



## 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 sentence completion 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 using 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 embedded 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. These findings clarify the factors responsible for 'active filler' effects in processing long-distance dependencies (Crain & Fodor, 1985; Fodor, 1978; Frazier & Clifton, 1989; Stowe, 1986) in ways not possible in head-initial languages. The results provide evidence that the processing of filler-gap dependencies is driven by the need to satisfy thematic role requirements of the fronted phrase, rather than by the need to create a gap as soon as possible. The paper also discusses implications of these findings for theories of reanalysis.

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### Introduction

In this paper 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 grammatically or lexically appropriate position in the sentence, we then proceed to show that Japanese speakers favor interpretation of fronted *wh*-fillers in embedded clauses. 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.

#### *Background on 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 its left. 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

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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. We refer to the displaced NP as a *filler*, and refer to its canonical position as a *gap* (marked by underlining in (1b)). Accordingly, a focus of research on such *filler-gap 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: Crain & Fodor, 1985; Fodor, 1978; Frazier, 1987; Frazier & Flores d'Arcais, 1989; Stowe, 1986), 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). This is 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. Experiment 2 below applies a similar technique in Japanese.

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

Related evidence for rapid construction of filler-gap dependencies has also been found in many languages, including Dutch (Frazier, 1987; Frazier & Flores d'Arcais, 1989; Kaan, 1997), Russian (Sekerina, 2003), Hungarian (Radó, 1999), Italian (De Vincenzi, 1991), and German (Schlesewsky, Fanselow, Kliegl, & Krems, 2000). A related effect involving the distance between in situ *wh*-phrases and question particles on verbs has been observed in Japanese (Miyamoto & Takahashi, 2003), a finding that is discussed in more detail below.

We can describe these results by saying that the parser initiates a search for a gap as soon as a filler has been identified. Frazier and Clifton's (1989) well-known formulation of this principle is the Active Filler Strategy (AFS) in (3). Importantly, the AFS focuses on the need to create a gap position as soon as possible. Taken literally, this suggests that gap creation is an end in itself.

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

Alternatively, the Active Filler Strategy may be understood as a descriptive generalization that should ultimately be explained in terms of more general parsing mechanisms. There have been a number of attempts to uncover the factors underlying this generalization. Interestingly, while all of these potential explanations are compatible with the relevant data from head-initial languages like English, the different explanations make different predictions with respect to the placement of gaps in scrambled constructions in Japanese, a head-final language. Before turning to the Japanese facts, we first review some alternative explanations of Active Filler effects.

(a) *Minimal Chains*. De Vincenzi (1991) argues that the Active Filler Strategy reduces to a more general least effort principle that favors parsing categories using only unavoidable structure. The principle is formulated as the Minimal Chain Principle: "Avoid postulating unnecessary chain members at S-structure, but do not delay required chain members" (De Vincenzi, 1991, p. 13). This principle forces the parser to interpret a category in its surface position where possible, and to postulate a filler-gap dependency only as a last resort. If the parser is forced to construct a filler-gap dependency, it should complete this dependency as soon as possible.

(b) *Thematic Role or Lexically Driven Approaches*. An alternative explanation for active filler effects focuses on the fact that the association of the filler with some other position in the sentence is crucial to its interpretation as an argument of a predicate. Thus, gap creation is not an end in itself, but rather stems from the grammatical constraint that all syntactically expressed categories must be interpreted, and associated with an array of appropriate grammatical features, such as case or a thematic role. This approach is well represented in both the principle-based parsing tradition (Gibson, 1991; Gibson, Hickok, & Schütze, 1994; Pritchett, 1988, 1991a, 1992; Weinberg, 1993, 1999) and the constraint-based lexicalist tradition (Altmann, 1999; Boland, Tanenhaus, Garnsey, & Carlson, 1995). For example, Pritchett's Theta Attachment constraint states that "The Theta Criterion attempts to apply at every point during processing. . ." (1988, p. 542). The Theta Criterion (Chomsky, 1981) has two components. One component requires each argument to receive an argument role. This suggests that as soon as a displaced phrase is identified, an active search is made to link it to an argument role. The second part of the Theta Criterion requires that all obligatory argument slots of a predicate be linked to syntactically realized constituents. Thus, a verb like 'give' must be syntactically linked to the three arguments coded in its lexical entry.

Current evidence suggests that the lexical properties of the verb play an important role in the construction of filler-gap dependencies in English, where verb information appears relatively early in the sentence. In addition to the self-paced reading studies reviewed above, there is further evidence for construction of filler-gap dependen-

cies as soon as an appropriate verb is identified. Relevant studies have used techniques such as implausibility detection (Garnsey, Tanenhaus, & Chapman, 1989; Traxler & Pickering, 1996), head-mounted eye-tracking (Sussman & Sedivy, 2003), cross-modal priming (Nicol, 1993; Nicol & Swinney, 1989), and event-related potentials (Garnsey et al., 1989; Kaan, Harris, Gibson, & Holcomb, 2000; Phillips, Kazanina, & Abada, submitted). Moreover, a number of studies showed that the active positing of gap sites is filtered by the lexical argument structure requirements of the verb (Boland et al., 1995; Clifton, Frazier, & Connine, 1984; Stowe, Tanenhaus, & Carlson, 1991; Tanenhaus, Boland, Garnsey, & Carlson, 1989; but cf. Pickering & Traxler, 2003). For example, Boland et al. (1995) show that the fit between the predicate and the argument may reflect selectional as well as simple argument structure constraints. They 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?*

One possibility is to interpret the ‘verb-driven’ (or ‘head-driven’) part of the Theta Criterion as the sole source of active filler effects. This predicts that a search for a filler is initiated only as soon as an appropriate predicate is identified. Alternatively, the requirement for thematic interpretation could be invoked as soon as a displaced filler is identified, initiating a search for a predicate that can assign an open argument role to the filler. Under this account, both the filler and the predicate can initiate the search for a gap. This may in turn be viewed as an example of more general constraint-based approaches, in which all categories are associated with lexical constraints, and all categories can initiate attempts to satisfy those constraints.

It is difficult to tease apart these two variants of the thematically driven account in a head-initial language. The Filled Gap Effect observed at the direct object position in (2b) could reflect satisfaction of the requirements of the filler or of the verb, or both. Because head-initial languages are compatible with all three of the accounts sketched above, the distinction between these alternative accounts of active gap creation (Active Filler, verb-driven, or full constraint-driven) has received limited attention. In this paper we investigate the mechanisms that drive long-distance dependency formation using evidence from Japanese, a language in which the three accounts make divergent predictions, due to the head-final word order of Japanese.

Note that the distinction between these approaches to the processing of filler-gap dependencies is independent of the issues investigated by studies such as Boland et al. (1995). That study argued that the thematic properties of a verb can be used to override the bias to posit a gap at the first available position in English. This does not challenge the existence of a

constraint that favors completion of a filler-gap dependency as early as possible, such as the Active Filler Strategy. Rather, it challenges the notion that this constraint applies in an encapsulated manner, blind to the thematic fit between a filler and a verb. In the current study, however, our concern is with the question of why active filler effects exist in the first place, independent of issues of verb-specific constraints and modularity in parsing. Moreover, we shall see that important decisions about the parsing of filler-gap dependencies are made in Japanese before any verb-specific information becomes available.

#### *Background on Japanese long-distance dependencies*

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 nakusita-to omotteiru.  
*John-top Mary-nom that book-acc lost-Comp thinks*  
 ‘John thinks that Mary lost that book.’

Two properties of Japanese question formation are important here. 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 is indicated by a scope marking affix such as the question particles *-ka* (embedded or main clauses) and *-no* (main clauses only). These particles contrast 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).

- (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?’  
 b. John-wa [Mary-ga dare-ni sono hon-o ageta-ka] itta.  
*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). In contrast to English, the position of the *wh*-phrase has no impact on the scope interpretation of the question. Both sentences in (7) are interpreted as indirect questions, due to the presence of a question particle on the embedded clause verb.

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

There is broad agreement that the canonical order of arguments in Japanese 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). Importantly for the current study, 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 (Tsuji-mura, 1996), as shown in (8).

- (8) John-ga sensei-ni [Mary-ga sono hon-o nakusita-to] tutaeta.  
*John-nom teacher-dat Mary-nom that book-acc lost-Comp told*  
 'John told the teacher that Mary lost that book.'

Taken together, these properties of Japanese make it possible to distinguish the predictions that the Active Filler Strategy, verb-driven, and full constraint-driven accounts of active filler effects make with respect to the processing of filler-gap dependencies, as shown in Fig. 1. 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, 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. The gap may be created before the main verb is processed, although this is not necessary. Importantly, when the parser encounters the embedded clause subject, which is the first indication that the sentence is bi-clausal, there is no reason for a parser that incorporates the Active Filler Strategy to revise its analysis, since the strategy has already been satisfied in an optimal fashion. The prediction of such an approach is illustrated in Fig. 1A. Note that Japanese allows liberal argument omission, and hence a dative *wh*-phrase could appear in sentence-initial position as a consequence of subject omission, rather than as a result of scrambling. It is only when subsequent NPs are processed that it becomes apparent that the dative NP has undergone scrambling.

On the other hand, if the parser's goal is to ensure that the argument roles of all verbs are lexically realized as soon as possible, as in verb-driven approaches, then a gap may be created as soon as the parser encounters the first verb in the sentence, provided that the verb has an appropriate open argument role that can be associated with the filler. In a two-clause Japanese sentence, the first verb is the embedded verb. A verb-driven approach therefore predicts that the fronted *wh*-phrase may be associated with the embedded clause, but that this association will occur only after the embedded clause verb has been processed. This prediction is illustrated in Fig. 1B.

Alternatively, in an approach where both the thematic requirements of both the filler and the verb can

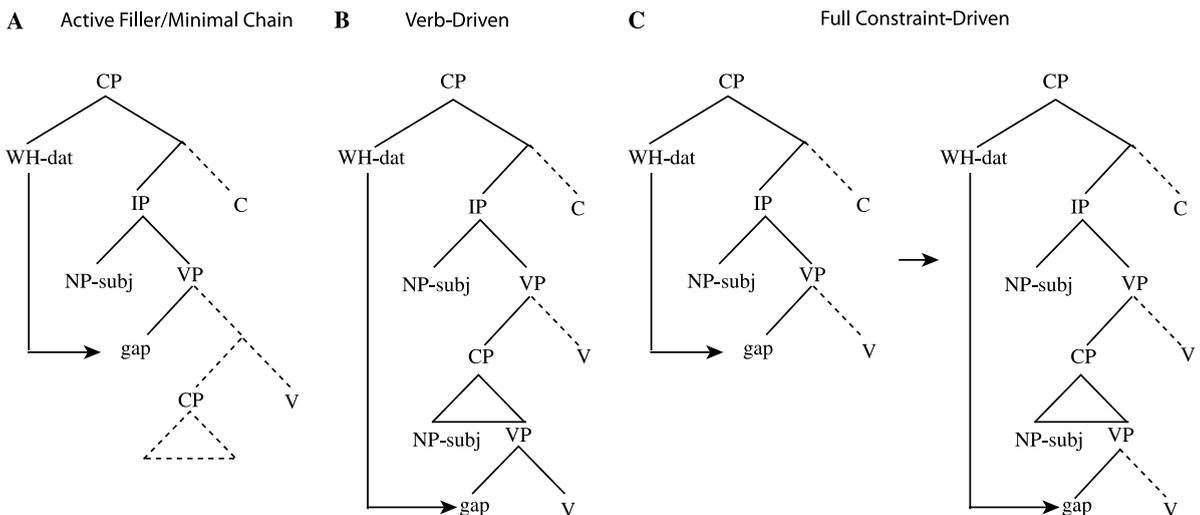


Fig. 1. Predictions of three different accounts of active filler effects for Japanese sentences containing a scrambled dative *wh*-phrase. Dashed lines indicate structure that is not yet confirmed when the filler-gap dependency is completed. (A) Active Filler Strategy: the first possible gap position is created in the main clause before a verb appears, and gap placement is unaffected by the presence of an embedded clause. (B) Verb-Driven Approach: the first verb is encountered in embedded clause, leading to creation of a gap position in the embedded clause once the verb is processed. (C) Full Constraint-Driven Approach: a gap is first posited in the main clause, and then re-positioned in the embedded clause once the embedded clause subject is processed, allowing the scrambled phrase to receive a thematic interpretation as early as possible.

initiate the search for a gap, the parser's immediate goal in a Japanese filler-gap construction will be to ensure that the filler receives a thematic interpretation as soon as possible. Under such an approach, the parser may posit a gap in an argument position before any verb is encountered. Therefore, the parser may first posit a gap in a main clause argument position, before it receives information that the sentence has more than one clause. This prediction is illustrated in the first structure in Fig. 1C. However, since creation of a gap site under this approach is not an end in itself, but rather serves to make thematic role assignment possible, the gap creation process does not terminate until an appropriate thematic role has been assigned. Therefore, when the beginning of the embedded clause is encountered, the parser may replace the gap in the main clause with a gap in the embedded clause, which would allow earlier confirmation of a thematic role, since the embedded verb appears before the main clause verb. This prediction is illustrated in the second structure in Fig. 1C.

