Processing filler-gap dependencies in a head-final language

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Abstract

This paper investigates the processing of long-distance filler-gap dependencies in Japanese, a strongly head-final language. Two self-paced reading experiments and one questionnaire study show that Japanese readers associate a fronted wh-phrase with the most deeply embedded clause of a multi-clause sentence. Experiment 1 demonstrates this based on evidence that readers expect to encounter a scope-marking affix on the verb of an embedded clause in wh-fronting constructions. Experiment 2 shows that the wh-phrase is already associated with the embedded clause before the verb is processed, based on a Japanese counterpart of the Filled Gap Effect (Stowe 1986). Experiment 3 corroborates these findings in a sentence completion study. Given that the first verb in a Japanese sentence appears in the most deeply embedded clause, these findings provide evidence that the processing of filler-gap dependencies is driven by the need to satisfy thematic role assignment requirements of the wh-phrase, rather than by the need to create a gap as soon as possible. The paper also discusses implications for theories of reanalysis and for debates over the status of gaps in sentence processing.

Key words:

Japanese, parsing, filler-gap dependencies, Active Filler Strategy, head-final languages, thematic roles, scope, reanalysis
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Introduction

In this article we use cross-language evidence to investigate the mechanisms that underlie the formation of long-distance dependencies in sentence comprehension, with a focus on the Japanese counterparts of so-called ‘filler-gap’ dependencies in wh-questions. After first reviewing evidence that English speakers consistently interpret wh-fillers in the highest position in the sentence that is grammatically or lexically appropriate, we then proceed to show that Japanese speakers present a profile that appears at first to be the exact opposite of this. However, we show that the English and Japanese patterns both follow from the same underlying parsing mechanism, and that the Japanese results help to decide among competing accounts of what drives the processing of long-distance dependencies.

Most languages contain a number of constructions in which an argument of a verb is displaced from its canonical position to a position in the sentence at some distance from the verb, most commonly to the left of the verb. For example, in addition to the English declarative sentence in (1a) in which the NP cereal appears in canonical direct object position following the verb eat, there is also the wh-question in (1b) in which the corresponding NP which cereal appears in sentence-initial position, and no NP appears in the canonical post-verbal object position of eat.

(1) a. Kim knows that Sam likes to eat cereal for breakfast.
   b. Which cereal does Kim know that Sam likes to eat ___ for breakfast?

Displacements of this kind are found in questions, relative clauses, topicalization and focus constructions, among others. In the language processing literature it has become common to refer to the displaced NP as a filler, and to refer to its canonical position as a gap (marked by underlining in (1b)). Accordingly, the relation between the displaced phrase and its canonical, thematic position has become known as a filler-gap dependency, and a focus of research on such dependencies has been on how speakers link fillers to their corresponding gaps during real-time processing.

An important early set of studies demonstrated that the parser actively predicts potential gap sites as a sentence unfolds (‘filler-driven’ parsing: Fodor, 1978; Crain & Fodor, 1985; Stowe, 1986; Frazier, 1987; Frazier & Flores D’Arcais, 1989), rather than waiting to identify an empty argument position.
before positing a gap (‘gap-driven’ parsing: Jackendoff & Culicover, 1971; Wanner & Maratsos, 1978). 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 wh-fronting condition (2b), relative to a control condition that did not involve wh-fronting (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. The slowdown is unexpected if the parser waits to identify an empty argument position before positing a gap. Experiment 2 below applies a similar technique in Japanese.

(2)  

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

Additional studies showed that the active positing of gap sites is filtered by the lexical argument structure requirements of the verb (Clifton, Frazier, & Connine, 1984; Tanenhaus, Boland, Garnsey, & Carlson, 1989; Stowe, Tanenhaus, & Carlson, 1991; Boland, Tanenhaus, Garnsey, & Carlson, 1995). For example, Boland et al. (1995) found that the Filled Gap Effect disappeared when a filler was an implausible direct object of an object control verb that allowed an additional gap site inside its complement, as in Which movie did Mark remind them to watch ___. Further evidence for construction of filler-gap dependencies as soon as an appropriate verb is identified has been found using techniques such as implausibility detection (Garnsey, Tanenhaus, & Chapman, 1989; Traxler & Pickering, 1996), head-mounted eye-tracking (Sussman & Sedivy, in press), cross-modal priming (Nicol & Swinney, 1989; Nicol, 1993), and event-related potentials (Garnsey et al., 1989; Kaan, Harris, Gibson, & Holcomb, 2000). Related evidence has also been found in many languages, including Dutch (Frazier, 1987; Frazier & Flores D’Arcais, 1989; Kaan, 1997), Russian (Sekerina, in press), Hungarian (Radó, 1999), Italian (de Vincenzi, 1991), and German (Schlesewsky, Fanselow, Kliegl, & Krems, 2000).

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 subroutine of the parser that initiates a search for a gap as soon as a filler has been identified. Frazier and Clifton (1989) provide a well-known formulation of this principle as the Active Filler Strategy (AFS) in (3). Importantly, the AFS focuses on the need to create a gap position as soon as possible; gap creation is an end in itself.
(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 focuses instead on the grammatical and semantic consequences of identifying a gap position, in particular the availability of thematic role assignment. Under such approaches, 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. This approach is well-represented in both the principle-based parsing tradition (Pritchett, 1988, 1991a, 1992; Gibson, 1991; Weinberg, 1993, 1999; Gibson, Hickok, & Schütze, 1994) and the constraint-based lexicalist tradition (Boland et al., 1995; Altmann, 1999). For example, Pritchett’s 1998 *Theta Attachment* constraint states that “The Theta Criterion attempts to apply at every point during processing…” (p.542).

The distinction between these two accounts of active gap creation has received limited attention, since they have very similar consequences in English-type languages. Nevertheless, the distinction is important, since it implies rather different underlying parsing mechanisms.

In this article we investigate the mechanisms that drive long-distance dependency formation using evidence from Japanese, a language in which the two accounts of active gap creation make divergent predictions, due to the word order properties of Japanese.

Japanese is a strongly verb-final language. Verbs follow all of their arguments, including clausal arguments. This contrasts with Germanic verb-final languages, where verbs may follow their nominal arguments, but typically precede clausal complements. As a result, in multi-clause sentences the verb of the embedded clause appears before the verb of the main clause (4).

(4) John-wa Mary-ga sono hon-o nkusita-to omotteiru.
    *John-top Mary-nom that book-acc lost-that thinks*
    ‘John thinks that Mary lost that book.’

Two properties of Japanese question formation are important for the studies that follow. First, whereas English uses the position of a *wh*-phrase to indicate the scope of a question as either a direct question (main clause scope, 5a) or an indirect question (embedded clause scope, 5b), in Japanese *wh*-scope needs to be indicated by a scope marker such as the question particles -*ka* (embedded or main clauses) and -*no* (main clauses only). These particles appear as verbal suffixes, and they are considered to be complementizers, contrasting with the standard declarative clause complementizer -*to*. Direct questions have a question particle on the main verb (6a), and indirect questions have a question particle on
an embedded verb (6b). In contrast to English, the position of the wh-phrase has no impact on the scope interpretation of the question.

(5) a. Who did John say that Mary saw?
    b. John said who Mary saw.

(6) a. 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 ‘Who did John say Mary gave that book to?’

    John-top Mary-nom whom-dat that book-acc gave-Q said ‘John said who Mary gave that book to.’

Second, Japanese allows wh-phrases to either appear in their canonical, thematic position (‘wh-in-situ’, 7a), or displaced to a position earlier in the sentence, including the front of the main clause (‘wh-fronting’ or ‘wh-scrambling’, 7b). Both sentences in (7) are interpreted as indirect questions, due to the presence of a question particle on the embedded clause verb.

    John-top Mary-nom whom-dat that book-acc gave-Q said ‘John said to whom Mary gave that book.’

    whom-dat John-top Mary-nom that book-acc gave-Q said ‘John said to whom Mary gave that book.’

One further important property of Japanese clause structure involves the canonical word order of clauses with multiple arguments. There is broad agreement that the canonical order of arguments is nominative-dative-accusative-verb, as in the embedded clause in (7a) (Hoji, 1985; Kitagawa, 1994; Takano, 1998; Yatsushiro, 1999). This assumption is confirmed by the results of corpus studies on Japanese (Miyamoto & Takahashi, 2002a). 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), as shown in (8).

    John-nom teacher-dat Mary-nom that book-acc lost-that told ‘John told the teacher that Mary lost that book.’
Taken together, these properties of Japanese make it possible to distinguish the predictions of the AFS and the interpretation-driven accounts of processing filler-gap dependencies. In a two-clause question in Japanese, a dative-marked wh-filler may appear in sentence-initial position. If the parser’s objective is to assign the filler to a gap position as soon as possible, as predicted by the AFS, the filler should be associated with a gap position in the main clause, preceding the embedded clause, since this is the first canonical argument position for dative arguments. On the other hand, if the parser’s goal is to ensure that the filler receives a thematic interpretation as soon as possible, it should explore all possible positions of interpretation and posit a gap in the embedded clause, where the first verb will be encountered, and hence an additional opportunity for thematic interpretation will arise. These two alternatives are illustrated in (9). 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, rather than with the main clause.

(9) a.
b. 

Of course, since the parser cannot know that it is dealing with a multi-clause sentence until it encounters embedded clause material, a gap site may initially be posited in the main clause, just as in (9a), but this analysis may be revised once the embedded clause subject is parsed, placing the gap inside the embedded clause instead, and thus allowing earlier satisfaction of thematic interpretation requirements. This scenario has implications for theories of reanalysis, which we take up in the General Discussion section.

It is important to clarify the relationship between our primary focus here, namely the mechanisms that drive the formation of filler-gap dependencies, and some other related issues in the processing of head-final languages and long-distance dependencies.

First, an important issue in the processing of head-final languages involves the question of whether structure is built fully-incrementally (Frazier, 1987; Inoue & Fodor, 1995; Mazuka & Itoh, 1995; Schneider 1999), or whether structure-building is delayed until key lexical heads, such as verbs, are encountered (‘head-driven’ parsing: Pritchett, 1991b, Mulders, 2002). Although this issue is logically independent from our main concern here, and incremental structure-building models are clearly compatible with either a main clause or an embedded clause gap site preference, it is possible that a head-driven model would independently predict a preference for an embedded clause gap site. This is because a model that delays structure-building until verbs are processed would have its first opportunity to build structure at the position of the embedded verb. Thus, this could be both the first opportunity to create a gap position and the first opportunity to give a thematic interpretation to a wh-filler.

