a natural consequence of the need to satisfy grammatical requirements as early as possible. Thus, this hypothesis can be revised as below.

(22) Active Filler Hypothesis (Revised)
When a filler has been identified, rank the option of *confirming grammatical feature requirements* above all other options.

This definition says that it should be possible to create a gap site if it provides an opportunity to satisfy grammatical feature requirements; at the point when the gap

[7] Edson Miyamoto (personal communication) points out that the evidence presented here might support a head-driven parsing model in which the parser does not create the gap site until it sees the first verb. If the experimental results are correct, however, our proposal does not follow a head-driven parsing model which forces the parser to postpone any structural analyses of predicate-arguments until the head verb has been processed (e.g. Pritchett 1991). We assume that a head-final language parser incrementally builds a connected tree (Fodor & Inoue 1995). Given this, a VP tree is built after the parser sees a subject NP, and analyses of predicate-argument relations start at this point of processing. The slowdown that we observe at the embedded verb allows us to conclude *at a minimum* that readers have an expectation for a Q-particle *before* they encounter the embedded verb. It is not yet clear exactly where the gap is posited, but this does not mean that one could argue that it is delayed until the verb is constructed. Moreover, if we were to follow a head-driven analysis, we would be left with the question of why a gap would be posited even given a head (the verb) that cannot assign appropriate features, given that the intuition behind head-driven parsing is that the parser waits until the bottom up information associated with the head informs it about appropriate structuring of previous material. See also Kamide and Mitchell (1999) for arguments against a head-driven account of Japanese.

site is created the parser cannot be certain that the feature requirements will in fact be satisfied. We assume that a *wh*-phrase has two types of features which need to be checked during processing; a *wh*-feature and a θ-feature.[8] When the *wh*-feature is confirmed by a scope-marker, an operator-variable relation is established, i.e. *wh*-scope is licensed. When the θ-feature is checked by a verb, the *wh*-phrase receives a thematic interpretation.

To sum up, we claim that the AFS (Active Filler Strategy) is an epiphenomenon of the on-line satisfaction of grammatical requirements, and accordingly we have revised the original Active Filler Hypothesis. We should emphasize that this reformulation relates the AFS to deeper grammatical principles, simply interpreting the grammatical principles of Greed and feature-checking incrementally, and does not constitute an independent parsing principle.

In the literature, we find previous arguments that filler-gap dependencies can be accounted for by independently motivated principles, without invoking the AFS. Although they propose different architectures to explain the filler-gap dependencies, Pritchett (1992) and Gibson, Hickok, and Schütze (1994) share the claim that the AFS is a sub-case of a principle that demands maximal satisfaction of thematic requirements at every point during processing. To the extent that satisfaction of grammatical requirements drives the processing of filler-gap dependencies, our conclusion is in accord with their claims. However, their processing models provide differing predictions for the processing of the *wh*-scrambling constructions we examined. Pritchett's model is related to ours in its reliance on principles such as thematic role assignment, but clearly makes a wrong prediction for the *wh*-scrambling constructions. Since Pritchett's head-driven parser builds the embedded clause separately until it encounters the matrix verb, the fronted *wh*-phrase would never be comprehended as an argument of the embedded verb. Gibson, Hickok, and Schütze's proposal seems to predict our results, provided that their parallel parsing theory, based upon Gibson (1991), can build the following two representations simultaneously: (i) one in which the gap is created in the matrix clause, and (ii) one in which the gap is in the embedded clause. When the parser encounters the embedded verb, there is no cost associated with the second structure with respect to the grammatical requirements of the *wh*-phrase, because the chain headed by the *wh*-phrase now receives a role from the embedded verb. In contrast, there is still a cost of one θ-violation

[8] Note that the terminology of 'feature' is used just for the sake of explanation. Hence, checking of a *wh*-feature means that the *wh*-scope is licensed, and checking of a θ-feature means that the argument is saturated by a verb either obligatorily or optionally.

associated with the first possible structure at the point of the derivation where the parser encounters the embedded verb.

Just and Carpenter (1992) and Gibson (1998) also argue that the processing of *wh*-phrases can be accounted without appealing to the AFS. Under their working-memory based models, a gap is created due to a memory cost involved in the retrieval of the filler from working memory. These models can straightforwardly be applicable to explain our findings. Memory cost is lower when the gap is created in the embedded clause, because the embedded verb provides the first opportunity in the linear order of the sentence to fix the scope and thematic status of the *wh*-phrase. Note that these models do not *replace* grammatical requirements with working memory metrics – rather, they use grammatical requirements such as thematic and scope dependencies as the currency of memory cost calculations.

4.2 Reanalysis

To the second question in (19), the results provide the answer that unforced reanalysis can take place. The TME observed at the embedded verb indicates that a gap was posited in the embedded clause in advance of the verb in the embedded clause. By parity of reasoning, it must be assumed that the same commitment was made in the matrix clause, when the matrix VP was first built. Thus, (23a) illustrates the first structure the parser commits to. When the parser incrementally builds a VP tree after the subject NP, a gap is assumed to be created in the VP structure. However, the results also show that the parser's ultimate analysis involves an embedded clause gap. This means that the first gap in (23b) must be canceled. This means that unforced reanalysis in fact takes place in this configuration.