The reading-time studies reported below focus on testing the predictions of the full constraint-driven model. This model predicts that Japanese speakers will preferentially associate a sentence-initial filler with an embedded clause, rather than with the main clause, and that it will be able to induce Filled Gap Effects even in argument positions that appear before the first verb position.

Note that in order for the prediction in Fig. 1C to be testably different from the other alternatives, it must be possible for the parser to revise its initial main clause gap assignment in order to create the embedded clause gap assignment, despite the fact that this reanalysis is not grammatically required. However, recent studies of reanalysis (Kamide & Mitchell, 1999; Schneider & Phillips, 2001; Sturt, Pickering, Scheepers, & Crocker, 2001) have argued that the parser resists reanalysis until tree construction can no longer proceed without revising an initial decision. If this Reanalysis as a Last Resort constraint applies at all times, then the reanalysis illustrated in Fig. 1C should not occur. However, we will show that the constraint applies less generally than previously argued, and that it allows the unforced revision shown in Fig. 1C. Note that although these predictions are stated in terms of a strictly serial model of structure building, similar predictions apply in ranked-parallel models, as discussed further in General discussion.

Our first experiment teases apart the predictions of the Active Filler Strategy from both versions of the thematic-role driven approach. If the parser's goal is simply to create a gap as soon as possible, then there is no motivation to interpret a fronted *wh*-phrase inside an embedded clause. On the other hand, the embedded clause interpretation is well motivated, if the parser's objective is to satisfy thematic requirements of the verb or of the *wh*-phrase.

Experiments 2 and 3 distinguish the two types of thematic-role driven approaches, based on the fact that they make contrasting predictions about the time-course of gap creation in multi-clause sentences. The verb-driven approach predicts that gap-creation occurs only once the embedded verb has been processed, whereas the full constraint-driven approach predicts that gap-creation occurs prior to the verb (Experiment 2). In the context of a sentence completion task (Experiment 3), the full constraint-driven approach predicts that speakers will spontaneously generate gap sites for the fronted dative *wh*-phrase in the embedded clause, and that this will be evident in the high numbers of embedded verbs generated in the sentence completions that select a dative-marked argument.

Note that the assumption of gap creation prior to the verb, which is shown in Figs. 1A and C, depends on two additional assumptions that are not inherent in the theories that we are comparing. The first assumption is that structure is built fully incrementally (Aoshima, 2003; Frazier, 1987; Inoue & Fodor, 1995; Mazuka & Itoh, 1995; Schneider, 1999). This contrasts with approaches that assume that structure building is delayed until key lexical heads, such as verbs, are encountered ('head-driven' parsing: Mulders, 2002; Pritchett, 1991b, 1992). The second assumption is that filler/gap dependencies involve the construction of gap sites in canonical argument positions ('gap-based' accounts: De Vincenzi, 1991; Frazier & Clifton, 1989; Gibson & Hickok, 1993; Nakano, Felser, & Clahsen, 2002; Nicol, 1993; Nicol & Swinney, 1989; Stowe, 1986). This is contrasted with theories that assume that filler-gap structures involve direct dependencies between the *wh*-filler and a verb ('direct association' accounts, Pickering & Barry, 1991; Pickering, 1994) or relations between a filler and a verb that is mediated by a sequence of SLASH features (Sag & Fodor, 1994). The literature contains gap-based accounts that are compatible with any of the approaches listed in Fig. 1. On the other hand, direct dependency accounts clearly entail a commitment to a mechanism based directly upon the formation of relationships between displaced NPs and verbs, and therefore the first opportunity in Japanese to form a direct dependency between a fronted phrase and a verb is at the first (i.e., most deeply embedded) verb.

Table 1 summarizes the predictions of the three different approaches to active formation of *wh*-dependencies illustrated in Fig. 1.

#### *Background on processing of long-distance dependencies in Japanese*

Although there have been, to our knowledge, no previous studies of the processing of ambiguous multi-clause *wh*-fronting in Japanese, previous literature on the processing of scrambling constructions and questions in

Table 1

Summary of predictions of different theoretical approaches to active filler effects for the studies of Japanese in this paper

	Experiment 1: Gap formation in embedded clause?	Experiment 2: Pre-verbal embedded clause gap?	Experiment 3: Embedded verbs select fronted phrase?
a. Active Filler/Minimal Chain Principle	No	No	No
b. Syntactic Constraints I: Verb-Driven	Yes	No	No
c. Syntactic Constraints II: Verb- and NP-Driven	Yes	Yes	Yes

Japanese provides relevant background information. A number of studies have investigated whether scrambled word orders in Japanese induce increased processing load. Despite initial uncertainty on this issue (Nakayama, 1995; Yamashita, 1997), there is now a consensus that scrambling does increase processing load, and a number of studies have begun to examine the time-course of this processing load, using both behavioral methods (Mazuka, Itoh, & Kondo, 2002; Miyamoto, 2002; Miyamoto & Takahashi, 2002a, 2002b; Nakano et al., 2002) and event-related potential techniques (Ueno & Klunder, 2003).

A study by Nakano et al. (2002) investigates the processing of phrases that have undergone long-distance (i.e., multi-clause) scrambling. Using a cross-modal priming technique, Nakano et al. argue that a sentence-initial accusative-marked NP is 'reactivated' shortly before the embedded verb, at least in those participants who receive high scores on a reading-span test of memory (Daneman & Carpenter, 1980). Although participants showed evidence of interpreting scrambled NPs in an embedded clause, this does not decide among the different approaches to processing filler-gap dependencies contrasted here, because the scrambled accusative NP in that study became unambiguous as soon as the embedded clause was processed. No verb in Japanese selects both a clausal complement and an accusative argument. Therefore, as soon as readers encountered an embedded clause, they could infer that the scrambled accusative NP was not an argument of the main clause verb.<sup>1</sup> The scrambled dative NP in our studies, on the other hand, is globally ambiguous.

Of particular relevance to our own studies is a recent series of experiments by Miyamoto and Takahashi (Miyamoto & Takahashi, 2000, 2003) 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 ques-

tion) 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 in a canonical argument position should initiate a search for a question particle. Using materials like the examples in (9), they show that in sentences containing an 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* (e.g., 9a) than for verbs marked with the question marker *-ka* (e.g., 9b) Miyamoto and Takahashi refer to the interference effect resulting from processing an unexpected verbal affix as the *Typing Mismatch Effect*.

(9)a. Senmu-ga donna-pasokon-o tukatteiru-to kakaricyoo-ga itta-no?  
director-nom what-kind-computer-acc using-is-Comp supervisor-nom said-Q  
'What kind of computer did the supervisor say the director is using?'

b. Senmu-ga donna-pasokon-o tukatteiru-ka kakaricyoo-ga itta.  
director-nom what-kind-computer-acc using-is-Q 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, 2003). For example, the sentence in (10a) is ungrammatical because the nominative *wh*-phrase in the main clause receives its thematic interpretation in a higher clause than the question particle on the embedded clause verb. The *wh*-phrase cannot be interpreted in the embedded clause, because nominative NPs disallow scrambling (Miyara, 1982; Nemoto, 1999; Saito, 1985; Takezawa, 1989). Example (10b), in which a question particle appears on both the main clause and the embedded verb, is acceptable. The main clause question particle marks the scope of the *wh*-phrase, and the embedded clause question particle indicates an indirect yes-no question.

(10)a. \*Dare-ga John-ga sono hon-o nakusita-ka sitteiru.  
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?'

<sup>1</sup> 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 completion study (Experiment 3) suggest a strong bias to treat embedded clauses as complement clauses.

The consequence of this generalization is 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 nominative and accusative *wh*-phrases. Miyamoto and Takahashi (2003) show that the parser does not simply blindly search for a question particle after encountering a *wh*-phrase. In sentences that begin with a main clause nominative *wh*-phrase no slowdown is observed when readers encounter a declarative complementizer on an embedded verb, relative to a control condition that lacks a *wh*-phrase. This is expected if the Typing Mismatch Effect is restricted to positions that could grammatically mark the scope of the *wh*-phrase. Experiment 1 below builds upon Miyamoto and Takahashi's generalization about in situ *wh*-phrases in order 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.

### Experiment 1

This experiment was designed as an initial test of how *wh*-phrases are interpreted in Japanese *wh*-fronting structures, using Miyamoto and Takahashi's Typing Mismatch Effect as a diagnostic of where a *wh*-phrase is interpreted. The aim was to determine whether a fronted *wh*-phrase in Japanese is preferentially interpreted in the main clause or in the most deeply embedded clause. If the parsing of *wh*-phrases is driven by the need to create a gap as soon as possible, then a gap should be created in the main clause, and there is no reason for the parser to revise this analysis once the embedded clause is encountered. If, on the other hand, the parsing of *wh*-phrases is driven by the need to satisfy interpretive requirements such as thematic role assignment, an ultimate embedded clause gap site is predicted. In a verb-driven account, the embedded verb provides the first opportunity for gap creation, since it precedes the main clause verb. In an approach in which all lexical items may introduce grammatical constraints, a gap may be created in a potential thematic position before any verb is encountered, leading to the following predictions. A main clause gap may be created as soon as a filler-gap dependency is detected, immediately after the main clause subject is processed. However, once the embedded clause subject is encountered, the main clause gap may be revised in favor of an embedded clause gap analysis, since this allows earlier assignment of a thematic role to the fronted phrase. This in turn leads to the prediction that in the clause in which the *wh*-phrase is ultimately interpreted, readers will anticipate a question particle, and hence read a declarative complementizer more slowly than a question particle.

In light of the close parallel between the experimental measure used in the current study and in Miyamoto and Takahashi's studies, this experiment included conditions in which the *wh*-phrase was in situ in an embedded clause, in order to allow direct comparison of fronted and in situ *wh*-phrases. If the fronted *wh*-phrase is interpreted in an embedded clause, we should observe similar Typing Mismatch Effects in *wh*-fronting and *wh*-in situ conditions.

### 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 \$5.00 or its equivalent for their participation in the experiment, which lasted about 30 min.

### Materials and design

Twenty-four sets of four conditions each were used in the experiment, in a  $2 \times 2$  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 24 sets of items were distributed among four lists in a Latin Square design. Each participant saw exactly one of the lists intermixed with 48 filler items in a random order. The filler items were matched with the target items in overall length and complexity, and were counterbalanced with regard to the distribution of interrogative and declarative complementizers in main and embedded clauses.

A sample set of experimental items is shown in Table 2. A full set of materials for this experiment can be found in Appendix A. In all four conditions a main clause subject NP marked with the topic-marker *-wa* was immediately followed by an embedded clause, which began with a nominative-marked NP. The nominative-marked NP provided a strong cue for the onset of an embedded clause, a supposition that is tested in Experiment 3. 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 in the scrambled conditions it appeared in

Table 2  
Sample set of experimental conditions for Experiment 1

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

sentence-initial position. 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 (‘declarative complementizer conditions’).

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 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 Active Filler Strategy approach. If the fronted dative *wh*-phrase is preferentially interpreted in the main clause, 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.

### 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 were presented on a single line. The segmentation indicated with spaces in Table 2 was used in the presentation. The embedded complementizer or question particle was presented together with the embedded verb, since both the complementizer and the question particle are bound morphemes in Japanese. Sentences were presented using Japanese characters with the 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, corresponding to the topic-marked NP and the nominative-marked NP in the target sentence, 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 on the keyboard. In the comprehension task, the two agent NPs were displayed without case-marking, in order to exclude the possibility of case-based question answering strategies. This task was adopted from Nagata (1993), and was similar to the task used in the studies by Miyamoto and Takahashi (2000, 2003). This task was

chosen because 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.

In order to familiarize participants with the subject–verb matching comprehension task, an off-line practice session was included prior to the self-paced reading task. Since the aim of the practice session was simply to ensure that participants were familiar with the experimental task, only two instances of *wh*-scrambling were included among the twenty practice items.

#### 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. Seven 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 were trimmed so that the data points beyond 2.5 standard deviations from the relevant condition  $\times$  region cell mean were discarded, corresponding to less than 2.7% of the test data. 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 50 participants included in the analysis, average comprehension accuracy was 88.4%. Mean accuracy scores did not differ significantly across the four conditions (all  $F_s < 1$ ).

#### Self-paced reading

The reading time analysis yielded the following results. Reading times for in situ conditions are shown in Fig. 2, and those for scrambled conditions are shown in Fig. 3.

At all regions prior to the fifth region, there were no significant differences between reading times in the declarative complementizer and question particle condi-

tions (all  $F_s < 1$ ). 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 observed a Typing Mismatch Effect, reflected in longer reading times for embedded declarative complementizers than for embedded question particles, in both in situ and scrambled word orders.