Second, our main question about what drives the formation of filler-gap dependencies is of course related to questions about whether such dependencies genuinely involve the construction of gap sites in canonical argument positions.
NP priming have undergone long-distance (i.e., multi-clause) scrambling. Using a cross-modal technique, Nakano et al. argue that a sentence-initial accusative-marked NP is ‘reactivated’ shortly before the embedded verb, at least in those participants
that receive high scores on a reading-span test of memory (Daneman & Carpenter 1980). Although participants in that study clearly interpreted fronted NPs in an embedded clause, this finding cannot choose between a position-based AFS approach and an interpretation-based approach. This is because the scrambled NP in that study became unambiguous as soon as the embedded clause was processed. The scrambled NP was marked with accusative case, and no verb in Japanese selects both a clausal complement and an accusative argument. Therefore, as soon as readers encountered an embedded clause, they could be confident that the scrambled accusative NP was not an argument of the main clause verb.1 By contrast, our studies are globally ambiguous since we use dative-marked wh-phrases, in order to keep open the possibility of either main clause or embedded clause interpretation. Therefore, we can more precisely trace the source of the embedded interpretation of the displaced constituent to interpretive constraints using our data.

Of particular relevance to our own studies is a recent series of experiments by Miyamoto and Takahashi (Miyamoto & Takahashi, 2000, 2001, 2002c) that have investigated the processing of in-situ wh-phrases in Japanese. As seen above, the surface position of a wh-phrase in Japanese does not determine the scope of a question; this property is instead indicated by a question particle affix that appears on either the main clause verb (direct question) or an embedded clause verb (indirect question). Miyamoto and 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. Using materials like the examples in (10), they show that in sentences that contain in-situ wh-phrase, Japanese speakers expect to encounter a question particle on the verb in the same clause. This is shown by slower reading times for verbs marked with the declarative complementizer –to than for verbs marked with the question marker –ka. Miyamoto and Takahashi refer to this slowdown upon encountering an unexpected verbal affix as the Typing Mismatch Effect (TME).

1 It would be possible, in principle, for speakers to maintain a main clause analysis of the accusative NP, if the embedded clause were analyzed as a non-complement clause, i.e. a relative clause or an adjunct clause. However, results from our sentence fragment completion study (Experiment 3) suggest that speakers are unlikely to do this. Participants provided multi-clause completions to sentence fragments beginning with dative-topic-nominative sequences in 99% of trials, but 96.4% of these multi-clause completions involved complement clauses; only 3.6% of completions involved relative clause completions, and there were no adjunct clause completions at all.
(10) a. Senmu-ga donna-pasokon-o tukatteiru-to
director-nom what-kind-computer-acc using-is-that
kakaricyoo-ga itta-no?
supervisor-nom said-Q
‘What kind of computer did the supervisor say the director
is using?’

b. Senmu-ga donna-pasokon-o tukatteiru-ka
director-nom what-kind-computer-acc using-is-Q
kakaricyoo-ga itta.
supervisor-nom said
‘The supervisor said what kind of computer the director is using.’

Importantly for our purposes, a *wh*-question in Japanese must be
associated with a question particle that is *at least as high* in the sentence as the
thematic position of the *wh*-phrase. This fact is confirmed both by off-line
acceptability judgment (Nishigauchi, 1990) and by reading-time studies
(Miyamoto & Takahashi, 2000, 2001, 2002c). For example, the sentence in (11a)
is ungrammatical because the *wh*-phrase in main clause subject position receives
its thematic interpretation in a higher clause than the question particle that appears
on the embedded clause verb. The *wh*-phrase cannot be interpreted in the
embedded clause, because nominative NPs disallow scrambling (Miyara 1982;
Saito 1985; Takezawa 1987; Nemoto 1999). The question marker in the
embedded clause in (11) is irrelevant to the licensing of the main clause wh-
phrase. This means that readers should first expect a question particle to appear on
the verb in the *same clause as the thematic position of the wh-phrase*. Miyamoto
and Takahashi’s studies confirm this generalization for in-situ phrases.

Who-nom John-nom that book-acc lost-Q knows
‘*Who knows whether John lost that book.’

b. Dare-ga John-ga sono hon-o nakusita-ka sitteiru-no?
Who-nom John-nom that book-acc lost-Q knows-Q
‘Who knows whether John lost that book?’

Experiment 1 below builds upon this generalization to provide 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 Typing Mismatch Effect 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 Typing Mismatch Effect should be observed at the embedded clause verb.

**Experiment 1A**

This experiment was designed as an initial test of how *wh*-expressions are interpreted in Japanese *wh*-fronting structures, using Miyamoto & Takahashi’s Typing Mismatch Effect as a diagnostic of where a *wh*-expression is interpreted. The aim was to determine whether a fronted *wh*-expression in Japanese is preferentially interpreted in the main clause or in the most deeply embedded clause. If the parsing of *wh*-expressions is driven by gap creation, then a main clause analysis is predicted; if, on the other hand, the parsing of *wh*-expressions is driven by interpretive requirements such as thematic interpretation, an embedded clause analysis is predicted. Building upon Miyamoto & Takahashi’s findings about the parsing of *in situ* *wh*-expressions in Japanese, we expect that in the clause in which the *wh*-expression is interpreted, readers will anticipate a question particle, and hence read a declarative complementizer more slowly than a question particle, i.e. a Typing Mismatch Effect. In light of the claim of the interpretation-driven theory that creation of gap positions is driven by interpretive constraints, we predict that gap creation should persist until the filler is actually interpreted. Thus, a gap position should be created in the embedded clause (as well, perhaps, as in the main clause). Therefore, the experiment included conditions in which the *wh*-expression was *in situ* in an embedded clause, in order to allow direct comparison of fronted and *in situ* *wh*-expressions. If the fronted *wh*-expression is interpreted in an embedded clause, we should observe parallel Typing Mismatch Effects in *wh*-fronting and *wh*-in *situ* conditions.

**Participants**

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

**Materials and Design**

Twenty-four 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). The twenty-four sets of items were distributed among four lists in a Latin Square design. Each subject saw exactly one of the lists intermixed with forty-eight unrelated items in a random order.

In all four conditions a main clause subject NP marked with the topic-marker –wa was immediately followed by an embedded clause. A nominative-marked NP following the topic provided a strong cue for the onset of an embedded clause. The position of the embedded clause immediately after the main clause subject is fully natural in Japanese. Since Japanese is a verb-final language, the main clause verb appeared at the end of the sentence, following the embedded clause. In order to ensure that any reading time effects associated with the embedded verb would not be confounded with effects at the main verb, an adverbial phrase and a dative-marked NP separated the embedded verb from the main clause verb.

The only differences among conditions involved the position of the dative wh-phrase and the distribution of verbal affixes. In the in-situ conditions the wh-phrase immediately followed the subject of the embedded clause, and it appeared in sentence-initial position in the scrambled conditions. Note that scrambling of the wh-phrase has no effect on the interpretation of the sentences: the scope of the question is determined by the position of the question particle. In two conditions the embedded verb was marked with the question particle -ka and the main clause verb had declarative force (‘question particle conditions’), and in the remaining two conditions the distribution was reversed: the embedded clause was marked with the declarative complementizer –to and the main clause verb was marked with the question particle.

A number of further details of the materials are relevant. First, the wh-phrase was marked with dative case in order to ensure that it could receive a grammatical interpretation in either the main clause or the embedded clause. Second, 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. All of the embedded verbs were simple monotransitive verbs that do not require a dative-marked argument, but freely allow a dative-marked NP to be interpreted as the beneficiary of the action described. Third, a second dative-marked NP that appeared in pre-final position in all conditions was included to allow testing of a prediction of the gap-creation theory. If the fronted dative wh-phrase is preferentially interpreted in the main clause, then readers should be surprised to encounter a second dative-marked NP in the same clause, relative to in-situ conditions, in which the dative wh-phrase is unambiguously interpreted in the embedded clause.
One full set of experimental conditions is shown in (12). A full set of materials for this experiment can be found in Appendix 1.

(12)  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?'

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.'

*Procedure*

The experiment was conducted on Macintosh G3 computers running the *mw-run* software developed at MIT. Participants were timed in a phrase-by-phrase self-paced non-cumulative moving-window reading task (Just, Carpenter, & Woolley, 1982). All sentences, including the filler items, were presented on a single line. The segmentation indicated with spaces in (12) was the actual segmentation used in the presentation. The embedded complementizer or question
A verb 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 font Osaka 14. Stimulus segments initially appeared as a row of dashes, and participants pressed the space bar of the keyboard to reveal each subsequent region of the sentences. Note that although Japanese text is often displayed in vertical columns, horizontal presentation is also common, and is the most familiar mode of presentation when Japanese text is presented on a computer screen.

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. This task was adopted from Nagata (1993), and was the same task used in the studies by Miyamoto and Takahashi (2000, 2001, 2002c). This task was chosen due to the fact that half of the target sentences and a quarter of the fillers were themselves direct questions, thereby precluding the use of a standard yes/no comprehension question task. Visual feedback indicated whether the answer given was incorrect. All trials on which the comprehension question was answered incorrectly were excluded from further analysis. The experimental trials were preceded by two screens of instructions and five practice trials.

Data Analysis

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 in this study (n=26, 35%). We address the reasons for this high attrition rate in the discussion section and in Experiment 1B. 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.

Results

Comprehension accuracy and reading times at each region were entered into a repeated-measures ANOVA, with word order (scrambled, in-situ) and embedded complementizer type (declarative, question particle) as within-subjects factors.
Comprehension Task Accuracy

Among the 48 participants included in the analysis, average comprehension accuracy was 79.9%. The average correct response percentage did not differ significantly across the four conditions (all Fs<1). 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 participants tested in Japan (37.5%) were excluded than participants tested in the United States (24%).

Self-Paced Reading

The reading time analysis yielded the following results. Reading times for in-situ conditions are shown in Figure 1, and those for scrambled conditions are shown in Figure 2.

At all regions preceding the embedded verb (region 5), there were no significant differences between reading times in the declarative complementizer and question particle conditions within each level of the word order factor (all Fs<1). This is expected, since the conditions are identical up to region 4. Comparisons between the in-situ and scrambled conditions are inappropriate for these regions, since the lexical material differed across conditions.

