Processing of Japanese *Wh*-scrambling Constructions*

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1. Introduction

This paper investigates the processing of Japanese long-distance *wh*-scrambling sentences. Results from two self-paced reading experiments show that Japanese readers preferentially associate a fronted *wh*-phrase with the most deeply embedded clause of a multi-clause sentence, before they encounter the first verb. The findings provide the evidence that the processing of filler-gap dependencies in all languages is driven by the need to satisfy the grammatical requirements of a *wh*-phrase, rather than by the need to create a gap as soon as possible.

The paper is organized as follows. Section 2 discusses how the processing of filler-gap dependencies is captured by two approaches in the literature; a strategy-based approach and a grammatical constraint-based

approach, and sets out the objectives of our studies. Section 3 presents the findings from two self-paced reading experiments. Section 4 discusses the implications of the experimental results for a well-known syntactic observation about the *wh*-scope readings obtained in long-distance *wh*-scrambling structures. Section 5 concludes.

2. Operation of 'Active Filler' Effects

Many languages contain *wh*-question structures in which an argument of a verb is displaced from its canonical position to a sentence-initial position, as in the English example in (1). In the language processing literature it is standard to refer to the displaced NP as a *filler*, and to refer to its canonical position as a *gap* (marked by underlining in (1)).

(1)   *Which movie* did John say that Mary likes to watch ___ ?

An important early set of studies demonstrated that the parser actively predicts potential gap sites as soon as possible as a sentence is processed (Crain & Fodor, 1985; Stowe, 1986; Frazier & Clifton, 1989). For instance, Stowe (1986) observed a Filled Gap Effect at the direct object position of the embedded verb in (2b), reflected in slower reading times for the pronoun *us* in the indirect *wh*-question condition (2b), relative to a control condition that lacked *wh*-extraction (2a). This slowdown is expected if the parser actively posits a direct object gap position in (2b) as soon as it encounters the transitive verb *bring*, and hence encounters difficulty when it finds an overt pronoun in the direct object position. Experiment 2 below applies a similar technique in Japanese.

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

The generalization about active positing of gap sites may be explained by at least two different approaches, which account equally well for the results listed above. One approach attributes active gap creation to an independent strategy of the parser that initiates a search for a gap as soon as a filler has been identified. While this result may have been motivated by interpretive considerations, it is implemented as an independent strategy known as the Active Filler Strategy (AFS) in (3).

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

A second approach in the principle-based parsing tradition (e.g., Pritchett, 1988, 1992; Weinberg, 1993; Gibson, Hickok, & Schütze, 1994) dispenses with this heuristic in favor of the direct instantiation of a grammatical principle for parser control. On-line interpretation of a *wh*-phrase is

triggered by the incremental satisfaction of a grammatical constraint known as the Theta Criterion. Under this approach, active gap creation is the result of parsing mechanisms that seek to maximize the satisfaction of lexical and grammatical constraints; gap creation is not an end in itself.

Studies based on English-type languages do not easily allow these two approaches to be distinguished. Since a verb in English-type languages is followed by its complement, the first possible gap position is also the first possible position where a thematic role can be assigned. A head final language like Japanese instead provides a useful testing ground in which the two accounts make divergent predictions. In a two-clause question in Japanese, a dative *wh*-filler may be scrambled to the sentence-initial position. If the parser's goal is to assign the filler to a gap position as soon as possible, as predicted by the AFS, the fronted *wh*-filler should be associated with a gap position in the main clause, since this is the first canonical argument position for dative arguments (4a). On the other hand, if the parser's objective is to ensure that the filler receives a thematic interpretation as soon as possible, the interpretation of the gap in this position becomes relevant. If the gap doesn't receive interpretive features, the parser might also consider postulation of a gap in a subsequent position to ensure interpretation; in this case, the embedded clause, where the first verb will be encountered (4b).