At the embedded verb (Region 5), there was no significant main effect of complementizer type ( $F_1 < 1$ ;  $F_2(1, 20) = 1.38$ ,  $MSe = 215,349$ ,  $p = .25$ ). There was a marginally significant main effect of word order ( $F_1(1, 49) = 2.14$ ,  $MSe = 253,613$ ,  $p = .15$ ;  $F_2(1, 20) = 4.06$ ,  $MSe = 163,417$ ,  $p = .06$ ). The interaction of complementizer type and word order was significant in the subject analysis ( $F_1(1, 49) = 6.65$ ,  $MSe = 208,091$ ,  $p < .05$ ), but not in the item analysis ( $F_2(1, 20) = 2.25$ ,  $MSe = 383,941$ ,  $p = .15$ ). Pairwise comparisons revealed that within the scrambled conditions declarative conditions were read significantly more slowly than question particle conditions ( $F_1(1, 49) = 4.16$ ,  $MSe = 168,859$ ,  $p < .05$ ;  $F_2(1, 20) = 5.76$ ,  $MSe = 186,472$ ,  $p < .05$ ). On the other hand, the same comparison for the in situ conditions showed no corresponding slowdown ( $F_1(1, 49) = 2.62$ ,  $MSe = 259,842$ ,  $p = .11$ ;  $F_2 < 1$ ).

At the main clause adverb (Region 6) there was no main effect of complementizer type ( $F_s < 1$ ), and the main effect of word order was only marginally significant in the participants analysis ( $F_1(1, 49) = 3.43$ ,  $MSe = 633,999$ ,  $p = .07$ ;  $F_2(1, 20) = 1.67$ ,  $MSe = 79,282$ ,  $p = .21$ ). There was a significant interaction of complementizer type and word order ( $F_1(1, 49) = 9.74$ ,  $MSe = 72,155$ ,  $p < .01$ ;  $F_2(1, 20) = 8.55$ ,  $MSe = 106,511$ ,  $p < .01$ ). 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 declarative conditions in the in situ conditions ( $F_1(1, 49) = 4.58$ ,  $MSe = 105,228$ ,  $p < .05$ ;  $F_2(1, 20) = 4.58$ ,  $MSe = 126,218$ ,  $p < .05$ ), but a slowdown for question particle conditions in the scrambled conditions ( $F_1(1, 49) = 3.78$ ,  $MSe = 61,333$ ,  $p = .05$ ;  $F_2(1, 20) = 9.65$ ,  $MSe = 38,279$ ,  $p < .01$ ). 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 or interaction among these factors (all  $F_s < 1$ ). At the sentence-final main verb (Region 8) there was a marginally significant main effect of complementizer type ( $F_1(1, 49) = 3.43$ ,  $MSe = 125,351$ ,  $p = .07$ ;  $F_2(1, 20) = 2.25$ ,  $MSe = 151,343$ ,  $p = .15$ ), due to longer reading times for declarative conditions, i.e., conditions in which a question particle appeared on the main clause verb in this region. There was no main effect of word order ( $F_1(1, 49) = 1.41$ ,  $MSe = 977,559$ ,  $p = .24$ ;  $F_2 < 1$ ), and

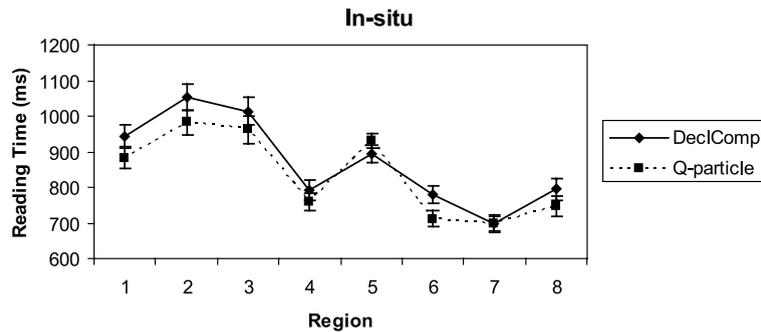


Fig. 2. Experiment 1, reading times per region for the *wh*-in situ conditions (NP-top<sub>1</sub> NP-nom<sub>2</sub> Wh-dat<sub>3</sub> NP-acc<sub>4</sub> V-DeclC/Q<sub>5</sub> Adverb<sub>6</sub> NP-dat<sub>7</sub> V-Q<sub>8</sub>).

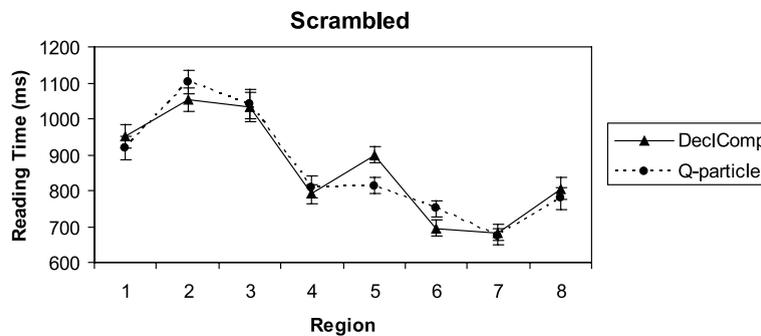


Fig. 3. Experiment 1, reading times per region for the *wh*-scrambled conditions (Wh-dat<sub>1</sub> NP-top<sub>2</sub> NP-nom<sub>3</sub> NP-acc<sub>4</sub> V-DeclC/Q<sub>5</sub> Adverb<sub>6</sub> NP-dat<sub>7</sub> V-Q<sub>8</sub>).

no interaction of complementizer type and word order (all  $F$ s < 1).

### 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 slowdown in the declarative complementizer conditions appeared one word later in the in situ conditions than in the scrambled conditions, a contrast that was not expected.

The Typing Mismatch Effect observed 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, due to 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. The finding that fronted *wh*-phrases are preferentially interpreted in the embedded clause clearly supports the predictions of the verb-driven and the full constraint-driven accounts of parsing *wh*-expressions.

The Typing Mismatch Effect was slightly delayed in the in situ conditions, appearing at the adverb immediately following the embedded verb. Despite the one-word delay, we see no reason not to assume that this effect was caused by the complementizer type on the embedded verb. Such delays are not uncommon in studies using the self-paced reading paradigm, and we are aware of no reason why the adverb itself should elicit slower reading times in the declarative condition. Note that in the corresponding in situ conditions in Miyamoto and Takahashi's studies (Miyamoto & Takahashi, 2003, Experiment 1) the Typing Mismatch Effect persisted beyond the embedded verb region.

Recall that the dative NP in region 7 was included as an additional test of whether readers interpret the

fronted dative *wh*-phrase in the main clause or in the embedded clause. If readers preferentially interpret the fronted *wh*-phrase in the main clause, then they should show surprise upon encountering the second dative NP in region 7 in the declarative-scrambled condition, compared to reading times for the same NP in the declarative-in situ condition. However, no such contrast was observed between the two declarative conditions ( $F_s < 1$ ).

The tendency for slower reading times in the declarative complementizer condition at the final region is consistent with the results of other recent studies of the processing of Japanese *wh*-questions. The final region contains the main clause verb, and in the conditions with embedded declarative complementizers the main verb is marked with a question particle. Similar slowdowns at clause-final complementizers were observed in Miyamoto and Takahashi's studies (Miyamoto & Takahashi, 2003, Experiments 1 & 3), and a related ERP effect was found at a sentence final question particle by Ueno and Klunder (2003). Miyamoto and Takahashi suggest that this effect may reflect the cost of computing long-distance scope marking relations between a *wh*-phrase and a question particle; in all of these studies a question particle appeared on the sentence-final verb.

Note that the bias to interpret the sentence-initial *wh*-phrase as taking scope in the embedded clause may appear to be at odds with the finding by Takahashi (1993) that in sentences with question particles in both the main clause and the embedded clause, Japanese speakers strongly prefer to assign main clause scope to a fronted *wh*-phrase, and judge embedded scope readings to be unacceptable. However, the conflict is only apparent. First, Takahashi's observations apply only to sentences that contain two question particles, whereas the critical effects in our study occur at a point when participants have seen only one question particle. Second, in an off-line rating study with 80 native speakers of Japanese, Aoshima, Phillips, and Weinberg (2003a) show that embedded clause scope readings are available even in sentences with two question particles, once contextual support is provided for the embedded scope reading.

The results of Experiment 1 support the prediction of the full constraint-driven account 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 accounts based directly on the Active Filler Strategy. Due to the use of dative-marked *wh*-phrases and monotransitive verbs, it is likely that this effect is not due 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 Introduction, the preference to interpret the fronted *wh*-phrase in the

embedded clause might also be explained by a verb-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 Experiment 1 also have implications for theories of reanalysis, which we address in General discussion.

## Experiment 2

Building upon the finding in Experiment 1 that fronted *wh*-phrases in Japanese are preferentially associated with an 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. 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. Our experiment conjoins this idea with the claim that parses are constructed fully incrementally. This conjunction of claims makes testably different predictions from the direct association approach. 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 (Mulders, 2002; Pritchett, 1991b, 1992) 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 Effect paradigm (Clifton & Frazier, 1989; Crain & Fodor, 1985; Stowe, 1986) 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 also involves an overt NP in a position where a gap was anticipated, but this position appears 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 min.

### Materials and design

Experimental materials consisted of 20 sets of sentences with two conditions each, which we refer to as the scrambled condition and the control condition, respectively. Table 3 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. In the scrambled condition 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 (Crain & Fodor, 1985; Stowe, 1986).

In the control condition the two sentence-initial NPs were 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; Nemoto, 1999; Saito, 1985; Takezawa, 1989). 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 and Mitchell (1999), who investigated the processing of dative-marked NPs in Japanese in very similar positions. Therefore, the second dative NP in the control condition 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 in the scrambled condition.

The 20 sets of items were distributed in a Latin Square design, creating two lists. Each participant saw one of the lists intermixed with 60 unrelated filler items in a random order.

### Off-line plausibility ratings

In the design of the materials for Experiment 2, the lexical content of the *wh*-phrase was held constant across the scrambled and control conditions, in order to ensure that in both conditions the *wh*-question asked about the same set of individuals (e.g., ‘which employee’ in the example in Table 3). However, this had the consequence that the thematic role of the participants in the sentences differed between the scrambled and control conditions. For example, in the example in Table 3 the *managing director* bears an agent thematic role in the scrambled condition and a goal thematic role in the control condition. This raises the possibility of plausibility contrasts between the conditions that could lead to reading-time differences. We therefore conducted an off-line plausibility rating study to test two specific concerns. First, if the dative NP in either condition of Experiment 2 is judged to be a more plausible co-argument of either the

Table 3  
Sample set of experimental conditions for Experiment 2

1	2	3	4	5	6	7	8
<i>a. Scrambled condition</i>							
Dono-syain-ni <i>Which</i> <i>employee-dat</i>	senmu-wa <i>managing</i> <i>director-dat</i>	syacyoo-ga <i>president-nom</i>	kaigi-de <i>meeting at</i>	kacyoo-ni <i>assistant</i> <i>manager-dat</i>	syookyuu-o <i>raise-acc</i>	yakusokusita-to <i>promised-DeclC</i>	iimasita-ka? <i>told-Q</i>
‘To which employee did the managing director tell that the president promised a raise to the assistant manager at the meeting?’							
<i>b. Control condition</i>							
Dono-syain-ga <i>Which</i> <i>employee-nom</i>	senmu-ni <i>managing</i> <i>director-top</i>	syacyoo-ga <i>president-nom</i>	kaigi-de <i>meeting at</i>	kacyoo-ni <i>assistant</i> <i>manager-dat</i>	syookyuu-o <i>raise-acc</i>	yakusokusita-to <i>promised-DeclC</i>	iimasita-ka? <i>told-Q</i>
‘Which employee told the managing director that the president promised a raise to the assistant manager at the meeting?’							

main clause or the embedded clause subject, then it is possible that participants might simply interpret the dative NP in whichever clause is judged to have the more plausible subject co-argument. Second, it is possible that the dative NP might be interpreted in the embedded clause simply because it is judged to be an implausible co-argument of the main clause subject.

For the plausibility rating study we constructed 16 sets of items in the 4 conditions, based on one of the experimental items in Experiment 2, and consisting of the main clause verb plus the dative NP and one of the two subject NPs. The 4 conditions were constructed according to the schema in (11), in which the subscripts *A*, *B*, and *C* refer to the NPs that appear, respectively, as the dative *wh*-phrase, the main clause subject and the embedded clause subject in the scrambled condition of Experiment 2.

- (11) a. *NP-nom<sub>C</sub> NP-dat<sub>A</sub> V*  
 President-nom employee-dat told  
 ‘The president told the employee something.’  
 b. *NP-top<sub>B</sub> NP-dat<sub>A</sub> V*  
 Managing director-top employee-dat told  
 ‘The managing director told the employee something.’  
 c. *NP-nom<sub>C</sub> NP-dat<sub>B</sub> V*  
 President-nom managing director-dat told  
 ‘The president told the managing director something.’  
 d. *NP-nom<sub>A</sub> NP-dat<sub>B</sub> V*  
 Employee-nom managing director-dat told  
 ‘The employee told the managing director something.’

The 16 sets of items were distributed among 4 lists in a Latin Square design, and each list was combined with 32 filler items of varying degrees of plausibility. Participants were 56 students from Meiji Gakuin University, Japan, who completed the rating questionnaire for partial course credit. Participants rated the plausibility of the sentences on a scale from 1 (highly implausible) to 5 (highly plausible).