At the embedded verb (Region 5), which included the critical declarative or interrogative affixes, 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 (F1(1,47)=10.53, MSe=155791, p<.005; F2(1,18)=8.74, MSe=221710, p<.01). In the analysis of word order type, there was a tendency for slower reading times in the in-situ conditions than in the scrambled conditions, but this tendency did not reach significance (F1(1,47)=0.78, MSe=195248, p=.38 F2(1,18)=2.37, MSe=251406, p=.14). There was no interaction of complementizer type and word order (Fs<1). Pairwise comparisons within each level of the word order manipulation yielded the following results. In the in-situ conditions, the declarative condition was read significantly more slowly than the question particle condition, although the effect was only marginally significant in the items analysis (F1(1,47)=4.74, MSe=161175, p<.05; F2(1,18)=2.87, MSe=305890, p=.11). In the scrambled conditions, the declarative complementizer condition was also read significantly more slowly than the question particle condition (F1(1,47)=4.64, MSe=188878, p<.05; F2(1,18)=8.0, MSe=133387, p<.05). This parallel pattern of results across in-situ and scrambled conditions indicates a Typing Mismatch Effect at the verb in the embedded clause, independent of the surface position of the wh-phrase.
The following regions all showed reading time patterns similar to region 5. At the main clause adverb (Region 6), there was a main effect of complementizer type, which was marginally significant both in the subject analysis and the item analysis \( (F_1(1,47)=3.83, \text{MSE}=132974, p=.05; F_2(1,18)=3.14, \text{MSE}=176221, p=.09) \). There was no significant main effect of word order or interaction (all \( Fs<1 \)). Pairwise comparisons within each level of the word order manipulation yielded the following results. In the in-situ conditions the declarative condition was read more slowly than the question particle condition; this effect was significant in the subject analysis \( (F_1(1,47)=4.13, \text{MSE}=101809.1, p<.05) \), but showed only a non-significant tendency in the same direction in the item analysis \( (F_2(1,18)=2.6, \text{MSE}=107438, p=.13) \). In the scrambled conditions, on the other hand, there was no significant difference between the declarative condition and the question particle condition \( (F_1<1; F_2(1,18)=1.4, \text{MSE}=213457, p=.26) \), although there was again a tendency for slower reading times in the declarative condition.

At the main clause dative-marked NP (Region 7) there was a main effect of complementizer type, which was significant in the subject analysis and marginally significant in the item analysis \( (F_1(1,47)=6.01, \text{MSE}=105418, p<.05; F_2(1,18)=4.1, \text{MSE}=227982, p=.06) \). The main effect of word order was marginally significant in the subject analysis \( (F_1(1,47)=3.79, \text{MSE}=97656.6, p=.06) \), due to longer reading times for the scrambled condition, and showed a non-significant tendency in the same direction in the item analysis \( (F_2(1,18)=2.64, \text{MSE}=98312.5, p=.12) \). There was no interaction \( (Fs<1) \). Pairwise comparisons within each level of the word order manipulation yielded the following results. In the in-situ conditions, the declarative condition was read marginally more slowly than the question particle condition \( (F_1(1,47)=3.11, \text{MSE}=68272.7, p=.08; F_2(1,18)=1.31, \text{MSE}=180872, p=.27) \). In the scrambled conditions, the declarative condition was again read more slowly than the question particle condition; this effect was only marginally significant in the subject analysis \( (F_1(1,47)=3.5, \text{MSE}=125882, p=.07; F_2(1,18)=4.19, \text{MSE}=185008, p=.06) \).

At the sentence-final main verb (Region 8) there was a main effect of complementizer type \( (F_1(1,47)=8.82, \text{MSE}=136494, p<.01; F_2(1,18)=6.1, \text{MSE}=193193, p<.05) \), again due to slower reading times for declarative conditions. The main effect of word order was marginally significant in the subject analysis, and did not reach significance in the item analysis \( (F_1(1,47)=3.04, \text{MSE}=136491, p=.08; F_2<1) \). There was no significant interaction of complementizer type and word order \( (F_1(1,47)=2.21, \text{MSE}=136494, p=.14; F_2(1,18)=2.0, \text{MSE}=193193, p=.16) \). However, pairwise comparisons within each level of the word order manipulation revealed a clear contrast. The in-situ conditions showed no effect of complementizer type \( (F_1(1,47)=1.38, \text{MSE}=120997, p=.24; F_2<1) \), but the scrambled conditions showed a clear effect of
complementizer type, due to longer reading times for the declarative condition \( F_1(1,47)=8.61, \text{MSe}=148223, p<.005; F_2(1,18)=7.46, \text{MSe}=212212, p<.01). \)

![In-situ](image1)

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

![Scrambled](image2)

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

Discussion

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 Typing Mismatch Effect in the in-situ conditions replicated Miyamoto and Takahashi’s results for the processing of wh-phrases, and extended their finding to the processing of non-subcategorized
wh-phrases. The Typing Mismatch Effect presumably occurs because readers expect to encounter a question particle as soon as possible after the thematic position of a wh-phrase. The parallel observation of a Typing Mismatch Effect 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. This reasoning follows from the grammatical requirement that wh-scope positions c-command thematic positions in Japanese. 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. This also suggests that readers ultimately interpret fronted wh-phrases as indirect questions. The finding that fronted wh-phrases are preferentially interpreted in the embedded clause clearly supports the prediction of the interpretation-driven theory of parsing wh-expressions.

Figure 3 illustrates the parallelism in patterns of reading time slowdown at the embedded verb. As predicted, a significant parallelism is observed between the wh-in-situ and the wh-scrambled structures in terms of the difference in reading time patterns at the embedded verb. In both structures, readers take a longer time to read the embedded verbs affixed by a declarative complementizer than to read those affixed by a Q-particle.

Figure 3: Experiment 1A, Reading times at the embedded verb (Region 5)

We also observed slower reading times in the declarative complementizer conditions at regions 6-8. It is likely that this reflects 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 test of whether readers interpret the fronted dative *wh*-phrase in the main clause or the embedded clause. If readers preferentially interpret the fronted *wh*-phrase in the main 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 in-situ conditions, since the thematic position of the *wh*-phrase is unambiguously inside the embedded clause. Also, there should be no slowdown in the question particle/scrambled condition, since the question particle in Region 5 in this condition provides a strong cue that the thematic position of the *wh*-phrase is inside the embedded clause. However, since the results show a slowdown in both declarative complementizer conditions, relative to their corresponding question particle conditions, we consider it more likely that the slowdown at Region 7 reflects a spillover from Region 5, rather than an effect of interpreting the fronted *wh*-phrase in the matrix clause. Note that in the region following the second dative-marked NP (Region 8) pairwise comparisons revealed that the main effect of complementizer type was primarily due to a slowdown in the declarative-scrambled condition. We cannot at this point exclude the possibility that this slowdown reflected a delayed surprise effect due to the second dative-marked NP, rather than the continued effect of the disruption in Region 5, although the results of Experiment 1B favor the second of these interpretations.

Although the results of this experiment support the predictions of the interpretation-driven theory, there are also some concerns with the results. First, there were many participants who showed low accuracy on the comprehension task, and there were also a number of items that yielded low comprehension accuracy. The low comprehension accuracy may have been due to the fact that participants found the subject-verb matching task with the filler items too easy, leading them to be over-confident in target trials (overall accuracy: Target 73.6% vs. Filler 90.7%, n=72). Additionally, it is possible that some participants had difficulty understanding the concept of ‘subject’, which was necessary in order to perform the task. Second, a substantial proportion of the Japanese speakers included in the study (18/48) were resident in the United States and were highly proficient users of English. It might be objected that the results could have been affected by these speakers’ familiarity with *wh*-fronting constructions in English. Experiment 1B is a replication study that was run specifically to address these concerns, and to verify the robustness of the results observed in Experiment 1A.

**Experiment 1B**

This experiment was designed to confirm the results of Experiment 1A, while also addressing concerns about comprehension accuracy and participant
backgrounds from the first experiment. The materials, design, and procedure in Experiment 1B were identical in format to those used in Experiment 1A, except in the following respects. First, items that yielded very low comprehension accuracy in Experiment 1A were replaced (n=6). Second, the length and difficulty of the 48 filler items was modified, so as to more closely match the complexity of the experimental items. Third, in order to address the possibility that some participants had difficulty understanding the subject-verb matching comprehension task, prior to the self-paced reading task, we added an off-line practice session for answering comprehension questions of the type used in the on-line experiment. Since the aim of the practice session was simply to ensure that participants were familiar with the concept of ‘subject’, we included only two instances of wh-scrambling among the 20 practice sentences.

Participants

Fifty-seven native speakers of Japanese participated in the experiment. All of them were students either at Shizuoka University or at Shizuoka Sangyo University, Japan. They were paid the equivalent of $5.00 for their participation in the experiment, which lasted about 30 minutes.

Data Analysis

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 80% in total were discarded. 7 participants failed to meet this criterion (12%). Items for which accuracy among the remaining subjects was below 65% were also excluded (n=3). Reading times longer than 3000ms were discarded. This procedure affected 2.85% of trials. The means and analyses presented below are based on the remaining trials.

Results

Comprehension accuracy and reading times at each region were entered into a repeated-measures ANOVA, with word order (scrambled, in-situ) and embedded complementizer type (declarative, question particle) as within-subjects factors.
Comprehension Accuracy

Among the 50 participants included in the analysis, average comprehension accuracy was 88.4%. Based upon the fact that in this study many fewer participants needed to be rejected, and overall error rates were cut almost in half, we can conclude that the low accuracy scores in Experiment 1A reflected design artifacts rather than problems with the experimental items themselves. Mean accuracy scores did not differ significantly across the four conditions (all Fs<1).

Self-Paced Reading

The reading time analysis yielded the following results. Reading times for in-situ conditions are shown in Figure 4, and those for scrambled conditions are shown in Figure 5.

At all regions prior to the fifth region, there were no significant differences between reading times in the declarative complementizer and question particle conditions (all Fs<1). Comparisons between the in-situ and scrambled conditions are inappropriate for these regions, since the lexical material differed across conditions.