(4) a.   b.
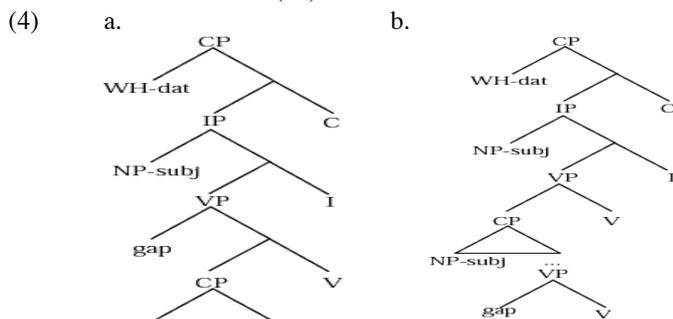
The reading-time studies reported below focus on testing the striking prediction of the constraint-driven model that Japanese speakers will preferentially associate a sentence-initial filler with an embedded clause.

3. Self-paced reading experiments

3.1 Experiment 1

This experiment was designed as a test of how *wh*-interrogatives are interpreted in Japanese *wh*-fronting structures. We used Miyamoto & Takahashi's (2000, 2001) *Typing Mismatch Effect* (TME) as a diagnostic of

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where a *wh*-phrase is interpreted. Investigating the processing of in-situ *wh*-phrases in Japanese, Miyamoto & Takahashi reasoned that whereas in English the processing of a fronted *wh*-phrase in a scope position initiates a search for a thematic position, in Japanese the processing of an in-situ *wh*-phrase should initiate a search for a question particle. By showing slower reading times (TME) for verbs marked with the declarative complementizer *–to* than for verbs marked with the question marker *–ka*, they conclude that in sentences that contain an in-situ *wh*-phrase, Japanese speakers expect a question particle on the verb in the same clause.

Experiment 1 takes the TME as a diagnostic of where a fronted *wh*-phrase receives its thematic interpretation, using dative *wh*-phrases that can be associated with either the main clause or an embedded clause. If long-distance dependency formation is driven by the need to create a gap as soon as possible, as predicted by the AFS, then readers should interpret the *wh*-phrase in the main clause, and no TME should be observed at the embedded clause verb. If, on the other hand, dependency formation is driven by requirements for thematic interpretation and scope marking, the *wh*-phrase should be interpreted in the embedded clause, and a TME should be observed at the embedded clause verb.

24 sets of four conditions each were used in the experiment, in a 2 X 2 factorial design, which manipulated the position of the *wh*-phrase (in-situ vs. scrambled) and the distribution of verbal affixes (question particle vs. declarative complementizer on the embedded verb), as shown in (5). [1]

(5)　　　a.　*Scrambled, Declarative Complementizer*
　　　　　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-Q
　　　　b.　*In-situ, Declarative Complementizer*
　　　　　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-Q
　　　　　'Which student did the class teacher tell the librarian at the
　　　　　 library that the principal read a book for?'

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[1] The twenty four sets of items were distributed among four lists in a Latin Square design. Each subject saw one list intermixed with 48 unrelated fillers. In order to ensure that any evidence for *wh*-phrase interpretation in the embedded clause could not be attributed to satisfaction of lexical requirements of the embedded verb, all embedded verbs were chosen such that they did not strictly subcategorize for a dative NP, but freely allow a dative-marked NP to be interpreted as the *beneficiary* of the action described.

c. *Scrambled, Question Particle*
   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-Q   library-at   librarian-dat   told
   d. *In-situ, Question Particle*
   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-Q   library-at   librarian-dat   told
   'The class teacher told the librarian at the library which student
   the principal read a book for.'

The experiment was conducted on Macintosh G3 computers running the `mw-run` software developed at MIT. Participants (n=74), who were tested in either Japan or the United States, were timed in a phrase-by-phrase self-paced non-cumulative moving-window reading task. Sentences were presented using Japanese characters. In order to ensure that participants attended to the stimuli, a subject-verb matching task was presented after each trial. A verb was displayed on the computer screen followed by two Agent NPs (one topic-marked NP and one nominative-marked NP) and participants had to decide which of the NPs was the subject of the verb in the sentence just read by pressing one of two keys of the keyboard.[2]

Among the 48 participants included in the analysis,[3] average comprehension accuracy was 79.9%. The average correct response percentage did not differ significantly across the four conditions (all Fs<1).