Results of the plausibility ratings are shown in Table 4. Results were entered into a  $2 \times 2$  repeated measures ANOVA that included the content of the dative argument (conditions a/b vs. conditions c/d) and the nominative argument (embedded clause in a/c vs. main clause in b/d). Plausibility ratings were highly similar across conditions, and there were no significant main effects or interactions (all  $F$ s < 1.15). We therefore conclude that plausibility is an unlikely confounding factor in Experiment 2.

Table 4  
 Experiment 2, ratings in off-line plausibility study

Conditions	Plausibility ratings		
	<i>N</i>	Mean	<i>SD</i>
a. <i>NP-nom<sub>C</sub> NP-dat<sub>A</sub> V</i>	224	4.54	0.84
b. <i>NP-top<sub>B</sub> NP-dat<sub>A</sub> V</i>	224	4.58	0.79
c. <i>NP-nom<sub>C</sub> NP-dat<sub>B</sub> V</i>	224	4.51	0.85
d. <i>NP-nom<sub>A</sub> NP-dat<sub>B</sub> V</i>	224	4.52	0.84

## 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 participants whose comprehension task accuracy was less than 70% in the target sentences and 75% in total were discarded ( $n = 7$ , 17%). The percentage of participants who were rejected may have been higher than usual in this study due to the overall complexity of the sentences being tested and due to the fact that the comprehension task used here was more unforgiving than the tasks typically used in reading-time studies of English. Participants could never receive credit for simply recognizing a verb or NP from the test sentence, and the correct answer always involved matching subject NPs with verbs that appeared 3–6 regions away from them in the test sentence. Reading times longer than 2500 ms 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 two conditions ( $F < 1$ ). 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 Fig. 4. At all regions except the third and fifth regions there were no significant differences between reading times in the scrambled and control conditions (all  $F$ s < 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

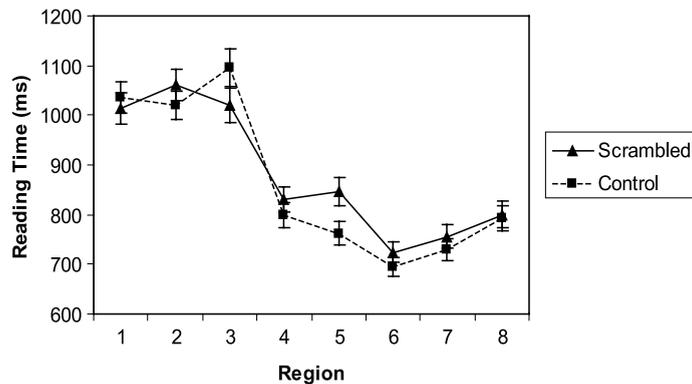


Fig. 4. Experiment 2, reading times per region  
(Scrambled: Wh-dat<sub>1</sub> NP-top<sub>2</sub> NP-nom<sub>3</sub> Adv<sub>4</sub> NP-dat<sub>5</sub> NP-acc<sub>6</sub> V-DeclC<sub>7</sub> V-Q<sub>8</sub>)  
(Control: Wh-nom<sub>1</sub> NP-dat<sub>2</sub> NP-nom<sub>3</sub> Adv<sub>4</sub> NP-dat<sub>5</sub> NP-acc<sub>6</sub> V-DeclC<sub>7</sub> V-Q<sub>8</sub>).

participant analysis but not significant in the items analysis ( $F_1(1, 33) = 5.93$ ,  $MSe = 290,485$ ,  $p < .05$ ;  $F_2(1, 19) = 1.23$ ,  $MSe = 373,698$ ,  $p = .28$ ).

At the dative NP in region 5 there was a significant difference between the two conditions ( $F_1(1, 33) = 11.37$ ,  $MSe = 102,598$ ,  $p < .005$ ;  $F_2(1, 19) = 6.4$ ,  $MSe = 128,504$ ,  $p < .05$ ), due to reading times that were 83 ms slower in the scrambled condition than in the control condition. There were no other observed significant differences.

### Discussion

The main result of this experiment is that a slowdown in reading time was observed in the scrambled condition at the embedded dative NP (region 5), relative to the reading time for the same NP in the control condition. We interpret this slowdown as the Japanese counterpart to the Filled Gap Effect (Crain & Fodor, 1985; 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 interpreted in the main clause (cf. Kamide & Mitchell, 1999). 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 2500 ms 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 the 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 (12a). Although, it is quite natural to analyze the nominative-marked NP as the subject of an embedded clause (12b), 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 (12c), or the nominative-marked NP could be the object of the special class of Japanese verbs that allows nominative objects (12d).

(12)a. *wh*-NP-dat NP-top NP-nom ...

- b. *Dono tomodati-ni John-wa Mary-ga kooen-de atta-ka sitteiru.*  
*which friend-dat John-top Mary-nom park-at met-Q knows*  
'John knows which friend Mary met at the park.'
- c. *Dono tomodati-ni John-wa Mary-ga syokaisita-no?*  
*which friend-dat John-top Mary-nom introduced-Q*  
'Which friend did Mary introduce John to?'
- d. *Dono tomodati-ni John-wa Mary-ga syokai-dekiru-no?*  
*which friend-dat John-top Mary-nom introduce-can-Q*  
'Which friend 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 fragment completion test was conducted with two objectives in mind. The first objective was 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.

The second objective of the study was to use spontaneous sentence completion data to provide an additional test of Japanese speakers' propensity to analyze fronted *wh*-phrases as having undergone long-distance scrambling from an embedded clause. Note that the predictions for a sentence fragment completion task, which is a kind of production task, are not as straightforward as the predictions in a comprehension task. The results of Experiments 1 and 2 suggest that fronted *wh*-phrases are structured in such a way that they will be assigned a thematic role at the first possible opportunity. In a sentence comprehension task, the surface order of words substantially governs the order of syntactic encoding, and hence we straightforwardly predict that fronted *wh*-phrases will be associated with the embedded clause verb. In sentence production, on the other hand, the surface order of words is a weaker predictor of the order of syntactic encoding. In particular, it is possible that in a verb-final language such as Japanese, speakers may sometimes syntactically encode the main verb of the sentence before they encode the embedded verb. If this occurs, early confirmation of thematic role assignments can be achieved by associating the fronted *wh*-phrase with the main clause verb. Therefore, although we expect to find that fronted *wh*-phrases are interpreted in the embedded clause to a significant extent in this study, uncertainty over the order of encoding in Japanese sentence generation makes this a weaker prediction than in the comprehension tasks of Experiments 1 and 2.

#### Participants

Sixty native speakers of Japanese participated in the experiment. All of them were students at Meiji Gakuin University, Japan, who received partial course credit for their participation. The experiment lasted about 20 min.

#### Materials and design

Experimental materials consisted of 15 sets of 5 conditions each. Four of the conditions independently manipulated the distribution of case morphemes (topic-nominative vs. nominative-nominative) and the position of a dative-marked *wh*-phrase (scrambled vs. in situ). A fifth condition began with a nominative-marked *wh*-phrase in a nominative-dative-nominative word order. Table 5 shows one set of conditions used in this experiment. The fragments in all conditions consisted of a

*wh*-phrase, two further referential NPs, and an adverbial phrase. All of the fragments used 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 dative *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. We included a condition with a nominative *wh*-phrase in order to provide a baseline measure, using a *wh*-phrase that cannot undergo scrambling.

The phrases used in the fragments were taken from the target items used in Experiment 2. The 15 sets of items were distributed among five lists in a Latin Square design. Each participant saw exactly one of the lists intermixed with thirty 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 possibility of a structural priming effect that might lead participants to use the same structure in all completions. The filler items yielded the expected distribution of mono-clausal and bi-clausal completions.

#### Results

This study yielded a total of 874 codable sentence fragment completions. The completions were classified according to the number of clauses used to complete the sentence fragment, the position of question particles that indicate the scope of the *wh*-phrase, and the argument structure of the embedded clause verb. 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'). Responses were also coded based on the argument structure of the verbs provided in the completions, in order to provide an additional measure of where participants interpreted the dative-marked NP. Embedded verbs that required a dative argument were coded as 'embedded only'; embedded verbs that optionally allow a dative argument were coded as 'embedded optional'; completions that allowed a dative argument only with the main clause verb were coded as 'main clause only.'

The analysis of the number of clauses provided in the completions showed that 98.6% of completions were multi-clausal (862/874 trials). The proportion of multi-clause completions ranged from 97.1 to 99.4% across the

Table 5  
Sample set of experimental conditions for Experiment 3

a. <i>Dono sinnyuusei-ni</i> <i>which new student-dat</i>	<i>tannin-wa</i> <i>class teacher-top</i>	<i>sisyo-ga</i> <i>librarian-nom</i>	<i>tosyositu-de...</i> <i>library-at</i>
b. <i>Dono sinnyuusei-ni</i> <i>which new student-dat</i>	<i>tannin-ga</i> <i>class teacher-nom</i>	<i>sisyo-ga</i> <i>librarian-nom</i>	<i>tosyositu-de...</i> <i>library-at</i>
c. <i>Tannin-wa</i> <i>class teacher-top</i>	<i>sisyo-ga</i> <i>librarian-nom</i>	<i>tosyositu-de</i> <i>library-at</i>	<i>dono sinnyuusei-ni...</i> <i>which new student-dat</i>
d. <i>Tannin-ga</i> <i>class teacher-nom</i>	<i>sisyo-ga</i> <i>librarian-nom</i>	<i>tosyositu-de</i> <i>library-at</i>	<i>dono sinnyuusei-ni...</i> <i>which new student-dat</i>
e. <i>Dono sinnyuusei-ga</i> <i>which new student-nom</i>	<i>tannin-ni</i> <i>class teacher-dat</i>	<i>sisyo-ga</i> <i>librarian-nom</i>	<i>tosyositu-de...</i> <i>library-at</i>

Table 6  
Experiment 3, counts and percentages of the number of clauses provided in completions sentence fragments

Conditions	Clause-number			
	Multi-clausal		Mono-clausal	
	<i>n</i>	%	<i>n</i>	%
<i>WH-dat NP-top NP-nom</i>	173	98.9	2	1.1
<i>WH-dat NP-nom NP-nom</i>	166	97.1	5	2.9
<i>NP-top NP-nom WH-dat</i>	176	98.9	2	1.1
<i>NP-nom NP-nom WH-dat</i>	175	99.4	1	0.6
<i>WH-nom NP-dat NP-nom</i>	172	98.9	2	1.1
<i>Total</i>	862	98.6	12	1.4

five experimental conditions. Fisher Exact tests showed that none of the differences between conditions were reliable. Results of the clause-number analysis are shown in Table 6.

In the analysis of question-type, 49.9% of fragments (435 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 particle in both clauses, the number of embedded clause responses rises to 53.7% (468 trials). There were large differences across conditions in the number of embedded clause responses. The proportion of trials in which a question particle was provided on the embedded clause verb was 97.5% for the in situ conditions (342/351 trials), 32.4% for the *wh*-scrambling conditions (112/346 trials), and 8.0% for the nominative *wh*-phrase condition (14/174 trials). Fisher Exact tests showed that the proportion of embedded question particle completions was significantly different between the in situ and *wh*-scrambling conditions ( $p < .0001$ , 2-tailed), and between the *wh*-scrambling conditions and the nominative *wh*-phrase condition ( $p < .0001$ , 2-tailed). These results held regardless of the classification of responses in which question particles were provided in both clauses. There

were no reliable differences due to the use of a topic-marker or a nominative case marker for the main clause subject. Results of the question-type analysis are shown in Table 7.

In the analysis of verb argument structure, trials in which a question particle was provided on the embedded verb only were separated from the trials in which a question particle was provided on the main clause verb or on both verbs. This reflects the general fact that a *wh*-phrase must be thematically interpreted below its scope position. Therefore, we predicted that in the responses with a question particle on the embedded verb only, the dative *wh*-phrase should be obligatorily interpreted in the embedded clause. On the other hand, when the question particle is on the main verb, the dative *wh*-phrase could be interpreted in either the main clause or the embedded clause. Responses with two question particles were not included in the analyses of verb argument structure.

In the analysis of verb argument structure in the responses with embedded question particles only, we disregarded the condition that began with a nominative *wh*-phrase, due to the low number of responses in this category ( $n = 11$ ) and due to the fact that these responses were ungrammatical. In the remaining four conditions, 96.3% of completions contained an embedded verb that was judged to obligatorily or optionally take a dative argument (418/434 trials). This proportion was higher in the in situ conditions (100%, 342/342 trials) than in the *wh*-scrambling trials (82.3%, 76/92 trials), a difference that was significant ( $p < .0001$ , Fisher Exact test, 2-tailed). Fisher Exact tests showed that there was no effect of the use of a topic-marker or a nominative marker on the main clause subject. Although the proportion of responses classified as 'embedded optional' was small in all conditions, it was significantly higher in the *wh*-scrambling conditions than in the in situ conditions ( $p < .001$ , Fisher Exact test, 2-tailed).

