Reanalysis of clause boundaries in Japanese as a constraint-driven process

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Running head: Reanalysis of clause boundaries

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Abstract

When processing the initial segment of a sentence, readers may favor an interpretation that will turn out to be incorrect as more words are read. In these cases, a reanalysis process is necessary in order to correct the mental representation built up to that point. It has been previously proposed that readers obey a minimum change restriction as they prefer to change the mental representation as little as possible. The present paper reports two experiments in Japanese suggesting that a minimal change restriction is unnecessary to characterize reanalysis. It is proposed instead that the present data and previous observations are more naturally explained by a constraint-driven model in which revisions are performed only when required by parsing constraints.

Key words: sentence processing, reanalysis, clause boundaries, case marking, Japanese
INTRODUCTION

When processing the initial segment of a sentence, readers may initially favor an interpretation that will turn out to be incorrect as more words are processed. A reanalysis process is necessary to correct the mental representation in such situations. One line of research has investigated why readers have difficulty in carrying out some types of reanalyses (e.g., Gorrell, 1995; Pritchett, 1992; Sturt & Crocker, 1996). Another question involves determining the preferred interpretation when more than one alternative is available during reanalysis. The present paper addresses the latter question.

The Japanese fragment in (1a) is preferentially interpreted as a single clause as in Mary saw John (see Yamashita, 1997, for experimental evidence). Because Japanese is a head-final language (in particular, the verb is always the last word in the clause), the incoming noun girl in (1b) is most naturally interpreted as the head of a relative clause (RC). In other words, girl indicates that the clause between square brackets must be reanalysed. (The following abbreviations will be used to indicate Japanese particles: Nom for nominative, Acc for accusative, Dat for dative, Top for topic).

(1) a. Mary-ga John-o mita ...
   Mary-Nom John-Acc saw
   ‘Mary saw John.’

   b. [ Mary-ga John-o mita ] onnanoko-ni
      Mary-Nom John-Acc saw girl-Dat

There are a number of alternative interpretations that readers may favor when reanalysing the clause above. In (2), two possible interpretations are presented (empty categories, co-indexation conventions, constituent structure are adopted from Government and Binding, Chomsky, 1981; see Tsujimura, 1999, for an overview of Japanese syntax in this framework).
(2) a. Expelling one NP (Mary-Nom)

Mary-ga \( [_{RC} e_i \text{ John-o} \text{ mita}] \) onnanoko\(_i\)-ni
Mary-Nom John-Acc saw girl-Dat

b. Expelling two NPs (Mary-Nom and John-Acc)

Mary-ga John-o \( [_{RC} \text{ pro}_i e_j \text{ mita}] \) onnanoko\(_j\)-ni
Mary-Nom John-Acc saw girl-Dat

In both interpretations, a new outer clause (i.e., a new matrix clause) is created by expelling NPs from the simple clause. The two interpretations differ in the number of NPs expelled. In (2a), only Mary was displaced. In this case, the matrix clause contains Mary and the complex NP the girl that saw John, and the sentence could be completed by an incoming verb such as hanashita (‘talked’): Mary talked to the girl that saw John. Alternatively, the reanalysis process could yield an interpretation such as (2b) in which both Mary and John were expelled to the matrix clause. In this case, the most natural interpretation for the RC is the girl that (somebody) saw, in which the subject is left implicit (in a null context, the most likely antecedent is Mary). This interpretation could be completed by a ditransitive verb such as shoukai-shita (‘introduced’): Mary introduced John to the girl that (Mary) saw.

Native speakers’ judgements indicate that (2a) is favored during reanalysis (Mazuka & Itoh, 1995; also Miyamoto, 2002, for related experimental evidence). This and other similar intuitive judgements have been used to argue for a minimal change restriction (MCR), according to which readers favor the interpretation involving the fewest number of changes, in the case above the fewest number of NPs displaced (minimal everything, Fodor & Inoue, 1998; minimal revisions, Frazier, 1990, 1995). The present paper investigates this claim in two experiments in Japanese. It will be suggested that such preferences are best accounted by a constraint-driven model in which amount of change does not play a part.
A MINIMAL CHANGE RESTRICTION DURING REANALYSIS

A minimal change restriction (MCR) during reanalysis may be justified in various ways. It may be a special instance of a general least-effort property of the human parser (Fodor & Inoue, 1998; Inoue & Fodor, 1995). In particular, a serial parser may perform piecemeal changes in the tree structure and stop as soon as a coherent interpretation is obtained (e.g., adjust, Fodor & Inoue, 1998). In this case, interpretations requiring fewer changes will preempt the consideration of interpretations involving more changes. According to this justification the MCR should be invoked when the preferred interpretation involves a subset of the changes required by competing interpretations. It is not clear whether some version of the MCR should apply when the competing changes do not overlap.

The MCR has been used to explain the processing of noun-noun compounds in English such as (3a) (from Frazier, 1990).

(3) a. the church pardon committee

b. the [church pardon] committee

c. the [church] [pardon committee]

The noun church in (3a) is ambiguous and can modify pardon as in (3b) or committee as in (3c). The MCR explains the preference for (3b) as follows. Initially, readers associate the sequence the church pardon as a NP. When committee is read, reanalysis has to take place and (3c) is dispreferred because it involves an extra change, namely, the association between church and pardon has to be undone.

The MCR has also been claimed to have cross-linguistic validity (see for example Frazier, 1995, for a discussion on adjective attachment in Japanese that closely follows the discussion on (3a)). Because of the nature of embedded clauses in Japanese, their processing
often requires reanalysis (as discussed for the relative clauses in (2)). Thus, various types of such constructions have been scrutinized in order to shed light on reanalysis processes and have served as a testbed to verify the crosslinguistic validity of reanalysis models. For example, the MCR can be used to justify native speakers’ preference for (2a) over (2b) because the former alternative requires only one change, namely, only one NP (Mary) has to be expelled from the simple clause Mary saw John to the new matrix clause. In procedural terms, a serial parser may be expelling NPs one by one, stopping as soon as possible. Because expelling the first NP Mary is sufficient to provide a coherent interpretation, the parser stops at this point and does not attempt to expel the second NP John.

To expel an NP is more complex an operation than suggested thus far. For example, it also involves the insertion of an empty category and determining its antecedent. In (2a), only the empty category $e_i$ has to be inserted, whereas in (2b) both $pro_j$ and $e_i$ are necessary. Therefore, (2a) and (2b) not only differ in the number of lexical NPs expelled but also in the number of empty categories inserted. The present paper will not address potential processing differences arising from empty categories.

Furthermore, even when no expelling occurs, RCs with subject gap are processed faster than RCs with object gap (Miyamoto & Nakamura, 2003). Thus, it is unclear whether the preference for (2a) should be characterized as a MCR phenomenon, or whether it is an instance of a general preference for subject gaps.