At the following regions we again observed a Typing Mismatch Effect, reflected in longer reading times for declarative complementizers than question particles, in both in-situ and scrambled word orders. In this respect, the results closely parallel Experiment 1A. However, due to the fact that the reading-time slowdowns were more short-lived than in Experiment 1A, and appeared earlier in one word order than the other, the pattern of statistical results appears different from Experiment 1A.

At the embedded verb (Region 5), there was no significant main effect of either complementizer type ($F_1<1$; $F_2(1,20)=2.5$, MSe=148942, p=.13) or word order type ($F_1(1,49)=1.1$, MSe=224462, p=.32; $F_2(1,20)=2.52$, MSe=168329, p=.13). When word-order conditions are combined, embedded verbs with declarative complementizers were read 31 milliseconds slower than embedded verbs with question particles. However, there was a significant interaction of the two main effects, seen in the subject analysis ($F_1(1,49)=5.38$, MSe=118612, p<.05), but not in the item analysis ($F_2<1$). Pairwise comparisons revealed that within the scrambled conditions declarative conditions were read more slowly than question particle conditions; this effect was significant in the participants analysis and marginally significant in the items analysis ($F_1(1,49)=5.42$, MSe=124402, p<.05; $F_2(1,20)=3.11$, MSe=190840, p=.09). On the other hand, the same comparison for the in-situ conditions showed no corresponding slowdown (all Fs<1).
At the main clause adverb (Region 6) there was no main effect of either complementizer type or word order type (all Fs<1). There was a marginally significant interaction ($F_1(1,49)=3.74$, MSe=115769, $p=.06$; $F_2(1,20)=3.46$, MSe=167599, $p=.07$). However, pairwise comparisons within each level of the word order factor revealed the mirror image of the results at Region 5. There was a significant slowdown in reading times for declaratives in the in-situ conditions ($F_1(1,49)=4.08$, MSe=162058, $p<.05$; $F_2(1,20)=3.89$, MSe=200673, $p=.06$), but no corresponding slowdown in the scrambled conditions (all Fs<1). Therefore, a Typing Mismatch Effect appears in both in-situ and scrambled conditions, but it appears one word later in the in-situ conditions.

At the main clause dative NP (Region 7) there was no main effect of complementizer type or word order (all Fs<1). The interaction was marginally significant in the subject analysis ($F_1(1,49)=2.87$, MSe=68395.1, $p=.09$; $F_2<1$). At the sentence-final main verb (Region 8) there was a marginal main effect of complementizer type ($F_1(1,49)=4.0$, MSe=120355, $p=.05$; $F_2(1,20)=2.63$, MSe=129773, $p=.12$). There was no main effect of word order ($F_1(1,49)=1.37$, MSe=99312.3, $p=.25$; $F_2<1$), and no interaction of complementizer and word order type (all Fs<1).

Figure 4: Experiment 1B  Reading times per region for the in-situ conditions (NP-top$^1$ NP-nom$^2$ Wh-dat$^3$ NP-acc$^4$ V-DeclC/Q$^5$ Adverb$^6$ NP-dat$^7$ V-Q/8)
Figure 5: Experiment 1B  Reading times per region for the scrambled conditions. (Wh-dat$_1$ NP-top$_2$ NP-nom$_3$ NP-acc$_4$ V-DeclC/Q$_5$ Adverb$_6$ NP-dat$_7$ V-Q/.$_8$)

Discussion

Experiment 1B was successful both in obtaining consistently high comprehension accuracy and in replicating the finding of a Typing Mismatch Effect in both in-situ and scrambled conditions. As in Experiment 1A we assume that the embedded verb triggers slower reading times in the declarative conditions because readers expect to encounter a question particle as soon as possible after the thematic position of a wh-phrase. In the scrambled conditions, this expectation could only arise in the embedded clause if readers create a gap-site in the embedded clause, given the requirement that wh-scope positions c-command thematic positions. The higher accuracy scores in this experiment indicate that the low accuracy observed in Experiment 1A was due to extraneous factors. Also, since all of the participants in Experiment 1B were resident in Japan, we can also exclude the possibility that the results of Experiment 1A might somehow be due to the high English proficiency of many of the participants.

The main contrast between the results of Experiment 1A and Experiment 1B is that the Typing Mismatch Effect was shorter-lived, appearing at one region only, and was slightly delayed in the in-situ conditions, appearing at the adverb immediately following the embedded verb. Although the Typing Mismatch Effect appeared after the embedded verb in the in-situ conditions, we see no reason not to assume that this effect was caused by the complementizer type on the embedded verb. It is common in studies using the self-paced reading paradigm to observe effects that are delayed by one or more regions, and we are aware of no
reason why the adverb itself should elicit slower reading times in the declarative condition. The fact that the slowdowns in reading times were shorter-lived in this study may be a corollary of the improved comprehension accuracy. By reading targets and fillers more cautiously, participants may have been able to correct errors more immediately.

Taken together, the results of Experiments 1A and 1B confirm the prediction of the interpretation-driven theory of the processing of long-distance dependencies, and indicate that Japanese speakers preferentially interpret a fronted $wh$-phrase inside the most deeply embedded clause. This finding argues against incremental models that assume that gap-creation is an end in itself, as predicted by the AFS. Due to the use of dative-marked $wh$-phrases and monotransitive verbs, it is likely that this effect is due not to the lexical argument structure requirements of the embedded verb, but rather reflects the requirement of the $wh$-phrase to receive a thematic interpretation. However, as discussed in the Introduction, the preference to interpret the fronted $wh$-phrase in the embedded clause might also be explained by a head-driven (delay) model or by a direct association model, because in both cases the first verb provides the first opportunity in the sentence to construct a $wh$-dependency. In light of these alternative explanations of the results, Experiment 2 sets out to examine the time-course of $wh$-dependency formation in more detail. The results of Experiments 1A and 1B also have implications for theories of reanalysis; we will address this issue in the General Discussion section.

**Experiment 2**

Building upon the finding in Experiment 1 that fronted $wh$-phrases in Japanese are preferentially associated with the most deeply embedded clause, Experiment 2 was designed with the goal of investigating the time-course of this association process. This time-course information is important, in order to distinguish among different possible accounts of what drives this 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. In fact, a direct association account of $wh$-dependency formation would predict that association with the embedded clause could only take place at the verb, since under this approach the fronted $wh$-phrase forms a dependency directly with the verb. Alternatively, the fronted $wh$-phrase may be associated with the embedded clause before the embedded verb is processed. Such a scenario would be possible under a theory in which the fronted $wh$-phrase is associated with a gap in a pre-verbal argument position in the embedded clause, rather than directly associated with the verb. Note, however, that the ‘indirect association’ approach does not automatically entail that filler-gap dependencies
are computed in advance of the verb in a head-final language such as Japanese. For example, the ‘head-driven’ approach to parsing Japanese (Pritchett, 1991b; Mulders, 2002) assumes the existence of pre-verbal gaps, but also assumes that structure-building is delayed until the verb is processed.

This experiment adapted the ‘filled gap’ paradigm (Crain & Fodor 1985; Stowe 1986; Clifton & Frazier 1989) for Japanese, in order to test whether filler-gap dependencies are created in advance of the verb in Japanese embedded clauses. In studies on English, the Filled Gap Effect is a surprise effect that is elicited when readers encounter an overt NP in a post-verbal position where a gap was anticipated. The Japanese equivalent should also involve an overt NP in a position where a gap was anticipated, but this position should appear in prior to the verb.

Participants

Forty-one native speakers of Japanese participated in the experiment. All of them were students either at the University of Maryland, USA (n=23), or at Shizuoka University or Shizuoka Sangyo University, Japan. They were paid $5.00 or its equivalent for their participation in the experiment, which lasted about 30 minutes.

Materials and design

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. (13) shows one set of conditions used in the experiment. In both conditions the two main clause NPs at the start of the sentence were followed by an embedded clause that contained an overt dative-marked NP. The verb of the embedded clause was marked with a declarative complementizer, and the verb of the main clause with a question particle, indicating that the sentence had the force of a direct question.

In both conditions, the dative NP in the embedded clause was the second dative NP in the sentence. However, in the scrambled condition (13a) the dative wh-phrase 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. This surprise effect would be the Japanese equivalent of the Filled Gap Effect (Stowe 1986).
In the control condition (13b) the two sentence-initial NPs are matched to the scrambled condition in the respect that there is one *wh*-phrase and one dative NP. However, in this condition there is no expectation that either of these NPs should be associated with the embedded clause. First, the sentence-initial nominative *wh*-phrase cannot be associated with the embedded clause, since nominative NPs in Japanese cannot be scrambled (Miyara 1982; Saito 1985; Takezawa 1987; Nemoto 1999). Second, the dative NP in second position should be interpreted in-situ, and should not be interpreted as if it were scrambled from the embedded clause, according to the results of Kamide & Mitchell (1999), who investigated the processing of dative-marked NPs in Japanese in very similar positions. Therefore, the second dative NP in (13b) should be understood 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 NP, just as they do in the scrambled condition.

The twenty sets of items were distributed in a Latin Square design, creating two lists. Each subject saw one of the lists intermixed with sixty unrelated filler items in a random order.

(13) a.  
**Scrambled condition**
Dono-syain-ni senmu-wa syacyoo-ga
*Which employee-dat managing director-top president-nom*
kaigi-de kacyoo-ni syookyuu-o yakuokusita-to
*meeting-at assistant manager-dat raise-acc promised-DeclC*
iimasita-ka?
told-Q

‘To which employee did the managing director tell that the president promised a raise to the assistant manager at the meeting?’

b.  
**Control condition**
Dono-syain-ga senmu-ni syacyoo-ga
*Which employee-nom managing director-dat president-nom*
kaigi-de kacyoo-ni syookyuu-o yakuokusita-to
*meeting-at assistant manager-dat raise-acc promised-DeclC*
iimasita-ka?
told-Q

‘Which employee told the managing director that the president promised a raise to the assistant manager at the meeting?’
Procedure

The self-paced reading procedure and the comprehension task were identical in format to that used in Experiment 1.

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=7, 17%). Reading times longer than 2500ms were discarded. This procedure affected 2.8% of trials. The means and analyses presented below are based on the remaining trials.

Results

Comprehension accuracy and reading times at each region were entered into a repeated-measures ANOVA, with word order (scrambled, control) as the within-subjects factors.

Comprehension Task Accuracy

Among the subjects who were included in the analysis, average comprehension accuracy was 86.3%. 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 (87.3%) and those who live in Maryland, USA (85.2%) (F<1).