In the analysis of verb argument structure in the responses with a question particle in the main clause only,

Table 7  
Experiment 3, counts and percentages of positions of question particles in completions of sentence fragments

Conditions	Question type					
	Embedded		Main		Both	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
<i>WH-dat HP-top NP-nom</i>	42	24.0	119	68.0	14	8.0
<i>WH-dat NP-nom NP-nom</i>	40	23.4	115	67.3	16	9.3
<i>NP-top NP-nom WH-dat</i>	172	97.8	4	2.2	0	0.0
<i>NP-nom NP-nom WH-dat</i>	170	97.2	5	2.8	0	0.0
<i>WH-nom NP-dat NP-nom</i>	11	6.3	160	92.0	3	1.7
<i>Total</i>	435	49.9	403	46.3	33	3.8

all 5 conditions were included. Overall, 33.4% of completions contained an embedded verb that was judged to obligatorily or optionally take a dative argument (134/404 trials). This proportion was 100% in the in situ conditions (9/9 trials), 41.0% in the *wh*-scrambling conditions (96/234 trials), and 17.5% in the nominative *wh*-phrase conditions (28/160 trials). Fisher Exact tests showed that the proportion was significantly different between the in situ and *wh*-scrambling conditions ( $p < .001$ , 2-tailed), and between the *wh*-scrambling and nominative *wh*-phrase conditions ( $p < .0001$ , 2-tailed). Pairwise comparison of the *wh*-scrambling conditions showed that the proportion of verbs that obligatorily or optionally take a dative argument was higher in the dative-nominative-nominative condition than in the dative-topic-nominative condition ( $p < .05$ , 2-tailed). Totals for the analyses of verb argument structure are shown in Table 8.

Finally, we combined information from the analyses of question particles and verb argument structure, in

order to provide a composite estimate of the proportion of trials in which the dative *wh*-phrase was interpreted in the embedded clause. The composite figure was based on the proportion of multi-clause responses in which there was either a question particle on the embedded clause verb or an embedded verb that obligatorily or optionally takes a dative argument. Unsurprisingly, 100% of in situ dative *wh*-phrases were interpreted in the embedded clause, according to this measure. More importantly, this measure provides an estimated proportion of 61.4% of fronted dative *wh*-phrases that were interpreted in the embedded clause (208/339 trials). The proportion was higher in the dative-nominative-nominative condition (68.1%, 113/166 trials) than in the dative-topic-nominative condition (54.9%, 95/173 trials),  $p < .05$ , Fisher Exact test, 2-tailed. No composite estimate was calculated for the nominative *wh*-phrase condition, since the verb argument structure analysis does not provide a measure of where the *wh*-phrase was interpreted in this condition.

Table 8  
Experiment 3, counts and percentages of verbs that select a dative-marked argument

Conditions	Embedded obligatory		Embedded optional		Main only	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
<b>A</b>	Dative Argument Structure (Embedded Q-Particle only)					
<i>WH-dat NP-top NP-nom</i>	34	81.0	3	7.1	5	11.9
<i>WH-dat NP-nom NP-nom</i>	36	72.0	3	6.0	11	22.0
<i>NP-top NP-nom WH-dat</i>	171	99.4	1	0.6	0	0.0
<i>NP-nom NP-nom WH-dat</i>	170	100.0	0	0.0	0	0.0
<i>WH-nom NP-dat NP-nom</i>	4	36.4	1	9.1	6	54.5
<i>Total</i>	415		8		22	
<b>B</b>	Dative Argument Structure (Main-clause Q-Particle only)					
<i>WH-dat NP-top NP-nom</i>	24	20.2	15	12.6	80	67.2
<i>WH-dat NP-nom NP-nom</i>	56	48.7	1	0.9	58	50.4
<i>NP-top NP-nom WH-dat</i>	4	100	0	0.0	0	0.0
<i>NP-nom NP-nom WH-dat</i>	5	100	0	0.0	0	0.0
<i>WH-nom NP-dat NP-nom</i>	18	11.3	10	6.3	132	82.5
<i>Total</i>	107		26		270	

(A) Trials with embedded clause question particles. (B) Trials with main clause questions particles.

Table 9  
Composite estimates of the total number of multi-clause responses in which the *wh* phrase was interpreted in

Conditions	Embedded		
	<i>N</i>	%	%
<i>WH-dat NP-top NP-nom</i>	95	54.9	61.4
<i>WH-dat NP-nom NP-nom</i>	113	68.1	
<i>NP-top NP-nom WH-dat</i>	176	100	100
<i>NP-nom NP-nom WH-dat</i>	175	100	
<i>WH-nom NP-dat NP-nom</i>	—	—	

Estimates of embedded clause interpretations for the dative *wh*-phrases are summarized in Table 9.

### Discussion

The first finding of this study is that Japanese speakers show a strong preference to analyze the nominative-marked NP as the subject of an embedded clause in a dative-topic-nominative sequence. The same is true for dative-nominative-nominative sequences. Therefore, it is safe to assume that participants in Experiments 1 and 2 recognized that the target items required an embedded clause analysis as soon as the embedded clause subject was read.

The second objective of the study was to investigate whether speakers exhibit the same bias to treat a fronted *wh*-phrase as long-distance scrambled both in their spontaneously generated sentence completions and in the on-line reading studies in Experiments 1 and 2. We used two measures of whether the fronted *wh*-phrase was interpreted in the embedded clause. First, the presence of a question particle on the embedded verb suggests embedded clause interpretation of the *wh*-phrase, since the grammar of Japanese requires that a question particle must be structurally higher than the argument position of the associated *wh*-phrase. Second, we used the proportion of embedded clause verbs that select a dative argument as an additional diagnostic of whether speakers intended the dative *wh*-phrase to be interpreted in the embedded clause. These two diagnostics show that the *wh*-phrases in the in situ conditions were thematically interpreted in the embedded clause 100% of the time. Since the surface position of these *wh*-phrases transparently indicates that they are in the embedded clause, this result serves as a validation of the diagnostics.

In comparisons of the *wh*-scrambling conditions with the in situ conditions, both diagnostics show that rates of embedded clause interpretation are significantly lower in the *wh*-scrambling conditions. However, the fronted *wh*-phrases showed substantially higher rates of embedded clause interpretations than the baseline condition. The proportion of question particles on the embedded verb was 4 times higher when the sentence began with a dative *wh*-phrase than when the sentence began with a nomina-

tive *wh*-phrase (32 vs. 8%). This difference suggests that participants understood many of the *wh*-scrambling fragments to involve long-distance scrambling from the embedded clause. The low rate of embedded question particles in the control condition is consistent with the fact that nominative NPs cannot undergo scrambling in Japanese.

In the analysis of the argument structure of the embedded verb, the relevant difference between the *wh*-fronting conditions and the control condition is that the dative NP appeared in sentence-initial position in the *wh*-fronting conditions, whereas it appeared in second position, in between the main clause subject and the embedded clause subject in the control conditions. The sentence-initial dative NP in the *wh*-fronting condition must be analyzed as either locally scrambled within the main clause, or long-distance scrambled from the embedded clause. The medial dative NP in the control condition could be analyzed as in situ in the main clause, or as locally scrambled to the front of the embedded clause. Results for completions in which the question particle was in the main clause showed that the proportion of embedded clause verbs that select a dative argument was more than twice as high in the *wh*-fronting conditions than in the control condition (41 vs. 17%). This again suggests a bias to interpret fronted *wh*-phrases as arguments of an embedded clause verb. The finding that 17% of embedded clause verbs selected a dative argument even in the control condition is consistent with the fact that Japanese grammar allows sentence-medial dative NPs to be interpreted as locally scrambled within the embedded clause, but the lower frequency of embedded clause interpretations in the control condition is consistent with the finding of Kamide and Mitchell (1999) that sentence medial dative NPs are likely to be interpreted in situ in the main clause. The contrast also lends support to the logic pursued in Experiment 2, where it was reasoned that sentence-initial dative NPs would be interpreted as embedded clause arguments more often than sentence-medial dative NPs.

A composite measure of the proportion of embedded clause interpretations provided an estimate of 61% embedded clause interpretations in the *wh*-fronting trials. Although, it is possible to apply each of our two diagnostics of embedded clause interpretation individually in the control condition, and both measures show substantially higher rates of embedded clause interpretation in the *wh*-fronting conditions than in the control condition, it is not possible to compare the composite total with a comparable measure for the control condition. This is because our two diagnostics both applied to the dative NP in the *wh*-fronting conditions, but applied to two different NPs in the control condition. Nevertheless, we regard it as significant that fronted *wh*-phrases were treated as phrases that had undergone long-distance scrambling from an embedded clause in more than 60% of trials. In a theory in which filler-gap dependencies are

required to be as short as possible, such as the Active Filler Strategy approach, this high rate of embedded clause interpretations is entirely unexpected. Meanwhile, in an approach based upon maximal satisfaction of the argument structure requirements of verbs, it is difficult to make a clear prediction about performance in this study, since the sentence fragments contained no verbs, and participants were required to generate verbs for themselves. On the other hand, in an approach to filler-gap dependencies that places value on early satisfaction of the thematic requirements of NPs, it is predicted that a high proportion of fronted NPs will be interpreted in the embedded clause, since this allows thematic role assignments to be confirmed early, as soon as the embedded verb is confirmed. The fact that this effect appeared in a sentence-fragment completion task shows that the bias for long-distance scrambling cannot be an artifact of the self-paced reading technique used in Experiments 1 and 2.

However, we must also consider why the rate of embedded clause interpretation was not even higher, and why the parallelism between *in situ* and *wh*-fronting conditions was weaker in this experiment than in the online reading results of Experiment 1. In line with the discussion above, we suggest that the sizeable proportion of main clause interpretations for fronted *wh*-phrases in this experiment may reflect the sequence of syntactic encoding operations in the sentence fragment completion task, which is a kind of sentence production task. In a verb-final language such as Japanese speakers may sometimes syntactically encode the main verb of a sentence in advance of an embedded verb. Under such circumstances, early thematic role assignment can be satisfied by interpreting a fronted *wh*-phrase as a main clause argument, rather than as an embedded clause argument. Therefore, if participants sometimes generated the main verb in advance of the embedded verb, this could account for why rates of embedded clause interpretation were not as high in the *wh*-fronting conditions as in the *in situ* conditions.

## 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 real-time formation of long-distance dependencies. The strict verb-final property of Japanese has the effect that more deeply embedded verbs appear before structurally higher verbs in a sentence. This property distinguishes the predictions of theories that claim that the formation of long-distance dependencies is driven by the satisfaction of syntactic and semantic constraints from those based upon the need to

create a gap as soon as possible. The former class predicts that a fronted phrase will be preferentially interpreted with a more deeply embedded verb when the more deeply embedded verb appears earlier in the sentence. This is descriptively the mirror image 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 same clause that contains the *wh*-phrase.

Experiment 1 showed that Japanese readers exhibit 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 and Takahashi (2000, 2003) 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). This shows 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 beginning of our critical items as part of a bi-clausal structure. This study also showed that when Japanese speakers complete sentence fragments that begin with a fronted *wh*-phrase, they spontaneously generate a sentence completion in which the fronted phrase is interpreted in the embedded clause in more than 60% of trials.

Taken together, our results indicate that readers prefer to associate a fronted *wh*-phrase with an embedded clause. This means that the *wh*-phrase is related not to the first possible gap position, but instead to the first verb that readers encounter (i.e., the embedded verb). Crucially, the parser seems to create enough structure in the embedded clause to allow immediate integration of the displaced constituent into the sentence structure. The embedded clause preference could not be due to the argument structure requirements 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 any verb, and since Experiment 3 left the choice of verb to the

participants. It is also 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 and Takahashi (2003) 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 (De Vincenzi, 1991; Frazier & Clifton, 1989). The Active Filler Strategy is optimally satisfied if readers posit a gap for a fronted dative *wh*-phrase in the first possible position, following the main clause subject, and it provides no motivation 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, or under any measure of derivational or representational complexity.

On the other hand, the finding of an embedded clause preference for fronted *wh*-phrases confirms a 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 conclude that the results favor an incremental, gap-based model of filler-gap 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. The thematic interpretation of the *wh*-phrase can be fixed by the verb, and the scope interpretation of the *wh*-question can be fixed by the presence of a question-marker affixed to the verb. Our results do not allow us to conclude that formation of *wh*-dependencies is specifically driven by the need to satisfy thematic requirements. Our results could be due to thematic requirements, scope-fixing requirements, or both. Additional studies involving scrambled non-interrogative phrases would be needed in order to distinguish these alternatives.

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 (Caplan & Waters, 1999; Gibson, 1998; Just & Carpenter, 1992; Kaplan, 1973; Wanner & Maratsos, 1978). 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 Active Filler Strategy approach or the constraint-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 in working memory or structurally linked to a gap position, then this theory would make the same predictions as the Active Filler Strategy, 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 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, such that it can apply even before the verb that checks the interpretive features is accessed. A similar argument is presented by Drury, Resnik, Weinberg, Genari, and 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. In order to account for the creation of a gap inside the embedded clause, it would be necessary to appeal to the additional interpretive benefits that result from positing an embedded clause gap. More generally, we consider it highly unlikely that the bias for long-distance scrambling over local scrambling shown in all three of our studies is a result of a statistical bias for long-distance scrambling in spoken or written Japanese. Yamashita (2002) shows that in a corpus of 2635 written Japanese sentences there are 11 occurrences of clause-internal fronting (0.4%) and only 1 occurrence of long-distance fronting (0.04%). Clearly, more extensive studies of written and spoken Japanese would be useful to confirm this expectation.