Reading times for in-situ conditions are shown in Figure 1, and those for scrambled conditions are shown in Figure 2. The reading time analysis of the critical region (the embedded verb which includes the critical declarative or interrogative affixes) yielded the following results. There was a significant main effect of complementizer type, due to reading times that were 106 msec slower for declarative complementizers than for question particles ($F_1(1,47)=10.53$, $p<.005$; $F_2(1,18)=8.74$, $p<.01$). In the analysis of

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[2] This task was chosen due to the fact that half of the target sentences and a quarter of the fillers were themselves questions, thereby precluding the use of a standard yes/no comprehension question task.

[3] Analyses were conducted on comprehension task response accuracy, item accuracy and reading times. All data from participants whose comprehension task accuracy was below 70% for target sentences and below 75% in total were discarded. This affected a large number of participants (n=26, 35%). Items whose accuracy among the remaining subjects fell below 60% were also excluded (n=5). 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.

word order type, there was a marginally significant main effect, due to slower reading times for in-situ conditions than for scrambled conditions ($F_1(1,47)=0.78$, $p=.38$ $F_2(1,18)=2.37$, $p=.14$). However, there was no interaction ($Fs<1$). Planned comparisons showed that reading times were slower in the declarative condition than the question particle condition for both the in-situ conditions ($F_1(1,47)=4.74$, $p<.05$; $F_2(1,18)=2.87$, $p=.11$) and for the scrambled conditions ($F_1(1,47)=4.64$, $p<.05$; $F_2(1,18)=8.0$, $p<.05$).
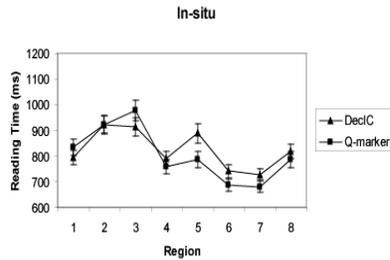

Figure 1: Reading times per region for the *wh*-in-situ conditions.
(NP-top$_1$ NP-nom$_2$ Wh-dat$_3$ NP-acc$_4$ <u>V-DeclC/Q</u>$_5$ Adverb$_6$ NP-dat$_7$ V-Q/.$_8$)
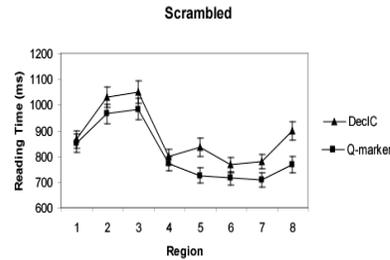
Figure 2: Reading times per region for the *wh*-scrambled conditions.
(Wh-dat$_1$ NP-top$_2$ NP-nom$_3$ NP-acc$_4$ <u>V-DeclC/Q</u>$_5$ Adverb$_6$ NP-dat$_7$ V-Q/.$_8$)

The main finding in this experiment was that Japanese speakers were surprised to encounter a declarative complementizer on the embedded verb, both when the *wh*-phrase was in-situ in the embedded clause and when it was scrambled to sentence-initial position. The TME in the in-situ conditions replicates Miyamoto and Takahashi's results for the processing of *wh*-phrases, and extends their finding to the processing of non-subcategorized *wh*-phrases. The parallel observation of a TME at the embedded verb region in the scrambled conditions suggests that readers expected to encounter a question particle in the embedded clause. This expectation could only arise if readers interpret the fronted *wh*-phrase such that it has a thematic position inside the embedded clause. The finding that fronted *wh*-phrases are preferentially interpreted in the embedded clause confirms the prediction of the principle-based theory of parsing *wh*-phrases.