It will not be crucial to the present discussion whether the mental representation built during sentence processing holds one interpretation (as in serial models of parsing; e.g., Frazier, 1987) or several interpretations (as in constraint satisfaction models, MacDonald, Pearlmutter & Seidenberg, 1994; *inter alia*; or as in ranked parallel models in general, Gibson, 1991; Gorrell, 1989). In serial models, reanalysis requires modifying the single interpretation being built (see Fodor & Ferreira, 1998, for several of such proposals). For ranked parallel models, the assumption is that reanalysis involves the re-ranking of alternative in-
interpretations available in the mental representation. In the following, a serial or parallel framework may be temporarily adopted for descriptive convenience. Although the MCR was originally proposed within serial processing frameworks, it may nevertheless have a correlate in parallel models in the sense that a ranked-parallel parser may prefer to promote interpretations that are more similar to interpretations being demoted.

REANALYSIS AS A CONSTRAINT-DRIVEN PROCESS

Although the MCR successfully explains reanalysis preferences in constructions such as (1) and (3), it fails to take into account an important characteristic of such examples. The extra change required in these cases is vacuous in the sense that it does not serve any apparent purpose, in particular, it does not satisfy any constraint that has been proposed to guide parsing decisions (MacDonald, Pearlmutter & Seidenberg, 1994; Trueswell, Tanenhaus & Garnsey, 1994; also, Gibson & Pearlmutter, 1998, for an overview). This observation suggests a different explanation according to which reanalysis is a constraint-driven process in which changes are performed only if they lead to the satisfaction of some constraint.

(4) Constraint driven changes (CDC): in reanalysis mode, the parser only makes changes required by parsing constraints.

Given that reanalysis is often triggered by the violation of some constraint (as indicated by the disambiguating segment of the sentence), the CDC is a natural extension of the role of constraints to the revision process itself.

The CDC can explain the processing of (1) as follows. Assume that the parser makes piecemeal changes on a single tree structure during reanalysis. When girl is read in (1b), it requires a gap it can be coindexed with. A gap can be created by expelling Mary to the outer clause. There is no further parsing constraint that requires John to be expelled as well. Therefore, a constraint-driven parser should prefer (2a) over (2b).

Similarly for the English noun-noun compound example, initially the NP the church
pardon is created. When committee is read, it is clear that pardon has to modify it. Because of grammatical constraints of English, the is dissociated from pardon and is re-attached as the specifier of committee. There is no further constraint that requires the association between church and pardon to be undone, therefore they remain linked yielding the preferred interpretation in (3b).

Discussions in the literature often confound amount of change with vacuous changes. As seen in the preceding discussion, extra changes in examples such as (2b) and (3c) do not serve any purpose. The following discusses a previous result showing that dative NPs are optional in Japanese (Kamide & Mitchell, 1999), and then a related Japanese construction is introduced in which amount of change and vacuous changes can be dissociated.

**Attachment Preference and Optionality of Dative NPs**

Kamide and Mitchell (1999) examined the Japanese construction schematically represented in (5) in which the dative NP₂ is optional and can be an argument of V₁ (the verb in the embedded clause) or V₂ (the verb in the main clause).

(5) NP₁-Nom NP₂-Dat NP₃-Nom ... V₁ ... V₂

Although NP₂ is closer to V₁, Kamide and Mitchell reported reading times indicating a preference to associate NP₂ with V₂ (see Hirose, 1994, for related results in Japanese; and Koh, 1997, for experimental data for the equivalent structure in Korean). Assuming an incremental model that associates NPs within clausal structures based on their case markers (Miyamoto, 2002), the parsing of (5) proceeds as follows. Initially, NP₁ and NP₂ are interpreted as belonging to a mono-clausal sentence. A clause boundary is posited between NP₂ and NP₃ because no verb in Japanese can take the three NPs as arguments. Thus, NP₁ and NP₂ remain as coarguments in the same clause, whereas NP₃ is part of an embedded clause. When V₁ is read, it is interpreted as the predicate of the embedded clause; the requirement for a dative NP is optional and, therefore NP₂ can remain as part of the
outer clause and is eventually attached to the main verb $V_2$.

The next section explores the optionality of dative NPs in a different construction.

**A Non-Vacuous Extra Change**

Consider the word-by-word processing of the following sentence.

(6) Shokuin-wa kakarichou-ni ocha-o onnanohito-ga dashita-to shiraseta.

employee-Top manager-Dat tea-Acc woman-Nom served-that said

‘The employee said (to the manager) that the woman served tea (to the manager).’

Initially, the first three NPs are associated within a single clause which requires a ditransitive verb as shown in (7a). The operation *associate* will be used as a shorthand for the attachment of case-marked NPs as co-arguments within a clause (see Miyamoto, 2002, and references therein for discussion). The NPs are not attached to each other, but rather their case markers (and other information such as animacy) force the prediction of a predicate with a specific type of argument structure. The clausal structure is built based on this expected predicate.

(7) a. Ditransitive clause:

Shokuin-wa kakarichou-ni ocha-o
employee-Top manager-Dat tea-Acc

b. New clause at *woman*:

Shokuin-wa kakarichou-ni ocha-o [ onnanohito-ga
woman-Nom

when the nominative NP *woman* is detected, it becomes clear that the sentence has more than one clause because no verb in Japanese can take those four NPs as arguments. A
clause boundary is posited at this point, leaving the first three NPs in the matrix clause as indicated by the square bracket in (7b). Note that there are grammatical ways of continuing this fragment (e.g., the nominative NP could be the beginning of a relative clause modifying an adjunct, for example, a locative or a temporal, in which case a dative predicate such as serve would suffice to complete the sentence as in The employee served tea to the manager at the meeting that the woman attended.).

Next, served-that is read and the complementizer indicates that the verb in the main clause is going to be a report verb. Because there is no verb in Japanese that can take an accusative NP as well as a sentential complement as arguments, the accusative NP tea cannot be part of the main clause and has to be shifted to the embedded clause as shown in (7c).

The operation in (7c) will be referred to as NP-lowering or just lowering in order to differentiate it from the expel operation in (2). The two operations differ in at least two aspects. First, expel displaces an NP from the embedded clause to the matrix clause, whereas in lowering an NP goes from the matrix clause to the embedded clause. Second, in general, expel requires the insertion of one or more empty categories in the embedded clause; the instances of lowering dealt in this paper do not involve empty categories.

**Alternatives to NP-lowering**

A reviewer (Lyn Frazier) suggested an alternative way in which parsing may take place when woman-Nom is processed in (6). Namely, readers may take employee-Top as the matrix subject, and the following three NPs are interpreted as part of the embedded clause. In other words, a clause boundary between the topicalized NP and the dative NP is inserted as soon as the nominative NP is read. In this case, there should not be reanalysis taking place at the embedded verb because the accusative NP is already part of the embedded clause before this verb is read. There are, however, two problems with this explanation.