Self-Paced Reading

Reading times for all regions are shown in Figure 6. At all regions except the third and fifth regions there were no significant differences between reading times in the scrambled and control conditions (all Fs<1).

At the embedded nominative subject NP in Region 3 the control condition was read more slowly than the scrambled condition; this effect was significant in the participant analysis and marginally significant in the items analysis (F1(1,33)=5.92, MSe=290485 p<.05; F2(1,19)=2.99, MSe=312139, p=.08).

At the dative NP in region 5 there was a significant difference between the two conditions (F1(1,33)=11.4, MSe=102598, p<.005; F2(1,19)=6.4, MSe=128504, p<.05), due to reading times that were 83 milliseconds slower in
the scrambled condition than in the control condition. There were no other observed significant differences.

![Graph of reading times per region](attachment:image.png)

**Figure 6 Reading times per region**

(Scramble: Wh-dat, NP-top, NP-nom, Adv, NP-dat, NP-acc, V-DeclC, V-Q)

(Control: Wh-nom, NP-dat, NP-nom, Adv, NP-dat, NP-acc, V-DeclC, V-Q)

**Discussion**

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, which does not appear until Region 7. The embedded dative NP is read more quickly in the control condition, because the other dative NP in that sentence is, by assumption (cf. Kamide & Mitchell 1999) interpreted in the main clause. 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.

We assume that the slower reading time in the control condition at Region 3 reflects the cost of the consecutive nominative-marked subject NPs (Miyamoto, 2002), as opposed to the scrambled condition, where the two subject NPs were marked with a topic marker and a nominative marker, respectively. 18% of trials
recorded in this region were slower than the 2500ms cut-off, and hence had to be discarded (compared to a 2.8% rejection rate overall). This implies that readers read the second nominative subject NP particularly slowly. Note that this difficulty did not extend beyond Region 3, and reading times for the two conditions were closely matched by Region 4.

One remaining concern with our results involves our assumption that participants clearly recognized that the target items in Experiments 1 and 2 required an embedded clause analysis as soon as the embedded clause subject was read. In both experiments the critical items began with a sequence of three animate NPs as in (14a). Although it is quite natural to analyze the nominative-marked NP as the subject of an embedded clause (14b), this is not the only possible continuation of the sentence, since the topic-marked NP in second position could potentially be a direct object NP (14c), or the nominative-marked NP could be the object of the special class of Japanese verbs that allows nominative objects (14d).

(14)  a.  wh-NP-dat NP-top NP-nom …

    b.  Dare-ni John-wa Mary-ga kooen-de atta-to omotteiru-no?
        Who-dat John-top Mary-nom park-at met-Comp thinks-Q
        ‘Who does John think that Mary met at the park?’

    c.  Dare-ni John-wa Mary-ga syokaisita-no?
        Who-dat John-top Mary-nom introduced-Q
        ‘Who did Mary introduce John to?’

    d.  Dare-ni John-wa Mary-ga syokai-dekiru-no?
        Who-dat John-top Mary-nom introduce-can-Q
        ‘Who can John introduce Mary to?’

Experiments 1 and 2 were predicated upon the assumption that the bi-clausal parse would be the preferred analysis, and that this preference should be enhanced by the use of animate NPs for both the topic-marked and the nominative-marked NP. However, it is important to validate this assumption.

**Experiment 3**

An off-line sentence completion test was conducted in order to examine the assumption that Japanese readers prefer to give a bi-clausal analysis to sequences of NPs appearing in the order dative-topic-nominative, as in the critical items in Experiments 1 and 2. If speakers provide bi-clausal completions to
sentence fragments consisting of dative-topic-nominative sequences, then it is reasonable to also assume that the participants in Experiments 1 and 2 also gave bi-clausal analyses to the sentence-initial NPs in the on-line studies.

Participants

Sixty-eight native speakers of Japanese participated in the experiment. All of them were students at Meiji Gakuin University, at the University of Tokyo, or at Kanda University of International Studies, Japan. The experiment lasted about 20 minutes.

Materials and Design

Experimental materials consisted of twelve sets of four conditions each, in a 2 x 2 factorial design, which manipulated the distribution of case morphemes (topic-nominative vs. nominative-nominative) and the position of the dative wh-phrase (scrambled vs. in-situ). (15) shows one set of conditions used in the experiment. The fragments in all conditions consisted of a dative-marked wh-phrase, two referential NPs, and an adverbial phrase. All of the fragments consisted only animate NPs. We manipulated the case of the first referential NP (topic marker –wa vs. nominative marker –ga), because both forms were used in our on-line studies, and in order to allow comparison with the on-line results of Miyamoto (2002), which shows that nominative-nominative sequences are preferentially analyzed as bi-clausal structures. We manipulated the position of the wh-phrase in order to examine whether the position of the wh-phrase affects the frequency of completions in which speakers place a question particle in the embedded clause.

(15)  a. Dono sinnyuusei-ni tannin-wa sisyo-ga tosyositu-de ...
    *which new student-dat class teacher-top librarian-nom library-at*

    b. Dono sinnyuusei-ni tannin-ga sisyo-ga tosyositu-de ...
    *which new student-dat class teacher-nom librarian-nom library-at*

    c. Tannin-wa sisyo-ga tosyositu-de dono sinnyuusei-ni ...
    *class teacher-top librarian-nom library-at  which new student-dat*

    d. Tannin-ga sisyo-ga tosyositu-de dono sinnyuusei-ni ...
    *class teacher-nom librarian-nom library-at  which new student-dat*
The phrases used in the fragments were taken from the target items used in Experiment 2. The twelve sets of items were distributed among four lists in a Latin Square design. Each subject saw exactly one of the lists intermixed with twenty-four unrelated items in a random order. The filler items were designed in such a way that speakers would be likely to give similar numbers of mono-clausal and bi-clausal completions, in order to offset the danger of a structural priming effect that might lead participants to use the same structure in all completions.

**Results and Discussion**

The completions were classified according to the number of clauses used to complete the sentence fragment, and according to the position of question markers that indicate the scope of the *wh*-phrase. Completions were classified as multi-clause responses if more than one verb was provided. Responses were classified as embedded (i.e. indirect) questions if exactly one question marker was provided, affixed to an embedded verb. Other possible responses placed the question marker on the main verb (direct question), or placed a question marker on main and embedded verbs (‘both’). Results are shown in Table 1.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Multi</th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
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<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td><em>Top-Nom, fronted</em></td>
<td>193</td>
<td>99.0</td>
<td>2</td>
<td>1.0</td>
<td>106</td>
<td>54.4</td>
<td>66</td>
<td>33.8</td>
<td>23</td>
</tr>
<tr>
<td><em>Nom-Nom, fronted</em></td>
<td>172</td>
<td>94.5</td>
<td>10</td>
<td>5.5</td>
<td>75</td>
<td>41.2</td>
<td>78</td>
<td>42.9</td>
<td>29</td>
</tr>
<tr>
<td><em>Top-Nom, in-situ</em></td>
<td>193</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>190</td>
<td>98.4</td>
<td>3</td>
<td>1.6</td>
<td>0</td>
</tr>
<tr>
<td><em>Nom-Nom, in-situ</em></td>
<td>184</td>
<td>97.9</td>
<td>4</td>
<td>2.1</td>
<td>183</td>
<td>97.3</td>
<td>5</td>
<td>2.7</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1: Experiment 3, Classification of sentence completions according to clause-number and question-type.

Participants provided completions for the sentence fragments on 92.9% of the trials (758 trials). Of these, 97.9% were multi-clausal (742 trials). The proportion of multi-clause completions was above 94% in all conditions. In the critical condition containing a scrambled *wh*-phrase followed by a topic and a nominative NP, 99.0 % of responses were multi-clause completions. Fisher Exact tests were used, in order to determine whether any of the small differences among conditions were reliable. Although mono-clausal completions were rare for all conditions, they were more common in scrambled than in in-situ conditions (p<.05, 2-tailed). Pairwise comparisons showed that among the scrambled conditions mono-clausal completions were less common for topic-nominative fragments than for nominative-nominative fragments (p<.05, 2-tailed), and that
there was a marginally significant tendency in the same direction among the in-situ conditions (p<.06, 2-tailed).

In the analysis of question-type, overall 72.8% of sentence fragments (554 trials) were completed as indirect questions, with a question marker on an embedded verb only. Once trials are added in which participants provided a question marker in both clauses, the number of embedded clause responses rises to 81.7%. Fisher Exact tests were used, in order to determine whether the differences among conditions were reliable. Since our primary interest was in the question of whether a question particle was produced on an embedded verb, we combined the ‘embedded clause only’ and ‘both clauses’ categories for purposes of this analysis. Results showed a highly reliable effect of word order (p<.0001, 2-tailed), due to many fewer main clause question particles in the in-situ conditions. Pairwise comparisons within each level of the word-order factor showed no significant effect of case marker, although among the scrambled conditions there was a marginally significant tendency for more embedded question particles in the topic-nominative condition (p<.09, 2-tailed).

Although more embedded question responses were provided in the in-situ conditions, it is important to note that in the critical conditions with fronted wh-phrases that began with a dative-topic-nominative sequence, 66.4% of sentence completions contained a question marker in an embedded clause.

The main result of this experiment is that Japanese readers have a strong preference to analyze the nominative-marked NP as the subject of an embedded clause in a dative-topic-nominative sequence. Therefore, it is safe to assume that participants in Experiments 1 and 2 also recognized that the target items required an embedded clause analysis as soon as the embedded clause subject was read.

This study also shows that in sentences that began with a fronted wh-phrase, participants mostly provided completions with a question marker attached to the embedded verb (i.e. indirect questions). This finding corroborates the reading-time results presented in Experiments 1 and 2, and shows further evidence that Japanese speakers have a strong propensity to interpret fronted wh-phrases inside an embedded clause.

**General Discussion**

*Processing of Filler-Gap Dependencies*

The goal of this paper was to take advantage of the word-order properties of Japanese to better understand the mechanisms that guide the real-time formation of long-distance dependencies. The strict verb-final property of Japanese has the effect that more deeply embedded verbs appear before the structurally highest verbs in a sentence. This property allows testing of a
prediction of theories that claim that the formation of long-distance dependencies is driven by the satisfaction of syntactic and semantic constraints, rather than simply by the need to create a gap. Such theories predict that a fronted phrase will be preferentially interpreted with a more deeply embedded verb in configurations where the more deeply embedded verb appears earlier in the sentence. This prediction amounts descriptively to the opposite of a robust generalization about the processing of verb-medial languages like English. In English it is consistently found that fronted wh-phrases are preferentially interpreted with the verb in the clause that contains the wh-phrase.