3.2 Experiment 2

Based upon the findings in Experiment 1, Experiment 2 was designed with the goal of investigating the time-course of this association process. The finding that declarative complementizers were read more slowly than question particles indicates that the association with the embedded clause occurs no later than the embedded verb. The 'head-driven' approach to

parsing Japanese advocated by Pritchett (1991, 1992) assumes the existence of pre-verbal gaps, but also assumes that structure-building is delayed until the verb is processed. Alternatively, the fronted *wh*-phrase may be associated with the embedded clause *before* the embedded verb is processed. Therefore, this experiment adapted the 'filled gap' paradigm (Crain & Fodor 1985; Stowe 1986) for Japanese, in order to test whether the gap is posited in advance of the verb in Japanese embedded clauses.

Experimental materials consisted of twenty sets of sentences with two conditions each, which we refer to as the scrambled condition and the control condition, respectively. (6) shows one set of conditions used in the experiment. In both conditions, the dative-marked NP in the embedded clause was the second dative NP in the sentence. However, in the scrambled condition (6a), the dative *wh*-NP in sentence-initial position should also be associated with the embedded clause, based upon the results of Experiment 1. If the fronted *wh*-phrase in the scrambled condition is associated with the embedded clause before the second dative NP is encountered, readers should be surprised to encounter the second dative NP, due to the fact that it is highly marked in Japanese to have two arguments marked with the same case in a single clause. In the control condition (6b), the two sentence-initial NPs are matched to the scrambled condition in the respect that there is one *wh*-NP and one dative-marked NP. However, in this condition there is no expectation that either of these NPs should be associated with the embedded clause, because Japanese nominative subject NPs cannot be scrambled (Saito 1985), and because base-generated dative NPs preferably stay in a matrix clause (Kamide & Mitchell 1999). Hence, the second dative NP in (6b) should be read as the only dative NP in the embedded clause, and should be read more quickly than the corresponding NP in the scrambled condition, despite the fact that readers have already encountered both a *wh*-element and a dative case, just as they do in the scrambled condition.

(6)   a. Dono-kodomo-ni hahaoya-wa otetudaisan-ga   daidokoro-de
           which child-dat   mother-top   housekeeper-nom kitchen-at
           titioya-ni obento-o watasita-to   iimasita-ka?
           father-dat lunch-acc handed-DeclC told-Q
         'To which child did the mother tell that the housekeeper
          handed lunch to the father at the kitchen?'
        b. Dono-kodomo-ga hahaoya-ni otetudaisan-ga   daidokoro-de
           which child-nom   mother-dat housekeeper-nom kitchen-at
           titioya-ni obento-o watasita-to   iimasita-ka?
           father-dat lunch-acc handed-DeclC told-Q
         'Which child told the mother that the housekeeper handed
          lunch to the father at the kitchen?'

The procedure was identical in format to that used in Experiment 1.[4]

Among the subjects who were included in the analysis,[5] average comprehension accuracy was 86.3%. Reading times for all regions are shown in Figure 3. At the dative NP in Region 5 there was a significant difference between the two conditions ($F_1(1,33)=11.4$, $p<.005$; $F_2(1,19)=6.4$, $p<.05$), due to reading times that were 83 milliseconds slower in the scrambled condition than in the control condition.
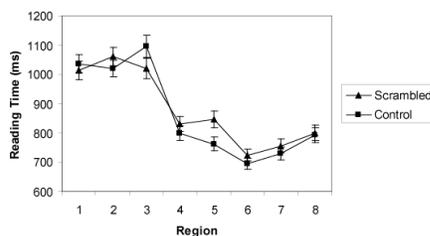

Figure 3: Reading times per region

(Scrambled: Wh-dat$_1$ NP-top$_2$ NP-nom$_3$ Adv$_4$ <u>NP-dat$_5$</u> NP-acc$_6$ V-DeclC$_7$ V-Q$_8$)
(Control: Wh-nom$_1$NP-dat$_2$NP-nom$_3$Adv$_4$ <u>NP-dat$_5$</u> NP-acc$_6$ V-DeclC$_7$ V-Q$_8$)

The main result of this experiment is that a slowdown in reading time is observed in the scrambled condition at the embedded dative NP (Region 5), relative to the reading time for the same region in the control condition. We interpret this slowdown as the Japanese counterpart to the Filled Gap Effect (Stowe 1986). The slowdown arises because readers do not expect to encounter a second dative NP in the embedded clause after they interpret the *wh*-phrase in the embedded clause. This effect could only arise if readers create a gap-site in the embedded clause *before* they reach the embedded verb. These results are in turn consistent with the results of Experiment 1: readers ultimately associate a fronted *wh*-phrase with the first verb that they encounter, rather than with the structurally highest verb or the first possible gap position.