First, it is unclear how the word-by-word processing would proceed in this proposal. The
discussion so far has assumed an incremental model in which readers do not delay parsing decisions. Thus, as soon as the first three NPs in (6) are read, they should be interpreted as co-arguments within a single clause (as shown in (7a)). Frazier’s explanation (which will be referred to as the early reanalysis model) suggests that this interpretation is broken, and reanalysis takes place at the nominative NP in order for the dative and the accusative NP to be associated as part of the embedded clause. However, this goes against revision as last resort (RaLR, Fodor & Frazier, 1980), according to which reanalysis should only take place when no other alternative is available. As shown in (7b), there is no need for reanalysis at this point and the insertion of a new clause starting at the nominative NP suffices to provide a possible continuation (as noted earlier, the nominative NP could be the beginning of a relative clause modifying a locative).

An alternative word-by-word parsing model, in which the processing of NPs in Japanese is assumed not to be incremental (the non-incremental model), could also yield predictions similar to the ones of the early reanalysis model. If the first three NPs are not associated within a clause, then the dative and the accusative NPs would be free to be associated as part of an embedded clause when the nominative NP is read. The problem then is to explain why the NPs have to be associated when the nominative NP is processed. In a strictly non-incremental model such as head-driven parsing (Pritchett, 1991), associations should only be computed when the verb is processed. In short, there does not seem to be a way of implementing Frazier’s explanation without violating the RaLR or incremental processing. One could always argue that most of the evidence for incremental processing and the RaLR are based on data from West-European languages, therefore it is possible that these principles are not applicable to Japanese processing. But that would entail radically different processing mechanisms across languages, that do not seem warranted at this point (see for example Inoue & Fodor, 1995, for discussion). Furthermore, there is mounting evidence that processing is incremental in Japanese (see Miyamoto, 2002, and references
therein).

A second argument against these models is that they cannot explain Kamide and Mitchell’s data in the previous section. If NP$_2$-Dat and NP$_3$-Nom in (5) are interpreted as part of the embedded clause when readers reach the latter NP (i.e., a clause boundary is inserted between NP$_1$-Nom and NP$_2$-Dat as soon as NP$_3$-Nom is read), then the preference should be to attach the dative NP to the embedded predicate, and not to the matrix predicate as Kamide and Mitchell have found.

In the following, Experiment 1 provides evidence that reanalysis is taking place at served-that in (6) in order to lower tea to the embedded clause. The results will provide empirical evidence against the early reanalysis model and the non-incremental model. However, from this first experiment alone, it will not be clear whether the dative NP manager is also lowered in the process. The predictions made by the MCR and the CDC differ in this case and will be explored in Experiment 2.

**EXPERIMENT 1**

**Method**

*Participants.* Thirty-eight native speakers of Japanese, residents in the Boston area, participated in the self-paced reading experiment. They had completed at least high school in Japan and went to the United States as adults.

*Materials.* Twenty-five sets of sentences such as the one shown in (8) were constructed (Appendix A contains the complete list of items used, which were partially based on items from Yamashita, 1994). Sentence (6) is repeated in (8a) and labeled as the Acc-lowering condition because its accusative NP tea is assumed to be lowered during reanalysis. Slow reading times at served would support the proposal that tea is lowered at that point.

The adverb *in a hurry* was inserted to avoid possible spill-over effects as readers may slow
Reanalysis of clause boundaries

down at the nominative NP *woman* in order to create the embedded clause boundary. The
ditransitive control condition in (8b) was used as a control. (Numbers above the sentences
indicate the region number according to the segmentation used in the self-paced reading
presentation.)

(8) a. Acc-lowering (AL)

1 2 3 4 5 6 7

Shokuin-wa kakarichou-ni ocha-o onnanohito-ga isoide dashita-to shiraseta.
employee-Top manager-Dat tea-Acc woman-Nom hurry served-that said
‘The employee said (to the manager) that the woman served tea (to the manager)
in a hurry.’

b. Ditransitive control (DC)

1 2 3 4 5 6 7

Shokuin-wa onnanohito-ga kakarichou-ni ocha-o isoide dashita-to shiraseta.
employee-Top woman-Nom manager-Dat tea-Acc hurry served-that said
‘The employee said that the woman served tea to the manager in a hurry.

When the first four NPs in the ditransitive control condition are read, it is clear that
the sentence contains more than one clause because no verb in Japanese can take those
NPs as arguments. A clause boundary is most naturally posited between the first two NPs.
Reanalysis does not occur at *served* because its three arguments (*woman*, *manager* and *tea*)
are already inside the embedded clause. Therefore, this sentence provides a baseline reading
time for the slow-down predicted for *served* in the Acc-lowering condition.

The following summarizes the three logically conceivable ways in which *tea*-Acc may be
processed in the Acc-lowering sentence. One alternative is for *tea* to remain as part of the
matrix clause until the end of the sentence. In this case, a slow-down should be detectable
at the main verb *said* because it cannot take *tea* as a direct object. Alternatively, *tea* may be
part of the matrix clause only until the embedded verb is seen. This is the NP-lowering option
advocated here. It predicts a slow-down at the embedded verb in order to lower tea. The third alternative is for tea to be part of the embedded clause even before the embedded verb is processed. This is the interpretation favored by the early reanalysis model and the non-incremental model and consequently they predict no difference at the embedded verb unless some independent factor intervenes. One possible factor could be that the scrambled word-order in the embedded clause of the Acc-lowering sentence (dative, accusative, nominative) is more difficult to process than the canonical order in the ditransitive control condition (nominative, dative, accusative). However, slow reading times related to scrambling have either not been observed at any point (Yamashita, 1997) or when detected they only occurred at the NPs but not at the verb (Mazuka, Itoh & Kondo, 2002; Miyamoto & Takahashi, 2002; but see Ueno & Klunder, in press, for Event Related Potential differences at the verb).

The experiment had a total of five conditions. The remaining three conditions, shown in (9), examined a similar construction with a transitive verb such as drank in the embedded clause. These sentences are not directly relevant to the present claims, but they were included in the discussion because they may provide further insights into the processing of their ditransitive counterparts.
(9) a. Ambiguous transitive (AT)

1 2 3 4 5 6 7
Shokuin-wa kakarichou-ni [ ocha-o onnanohito-ga isoide nonda-to ] shiraseta.
employee-Top manager-Dat tea-Acc woman-Nom hurry drank-that said
‘The employee said to the manager that the woman drank tea in a hurry.’

b. Transitive control (TC)

1 2 3 4 5 6 7
Shokuin-wa kakarichou-ni [ onnanohito-ga ocha-o isoide nonda-to ] shiraseta.
employee-Top manager-Dat woman-Nom tea-Acc hurry drank-that said
‘The employee said to the manager that the woman drank tea in a hurry.’

c. Scrambled transitive control (STC)

1 2 3 4 5 6 7
Kakarichou-ni shokuin-wa [ onnanohito-ga ocha-o isoide nonda-to ] shiraseta.
manager-Dat employee-Top woman-Nom tea-Acc hurry drank-that said
‘The employee said to the manager that the woman drank tea in a hurry.’