Experiments 1A and 1B both showed that Japanese readers demonstrate a clear parallelism between the processing of wh-questions in which the wh-phrase is scrambled to the front of the main clause and wh-questions in which the wh-phrase is in-situ in an embedded clause. In both configurations, participants read embedded verbs more quickly if they were marked with question particles than if they were marked with a standard declarative complementizer. The results for in-situ wh-phrases replicate and extend the finding of Miyamoto & Takahashi (2000, 2001, 2002c) that Japanese readers expect to encounter a question particle on the verb of a clause that contains an in-situ wh-phrase. The parallel results for fronted wh-phrases indicate that readers treat the fronted wh-phrase as if it has been scrambled from the embedded clause, and therefore anticipate a question particle on the embedded clause verb.

Experiment 2 also showed that Japanese readers preferentially interpret a fronted wh-phrase in an embedded clause, based on a Japanese version of the Filled Gap Effect (Crain & Fodor, 1985; Stowe, 1986) that made it possible to see that participants formed wh-dependencies with the embedded clause before they encounter the embedded clause verb.

Experiment 3 used an off-line sentence completion task to verify that Japanese speakers show an overwhelming bias to interpret the sequences of NPs that appeared at the start of our key items as part of a bi-clausal structure. This lends support to our assumption that when readers form a wh-dependency after the embedded clause subject, they are doing so in the context of a structure that is already bi-clausal. This study also showed that when Japanese speakers complete sentence fragments that begin with a fronted wh-phrase, they spontaneously produce a question particle on the embedded clause verb in two-thirds of trials.

Taken together, therefore, our results indicate that readers create a gap in the embedded clause before they encounter the embedded verb, and hence prefer to associate a fronted wh-phrase with an embedded clause. This means that the wh-phrase is related not to the structurally highest verb with which the first possible gap position would be associated (i.e. the main clause verb), but instead to the first verb that readers encounter (i.e. the embedded verb). Crucially, the parser seems to allow enough structure in the embedded clause to allow
immediate interpretation of the displaced constituent. The embedded clause preference could not be due to the argument structure of the embedded verb, since we only used embedded verbs that do not require a dative-marked complement, and since Experiment 2 showed that the *wh*-dependencies are formed in advance of the embedded verb, and Experiment 3 left the choice of verb to the participants. Furthermore, it is unlikely that the embedded clause preference reflects a grammar-blind mechanism that associates a *wh*-phrase with the closest verb, regardless of whether this is grammatically possible: recall that Miyamoto & Takahashi (2002c) showed that nominative-marked *wh*-phrases in Japanese, which are known to resist scrambling, do not give rise to a Typing Mismatch Effect on the immediately following verb, if that verb is in a more deeply embedded clause.

The preference to associate fronted *wh*-phrases with an embedded clause is unexpected if the formation of *wh*-dependencies is driven simply by the requirement to create a gap position as soon as possible, as predicted by the Active Filler Strategy and related approaches (Frazier & Clifton, 1989; de Vincenzi, 1991). As explained in the introduction, the AFS predicts that Japanese readers should be able to posit a gap for a fronted *wh*-phrase in the first possible position, following the main clause subject. A gap in this position would satisfy the AFS. In addition, this would leave no reason to revise this analysis once the embedded clause is encountered, since an embedded clause gap site would be more distant from the surface position of the *wh*-phrase, under any measure of linear or hierarchical distance.

On the other hand, the finding of an embedded clause preference for fronted *wh*-phrases confirms a striking prediction of 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. This view can be found in both gap-based and direct association models of long-distance dependencies. However, based on the evidence from Experiment 2 that Japanese speakers form *wh*-dependencies in the embedded clause before they reach the embedded verb, we concluded that the results favor an incremental, gap-based model of long-distance dependencies over models that assume that dependencies cannot be created until the verb position, due to direct association or to head-driven structure-building.

It is important to note that in the interrogative structures tested in our studies, two independent grammatical requirements can be satisfied at the position of the embedded verb. First, the thematic interpretation of the *wh*-phrase can be fixed by the verb. Second, the scope interpretation of the *wh*-question can be fixed by the presence of a question-marker affixed to the verb. Therefore, our results do not allow us to conclude that formation of *wh*-dependencies is driven specifically by the need to satisfy thematic requirements. Our results could be due to thematic
requirements, scope-fixing requirements, or both. In order to determine whether thematic requirements are sufficient to give rise to an embedded clause interpretation preference, it would be necessary to conduct additional studies involving scrambled non-interrogative phrases.

It is also important to clarify the relationship between our findings and theories that argue that the processing of filler-gap dependencies is driven by the need to minimize the consumption of resources in working memory or in a specialized resource pool for sentence processing (Just & Carpenter, 1992; Gibson, 1998; Caplan & Waters, 1999). First, it should be noted that such models do not replace grammatical requirements with working memory metrics – rather, they use grammatical requirements such as thematic and scope relations as the currency of memory cost calculations. Second, it is possible to implement a version of either the position-based AFS approach or the interpretation-driven approach in memory-based models, depending on the specific representational assumptions adopted. For example, if cost were calculated in terms of whether a displaced constituent is held working memory or structurally linked to a gap position, then this theory would make the same predictions as the AFS, and would make incorrect predictions for Japanese. Alternatively, if cost were calculated in terms of whether a displaced constituent has been entered into the compositional interpretation of the sentence, then it could be argued that 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. Such an approach could account for our findings about Japanese. It should be clear, however, that such an approach is a specific implementation of the view that long-distance dependency formation is driven by syntactic and semantic constraints, rather than an alternative to this view.

Finally, our results bear on the eliminative program that has informed much recent work in constraint-based processing. This work has shown that much of the psycholinguistic data previously attributed to general grammatical constraints such as the Theta Criterion, or other interpretive principles, was in fact more correctly attributable to stochastically conditioned constraints stored with a lexical item. Taken to its logical conclusion, this suggests elimination of these general constraints in favor of conditions that track the frequency with which a lexical item appears in one construction or in one form over another. The Japanese case is interesting in this regard. Experiment 2 in particular, suggests that a wh-element is interpreted as the indirect object of a clause without reference to how frequently any particular item appears as the indirect object of any particular verb, since the Filled Gap Effect occurs before readers encounter the embedded verb. This favors an approach that incorporates the drive for early interpretation as a direct constraint, independent of the statistical or selectional
properties of individual verbs, and so can apply even before the verb that checks the interpretive features is accessed. A similar argument is presented by Drury, Resnik, Weinberg, Gennari, & Aoshima (2002), based on evidence from reciprocal verbs in English. Furthermore, a construction-based stochastic constraint in the sense of Jurafsky (1996) is also unlikely to capture our findings about Japanese. One might argue that scrambled dative NPs are frequently indirect objects, allowing them to be placed inside a VP before the head verb is encountered. However, this would predict a gap site in the highest clause, as this is the first opportunity to satisfy this purely syntactic fact about this construction. In order to account for the creation of a gap inside the embedded clause, we must appeal to the additional interpretive benefits that result from positing an embedded clause gap.

*Unforced Reanalysis*

This section discusses the implications of our findings in Japanese for theories of reanalysis in sentence processing. We can briefly summarize the puzzle that our results present as follows. Although we have focused on the ultimate embedded clause interpretation of fronted *wh*-phrases, our results also imply that Japanese readers arrive at this analysis after first considering a single-clause analysis, in which the *wh*-phrase is associated with a gap site in the main clause. This in turn means that in order to arrive at the ultimate embedded clause gap analysis, Japanese speakers must carry out an *unforced* reanalysis. By unforced reanalysis, we mean a revision that is not licensed by any incompatibility of the initial analysis of the parse with subsequent material. There are grammatical continuations of bi-clausal sentences like (13) where the initial *wh*-element remains interpreted in the matrix clause. This finding contrasts with a number of recent studies that have argued that reanalysis is a last resort operation, that is undertaken only when necessary. This apparent discrepancy demands an account of when unforced reanalysis is and is not possible.

There are two reasons to think that Japanese readers consider a main clause gap analysis. First, the Filled Gap Effect observed in Experiment 2 indicates that a gap was posited in the embedded clause, in advance of the verb in that clause. By parity of reasoning, it should be assumed that a similar commitment was made in the main clause, in advance of the verb in that clause and before any embedded clause material was encountered. Thus, (16a) illustrates the first gap site that the parser commits to. When the parser incrementally builds a VP structure after the main clause subject NP, a gap is created for the dative *wh*-phrase in the VP structure. However, the results of Experiments 1 and 2 also show that the parser’s ultimate analysis involves an embedded clause gap. This means that the first gap in (16b) must be canceled. This implies that unforced
reanalysis takes place in this configuration. The reanalysis is unforced, since it would be fully grammatical to maintain the analysis in which the *wh*-phrase is associated with a gap site in the main clause.

(16)  

\begin{align*}
\text{(a)} & \quad \begin{array}{c}
\text{CP} \\
\text{WH-nt} \\
\text{S} & \text{C} \\
\text{NP-wa/ga} & \text{VP} \\
\text{gap} & \text{V}
\end{array} \\
\text{(b)} & \quad \begin{array}{c}
\text{CP} \\
\text{WH-nt} \\
\text{S} & \text{C} \\
\text{NP-wa} & \text{VP} \\
\text{gap} & \text{V} \\
\text{CP} & \text{V} \\
\text{NP-ga} & \text{VP} \\
\text{gap} & \text{V}
\end{array}
\end{align*}

The second reason to assume that the parser first constructs a main clause gap site comes from an additional study that we have conducted on Japanese *wh*-questions, involving the incremental application of constraints on pronoun interpretation (Aoshima, Phillips & Weinberg, 2003). The study investigates the circumstances under which a pronoun in a Japanese *wh*-phrase such as *(to) which of his friends* may take a subsequent NP in the same clause as its antecedent. An acceptability rating study shows that when the pronoun is contained within a scrambled dative NP it may take as its antecedent a following clause-mate nominative NP (17a), but that coreference is less acceptable in an unscrambled word order, when the pronoun is contained within a sentence-initial nominative NP and the antecedent is a following dative NP (17b). We assume that this contrast reflects the fact that when the scrambled dative *wh*-phrase in (17a) is
associated with a gap in its canonical (unscrambled) position, the antecedent c-commands the pronoun, whereas the pronoun is never c-commanded by its antecedent in the unscrambled word order in (17b). A subsequent self-paced reading study showed that in scrambled word-order sentences like (17a) Japanese readers slowdown upon encountering a nominative NP that could not serve as an antecedent to the pronoun due to a gender-mismatch. No such slowdown was observed when readers encounter a gender-mismatched dative NP in non-scrambled word-order sentences like (17b). This pattern of results suggests that readers immediately recognize that the pronoun inside the dative wh-phrase in (17a) may take the nominative NP as its antecedent. This, in turn, suggests that readers immediately construct a gap for a fronted dative wh-phrase in the clause where the wh-phrase appears overtly.² Therefore, the combination of the evidence from this study for a local gap with the evidence from Experiments 1 and 2 above for a non-local (embedded clause) gap again suggests that readers make successive attempts to posit a gap for a fronted wh-phrase.