3.3 General Discussion

The findings from Experiment 1 and 2 show that readers create a gap in the embedded clause before they encounter the embedded verb, and hence

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[4] The twenty sets of items were distributed in a Latin Square design, creating two lists. Each subject saw one of the lists intermixed with 60 unrelated filler items. 41 native speakers of Japanese participated in the experiment.

[5] 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=7, 17%). Reading times longer than 2500ms were discarded. This procedure affected 2.8% of trials.

prefer to associate a fronted *wh*-phrase with an embedded clause. This means that the *wh*-phrase is ultimately related not to the structurally highest verb with which the first possible gap position would be associated (i.e. the matrix verb), but instead to the first verb that readers encounter (i.e. the embedded verb). Crucially, the first opportunity to interpret a postulated gap appears in the embedded clause, and therefore the parser adopts this analysis.

The finding is unexpected if the formation of filler-gap dependencies is driven simply be the requirement to create a gap position as soon as possible, as predicted by the AFS. On the other hand, the finding of an embedded clause preference for fronted *wh*-phrases supports approaches that claim that the creation of long-distance dependencies is motivated by the need to satisfy syntactic and semantic requirements of the fronted phrase.

Furthermore, based on the evidence from Experiment 2 that Japanese speakers form *wh*-dependencies in the embedded clause before they reach the embedded verb, the results favor an incremental model of long-distance dependencies over models that assume that dependencies cannot be created until the verb position, due to head-driven structure-building.

4. Implications for the Syntax of *Wh*-scrambling

Our experimental results indicate that sentence-initial *wh*-phrases are preferentially interpreted in the most deeply embedded clause during on-line processing. This raises the question of whether the embedded *wh*-scope reading is always available in *wh*-scrambling structures. In fact, Takahashi (1993) specifically uses the *unavailability* of the embedded *wh*-scope reading in certain contexts as the key observation in his argument that Japanese *wh*-scrambling is equivalent to English *wh*-movement. Focusing on sentences in which both the main clause and the embedded clause contain a question particle (7), Takahashi argues that the scrambled *wh*-phrase can only take matrix scope (7b), and does not allow embedded scope (7a).

(7)   Nani-o   Taro-wa   Hanako-ga   tabeta-ka siritagatteiru-no?
        what-acc Taro-top   Hanako-nom   ate-Q   wants-to-know-Q
        a. 'Does Taro want to know what Hanako ate?'
        b. 'What does Taro want to know whether Hanako ate?'

If Takahashi's analysis of (7) is correct, it would indicate that the experimentally-demonstrated embedded scope preference might sometimes turn out to be ungrammatical. Experiment 3, an off-line questionnaire study,

provides evidence that both scope possibilities in (7) are available, once semantic context is appropriately controlled.[6]

Each test item consisted of three parts: Context, Question, and Answer. The subject's task was to judge whether the Answer was an appropriate response to the Question. The question-answer pairs highlighted different scope readings. Subjects first read the *Context*, which was biased in favor of the embedded *wh*-scope reading. The *Questions* were all double question marker questions as in (7), with either a scrambled or an in-situ *wh*-phrase. The embedded clause was either a complement clause ('non-island conditions'), which allows long-distance scrambling, or a relative clause, which is an island that blocks scrambling ('island conditions'). *Answer* sentences highlighted either matrix or embedded scope readings for the questions. (8) shows an example of the scrambled & non-island condition.