The accusative argument tea in (9a) is initially assigned to the matrix clause (the square brackets indicate the final interpretation) and reanalysis has to take place in order to lower this NP to the embedded clause when the embedded verb drank is read. The dative manager cannot be lowered to the embedded clause because drank does not subcategorize for a dative NP. In the controls (9b,c), reanalysis does not occur at drank because tea is assigned to the embedded clause before this verb is read. In (9c), manager was scrambled to the beginning of the sentence in order to reinforce the interpretation in which this NP is part of the main clause.

Procedure. The experiment was conducted with PsyScope (Cohen, MacWhinney, Flatt & Provost, 1993) running on Macintosh computers with a button-box. The
self-paced reading moving-window program presented sentences (Just, Carpenter & Woolley, 1982) one word at a time (to be more precise, a content word followed by particles such as case-markers) on a single line in a non-cumulative fashion. Initially, all words were presented masked with dots with spaces separating adjacent words. Participants pressed the leftmost button of the button-box to reveal each subsequent word and cause the previous word to revert to dots. The blank spaces in (8) and (9) indicate the segmentation used; numbers above the words indicate the regions in the self-paced reading presentation.

The experimental trials were preceded by one screen of instructions and eight practice trials. The experiment took participants approximately 15 minutes. Twenty-five items distributed in a Latin Square design were presented with 44 filler items in pseudo-random order using the uniform-width Japanese font Osaka Tohaba. A yes-no question was presented after each item followed by auditory feedback. Because comprehension questions about the main clause are relatively easy to respond, most of the questions (approximately two-thirds) following the test items referred to the embedded predicate, and the remaining questions were about the matrix predicate.

Data analysis. Analyses were performed on comprehension question response accuracy and on reading times. The reading time analyses only included the items for which the participants answered the comprehension question correctly. A linear regression between word lengths and reading times was performed on each participant’s data set (Ferreira & Clifton, 1986). The portion of the reading time predicted by the length of the word was subtracted from the original raw reading time, yielding a residual reading time (RRT). The RRT obtained in this way can be a positive or negative number, which indicates by how much the participants diverged from their individual average reading time for a word of that length. Furthermore, the data were trimmed so that data points beyond 3.5 standard deviations from the relevant condition × region cell mean were discarded, corresponding to less than 2% of the data. The means and the analyses of variance reported are based on the
trimmed RRTs. The analysis on the raw reading times revealed patterns similar to the RRT results.

**Results**

*Comprehension Task.* The percentages of correct responses to the comprehension questions for the two ditransitive conditions were not reliably different (78.9% for the Acc-lowering; 79.5% for the ditransitive control; $F_s < 1$). The three transitive conditions did not differ either (76.8 for the ambiguous transitive; 81% for the transitive control; 78.9% for the scrambled transitive control; $F_s < 1$).

*Reading Times.* In the reading time analyses, there were two regions of interest: region 6 (the embedded verb) and region 7 (the matrix verb). (See Figures 1 and 2 for the RRTs per region.)

Results were as follows for the two ditransitive conditions. In region 6, the Acc-lowering condition was read more slowly than the ditransitive control condition in both analyses ($F_1(1,37) = 9.0$, $P < 0.01$; $F_2(1,24) = 7.26$, $P < 0.05$). In region 7, the two conditions did not differ ($F_s < 0.5$; analysis for this region excluded one item because its matrix verb was incorrect).

The analysis results for all the regions of the ditransitive conditions are presented in Table 1. The difference found between the two conditions in the item analysis of region 1 must be due to chance given that the same word was read in both conditions. The difference may have been observed because participants sometimes rest from the previous sentence.
instead of reading the word as soon as it appears. The slow reading times observed in regions 2 and 3 in the ditransitive control condition, and in region 4 in the Acc-lowering condition should be expected given that those are the points in which the embedded clause is constructed (Miyamoto, 2002).

The three transitive conditions did not differ in region 6 ($F_1(2,74) = 1.75, P = 0.18$; $F_2(2,48) = 1.98, P = 0.15$) or in region 7 ($F$s < 2; analysis for region 7 only included 24 items). Results for all regions are given in Table 2, and the relevant pairwise comparisons in Table 3. Numerically, the transitive conditions yielded the expected result at the embedded verb with the ambiguous condition being slower than the two controls. The tendency for a smaller difference between the ambiguous transitive condition and its transitive control, compared to the difference between the two ditransitive conditions (interaction verb type/ambiguity: $F_1(1,37) = 3.47, P = 0.071$; $F_2(1,24) = 3.99, P = 0.057$), may be explained if the number of NPs that have to be lowered during reanalysis affects the magnitude of the slow-down at the embedded verb. Note that only the accusative NP has to be lowered in the ambiguous transitive condition, whereas in the Acc-lowering condition it may be necessary to lower the dative NP as well.

Discussion

The slow-down at the embedded verb (region 6) in the Acc-lowering sentence suggests that reanalysis is taking place in order to lower tea from the matrix to the embedded clause.
Reanalysis of clause boundaries

The lack of reliable difference in the last region (the matrix verb) of the two ditransitive sentences is also compatible with the hypothesis that tea is being lowered into the embedded clause in the Acc-lowering sentence. As noted earlier, if tea had remained in the matrix clause, there should have been a slow-down at the verb said because it cannot take tea as a direct object.

The non-incremental model and the early-reanalysis model (the alternatives discussed for the processing steps in (7)) could explain the slow reading times at the nominative NP of the Acc-lowering sentence because readers may be creating the embedded clause with the dative NP, the accusative NP and the nominative NP at that point. But crucially, these models cannot explain the difference at the embedded verb. Proponents of such models could argue that the complexity of the embedded clause with its two object NPs in non-canonical order may lead to more difficulty at the embedded verb than the canonical order in the embedded clause of the ditransitive control sentence. However, as noted earlier, experiments specifically designed to examine non-canonical orders have either not detected any reliable slow-downs at any point in the sentences tested (Yamashita, 1997) or found them only at the scrambled NPs but not at the ensuing verb (Mazuka, Itoh & Kondo, 2002; Miyamoto & Takahashi, 2002).

The possibility that the dative and accusative NPs are already inside the embedded clause before the embedded verb is processed is further undermined by the results in the transitive sentences. If readers were associating the dative, accusative and nominative NPs in a single clause, they should be surprised when seeing the transitive verb drank because it cannot take the dative NP as an argument (Yamashita, 1997). Consequently, there should be a larger slow-down at the transitive verb in the ambiguous transitive sentence than at the ditransitive verb in the Acc-lowering sentence. However, when the two ditransitive conditions are compared to the ambiguous transitive sentence and its transitive control, the tendency is in the opposite direction as the difference between the ditransitive conditions tends to be
larger than between the transitive conditions (interaction verb type/ambiguity: $F_1(1,37) = 3.47, P = 0.071; F_2(1,24) = 3.99, P = 0.057$).