(23) a. [$_{CP}$ **Wh** [$_{IP}$ NP-subj [$_{VP}$ **<gap>** …
b. [$_{CP}$ **Wh** [$_{IP}$ NP-subj [$_{VP}$ ~~**<gap>**~~ [$_{CP}$ [$_{IP}$ NP-subj [$_{VP}$ **<gap>** …

How, then, can the parser reanalyze the first commitment of (23a)? Given the assumption that *wh*-phrases have a *wh*-feature and a θ-feature which both need to be checked, the first commitment can be illustrated as (24a). The *wh*-phrase is assumed to have two features that need to be checked, and hence the gap carries over those features when the gap is posited in the matrix VP structure. Crucially, neither of the features is checked at this point of processing, because no verb has yet been encountered. In addition, since the gap is not pronounced, positing the gap does not entail any new phonological commitments. We assume that this is the reason why the parser can reanalyze its first commitment: it is allowed to revise its first commitment, since that analysis did not involve fulfillment of any feature requirements. When reanalysis occurs and the second gap in the embedded clause is posited, the same features are carried over, as illustrated in (24b).

(24) a. $[_{CP}$ **Wh** $[_{IP}$ NP-subj $[_{VP}$ **<gap>** …
{wh}{□} ?{wh}?{□}
b. $[_{CP}$ **Wh** $[_{IP}$ NP-subj $[_{VP}$ ~~<gap>~~ $[_{CP}$ $[_{IP}$ NP-subj $[_{VP}$ **<gap>** …
{wh}{□} ~~?{wh}?{□}~~ {wh}{□}

When readers encounter the Q-particle on the embedded verb, as in (25a), both features are checked. The *wh*-feature is checked because the Q-particle is a scope marker, and the □-feature is also checked because it can be recognized as an argument (either obligatory or optional) of the verb. On the other hand, in (25b) when readers encounter the first verb without a Q-particle, the □-feature is checked for the same reason as in (25a), but the *wh*-feature is not. A declarative complementizer is not a scope marker. In order for the parser to consider the possibility of satisfying □-features and Q-scope features in the embedded clause, it must be actively searching for feature licensers in the embedded clause. This is why a slowdown is observed in this condition.

(25) a. [**Wh** [NP-subj [[$[_{IP}$ NP-subj $[_{VP}$ **<gap>** … Verb-**QP**] …
{wh}{□} ✓{wh}✓{□}
b. [**Wh** [NP-subj [[$[_{IP}$ NP-subj $[_{VP}$ **<gap>** … Verb-**DeclC**] …
{wh}{□} ?{wh} ✓{□}

To summarize, we assume that an unforced reanalysis is permitted, provided that the initial analysis led to confirmation of no features.

We must now show, however, how this analysis is compatible with previous studies that have argued that reanalysis is a last resort; i.e. that unforced reanalysis is disallowed (Kamide & Mitchell 1999; Sturt et al., 2001; Schneider & Phillips, 2001). We will now compare our analysis with previous studies of reanalysis, showing that the confirmation-based analysis can account for differences between allowance and avoidance of reanalysis.

Kamide and Mitchell (1999) (henceforth, K&M) suggest that reanalysis is avoided in Japanese sentence processing, by showing that the dative NP is preferentially interpreted as an argument of the matrix verb in the following ambiguous configuration (26).

(26) NP-nom NP-dat [[NP-nom ditransitiveVerb] NP]-acc (di)transitiveVerb
Kyooju-ga gakusei-ni tosyokansisyo-ga kasita mezurasii
professor-nom student-dat librarian-nom lent unusual
komonjo-o yabutta / miseta.
ancient manuscript-acc tore/ showed
'The professor tore the book that the librarian lent to the student.'
'The professor showed to the student the book that the librarian lent to someone (pro).'

If the first verb is ditransitive and the second is transitive, readers read the last verb significantly slower than they do in the case where the second verb is ditransitive. K&M suggest that this shows an initial attachment as a co-argument of the matrix subject and a reluctance to re-associate the verb with an embedded clause, causing a slowdown even though the embedded verb requires a Goal argument.[9] If their finding is extended to the case of *wh*-scrambling sentences as in (3b), one might expect that the first gap position should be created and never reanalyzed. The second gap position would not be posited, since reconstruction of the gap to an embedded clause is not allowed. This might suggest that there is a contradiction between what K&M found and what we found.

Under our assumption that the parser is allowed to reanalyze its first commitment when feature requirements remain unconfirmed, however, K&M's structure and the *wh*-scrambling structure differ in terms of confirmation of features. First, consider (27a) which illustrates K&M's structure.