(17)  

```
a. kare-no dono-kodomo-ni cyoosyoku-go oji-ga
   he-gen which-children-dat breakfast-after uncle-nom
   obento-o wasasita-ka titiya-wa oboeteita.
   lunchbox-acc handed-Q father-top remembered
   ‘The father remembered to which of his children the uncle handed
    a lunch box after breakfast.’

b. kare-no dono-kodomo-ga cyoosyoku-go oji-ni
   he-gen which-children-nom breakfast-after uncle-dat
   obento-o wasasita-ka titiya-wa oboeteita.
   lunchbox-acc handed-Q father-top remembered
   ‘The father remembered which of his children handed a lunch box
    to the uncle after breakfast.’
```

We have already discussed at length what motivates Japanese readers to make successive attempts at positing a gap, first in the main clause and then in an embedded clause. These attempts are undertaken in order to satisfy constraints on thematic and/or scope interpretation as soon as possible. What remains to be

² In the examples in (17) the first clause of the sentence turns out to be a fronted embedded clause. The critical material was always contained in an embedded clause, in order to guarantee that there would always be a potential antecedent for the pronoun in the higher clause, even if no antecedent was available in the same clause as the pronoun. Fronting of embedded clauses is both common and natural in Japanese. Importantly for our purposes, however, readers had no indication that the opening regions of the sentence formed part of an embedded clause at the point when they read these regions.
explained is why successive attempts at gap sites are even possible, in light of recent evidence that reanalysis is a last resort operation and that unforced reanalysis is impossible (Kamide & Mitchell, 1999; Sturt, Pickering, Scheepers, & Crocker, 2001; Schneider & Phillips, 2001).

Sturt et al. (2001) and Schneider & Phillips (2001) both present very similar arguments from English that unforced reanalysis is avoided. In sentence (18a) the parser faces two alternative ways of incorporating the second verb (‘likes’) into the structure. One involves a local reanalysis, such that the verb takes the preceding NP (‘the woman’) as its subject to form an embedded clause (18d). This reanalysis operation is independently known to be easy (Sturt, Pickering & Crocker, 1999; Fodor & Ferreira, 1998), based on evidence from structures where the reanalysis is required. The second alternative involves a non-local attachment without reanalysis, such that the verb becomes the main verb, taking the non-local NP ‘the man’ as its subject (18c). Based on garden path effects observed at the point of disambiguation of local reanalysis examples like (18d), 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. In other words, unforced reanalysis is avoided.

(18)  a. The man who knows the woman likes…

b. 

```
S
   |   
NP  | VP
   |   
CP  | NP
   |   
the man who | the woman
NP  | VP
   |   
CP  | VP
   |   
who | knows[the woman]
```

c. \[[IP [NP The man [CP who [VP knows [NP the woman]]]] [VP likes the recipe himself …]


d. \[\text{IP}_{\text{NP}} \text{The man } [\text{CP} \text{ who } [\text{VP} \text{ knows } [\text{CP} \text{ the woman}]] \text{ [VP likes the recipe herself ...} \]

The conclusion that reanalysis is always a last resort option is probably too strong, in light of the evidence from Japanese presented here. At least some kinds of unforced reanalysis appear to be possible. The Japanese examples and the English cases in (18) differ in a number of respects. First, in (18) local reanalysis requires giving up an existing commitment that the NP ‘the woman’ is the direct object of the verb ‘knows’. This is a structural commitment that already led to the satisfaction of the thematic requirements of the verb and the NP. The change also requires revising the argument structure of the verb ‘knows’ from an NP-complement analysis to a sentential complement analysis. Neither of these changes is required in the Japanese reanalysis, where a hypothesized gap position is simply moved from one clause to another. Third, in the English examples the potential reanalysis involves a revision in the analysis of an overt NP (‘the woman’), whereas in the Japanese examples the reanalysis involves a revision in the position of a phonetically null element. Any of these factors could distinguish those unforced reanalyses that are freely available from those that are available only as a last resort operation.

An alternative possibility would be to simply assume that Japanese and English employ different parsing mechanisms, such that unforced reanalysis is more freely undertaken in Japanese than in English. This would be an elaboration on earlier proposals that Japanese speakers fare better than English speakers with forced reanalyses (Inoue & Fodor, 1995). However, this alternative is unlikely, in light of arguments from Kamide & Mitchell (1999: henceforth, K&M) that reanalysis is a last resort operation in Japanese. K&M show that in ambiguous configurations like (19) the dative NP is preferentially interpreted as an argument of the main clause verb.

(19) \text{NP-nom NP-dat }[[\text{NP-nom ditransitiveVerb} \text{ NP}-acc (di)transitiveVerb}}
Kyooju-ga         gakusei-ni   tosyokansyo-ga  kasita  mezurasii
professor-nom student-dat librarian-nom        lent     unusual
komonjo-o                        yabutta / miseta.
\text{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).’

When the first verb is ditransitive and the second is transitive, readers read the last verb significantly more slowly than they do in the case where the second verb is
ditransitive. K&M suggest that this shows an initial attachment of the dative NP as a co-argument of the main clause subject and a reluctance to re-associate the verb with an embedded clause, despite the subsequent evidence that the embedded verb requires a Goal argument. Based on this evidence that reanalysis is avoided, K&M conclude that reanalysis must be a last resort operation.

K&M’s examples are more similar to our Japanese wh-question examples in a number of regards. First, both sets of examples involve dative NPs that at least could receive an analysis as a scrambled NP. Second, in both our examples and K&M’s examples, the benefit of reanalyzing the dative NP is earlier confirmation of the thematic role of the NP and, in the case of K&M’s materials, use of the dative NP to satisfy the thematic requirements of the embedded verb. It is therefore interesting that whereas our wh-fronting examples show unforced reanalysis in the embedded clause, even before the verb is reached, K&M’s results indicate that reanalysis is avoided, even when the ditransitive embedded verb is reached.

There are a couple of possible reasons why unforced reanalysis may have been possible in our studies but not in K&M’s study. First, it is clear in our study that the dative wh-phrase has been scrambled to sentence-initial position. Therefore, the unforced reanalysis that takes place changes one scrambling analysis to another scrambling analysis. In K&M’s materials, on the other hand, the initial analysis of the dative NP is as an in-situ NP in the main clause. The reanalysis that is avoided requires a change from a non-scrambling analysis to a scrambling analysis that requires an additional structural dependency. Therefore, reanalysis may be avoided when it entails the construction of an additional structural dependency, as predicted, for example, by the Minimal Chain Principle (de Vincenzi, 1991). If scrambled NPs are lexically marked with an additional feature (Miyagawa, 1997), then a revision of this kind would require lexical reanalysis, as in the English examples discussed above. Furthermore, if the analysis of the dative NP in K&M’s study were changed from an in-situ analysis to a scrambling analysis, this would entail reanalysis of the surface position of the dative phrase, from a canonical argument position, to a non-argument position, possibly adjoined to the embedded clause. No such change is required in our experiments in the analysis of the surface position of the dative wh-phrase. Therefore, it is possible that unforced reanalysis is avoided when it entails reanalysis of phonologically overt material. Our current results cannot currently choose between any of these interpretations.

A second possibility is that the critical difference between our studies and K&M’s study is that our studies examined the processing of wh-phrases, whereas K&M focused on referential NPs. We cannot at present exclude the possibility that it is the search for a question marker particle that was critical in driving the
unforced reanalysis in our studies. This would suggest that early scope assignment plays a special role in processing.³

In sum, our results show evidence for unforced reanalysis that contrasts with a number of recent studies that have argued that reanalysis is available only as a last resort operation. Comparison of the structures examined in these different studies leads us towards a finer-grained understanding of when unforced reanalysis is and is not possible, although further studies are required in order to conclusively resolve the issue.

Although we have presented this discussion in terms of reanalysis in a serial model of parsing, for ease of exposition, the same issues may be viewed from the perspective of a parallel model of parsing that replaces reanalysis with re-ranking of alternative parses. For example, the parallel, principle-based model of processing filler-gap dependencies in Gibson, Hickok & Schütze (1994) could probably be elaborated in such a way that it could handle the Japanese findings discussed here, since it shares our assumptions of incremental creation of gap positions, driven by the need to satisfy grammatical requirements. Since re-ranking of alternative parses is available by default in such models, our finding of unforced reanalysis in Japanese wh-questions could be handled straightforwardly. The challenge for such models, on the other hand, is to prevent free re-ranking of alternative parses in those cases in English and Japanese where unforced reanalysis has been shown to be unavailable. Although a full account along these lines remains to be worked out, see Vosse and Kempen (2000) for a promising parallel account that uses a lateral inhibition mechanism to suppress competing analyses when an individual analysis is highly supported.