Finally, the nominative NP in region 4 in the Acc-lowering condition shows a tendency for longer reading times than the nominative NP in region 2 in the ditransitive control sentence (interaction region/case marker: $F_1(1,37) = 2.99, P = 0.092; F_2(1,24) = 3.45, P = 0.076$). This could suggest that there is more going on at the nominative NP in region 4 than just the creation of the embedded clause. For example, it could indicate that reanalysis is taking place as suggested by the early reanalysis model. However, as observed earlier following the RaLR (Fodor & Frazier, 1980), there is no reason why reanalysis should be taking place at that point. Moreover, there seems to be a tendency for Japanese readers to prefer an accusative NP to be immediately followed by a verb (see Miyamoto & Takahashi, 2002, for a discussion on an adjacency constraint between direct objects and verbs). Thus, there may be more of an expectation for the verb to come in region 4 in the Acc-lowering sentence than in region 2 in the ditransitive control sentence, and consequently the unexpected nominative NP should be more disruptive in the former context.

Although the present results provide evidence for reanalysis taking place at the embedded verb in the Acc-lowering condition, it is not clear whether the dative NP manager remains in the matrix clause or is lowered together with tea during reanalysis of the Acc-lowering sentence. Given that dative NPs are optional (see discussion in the introduction on the findings by Kamide & Mitchell, 1999), either interpretation is possible. The two scenarios are shown in (10), with the left square brackets indicating the two potential beginnings of the embedded

**EXPERIMENT 2**

From the result of Experiment 1, it remains unclear whether the dative manager stays in the main clause or is lowered together with tea during reanalysis of the Acc-lowering sentence. Given that dative NPs are optional (see discussion in the introduction on the findings by Kamide & Mitchell, 1999), either interpretation is possible. The two scenarios are shown in (10), with the left square brackets indicating the two potential beginnings of the embedded
clause after reanalysis.

(10) a. Shokuin-wa kakarichou-ni ocha-o onnanohito-ga isoide dashita-to...
    employee-Top manager-Dat tea-Acc woman-Nom hurry served-that

    b. Shokuin-wa [ kakarichou-ni ocha-o onnanohito-ga isoide dashita-to...]
    employee-Top manager-Dat tea-Acc woman-Nom hurry served-that

The minimal change interpretation is shown in (10a) with the accusative NP *tea* in the embedded clause and the dative *manager* in the matrix clause together with *employee*. This is the preferred interpretation according to the MCR. Note that the complementizer *that* following *served* is an indicator that the main verb is going to be a report verb, therefore suggesting that *manager* can be part of the main clause as the goal for this verb.

The CDC, on the other hand, predicts that (10b) will be the preferred interpretation because the dative NP is lowered in order to satisfy processing constraints, such as thematic requirements, as early as possible. If lowered, the dative NP is associated with the embedded verb, consequently its thematic role is determined right away and the verb can discharge a thematic role, therefore reducing the number of thematic violations at this point (see Gibson, 1991; Pritchett, 1992, who argue that readers try to minimize the number of thematic violations, e.g., the number of NPs with unspecified thematic role; also Tanenhaus, Carlson & Trueswell, 1989, for an overview of the importance of thematic roles in sentence processing). In this case, lowering should be modulated by the argument structure of the embedded verb: The more a verb requires a dative NP, the more likely lowering should take place.

In order to verify the preferred interpretation after reanalysis, native speakers of Japanese were tested in an off-line survey in which they rated whether the dative NP should be attached to the embedded verb or the main verb.

**Method**
Participants. Twenty-four native speakers of Japanese residents in the Kansai area of Japan answered the questionnaire. None of them had taken part in Experiment 1.

Materials. The Acc-lowering condition is repeated below in (11a), and the no-reanalysis condition in (11b) provides a baseline for comparison.

(11) a. Acc-lowering

Ofisu-dejimina shokuin-ga kakarichoo-ni shibui ocha-o onnanohito-ga office-at plain employee-Nom manager-Dat bitter tea-Acc woman-Nom dashita-to shinsetsuni shiraseta.

served-that politely said

‘At the office, the plain employee politely said (to the manager) that the woman served the bitter tea (to the manager).’

b. No-reanalysis

Ofisu-de jiminaga kakarichoo-ni onnanohito-ga shibui ocha-o office-at plain employee-Nom manager-Dat woman-Nom bitter tea-Acc dashita-to shinsetsuni shiraseta.

served-that politely said

‘At the office, the plain employee politely said (to the manager) that the woman served the bitter tea (to the manager).’

Both sentences are globally ambiguous in that the dative manager can be attached to served or said. In either case, the nominative NP woman is taken to be part of the embedded clause. Because of the argument structure of the verbs, the only possible interpretation for the accusative NP in italics is to be part of the embedded clause. The difference is that in the Acc-lowering sentence, the accusative NP is initially interpreted as being part of the matrix clause, and hence reanalysis is required at the verb served as attested by Experiment 1.
Reanalysis is not taking place in the no-reanalysis sentence in (11b) because the dative NP *manager* is optional and can be left in the main clause (Kamide & Mitchell, 1999), whereas *tea* is interpreted as being part of the embedded clause from the start because of its position after the nominative NP *woman*.

If the reanalysis process in the Acc-lowering condition does not lower the dative *manager* to the embedded clause, the attachment preference for that NP should be the same in both sentences. However, if reanalysis does displace *manager* together with *tea*, then the preference to attach *manager* to *served* should be stronger in this sentence than in the no-reanalysis condition. Because both sentences are globally ambiguous, and both embedded and matrix attachments are grammatical, we should not expect the Acc-lowering sentence to show an absolute preference for the embedded verb attachment, but only a relative bias compared to the control sentence.

Twenty-four of the 25 items in Experiment 1 were used in the present experiment, with adjectives and adverbs added. One item was not included in the analysis because its matrix verb was incorrect. (Appendix A contains the complete list of items used.)

There were a total of four conditions in the experiment. The other two conditions are shown in (12) and were unrelated to the present claims. The italicized case markers were manipulated to vary at which point readers must posit the embedded clause boundary (two accusative NPs, as the ones in the Acc-Acc condition, cannot be associated with the same verb; therefore, *manager* has to be part of the main clause and *tea* must be part of the embedded clause).
(12) a. Dat-Acc condition

Ofisu-de jimin ga kakaricho- ni shibui ocha- o dashita
office- at plain employee- Nom manager-Dat bitter tea- Acc served
josei- o teineini shoukai-shita.
woman- Acc politely introduced

‘At the office, the plain employee politely introduced (to the manager) the woman
who served the bitter tea (to the manager).’

b. Acc-Acc condition

Ofisu-de jimin ga kakaricho- o shibui ocha- o dashita
office- at plain employee- Nom manager- Acc bitter tea- Acc served
josei- ni teineini shoukai-shita.
woman- Dat politely introduced

‘At the office, the plain employee politely introduced the manager to the woman
who served the bitter tea.’

Procedure. Twenty-four items were presented with Japanese fonts in a Latin
Square design together with 36 filler items in pseudo-random order. Words in each item
were presented contiguously without intervening spaces, as usual in Japanese writing. First,
participants rated how hard it was to understand each sentence by choosing a number on a
scale from 1 (easy) to 7 (difficult).