#### Unforced reanalysis

This section discusses the puzzle posed by our findings for theories of reanalysis in sentence processing. Although we have focused on the ultimate embedded clause interpretation of fronted *wh*-phrases, our results also suggest that Japanese readers arrive at this analysis after first considering a single-clause analysis, in which the *wh*-phrase is associated with a gap in the main clause. This in turn means that in order to arrive at the ultimate 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 in Tables 2 and 3 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. 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 filler-gap association must be weakened or abandoned altogether. This implies that unforced reanalysis takes place, 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.

The second reason to assume that the parser first constructs a main clause gap site is based upon empirical evidence from a study of incremental pre-verbal struc-

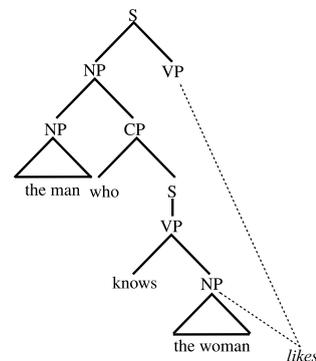
ture building in Japanese (Aoshima, Phillips, & Weinberg, 2003b). This study argued that co-reference relations among NPs are constructed in advance of the verb in mono-clausal structures, even in cases where a filler-gap dependency must first be constructed in order to establish an appropriate co-reference relation.

Given these arguments, we assume that the embedded clause interpretation of fronted phrases is the result of displacement from an initial main clause association between filler and gap. What remains to be explained is why successive attempts at filler-gap associations are even possible, in light of recent evidence that reanalysis is a last resort operation and that unforced reanalysis is impossible (Kamide & Mitchell, 1999; Schneider & Phillips, 2001; Sturt et al., 2001).

Sturt et al. (2001) and Schneider and Phillips (2001) both present similar arguments that unforced reanalysis is avoided in English. In sentence (13a) the parser faces two alternative ways of incorporating the second verb ('likes') into the structure, as illustrated in (13b). One involves a local reanalysis, such that the verb takes the preceding NP ('the woman') as its subject to form an embedded clause (13d). This reanalysis operation is independently known to be easy (Fodor & Ferreira, 1998; Sturt, Pickering, & Crocker, 1999), based on evidence from structures where it is grammatically 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 (13c). Garden path effects are observed at the point of disambiguation of local reanalysis examples like (13d). Therefore, 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.

(13)a. The man who knows the woman likes...

b.



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

d. [IP [NP The man [CP who [VP knows [CP [NP the woman] [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. We must replace this statement with an account that can distinguish English from Japanese. The Japanese examples and the English cases in (13) differ in a number of respects. We claimed above that successive gap postulation is triggered by the filler's lack of association with its required thematic role or grammatical case. Association with a gap position in either the main clause or embedded clause does not lead to this required association, but only places the category in an appropriate position where its thematic role may subsequently be confirmed by a following verb. Reanalysis in these cases does not cause the filler to be disassociated from a previously confirmed thematic role. By contrast, in (13) local reanalysis requires giving up an existing commitment that the NP 'the woman' is the direct object of the verb 'knows.' The change also requires revising the argument structure of the verb 'knows' from an NP-complement analysis to a sentential complement analysis, with the concomitant need to build additional structure. 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. Thus, in a number of different respects, the availability of unforced reanalysis may reflect the limited confirmation of the existing parse, and the fact that few existing commitments must be rescinded in order to move the gap to the embedded clause.

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 and Mitchell (1999) that reanalysis is a last resort operation in Japanese. Kamide and Mitchell show that in ambiguous configurations like (14) the dative NP is preferentially interpreted as an argument of the main clause verb.

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

When the first verb is ditransitive and the second is transitive, the last verb is read significantly more slowly than in the case where the second verb is di-

transitive. Kamide and Mitchell suggest that this shows an initial attachment of the dative NP as a co-argument of the main clause subject and reluctance to re-associate the verb with an embedded clause, despite the subsequent evidence that the embedded verb requires a goal argument. Kamide and Mitchell therefore conclude that reanalysis must be a last resort operation.

Kamide and Mitchell's examples are similar to our Japanese *wh*-question examples in a number of regards. First, both sets of examples involve dative NPs that could receive an analysis as a scrambled NP. Second, in both sets of examples the benefit of reanalyzing the dative NP is earlier confirmation of the thematic role of the NP and, in the case of Kamide and Mitchell's materials, satisfaction of 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, Kamide and Mitchell'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 Kamide and Mitchell's study. First, it is clear in our study that the dative *wh*-phrase has been scrambled to sentence-initial position. Therefore, the forced reanalysis that takes place changes one scrambling analysis to another scrambling analysis. In Kamide and Mitchell'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 involves a change from a non-scrambling analysis to a scrambling analysis. Therefore, the availability of unforced reanalysis in our study may reflect the fact that it does not entail an additional structural dependency (De Vincenzi, 1991; Weinberg, 1999). It may be available because Reanalysis as a Last Resort applies only to phonologically overt material, whereas it is a gap position that undergoes reanalysis in our study. Alternatively, it may be that unforced reanalysis is possible for structural predictions, but not for confirmed structural commitments. Although we have argued that filler-gap dependencies are constructed in advance of the verb in Japanese, it is possible that the parser treats these structures as firm commitments only once an appropriate verb has been encountered, as would be predicted by a theory that measures 'firmness of commitment' by satisfaction of constraints. Our current results cannot choose among these alternative interpretations.

A further possibility that is consistent with our results is that the critical difference between our studies and Kamide and Mitchell's study is that our studies examined the processing of *wh*-phrases, whereas Kamide and Mitchell focused on referential NPs. We cannot at

present exclude the possibility that early scope assignment plays a special role in processing.<sup>2</sup>

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 search for underlying factors that apply cross-linguistically yet result in different outcomes given independent differences such as the position of the verb or the presence or absence of overt scope markers.

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 et al. (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. The difference between serial and parallel models does not affect the main arguments presented in this paper, since a parallel model would still have to explain why the embedded clause gap site becomes the favored alternative in Japanese, despite the fact that the gap that was previously created in the main clause is entirely well-formed. 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 com-

peting analyses when an individual analysis is highly supported.

## Conclusion

The ‘active filler’ effects observed in the processing of long-distance dependencies have received several different treatments. 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. This second class of accounts may be divided into approaches that focus on the need to satisfy a verb’s syntactic requirements, and full constraint-driven approaches that allow the grammatical needs of any element to drive dependency formation. These approaches all make similar predictions for verb-medial languages such as English. However, the predictions of the different approaches diverge in head-final languages such as Japanese. In this paper we tested a prediction of the constraint-driven (or ‘principle-based’) approach. This theory predicts 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 Japanese speakers expect to encounter a question-marker particle on the verb of the embedded clause in sentences with sentence-initial *wh*-phrases. 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, our results argue that general, grammatically based constraints govern several aspects of syntactic processing behavior. In addition, we sharpen our understanding of how these constraints are deployed. 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 the Active Filler Strategy should be understood as a processing mechanism that satisfies syntactic and semantic requirements. Second, initial

<sup>2</sup> 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 Kamide and Mitchell at the main clause verb could be a reflex of this lingering initial analysis. Since Kamide and Mitchell’s critical conditions contained verbs that selected a dative argument in both main and embedded clauses, we cannot at present exclude this possibility.

theorizing (e.g. Ford, Bresnan, & Kaplan, 1982; MacDonald, Pearlmuter, & Seidenberg, 1994; Pritchett, 1988) suggested that this constraint satisfaction routine could only be attempted upon retrieval of a grammatical head. This predicts that when critical lexical heads are delayed, as in a verb-final language such as Japanese, dependency formation should be correspondingly delayed (e.g. Pritchett, 1991b, 1992; Mulders, 2002). Our findings about Japanese filler-gap dependencies contradict this assertion. We show that a wider range of categories impose grammatical licensing constraints which can be satisfied in a fully incremental manner, as soon as the potential licensing environment is encountered in the parse (see Abney, 1987; Frank, 1992; Weinberg, 1993). In addition, grammatical constraint satisfaction is also relevant to predicting when reanalysis of initial constituent structure is undertaken. If the initial structure allows local constraint satisfaction, reanalysis is to be avoided, but it may be attempted if initial structures do not lead to immediate constraint satisfaction.

Finally, our results illustrate the value of a cross-language approach to understanding real-time comprehension mechanisms. Japanese speakers' bias to treat

fronted *wh*-phrases as if they have undergone long-distance scrambling is descriptively very different from the bias for shorter filler-gap dependencies in languages like English, yet it can be accounted for by a common parsing mechanism, and helps to decide among competing theoretical accounts of the English phenomena.

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### Appendix A. Experimental materials for Experiment 1

Each of the items in this list represents a full set of stimuli from Experiment 1. 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 (/).

1. {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。/。]  
{dono seito-ni} tannin-wa kotyoo-ga {dono seito-ni} eigo-no hon-o yonda[to/ka] tosyositu-de sisyo-ni iimasita[ka/.]  
{which student-dat} class teacher-top principal-nom {which student-dat} English-gen book-acc read[comp/Q]  
said[Q/.]  
'{Which student} [did] the class teacher [say/said] to the librarian at the library {which student} [that] the principal read an English book for [?/.]
2. {どの女の子に} 司会者は ミュージシャンが {どの女の子に} 歌を 歌った[と/か] スタジオで 観客に 説明しました[か。/。]  
{dono onnanoko-ni} sikaisya-wa myuujisyan-ga {dono onnanoko-ni} uta-o utatta[to/ka] sutajio-de kankyaku-ni setumeisimasita[ka/.]  
{which girl-dat} mc-top musician-nom {which girl-dat} song-acc sang[comp/Q] studio-at audience-dat explained[Q/.]  
'{Which girl} [did] the mc explain[ed] to the audience at the studio {which girl} [that] the musician sang a song for [?/.]
3. {どの子供に} 叔母は 母親が {どの子供に} ケーキを 焼いた[と/か] 台所で お手伝 いさんに 知らせました[か。/。]  
{dono kodomo-ni} oba-wa hahaoya-ga {dono kodomo-ni} keeki-o yaita[to/ka] daidokoro-de otetudaisan-ni sirasemasita[ka/.]  
{which child-dat} aunt-top mother-nom {which child-dat} cake-acc bake[comp/Q] kitchen-at housekeeper-dat informed[Q/.]  
'{Which child} [did] the aunt inform[ed] to the housekeeper at the kitchen {which child} [that] the mother baked a cake for [?/.]
4. {どの老婆に} 牧師は ボランティアが {どの老婆に} ごはんを 炊いた[と/か] 教会で 信者に 伝えました[か。/。]  
{dono rooba-ni} bokusi-wa borantiaa-ga {dono rooba-ni} gohan-o taita[to/ka] kyookai-de sinja-ni tutaemasita[ka/.]  
{which old woman-dat} pastor-top volunteer-nom {which old woman-dat} rice-acc made[comp/Q] church-at church-goers-dat told[Q/.]  
'{Which old woman} [did] the pastor [tell/told] to the church-goers at the church [that] the volunteers made rice for [?/.]
5. {どの女性に} 部長は 社長が {どの女性に} 新車を 買った[と/か] 食堂で 専務に 教えました[か。/。]  
{dono josee-ni} botyoo-wa syatyoo-ga {dono josee-ni} sinsya-o katta[to/ka] syokudoo-de senmu-ni osiemasita[ka/.]  
{which woman-dat} manager-top president-nom {which woman-dat} a new car-acc bought[comp/Q] cafeteria-at director-dat notified[Q/.]

{Which woman} [did] the manager notif[ied] to the director at the cafeteria {which woman} [that] the president bought a new car for [?/.]

6. {どの教え子に} 研究助手は 教授が {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。/。]  
 {dono osiego-ni} kenkyuu-josyu-wa kyooju-ga {dono osiego-ni} kenkyuu-teema-o eranda[to/ka] jikkensitu-de ga-kutyoo-ni setumeisimasita[ka/.]

{which advisee-dat} researcher assistant-top professor-nom {which advisee-dat} research theme-acc chose[comp/Q] lab-at dean-dat explained[Q/.]

{Which advisee} [did] the research assistant explain[ed] to the dean at the lab {which advisee} [that] the professor chose a research theme for [?/.]

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。/。]

{dono fan-ni} kantoku-wa sensyu-ga {dono fan-ni} nigaoe-o kaita[to/ka] rokkaaruumu-de maneejaa-ni iimasita[ka/.]  
 {which fan-dat} coach-top player-nom {which fan-dat} portrait-acc drew[comp/Q] locker room-at manager-dat said[Q/.]

{Which fan} [did] the coach said [say/said] to the manager at the locker room {which fan} [that] the player drew a portrait for [?/.]