(27) a. NP-subj [$_{VP}$ **NP-dat** …
?{□}
b. Wh NP-subj [$_{VP}$ **<gap>** …
?{wh} ?{□}

At the point of the dative-marked NP in (27a), the □□feature of this noun phrase has not been satisfied yet because the verb has not been encountered. A *wh*-feature is irrelevant because the dative NP is not a *wh*-phrase. Moreover, this NP is phonologically realized, so a phonological commitment is made at this

[9] K&M did not find any significant difference in reading times at the embedded verb region (ditransitive versus transitive). If the dative NP is always attached to the higher verb as they suggest, the embedded clause must include a small *pro* as a null argument (either Goal or Theme) in the case where the embedded verb is ditransitive, as illustrated in (i).

(i) NP-nom NP-dat [[NP-nom *pro* ditransitive-Verb] NP]-acc (di)transitive-Verb

This suggests that the insertion of small pro does not induce any measurable cost of processing.

point of processing. Now consider the feature status in the *wh*-scrambling structure, as in (27b). The parser creates a gap site immediately after the subject. The status of the features is very different from that in the NP-dative in (27a). None of the features have been checked at this point. In K&M's structure, there are more confirming factors when the dative NP is processed, whereas in the *wh*-scrambling structure there is no confirming factor when the first gap is posited. When the embedded clause is processed and the parser sees the first verb, in K&M's structure, the parser avoids reanalysis of its existing commitments. On the other hand, in the *wh*-scrambling structure, the parser is allowed to reanalyze the first commitment because its existing commitment involved no confirmation.

How about the English cases? Sturt et al. (2001) and Schneider and Phillips (2001) claim that reanalysis is a last resort operation. For instance, consider (28) and (29).

(28) a. The man [$_{\text{VP}}$ knows [$_{\text{NP}}$ the woman … ← *likes*
b. The man [$_{\text{VP}}$ knows [$_{\text{CP}}$ [$_{\text{NP}}$ the woman] [$_{\text{VP}}$ likes …
(29) a. [$_{\text{NP}}$ The man [$_{\text{CP}}$ who [$_{\text{VP}}$ knows [$_{\text{NP}}$ the woman … ← *likes*
b. [$_{\text{NP}}$ The man [$_{\text{CP}}$ who [$_{\text{VP}}$ knows [$_{\text{NP}}$ the woman]]]] [$_{\text{VP}}$ likes the recipe himself …
c. [$_{\text{NP}}$ The man [$_{\text{CP}}$ who [$_{\text{VP}}$ knows [$_{\text{CP}}$ [$_{\text{NP}}$ the woman] [$_{\text{VP}}$ likes the recipe herself …

When the second verb, *likes*, is processed as in (28a), it is clear that the reanalysis shown in (28b) is the right conclusion. (28b) is a case of forced reanalysis. In contrast, (29a) presents two alternative resolutions, one involving a local reanalysis (29c), and one involving a non-local attachment without reanalysis (29b). Based on garden path effects observed at the point of disambiguation of local reanalysis examples like (29c), Sturt et al. (2001) and Schneider and Phillips (2001) conclude that non-local analyses that avoid reanalysis are favored over local analyses that require an easy reanalysis. Therefore, they claim that reanalysis is a last resort operation. The parser's existing structural commitments constrain its subsequent parsing decisions.

Their finding is in fact accounted for under the present analysis based on the confirmation of feature requirements.

(30) a. [$_{\text{NP}}$ The man [$_{\text{CP}}$ who [$_{\text{VP}}$ knows [$_{\text{NP}}$ the woman … ← *likes*
b. … [$_{\text{VP}}$ knows [$_{\text{NP}}$ the woman …
✓{□}

Since English verbs precede their direct objects, the features on an NP can be confirmed by the verb already processed. In (30b), both the □-feature and phonological realization are already confirmed by the first verb, with the result that reanalysis is not an available option when the second verb is encountered.

To sum up our discussion regarding comparison between previous studies and the present analysis, the proposal provided here is compatible with previous studies. We argue that previous claims about the last-resort status of reanalysis have been too general. Reanalysis is avoided when features are already confirmed. This is the case in K&M's structures and in the English structures. On the other hand, reanalysis is allowed when no features are yet confirmed, as is the case in our example of gap-placement in Japanese *wh*-scrambling structures. This suggests that the parser is sensitive to the feature status of phrases.

5 Concluding remarks

This paper reported that readers prefer to associate a fronted *wh*-phrase with an embedded clause in Japanese *wh*-scrambling constructions. That is, the *wh*-phrase is related not to the highest verb, but to the first verb that readers encounter. This finding leads to two closely related conclusions about Active Filler effects and about the possibility of unforced reanalysis. Active Filler effects are seen as a consequence of a mechanism that creates gap-sites in such a way as to allow confirmation of feature requirements as soon as possible. Meanwhile, unforced reanalysis is possible if the initial analysis did not lead to confirmation of any grammatical features; reanalysis is a last resort if the initial analysis involved confirmed features. Both of these revisions account for our results from Japanese and previous results in the literature on English and other languages.

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