Next, participants were asked to choose between two partial paraphrases of the sentence
read. One phrase had the dative NP as the object of the embedded verb and the other
phrase had the same dative NP as the object of the matrix verb. Participants chose a
number on a scale from 1 to 7, each extreme representing the participant’s preference for
one interpretation. The presentation order of the paraphrases was counterbalanced and
yielded no reliable differences in the judgements; therefore, for the following analyses, the
numbers were converted so that 1 stands for the embedded verb attachment preference and, 7 for the matrix verb attachment preference.

The task was the same for the two unrelated conditions in (12). For the Acc-Acc condition in (12b), the NP manager was marked as dative in the paraphrases.

**Results**

**Difficulty Rating.** The Acc-lowering condition \((M = 3.93)\) was rated as being more difficult than the no-reanalysis condition \((M = 3.42)\) in the subject analysis \((F_1(1,23) = 6.85, P < 0.05; F_2(1,22) = 3.52, P = 0.074;\) see the lefthand side of Figure 3).

**Attachment Preference.** The dative NP was attached to the embedded verb in the Acc-lowering condition \((M = 4.02)\) more often than in the no-reanalysis condition \((M = 4.73; F_1(1,23) = 9.05, P < 0.01; F_2(1,22) = 16.11, P < 0.01;\) see the righthand side of Figure 3).

Analyses for the two conditions unrelated to the present claims had the following results. The Acc-Acc condition in (12b) was judged as more difficult \((M = 4.46)\) than the Dat-Acc condition in (12a) although only marginally in the subject analysis \((M = 4.01; F_1(1,23) = 4.02, P = 0.057; F_2(1,23) = 5.39, P < 0.05). The result is expected given that the sequence with two adjacent accusative NPs is unusual (see Miyamoto, 2002, for related self-paced reading data). The preference for the matrix verb attachment interpretation was stronger in the Acc-Acc condition \((M = 6.35)\) than in the Dat-Acc condition \((M = 4.15; Ps < 0.01).\)

**Discussion**

The attachment preference pattern suggests that the dative NP is more likely to be attached to the embedded verb when the accusative NP is lowered during reanalysis.

The result supports a constraint-driven reanalysis process in which readers prefer the
interpretation that satisfies more parsing constraints even if it requires more changes.

**DEGREES OF OPTIONALITY OF \textit{ni}-MARKED NPS**

The results of Experiment 2 support the assumption that the dative NP is more likely to be lowered if the accusative NP is lowered during reanalysis. However, judgements collected at sentence end do not provide detailed information about the reanalysis process taking place at the embedded verb. It would be desirable to show that the reading times at the embedded verb are influenced by the strength of parsing constraints. The following provides a partial analysis of the reading time results of Experiment 1 showing the influence of the argument structure of the embedded verb.

Although all occurrences of \textit{ni} have been referred so far as datives, this particle has two distinct uses in Japanese: It can function as a postposition or as a dative case marker. This is relevant because in some respects the distinction between case-marked NPs and postpositional phrases is similar to the differences between arguments and adjuncts (Miyagawa, 1989, p. 34). Based on an extensive survey of the various environments in which \textit{ni} can occur, Sadakane and Koizumi (1995) concluded that the function of this particle correlates with the degree of affectedness of its accompanying NP in relation to the subcategorizing verb. They propose a hierarchy in which NPs with the accusative marker are highly affected, followed by NPs with the dative case marker \textit{ni} (\textit{ni}-NPs for short; e.g., a goal), and the least affected are NPs with the postposition \textit{ni} (\textit{ni}-PPs; e.g., a benefactive). They also propose another category for ambiguous \textit{ni} whose affectedness can vary depending on the interpretation given to the \textit{ni}-marked constituent.
Assume that the affectedness of an NP in relation to a verb correlates with the degree to which the NP is required to be lexically realized when the verb is processed. Thus, the more strongly a constituent is affected by the embedded verb, the more likely it will be lowered from the matrix to the embedded clause during reanalysis in the Acc-lowering sentence in Experiment 1. In particular, a *ni*-NP is more likely to be lowered than a *ni*-PP. Furthermore, if the number of constituents lowered correlates with processing difficulty (see Mazuka & Itoh, 1995, for such a proposal for the expel operation), then we should expect a more marked slow-down for the *ni*-NPs than with *ni*-PPs at the embedded verb of the Acc-lowering condition in (8a). But no difference should be detectable in the ditransitive control in (8b) because reanalysis is not taking place in this case.

Further analyses conducted with the reading times for the embedded verb of the two ditransitive sentences in Experiment 1 tend to support the prediction. Following the tests in Sadakane and Koizumi (1995), the stimuli used in Experiment 1 were divided in three categories according to the relation between the dative NP and the embedded verb: *ni*-NPs, *ni*-PPs, and ambiguous. There were eight items of the *ni*-NP type and eight of the *ni*-PP type (see Appendix A for the classification of the items). The remaining nine items were ambiguous and will not be discussed further. Figure 4 presents the mean RRTs at the embedded verb according to condition (ambiguous or unambiguous) and *ni* type (*ni*-NPs or *ni*-PPs).

Because this was not the original intent of Experiment 1, most participants did not see all the conditions in this 2×2 design, and the analysis by subjects could not be carried out. In the analysis by items, the interaction between ambiguity and type of *ni* was not reliable ($F_2(1,14) = 3.37, P < 0.09$), but the tendency was in the direction predicted. For the Acc-lowering sentences, the *ni*-NPs were marginally slower than the *ni*-PPs ($F_2(1,14) = 4.3$,
For the ditransitive control sentences, the difference was not reliable ($F_2 < 1$).

The tests used by Sadakane and Koizumi (1995) do not always yield consistent results for a given verb; hence, a second analysis was conducted with the more typical items of each class (including five ni-NPs and three ni-PPs), and yielded the same pattern of results (interaction: $F_2(1, 6) = 4.38$, $P < 0.09$).

Given the results in Experiments 1 and 2 alone, it could have been argued that the phenomenon observed is structural, in that an accusative NP cannot be lowered alone and the whole VP containing the ni and the o objects has to be lowered as a single structure (this is particularly appealing in proposals that assume tree lowering, Gorrell, 1995; Sturt & Crocker, 1996). But with the distinction advocated between the two types of ni, which is dependent on the subcategorization frame of the verb, such a structural explanation becomes less plausible.

**GENERAL DISCUSSION**

The revision process advocated in this paper implies that readers make changes in the mental representation based on the cues available (see Fodor & Inoue, 1994, for extensive discussion; see also Frazier & Clifton, 1998, for a version of minimal revisions that incorporates information from the error signal in its definition). There is no need to assume a minimal effort strategy which keeps the number of changes to a minimum. Once reanalysis is triggered, the changes to be performed are determined by the strength of the constraints involved. In the present case, the strength of the constraint is related to the optionality of the dative NP, which in turn is related to the argument structure of the verbs in the sentences.