(8)   *Context*

Taro-wa   Hanako-ga   kooen-de dare-ni atta-ka sitteiru.
Taro-top Hanako-nom park-at   who-dat met-Q knows.
'Taro knows who Hanako met at the park.'
Tomoko-mo Hanako-ga   kooen-de dare-ni atta-ka sitteiru.
Tomoko-also Hanako-nom park -at who-dat met-Q knows.
'Tomoko also knows who Hanako met at the park.'
Question
Demo, dare-ni   Jiro-wa Hanako-ga kooen-de atta-ka sitteiru-no?
But,   who-dat Jiro-top Hanako-nom park-at met-Q knows-Q
Answer
[Matrix answer] Saburo-ni desu. 'Saburo'
[Embedded answer] Hai, Jiro-mo sitteiru. 'Yes, he does.'

If the embedded *wh*-scope reading in (7a) is grammatically possible, then speakers should rate the embedded scope reading significantly higher than the matrix scope reading in the non-island conditions, independent of the position of the *wh*-phrase. This prediction was confirmed. There was a significant main effect of answer type in the non-island conditions, due to higher ratings for embedded answers than for matrix answers ($F_1(1,79) =$ 39.1, p<.0001). Note that the average rating of 3.6 for the non-island/scrambled/embedded condition represents a high rating for sentences of this complexity.

The island conditions were included in order to show that the effect of context is not so strong as to make ungrammatical readings possible.

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[6] Takahashi's judgment is in fact controversial. As Maki & Ochi (1998) and Kuwabara (1999) note, some native speakers of Japanese can take (7) as a yes-no question as well as a *wh*-question. Ishihara (2002) and Kitagawa & Fodor (2002) also argue that ambiguity of the *wh*-scope readings can be obtained in specific prosodic structures.

Results in these conditions confirmed that when the *wh*-phrase was in-situ only the embedded scope was rated highly, and when the *wh*-phrase was in sentence-initial position only the matrix scope was rated highly. Context did not help to make available the scope reading in which the sentence-initial *wh*-phrase is associated with scope inside the syntactic island. The 16 sets of items were distributed in a Latin Square design, creating eight lists. Each subject saw one of the lists intermixed with 16 unrelated filler items. Eighty native speakers of Japanese participated in the experiment.
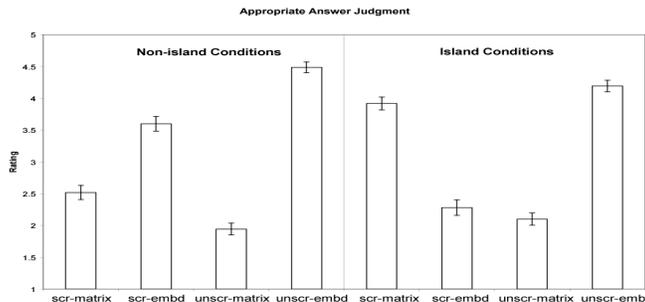

Figure 4: Experiment 3: Ratings of appropriate answer judgment.

These results show that the scope reading in (7a) is possible in Japanese, contrary to Takahashi's claim. The argument that this reading is genuinely grammatically available is reinforced by the finding that context fails to yield an embedded scope reading in conditions where this would require violation of an island constraint. Thus, the off-line judgments are compatible with the on-line preferences that we have observed.[7]

5. Conclusion

This paper reported that Japanese readers prefer to associate a fronted *wh*-phrase with an embedded clause before they reach the embedded verb. This finding leads to two closely related conclusions about Active Filler effects and about the possibility of head-driven parsing. Active Filler effects are seen as a consequence of a mechanism that creates gap-sites in such a way as to satisfy theta-role assignment requirements as soon as possible. Hence, the AFS is an epiphenomenon of the on-line satisfaction of grammatical constraints. Meanwhile, head-driven parsing is difficult to reconcile with the finding that the gap is posited in advance of any verb. We

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[7] Although the results of our off-line study challenge Takahashi's claim that (7a) is impossible, we agree with Takahashi that the matrix *wh*-scope reading in (7b) is preferred in a null context. We leave open the question of why the matrix *wh*-scope reading is preferred, despite the on-line scope preference demonstrated above.

also confirmed that long-distance *wh*-scrambled phrases with double question-markers can also be interpreted with embedded clause scope.

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