Conclusion

Accounts of the processing of long-distance dependencies fall into two general classes. Some accounts assume that long-distance dependency formation is driven by the need to create gap positions as soon as possible after encountering a filler. Other accounts assume that dependency formation is driven by the need to satisfy syntactic and semantic principles or constraints as soon as possible. Both

³ We have taken Kamide and Mitchell’s study to show that there was no consideration of the embedded clause as a potential site of interpretation. Another possible interpretation is suggested by recent work by Ferreira and her colleagues (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira, Christianson, & Hollingworth, 2001). These authors show that in at least some cases interpretive commitments made prior to reanalysis linger after reanalysis, based on English examples like ‘While John was hunting the deer hid in the bushes’, where speakers believe that John was hunting deer, although the sentence does not assert this. The reading time difference found by K&M at the main clause verb could be a reflex of this lingering initial analysis. Since K&M’s critical conditions contained verbs that selected a dative argument in both main and embedded clauses, we cannot at present exclude this possibility.
families of approaches make rather similar predictions for verb-medial languages such as English. However, the predictions of the two approaches diverge in head-final languages such as Japanese. In this article we tested a prediction of the principle-based approach, that fronted \(wh\)-phrases should be preferentially associated with an embedded clause in Japanese, because this allows earlier satisfaction of constraints on thematic interpretation and scope licensing. This prediction was confirmed in three studies, using three different measures of \(wh\)-dependency formation. Experiment 1 showed that in sentences with sentence-initial \(wh\)-phrases Japanese speakers expect to encounter a question-marker particle on the verb of the embedded clause. Experiment 2 demonstrated that a Japanese counterpart of the Filled Gap Effect occurs at a preverbal position in an embedded clause in sentences with fronted \(wh\)-phrases. The finding of a pre-verbal effect of dependency formation in Experiment 2 shows that filler-gap dependencies are created incrementally in Japanese, just as in English, and that there is no need to assume that dependency formation is delayed until the clause-final verb is processed. It further suggests that the constraints that drive dependency formation are independent of the lexical properties of individual verbal heads. Experiment 3 showed an embedded clause preference for the positioning of question particles in an off-line sentence completion task involving scrambled \(wh\)-phrases.

In sum, theories of parsing that are variously known as principle-based, constraint-based or head-driven have been associated with two closely related but logically independent claims. The first claim is that real-time dependency formation is driven by the need to satisfy the syntactic and semantic requirements of lexical heads (e.g. Ford, Bresnan, & Kaplan, 1982; Pritchett 1988; MacDonald, Pearlmutter, & Seidenberg, 1994). The second claim is that when critical lexical heads are delayed, as in a head-final language such as Japanese, dependency formation should be correspondingly delayed (e.g. Pritchett, 1991b, Mulders, 2002). Our findings about Japanese filler-gap dependencies provide support for the first of these claims, but also show that this is compatible with incremental parsing, assuming a slightly more expansive notion of constraint (one not necessarily tied to a lexical head), contrary to the second claim.

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Appendix A: Experimental materials for Experiment 1A and 1B

Each of the items in this list represents a full set of stimuli from Experiment 1A and 1B. Alternative word orders of wh-phrases (scrambled or in-situ) are given in parentheses. The alternation of the declarative complementizer and the question particle is indicated in square brackets, separated by a slash (/). Where different items were used in Experiments 1A and 1B, both items are shown.

A full set of conditions from item number (1) can be seen below.

Scrambled, Declarative Complementizer
どの生徒に 担任は 校長が 本を 読んだと 図書室で 司書に 言いましたか。  
In-situ, Declarative Complementizer
担任は 校長がどの生徒に 本を 読んだと 図書室で 司書に 言いましたか。  
Scrambled, Question Particle
どの生徒に 担任は 校長が本を 読んだか 図書室で 司書に 言いました。  
In-situ, Question Particle
担任は 校長がどの生徒に 本を 読んだか 図書室で 司書に 言いました。

The main clause verbs, which all require a dative-marked argument, were all ‘report’ verbs; tutaeta ‘told’, itta ‘said’, siraseta ‘informed’, osieta ‘taught’,

setumeisita ‘explained’, and hookokusita ‘reported’.

The embedded verbs, which optionally allow a dative-marked object NP with an interpretation as the beneficiary of the event, were yonda ‘read’, utatta ‘sang’, yaita ‘baked’

1. {どの生徒に} 担任は 校長が {どの生徒に} 本を 読んだ[と/ か] 図書室で 司書に
   言いました[か。/。]
1B. [どの生徒に] 担任は 校長が [どの生徒に] 英語の本を 読んだ[と/か] 図書室で
司書に 言いました[か。/。]
2. [どの女の方に] 司会者は ミュージシャンが [どの女の方に] 歌を 歌った[と/か]
スタジオで 観客に 説明しました[か。/。]
お手伝いさんに 知らせました[か。/。]
信者に 伝えました[か。/。]
教えました[か。/。]
所長に 説明しました[か。/。]
6B. [どの教え子に] 研究助手が [どの教え子に] 研究テーマを 選んだ[と/か]
実験室で 学長に 説明しました[か。/。]
7. [どのファンに] 監督は 選手が [どのファンに] 似顔絵を 描いた[と/か]
ロッカールームで マネージャーに 言いました[か。/。]
8. [どの家族に] 夫は 妻が [どの家族に] サンドイッチを作った[と/か]
公園で 友人に 伝えました[か。/。]
医者に 報告しました[か。/。]
報告しました[か。/。]
教えました[か。/。]
学部長に 説明しました[か。/。]
練習室で 声楽家に 言いました[か。/。]
知らせました[か。/。]
祖母に 知らせました[か。/。]
15. [どの男の子に] 班長は 指導員が [どの男の子に] かぶと虫を とった[と/か]
キャンプ場で 団長に 知らせました[か。/。]
15B. [どの男の子に] 班長が ガイドが [どの男の子に] 大きなカブト虫を 取った[と/か]
キャンプ場で 団長に 知らせました[か。/。]
教えました[か。/。]
Appendix B: Experimental materials for Experiment 2

Each of the items in this list represents a full set of stimuli from Experiment 2. The two conditions (Scrambled and Control) differ in the case markers in the first two noun phrases. The alternation of the case markers is indicated in square brackets, separated by a slash (/).

A set of conditions from item number (1) can be seen below.

Scrambled
どの新入生に 担任は 司書が 図書室で 校長先生に 漫画本を すすめたと 言いましたか。

Control
どの新入生が 担任に 司書が 図書室で 校長先生に 漫画本を すすめたと 言いましたか。

1. この新入生[に/が] 担任[は/に] 司書が 図書室で 校長先生に 漫画本を すすめたと 言いましたか。
2. この警備員[に/が] 司会者[は/に] ミュージシャンが スタジオで 観客に マイクを 投げたと 知らせましたか。
3. どの子供[に/が] 母親[は/に] お手伝いさんが 台所で 父親に お弁当を 渡したと言いましたか。
4. どの女性社員[に/が] 専務[は/に] 社長が 会議で 部長に 昇給を 約束したと教えましたか。
5. どの教授[に/が] 学部長[は/に] 助手が 実験室で 大学院生に 実験を 見せたと説明しましたか。
6. どのマネージャー[に/が] 監督[は/に] 選手が ロッカールームで ファンに ボールを配ったと報告しましたか。
7. どの看護婦[に/が] 院長[は/に] 担当医が 診察室で 患者に 風邪薬を 処方したと伝えたか。
8. どの友人[に/が] 妻[は/に] 夫が 電話で 獣医に 子犬を 預けたと報告しましたか。
9. どの孫[に/が] 祖母[は/に] 祖父が すし屋で 母親に すしを ごちそうしたと教えましたか。
10. どの警官[に/が] 刑事[は/に] 容疑者が 現場で 被害者に 身の上話を 語ったと教えましたか。
11. どのピアニスト[に/が] 指揮者[は/に] 声楽家が 楽屋で バイオリン奏者に 花束を贈ったと言いましたか。
12. どの園児[に/が] 先生[は/に] 留学生が 教室で 園長に 民族衣装を 著せたと知らせていましたか。
14. どの記者[に/が] 付き人[は/に] やくざが 事務所で 女優に 手切れ金を 請求したと伝えましたか。
15. どの編集者[に/が] アシスタント[は/に] 編集長が 廊下で 作家に 原稿を 手渡したと伝えましたか。
16. どの国会議員[に/が] 秘書[は/に] 知事が 文書で 建設会社に 工事を 許可したと説明しましたか。
17. どのウエイトレス[に/が] 料理長[は/に] 見習いが 調理場で 常連客に やきそばを食べさせたと教えましたか。
18. どの店員[に/が] 母親[は/に] 店長が 店先で 子供に ゲームを紹介したと言いましたか。
19. どの運転手[に/が] 刑事[は/に] 警官が 車内で 犯人に 警察官バッジを 提示したと伝えましたか。
20. どの老婦人[に/が] 販売員[は/に] 販売員が 展示会で 若い女性に 靴を 売ったと説明しましたか。
Appendix C: Experimental materials for Experiment 3

Each of the items in this list represents one full set of stimuli from Experiment 3. Alternative word orders of wh-phrases (scrambled or in-situ) are given in parentheses. The alternation of the topic marker and nominative case marker is indicated by square brackets, separated by a slash (/).

A full set of conditions from item number (1) can be seen below.

Fronted, Topic-Nominative
どの新入生に 担任は 司書が 図書室で ...

Fronted, Nominative-Nominative
どの新入生に 担任が 司書が 図書室で ...

In-situ, Topic-Nominative
担任は 司書が 図書室で どの新入生に ...

In-situ, Nominative-Nominative
担任が 司書が 図書室で どの新入生に ...

1. {どの新入生に} 担任[は/が] 司書が 図書室で {どの新入生に} ...
2. {どの警備員に} 司会者[は/が] ミュージシャンが スタジオで{どの警備員に} ...
3. {どの子供に} 母親[は/が] お手伝いさんが 台所で{どの子供に} ...
4. {どの女性社員に} 専務[は/が] 社長が 会議で {どの女性社員に} ...
5. {どの教授に} 学部長[は/が] 助手が 実験室で {どの教授に} ...
6. {どのマネージャーに} 監督[は/が] 選手が ロッカールームで {どのマネージャーに} ...
7. {どの看護婦に} 院長[は/が] 担当医が 診察室で {どの看護婦に} ...
8. {どの友人に} 娘[は/が] 夫が 電話で {どの友人に} ...
9. {どの孫に} 祖母[は/が] 祖父が すし屋で {どの孫に} ...
10. {どの警官に} 刑事[は/が] 容疑者が 現場で {どの警官に} ...
11. {どのピアニストに} 指揮者[は/が] 声楽家が 楽屋で {どのピアニストに} ...
12. {どの園児に} 先生[は/が] 留学生が 教室で {どの園児に} ...

References