One can speculate about a class of constructions in which the MCR is nevertheless necessary. In a reanalysis process in which one single constraint is involved and can be satisfied through two non-overlapping sets of revisions, the CDC would be indifferent to either
alternative, whereas the MCR would prefer the alternative that requires the fewest changes. One problem in this kind of example is that, in order to choose among the alternatives, readers would have to know in advance which interpretation involves fewer changes. To avoid such a lookahead requirement, MCR related proposals have only considered sets of changes that are in a superset/subset relation (as is the case of the reanalysis process explored in the present paper). Whether examples with non-overlapping changes can be explained by the MCR without recourse to lookahead remains unclear at this point.

**Further on-line evidence for NP-lowering**

The crucial result supporting the CDC was based on the questionnaire in Experiment 2. Although such sentence-end tasks generally mirror on-line preferences, it would be desirable to come up with constructions that allow the on-line investigation of the present predictions in more detail. The partial analysis of the data of Experiment 1 in terms of the optionality of the *ni* marked NPs is one such attempt. A reviewer (Hiroko Yamashita) suggested the following sentences as a possible source for further on-line evidence.

(13) a. Shokuin-wa kakarichoo-ni ocha-o onnanohito-ga isoide employee-Top manager-Dat tea-Acc woman-Nom hurry
dashita-to baitosee-ni shiraseta. served-that intern-Dat said
‘The employee said to the intern that the woman served tea to the manager in a hurry.’

b. Shokuin-wa onnanohito-ga kakarichoo-ni ocha-o isoide employee-Top woman-Nom manager-Dat tea-Acc hurry
dashita-to baitosee-ni shiraseta. served-that intern-Dat said
‘The employee said to the intern that the woman served tea to the manager in a
hurry.'

The crucial comparison is at the penultimate word (the dative *intern*) where a slow-down similar to the filled-gap effect in English (Stowe, 1986) may be observed for (13a). The accusative NP *tea* should be lowered when *served* is read in (13a). But if *manager* is not lowered and remains in the matrix clause, there should be a slow-down at *intern* because the two dative animate NPs would compete for the same thematic role. Sentence (13b) serve as a control. Because the dative *manager* comes after the nominative *woman*, it is necessarily interpreted as part of the embedded clause and, hence, there is no conflict with *intern*. Although evidence along those lines is desirable, it is likely that Yamashita’s design may not yield the required results. As noted earlier, the dative NP is optional, therefore it is not obligatory for readers to lower it when the embedded verb is read; hence, the instances in which *manager* is not lowered could still be in conflict with *intern* leading to a slow-down at that point. Furthermore, even if verbs that strongly require the dative NP are chosen (thus, forcing the lowering operation), the prediction would be for a null result, namely a lack of difference in the reading time of *intern* in the two sentences. Null results are not easily interpretable because they can be blamed on lack of statistical power. One way of solving these problems may be to adopt a more complex $2 \times 2$ design, in which two types of embedded verbs are used for each of the two sentences in (13). When verbs that strongly subcategorize for the dative NP are used, lowering of this NP would be more likely to occur, and therefore no difference should be observed at *intern*. In contrast, with verbs that subcategorize weakly for the dative NP, lowering should occur less often and therefore more conflicts should occur at *intern*, and consequently, a reading time difference should emerge at that point.

**Reanalysis with and without a predicate**

The present paper has assumed that the processing of Japanese occurs in the same way as in English, despite the striking differences in the grammars of the two types of languages. Until evidence to the contrary this should be the null hypothesis adopted (but see
Mazuka, 1998; Mazuka & Lust, 1990, for claims that bottom-up/top-down parameterizations are necessary in order to account for the processing of these languages; see Hasegawa, 1990; Inoue & Fodor, 1995, for critiques of such claims; also Abney & Johnson, 1991, for parsing algorithms that are cognitively plausible and do not require such parameterizations).

There is, however, one aspect that is directly relevant to the present discussion and requires considerable future research. The incremental model adopted assumes that NPs are associated to each other as clausal structure is built (i.e., readers predict how many predicates are upcoming in the sentence and which NPs are going to be arguments of which predicate) even before any predicate is processed (see Miyamoto, 2002, and references therein for discussion). That these associations are created is supported by available evidence (see Miyamoto, 2002, for self-paced reading data; Kamide, Altmann & Haywood, 2000, for head-mounted eye-tracking evidence; also, Scheepers, Hemforth & Konieczny, 1999, for similar discussion on head-final clauses in German), what is not clear is whether associations created in the absence of a predicate are as strong as associations in which the predicate is available. It is possible that readers associate NPs before seeing a predicate but that their commitment to such interpretations is weaker compared to cases in which a predicate is present. In particular, it is unclear whether the commitment is weak enough to obviate the application of principles such as the RaRL (Fodor & Frazier, 1980). However, considering that readers are associating NPs within clauses (or in chunks, following Miller, 1963) in order to alleviate working-memory load, the most natural assumption at this point seems to be that those associations are committed to memory and are reanalysed only when no alternative is available.

Even if it is eventually shown that there is a difference in association strength depending on the presence of a predicate, it would not necessarily imply the need for crosslinguistic parameterization. Although it is true that most NP associations in English are conducted in the presence of a verb, whereas in Japanese they are not, the difference should not be
cast in terms of a difference between languages, but rather as a difference between types of constructions. In other words, the crucial question is not whether English is different from Japanese, but whether, in a single language, for example Japanese, the associations created in the presence of a predicate are qualitatively different from the associations created when a predicate is not available.

The rationale behind this discussion on association strength can be equally applied to reanalysis processes as well. It could be argued that there are crosslinguistic differences in reanalysis because in English it occurs in the presence of a predicate whereas in Japanese it occurs without a predicate. However, both types of reanalysis are possible in either language, although they occur with different frequencies in each language. For example, in English, it is often the case that reanalysis occurs after a verb has been read, however there are cases (although rare) in which reanalysis may occur before the verb is seen as in the following sentence.

(14) John Mary likes.

*John* is initially taken as the subject of an upcoming verb, however when *Mary* is read, reanalysis is necessary in order to make *John* the object. In Japanese both types of reanalysis, with and without a predicate, are fairly common. In this paper, the assumption has been that the two types of reanalysis do not differ and follow the same principles that have been proposed for cases in English where a predicate is already available. Here again, the question is not whether reanalysis in Japanese is the same as in English. It should be assumed that it is so unless evidence to the contrary becomes available. The more immediate question is whether reanalysis in the presence of a predicate is substantially different from reanalysis before a predicate has been detected. Clearly, the amount of information differs. Verbs provide crucial subcategorization information that case markers can only partially indicate. But apart from that, it is not clear whether the absence of a predicate drastically affects
the nature of the reanalysis process. The fact that both types of reanalysis are common in Japanese should allow for detailed comparisons in the future.