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。/。]

{dono kazoku-ni} otto-wa tuma-ga {dono kazoku-ni} sandoitti-o tukutta[to/ka] kooen-de yuujin-ni tutaemasita[ka/.]  
 {which family-dat} husband-top wife-nom {which family-dat} sandwich-acc made[comp/Q] park-at friend-dat told[Q/.]

{Which family} [did] the husband [tell/told] to the friend at the park {which family} [that] the wife made sandwich for [?/.]

9. {どの老人に} 看護婦は お坊さんが {どの老人に} お経を 唱えた[と/か] 病室で 医者に 報告しました[か。/。]

{dono roojin-ni} kangofu-wa oboosan-ga {dono roojin-ni} okyoo-o tonaeta[to/ka] byoositu-de isya-ni hookokusimasita[ka/.]

{which old man-dat} nurse-top priest-nom {which old man-dat} sutra-acc chanted[comp/Q] ward-at doctor-dat reported[Q/.]

{Which old man} [did] the nurse report[ed] to the doctor at the ward {which old man} [that] the priest chant sutra for [?/.]

10. {どの先生に} 校長は 生徒が {どの先生に} 詩を 詠んだ[と/か] 職員室で 教頭に 報告しました[か。/。]

{dono sensei-ni} kootyoo-wa seito-ga {dono sensei-ni} si-o yonda[to/ka] syokuinsitu-de kyootoo-ni hookokusimasita[ka/.]

{which teacher-dat} principal-top pupil-nom {which teacher-dat} poem-acc recited[comp/Q] teacher's room-at deputy headteacher-dat reported[Q/.]

{Which teacher} [did] the principal report[ed] to the deputy headteacher at the teacher's room {which teacher} [that] the pupil recited the poem for [?/.]

11. {どの孫に} 祖母は 祖父が {どの孫に} 家を 購入した[と/か] 居間で 父親に 教えました[か。/。]

{dono mago-ni} sobo-wa sofu-ga {dono mogo-ni} ie-o koonyuu[to/ka] ima-de titioya-ni osiemasita[ka/.]

{which grandchild-dat} grandmother-top grandfather-nom {which grandchild-dat} house-acc purchased[comp/Q] living room-at father-dat informed[Q/.]

{Which grandchild} [did] the grandmother inform[ed] to the father at the living room {which grandchild} [that] the grandfather purchased a house for [?/.]

12. {どの学生に} 教授は 父親が {どの学生に} 就職先を 見つけた[と/か] 研究室で 学部長に 説明しました[か。/。]

{dono gakusei-ni} kyooju-wa titoya-ga {dono gakusei-ni} syuusyokusaki-o mituketa[to/ka] kenkyuusitu-de gakubutyoo-ni setumeisimasita[ka/.]

{which student-dat} professor-top father-nom {which student-dat} job-acc found[comp/Q] research office-at chair-dat explained[Q/.]

{Which student} [did] the professor explain[ed] to the chair at the research room {which student} [that] his father found a job for [?/.]

13. {どのピアニストに} 指揮者は 音楽家が {どのピアニストに} オペラを 作曲した [と/か] 練習室で 声楽家に

言いました[か。/。]

{dono pianisto-ni} sikisya-wa ongakuka-ga {dono pianisto-ni} opera-o sakkyokusita[to/ka] rensyuusitu-de seigakuka-ni iimasita[ka/.]

{which pianist-dat} conductor-top musician-nom {which pianist-dat} opera-acc composed[comp/Q] rehearsal room-at vocalist-dat said[Q/.]

{Which pianist} [did] the conductor [say/said] to the vocalist at the rehearsal room {which pianist} [that] the musician composed an opera for [?/.]

14. {どの少年に} 祖父は おじさんが {どの少年に} 大きなフナを 釣った[と/か] 庭で 祖母に 知らせました[か。/。]  
 {dono syoonen-ni} sofū-wa ojisan-ga {dono syoonen-ni} ookina funa-o tutta[to/ka] niwa-de sobo-ni sirasemasita[ka/.]  
 {which boy-dat} grandfather-top uncle-nom {which boy-dat} big carp-acc caught[comp/Q] garden-at grandmother-dat informed[Q/.]  
 ‘{Which boy} [did] the grandfather inform[ed] to the grandmother at the garden {which boy} [that] the uncle caught a big fish for [?/.]’
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。/。]  
 {dono otokonoko-ni} hantyoō-wa sidōin-ga {dono otokonoko-ni} kabutomusi-o totta[to/ka] campujoo-de dantyoō-ni sirasemasita[ka/.]  
 {which boy-dat} group leader-top guide-nom {which boy-dat} beetle-acc caught[comp/Q] camp site-at head-dat informed[Q/.]  
 ‘{Which boy} [did] the group leader inform[ed] to the head at the camp site {which boy} [that] the guide caught a beetle for [?/.]’
16. {どの園児に} 先生は 留学生が {どの園児に} 折り紙を 折った[と/か] 教室で 父兄に 教えました[か。/。]  
 {dono enji-ni} sensei-wa ryuugakusei-ga {dono enji-ni} origami-o otta[to/ka] kyoositu-de fukei-ni osiemasita[ka/.]  
 {which kindergarten child-dat} teacher-top foreign student-nom {which kindergarten child-dat} origami-acc made[comp/Q] classroom-at parents-dat told[Q/.]  
 ‘{Which kindergarten child} [did] the teacher tell [told] to the parents at the classroom {which kindergarten child} [that] the foreign student made an origami for [?/.]’
17. {どの女優に} マネージャは 歌手が {どの女優に} 花を 摘んだ[と/か] テレビで 記者に 伝えました[か。/。]  
 {dono joyuu-ni} maneejaa-wa kasyu-ga {dono joyuu-ni} hana-o tunda[to/ka] terebi-de kisyā-ni tutaemasita[ka/.]  
 {which actress-dat} manager-top singer-nom {which actress-dat} flowers-acc picked-up[comp/Q] TV-at reporters-dat told[Q/.]  
 ‘{Which actress} [did] the manager [tell/told] to the reporters on TV {which actress} [that] the singer picked up flowers for [?/.]’
18. {どの乗客に} スチュワーデスは 警備員が {どの乗客に} ドアを 開けた[と/か] 操縦室で 機長に 報告しました[か。/。]  
 {dono jookyaku-ni} sutyuwaadesu-wa keibin-ga {dono jookyaku-ni} doa-o aketa[to/ka] soojusitu-de kityoo-ni hookokusimasita[ka/.]  
 {which passenger-dat} flight attendant-top guardsman-nom {which passenger-dat} door-acc opened[comp/Q] cockpit-in chief pilot-dat reported[Q/.]  
 ‘{Which passenger} [did] the flight attendant report[ed] to the chief pilot in the cockpit {which passenger} [that] the guardsman opened the door for [?/.]’
19. {どの女の人に} ディレクターは タレントが {どの女の人に} ギターを 弾いた[と/か] 楽屋で 記者に 説明しました[か。/。]  
 {dono onnanohito-ni} direkutaa-wa tarento-ga {dono onnanohito-ni} gitaa-o hiita[to/ka] gakuya-de kisyā-ni setumeisimasita[ka/.]  
 {which woman-dat} director-top talent-nom {which woman-dat} guitar-acc played[comp/Q] dressing room-in reporter-dat explained[Q/.]  
 ‘{Which woman} [did] the director explain[ed] to the reporters in the dressing room {which woman} [that] the talent played the guitar for [?/.]’
20. {どの作家に} 担当者は 編集長が {どの作家に} アシスタントを 雇った[と/か] 会議で 出版者に 教えました[か。/。]  
 {dono sakka-ni} tantoosya-wa hensyuutyoo-ga {dono sakka-ni} asiantanto-o yatotta[to/ka] kaigi-de syuppannsya-ni osiemasita[ka/.]  
 {which writer-dat} person in charge-top chief editor-nom {which writer-dat} assistant-acc hired[comp/Q] meeting-in publisher-dat told[Q/.]  
 ‘{Which writer} [did] the person in charge [tell/told] to the publisher at the meeting {which writer} [that] the chief editor hired an assistant for [?/.]’
21. {どの議員に} 受付嬢は 助役が {どの議員に} タクシーを 呼んだ[と/か] 電話で 市長に 報告しました[か。/。]  
 {dono giin-ni} uketukejoo-wa joyaku-ga {dono giin-ni} takusii-o yonda[to/ka] denwa-de sityoo-ni hookokusimasita[ka/.]  
 {which senator-dat} receptionist -top deputy mayor -nom {which senator-dat} taxi-acc called[comp/Q] phone-by mayor-dat reported[Q/.]  
 ‘{Which senator} [did] the receptionist tell[told] to the mayor on phone {which senator} [that] the deputy mayor called a taxi for [?/.]’
22. {どの課長に} 専務は 新入社員が {どの課長に} 文書を作成した[と/か] 会議室で 部長に 言いました[か。/。]  
 {dono katyoo-ni} senmu-wa sinnnyuusyain-ga {dono katyoo-ni} bunsyo-o sakuseisita[to/ka] kaigisitu-de butyoo-ni iimasita[ka/.]

{which section manager-dat} managing director -top new employee -nom {which section manager-dat} document-acc made[comp/Q] meeting room-in section director-dat said[Q/.]

{Which section manager} [did] the managing director say[said] to the section director in the meeting room {which section manager} [that] the new employee made a document for [?/.]

23. {どの客に} 店長は コックが {どの客に} 野菜を 炒めた[と/ か] 調理場で ウエイトレスに 知らせました[か。/。]

{dono kyaku-ni} tentyoo-wa kokku-ga {dono kyaku-ni} yasai-o itameta[to/ka] tyooriba-de ueitoresu-ni sireasemasita[ka/.]

{which customer-dat} store manager-top cook -nom {which customer-dat} vegetable-acc fried[comp/Q] kitchen-in waitress-dat informed[Q/.]

{Which customer} [did] the store manager inform[ed] to the waitress in the kitchen {which customer} [that] the cook fried vegetable for [?/.]

24. {どの子に} 母親は 店員が {どの子に} 模型を 組み立てた[と/ か] 店先で 店長に 伝えました[か。/。]

{dono ko-ni} hahaoya-wa tenin-ga {dono ko-ni} mokei-o kumitateta[to/ka] misesaki-de tentyoo-ni tutaemasita[ka/.]

{which child-dat} mother-top clerk -nom {which child-dat} model-acc assembled[comp/Q] front-of-store-at manager-dat told[Q/.]

{Which child} [did] the mother [tell/told] to the manager in front of the store {which child} [that] the clerk assembled a model for [?/.]

## 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 (/).

1. どの新入生[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。

dono-sinnyuusei-[ni/ga] tannin-[wa/ni] sisyo-ga tosyositu-de kootyoo-sensei-ni mangabon-o susumeta-to iimasita-ka? which new student-[dat/nom] class teacher-[top/dat] librarian-nom library-at principal-dat comic book-acc recommended-comp said-Q

'To which student did the class teacher say that the librarian recommended the comic book to the principal?'

'Which student said to the class teacher that the librarian recommended the comic book to the principal?'

2. どの警備員[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。

dono-keibiin-[ni/ga] sikaisya-[wa/ni] muujisyan-ga sutajio-de kankyaku-ni maiku-o nageta-to sirasemasita-ka? which guardsman-[dat/nom] MC-[top/dat] musician-nom studio-at audience-dat microphone-acc threw-comp informed-Q

'To which guardsman did the MC inform that the musician threw the microphone to the audience?'

'Which guardsman informed of the MC that the musician threw the microphone to the audience?'

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。

dono-kodomo-[ni/ga] hahaoya-[wa/ni] otedudaisan-ga daidokoro-de titioya-ni obento-o atasita-to said-ka?

which child-[dat/nom] mother-[top/dat] housekeeper-nom kitchen-at father-dat lunchbox-acc handed-comp informed-Q

'To which child did the mother say that the housekeeper handed the lunchbox to the father?'

'Which child said to the mother that the housekeeper handed the lunchbox to the father?'

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。

dono-joseisyain-[ni/ga] senmu-[wa/ni] syatyoo-ga kaigi-de bucyoo-ni syookyuu-o yakusokusita-to osiemasita-ka? which female employee-[dat/nom] director-[top/dat] president-nom meeting-at manager-dat raise-acc promised-comp notified-Q

'To which female employee did the director say that the president promised a raise to the manager?'

'Which female employee notified to the director that the president promised a raise to the manager?'

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。

dono-kyooju-[ni/ga] gakubutyoo-[wa/ni] josyu-ga jikkensitu-de daigakuinsei-ni jikken-o miseta-to setumeisimasita-ka?

which professor-[dat/nom] chair-[top/dat] assistant-nom lab-at graduate student-dat experiment-acc showed-comp explained-Q

'To which professor did the chair say that the assistant showed the experiment to the graduate student?'

'Which professor notified to the chair that the assistant showed the experiment to the graduate student?'

6. どのマネージャー[に/が] 監督[は/に] 選手が ロッカーームで ファンに ボールを 配ったと 報告しましたか。

dono-maneejaa-[ni/ga] kantoku-[wa /ni] sensyu-ga rokkaaruumu-de fan-ni booru-o watasita-to hookokusima-sita-ka?

which manager-[dat/nom] coach-[top/dat] player-nom locker room-at fan-dat ball-acc passed-comp reported-Q

'To which manager did the coach explain that the player passed the ball to the fan?'

'Which manager notified to the coach that the player passed the ball to the fan?'

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 伝えましたか。

dono-kangofu-[ni/ga] intyoo-[wa/ni] tantooi-ga sinsatusitu-de kanja-ni kazegusuri-o syohoosita-to tutaemasita-ka?  
which nurse-[dat/nom] chief doctor-[top/dat] doctor-nom doctor's office-at patient-dat cold medicine-acc prescribed-comp told-Q

'To which nurse did the chief doctor tell that the doctor prescribed cold medicine for the patient?'

'Which nurse told the chief doctor that the doctor prescribed cold medicine for the patient?'

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。

dono-yuujin-[ni/ga] tuma-[wa/ni] otto-ga denwa-de juui-ni koinu-o azuketa-to hookokusimasita-ka?  
which friend-[dat/nom] wife-[top/dat] husband-nom phone-on veterinarian-dat puppy-acc left-comp reported-Q

'To which friend did the wife reported that her husband left the puppy to the veterinarian?'

'Which friend reported to the wife that her husband left the puppy to the veterinarian?'

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。

dono-mago-[ni/ga] sobo-[wa/ni] sofu-ga susiya-de hahaoya-ni sushi-o gotisoosita-to osiemasita-ka?  
which grandchild-[dat/nom] grandmother-[top/dat] grandfather-nom sushi bar-at mother-dat sushi-acc treated-comp told-Q

'To which grandchild did the grandmother tell that the grandfather treated sushi for the mother?'

'Which grandchild told the grandmother that the grandfather treated sushi for the mother?'

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 伝えましたか。

dono-keikan-[ni/ga] keiji-[wa/ni] yoogisya-ga genba-de higaisya-ni minouebanasi-o katatta-to osiemasita-ka?  
which policeman-[dat/nom] detective-[top/dat] suspect-nom crime site-at victim-dat personal story-acc spoke-comp told-Q

'To which policeman did the detective tell that the suspect spoke about his personal story to the victim?'

'Which policeman told the detective that the suspect spoke about his personal story to the victim?'

11. どのピアニスト[に/が] 指揮者[は/に] 声楽家が 楽屋で パイオリン奏者に 花束を 贈ったと 言いましたか。

dono-pianisto-[ni/ga] sikisya-[wa/ni] seigakuka-ga gakuya-de viorin soosya-ni hanataba-o okutta-to iimasita-ka?  
which pianist-[dat/nom] conductor-[top/dat] singer-nom dressing room-at violinist-dat flowers-acc presented-comp said-Q

'To which pianist did the conductor say that the singer presented flowers to the violinist?'

'Which pianist said to the conductor that the singer presented flowers to the violinist?'

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 着せたと 知らせ ましたか。

dono-enji-[ni/ga] sensei-[wa/ni] ryuugakusei-ga kyoositu-de encyoo-ni minzokuisyoo-o kiseta-to sirasemasita-ka?  
which kindergarten child-[dat/nom] teacher-[top/dat] foreign student-nom class room-at director-dat folk costume-acc wear-causative-comp informed-Q

'To which kindergarten child did the teacher inform that the foreign student let the director wear the folk costume?'

'Which kindergarten child informed of the teacher that the foreign student let the director wear the folk costume?'

13. どのスチュワーデス[に/が] 副操縦士[は/に] 機長が 機内で 乗客に 出身地を 尋ねたと 知らせ ましたか。

dono-sutyuwaadesu-[ni/ga] fukusoojuusi-[wa/ni] kityoo-ga kinai-de jookyaku-ni syussinti-o tazuneta-to sirasemasita-ka?

which flight attendant-[dat/nom] pilot-[top/dat] chief pilot-nom inside plane-at passenger-dat hometown-acc asked-comp informed-Q

'To which flight attendant did the pilot inform that the chief pilot asked a passenger about his hometown?'

'Which flight attendant informed of the pilot that the chief pilot asked a passenger about his hometown?'

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。

dono-kisya-[ni/ga] tukibito-[wa/ni] yakuza-ga jimusyo-de joyuu-ni tegirekin-o seikyusita-to tutaemasita-ka?  
which reporter-[dat/nom] attendant-[top/dat] gang-nom office-at actress-dat consolation money-acc requested-comp told-Q

'To which reporter did the attendant tell that the gang requested consolation money to the actress?'

'Which reporter told the attendant that the gang requested consolation money to the actress?'

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 したと 伝え ましたか。

dono-hensyuusya-[ni/ga] asisutanto-[wa /ni] hensyuutyoo-ga rooka-de sakka-ni genkoo-o tewatasita-to tutaemasita-ka?

which editor-[dat/nom] assistant-[top/dat] chief editor-nom hallway-at writer-dat paper-acc handed-comp told-Q

‘To which editor did the assistant tell that the chief editor handed the paper to the writer?’

‘Which editor told the assistant that the chief editor handed the paper to the writer?’

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。

dono-kokkai giin-[ni/ga] hisyo-[wa/ni] tiji-ga bunsyo-de kensetugaisya-ni kouji-o kyokasita-to setumeisimasita-ka?  
which senator-[dat/nom] secretary-[top/dat] governor-nom document-with construction company-dat construction-acc permitted-comp explained-Q

‘To which senator did the secretary explain that the governor permitted the construction company construction?’

‘Which senator explained to the secretary that the governor permitted the construction company construction?’

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。

dono-ueitoresu-[ni/ga] ryoorityoo-[wa/ni] minarai-ga tyooriba-de joorenkyaku-ni yakisoba-o tabesaseto-to osiema-sita-ka?

which waitress-[dat/nom] chief cook-[top/dat] apprentice-nom kitchen-at regular customer-dat fried noodles-acc ate-causative-comp notified-Q

‘To which waitress did the chief cook notify that the apprentice let the regular customers eat fried noodles?’

‘Which waitress notified to the chief cook that the apprentice let the regular customers eat fried noodles?’

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。

dono-tenin-[ni/ga] hanaoya-[wa/ni] tentyoo-ga misesaki-de kodomo-ni geemu-o syookaisita-to iimasita-ka?  
which clerk-[dat/nom] mother-[top/dat] manager-nom store front-at child-dat game-acc introduced-comp said-Q

‘To which clerk did the mother say that the manager introduced the game to the child in front of the store?’

‘Which clerk said to the mother that the manager introduced the game to the child in front of the store?’

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。

dono-untensyu-[ni/ga] keiji-[wa/ni] keikan-ga syanai-de hannin-ni keisatukanbajji-o teijsisita-to tutaemasita-ka?  
which driver-[dat/nom] detective-[top/dat] policeman-nom car inside-at criminal-dat policeman badge-acc showed-comp told-Q

‘To which driver did the detective tell that the policeman showed his badge to the criminal?’

‘Which driver told the detective that the policeman showed his badge to the criminal?’

20. どの老婦人[に/が] 支配人[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。

dono-roofujin-[ni/ga] sihainin-[wa/ni] hanbaiin-ga tenjikai-de wakai josei-ni kutu-o utta-to setumeisimasita-ka?  
which old lady-[dat/nom] manager-[top/dat] salesperson-nom exhibition-at young lady-dat shoes-acc sold-comp explained-Q

‘To which old lady did the manager explain that the salesperson sold the shoes to the young lady at the exhibition on sale?’

‘Which old lady explained to the manager that the salesperson sold the shoes to the young lady at the exhibition on sale?’

### 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 case markers is indicated by square brackets, separated by a slash (/).

1. {どの新入生[に/が]} 担任[は/が] 司書が 図書室で {どの新入生に}...

{dono sinyuusei-[ni/ga]} tannin-[wa/ga] sisyo-ga tosyositu-de {dono sinyuusei-ni} ...

{which new student-[dat/nom]} class teacher-[top/nom] librarian-nom library-at {which new student-dat} ...

2. {どの警備員[に/が]} 司会者[は/が] ミュージシャンが スタジオで {どの警備員に}...

{dono keibiin-[ni/ga]} sikaisya-[wa/ga] musician-ga stjajo-de {dono keibiin-ni} ...

{which guardsman-[dat/nom]} MC-[top/nom] musician-nom stage-at {which guardsman-dat} ...

3. {どの子供[に/が]} 母親[は/が] お手伝いさんが 台所で {どの子供に}...

{dono kodomo-[ni/ga]} hahaoya-[wa/ga] otetudaisan-ga daidokoro-de {dono kodomo-ni}...

{which child-[dat/nom]} mother-[top/nom] housekeeper-nom kitchen-at {which child-dat} ...

4. {どの女性社員[に/が]} 専務[は/が] 社長が 会議で {どの女性社員に}...

{dono josei syain-[ni/ga]} senmu-[wa/ga] syatyoo-ga kaigi-de {dono josei syain -ni}...

{which female worker-[dat/nom]} director-[top/nom] president-nom meeting-at {which female worker-dat}...

5. {どの教授[に/が]} 学部長[は/が] 助手が 実験室で {どの教授に} ...

{dono kyooju-[ni/ga]} gakubutyoo-[wa/ga] assistant-ga jikkensitu-de {dono kyooju-ni}...

{which professor-[dat/nom]} dean-[top/nom] assistant-nom lab-at {which professor-dat}...

6. {どのマネージャー[に/が]} 監督[は/が] 選手が ロッカールームで {どのマネージャー に} ...  
 {dono maneejaa-[ni/ga]} kantoku-[wa/ga] sensyu-ga rokkaaruumu-de {dono maneejaa-ni}...  
 {which manager-[dat/nom]} coach-[top/nom] player-nom locker room-at {which manager-dat}...
7. {どの看護婦[に/が]} 院長[は/が] 担当医が 診察室で {どの看護婦に} ...  
 {dono kangofu-[ni/ga]} intyoo-[wa/ga] tantooi-ga sinsatusitu-de {dono kangofu-ni}...  
 {which nurse-[dat/nom]} chief doctor-[top/nom] doctor in charge-nom exam room-at {which nurse-dat}...
8. {どの友人[に/が]} 妻[は/が] 夫が 電話で {どの友人に} ...  
 {dono yuujin-[ni/ga]} tuma-[wa/ga] otto-ga denwa-de {dono yuujin-ni}...  
 {which friend-[dat/nom]} wife-[top/nom] husband-nom phone-at {which friend-dat}...
9. {どの孫[に/が]} 祖母[は/が] 祖父が すし屋で {どの孫に} ...  
 {dono mago-[ni/ga]} sobo-[wa/ga] sofu-ga sushiya-de {dono mago-ni}...  
 {which grandchild-[dat/nom]} grandmother-[top/nom] grandfather-nom sushi restaurant-at {which nurse-dat}...
10. {どの警官[に/が]} 刑事[は/が] 容疑者が 現場で {どの警官に} ...  
 {dono keikan-[ni/ga]} keiji-[wa/ga] yoogisyaa-ga genba-de {dono keikan-ni}...  
 {which policeman-[dat/nom]} detective-[top/nom] suspect-nom crime place-at {which policeman-dat}...
11. {どのピアニスト[に/が]} 指揮者[は/が] 声楽家が 楽屋で {どのピアニストに} ...  
 {dono pianist-[ni/ga]} sikisya-[wa/ga] seigakuka-ga gakuya-de {dono pianist-ni}...  
 {which pianist-[dat/nom]} conductor-[top/nom] singer-nom backstage-at {which pianist-dat}...
12. {どの園児に} 先生[は/が] 留学生が 教室で {どの園児に} ...  
 {dono enji-[ni/ga]} sensei-[wa/ga] ryuugakusei-ga kyuusitu-de {dono enji-ni}...  
 {which kindergarten child-[dat/nom]} teacher-[top/nom] foreign student-nom classroom-at {which kindergarten child -dat} ...
13. {どのстюワーデス [に/が]} 副操縦士[は/が] 機長が機内で {どのстюワーデスに} ...  
 {dono sucyuwaadesu-[ni/ga]} fukusoojuusi-[wa/ga] kityoo-ga kinai-de {dono sucyuwaadesu-ni}...  
 {which flight attendant-[dat/nom]} co-pilot-[top/nom] chief pilot-nom inside-the-plane-at {which policeman-dat} ...
14. {どの編集者[に/が]} アシスタント[は/が] 編集長が廊下で {どの編集者に} ...  
 {dono hensyuusya-[ni/ga]} asisantanto-[wa/ga] hensyuutyoo-ga rooka-de ...  
 {which editor-[dat/nom]} assistant-[top/nom] chief editor-nom hallway-at {which editor-dat}...
15. {どの国会議員[に/が]} 秘書[は/が] 知事が文書で {どの国会議員に} ...  
 {dono kokkaigiin-[ni/ga]} hisyo-[wa/ga] tiji-ga bunsyo-de {dono kokkaigiin -ni}...  
 {which senator-[dat/nom]} secretary-[top/nom] governor-nom document-with {which senator-dat}...

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