In this paper, the assumption has been that there is no difference in reanalysis depending on the presence of a predicate. In this way, the present discussion contributes not only by reporting empirical evidence against the MCR and defining an alternative reanalysis constraint that may be extended to first-pass processing, but it also illustrates in detail a word-by-word processing model for Japanese that is compatible with proposals for the processing of English.
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Appendix A.

The following is the list of stimuli used in Experiments 1 and 2, which were based on sentences from Yamashita (1994). Item 21 was not included in the analyses of Experiment 2 and in the analysis of the last region of Experiment 1 because the matrix verb was incorrect.

Following the tests in Sadakane and Koizumi (1995), the *ni* markers in sentences 2, 4, 7, 8, 9, 14, 16, 19 were classified as case markers, whereas in sentences 3, 6, 10, 17, 20, 22, 23, 25 as postpositions (see Figure 4). The rest of the items were ambiguous and were not used in the analysis. In the analysis restricted to 8 items, the *ni* markers in sentences 4, 7, 8, 9 and 19 were classified as case markers; and the ones in sentences 17, 23 and 25 as postpositions.

For item 1, the five conditions for Experiment 1 and the four conditions for Experiment 2 are presented. For the remaining items, only condition (a) of Experiment 1 is provided, from which the other conditions of both experiments can be obtained based on the words provided, namely, Tv (the transitive verb in the embedded clause of the transitive conditions), Adv1 (the adverb in the first region of all conditions of Experiment 2), Adj1 (the adjective modifying the initial nominative NP in all conditions of Experiment 2), Adj2 (the adjective modifying the accusative NP in all conditions of Experiment 2) and Adv2 (the adverb preceding the matrix verb in the ditransitive conditions of Experiment 2).

The slashes indicate the segmentation used in the self-paced reading presentation of Experiment 1. The items in Experiment 2 were presented without intervening spaces between the regions. Item 25 was not used in this experiment.

Item (1) for Experiment 1:

1a. Ambiguous ditransitive condition

職員は / 係長に / お茶を / 女の人 / 急いで / 出したと / 知らせた。

‘The employee said that the woman served tea in a hurry (to the manager).’

1b. Unambiguous ditransitive condition
The employee said that the woman served tea to the manager in a hurry.

1c. Ambiguous transitive condition

The employee said to the manager that the woman drank tea in a hurry.

1d. Unambiguous transitive condition

The employee said to the manager that the woman drank tea in a hurry.

1e. Scrambled (unambiguous) transitive condition

The employee said to the manager that the woman drank tea in a hurry.

Item (1) for Experiment 2:

1a. Ambiguous ditransitive condition (requiring reanalysis)

At the office, the plain employee politely said that the woman served sour tea (to the manager).

1b. Unambiguous ditransitive condition not requiring reanalysis

At the office, the plain employee politely said that the woman served sour tea (to the manager).

1c. Unrelated condition (DAT-ACC)

At the office, the plain employee politely introduced the woman who served sour tea (to the manager).

1d. Unrelated condition (ACC-ACC)

At the office, the plain employee politely introduced the manager to the woman who served sour tea.

TV (Transitive Verb) 飲んだと; Adv1 (Adverb1) オフィスで; Adj1 (Adjective1) 地味な; Adj2
The following items are accompanied by fairly literal translations that attempt to maintain the same order: matrix-subj report-verb complementizer embedded-subject ditransitive-verb direct-object adverb, and the ni object between parentheses.

2a. お客様 / オーナーに / 花びんを / ホステスが / 静かに / 見せたと / 言った。

‘The customer said that the hostess showed the vase quietly (to the proprietor).’

TV 飾ったら; Adv1 東京で; Adj1 いらない; Adj2 珍しい; Adv2 しつこく.

3a. 先生は / 大学生に / 公式を / 研究者が / 苦労して / 説明したと / 話した。

‘The teacher said that the researcher explained the formula with difficulty (to the student).’

TV 発見したと; Adv1 教室で; Adj1 優しい; Adj2 複雑な; Adv2 静かに.

4a. 不良品 / ウエートレスに / 後輩を / オーナーが / 上手に / 紹介したと / 話した。

‘The punk said that the proprietor introduced his younger buddy skillfully (to the waitress).’

TV 説得したと; Adv1 喫茶店で; Adj1 生意気な; Adj2 のんきな; Adv2 うるさく.

5a. 少年は / 係員に / 荷物を / 駅員が / 造作に / 渡したと / 文句をいった。

‘The younger complained that the station staff handed the baggage carelessly (to the person in charge).’

TV 捨てたと; Adv1 京都駅で; Adj1 きざな; Adj2 重い; Adv2 なまいきに.

6a. 運転手 / おばさんに / 定食を / 若者達が / 本当に / 注文したと / 知らせた。

‘The driver informed that the young people ordered the meal for sure (to the woman).’

TV 味わったと; Adv1 食堂で; Adj1 たくましい; Adj2 安い; Adv2 元気に.

7a. 弟子は / 記者に / カメラを / 写真家が / 実際は / 謝ったと / 認めた。

‘The apprentice acknowledged that the photographer gave the camera for a fact (to the reporter).’

TV 壊したと; Adv1 田野舎で; Adj1 けちな; Adj2 いい; Adv2 正直に.
8a. 主人は / 弟子に / 車を / 有名人が / 威張って / まかせたと / 言った。

‘The boss said that the star entrusted the car arrogantly (to the apprentice).’

TV 動かしたと; Adv1 京都で; Adj1 頑固な; Adj2 新しい;; Adv2 こそそも。

9a. お兄さんは / おばあさんに / ビデオを / 仲間が / こっそり / 貸したと / 話した。

‘The elder brother said that (his) associate lent the video secretly (to the old woman).’

TV 映したと; Adv1 住宅で; Adj1 面白い; Adj2 難な; Adv2 ぺらぺら。

10a. おばあさんは / 米屋に / 借金を / 酒屋が / 本当に / 払ったと / しゃべった。

‘The old woman chatted that the liquor shop owner paid the debt for sure (to the rice shop owner).’

TV 忘れれたと; Adv1 下町で; Adv1 白髪の; Adj2 古い; Adv2 のろのろと。

11a. 歌手は / オーナーに / 歌を / お客が / 気持ち良く / 挟げたと / ささやいた。

‘The singer whispered that the customer dedicated the song happily (to the owner).’

TV 聴いたと; Adv1 カラオケで; Adv1 うまい; Adj2 短い; Adv2 素早く。

12a. 女優は / 監督に / 手袋を / 観客が / 確かに / 投げたと / 言っていた。

‘The actress was saying that the tourist threw the glove for sure (to the manager).’

TV 忘れれたと; Adv1 大阪で; Adv1 下手な; Adv2 黒い; Adv2 ほんやりと。

13a. 婦人は / 長男に / かばんを / 友達が / ほんやり / 順けたと / 説明した。

‘The woman explained that the friend entrusted the briefcase absentmindedly (to the eldest son).’

TV 抱ええたと; Adv1 駅で; Adv1 上品な; Adj2 大切な; Adv2 心配そう。

14a. 社員は / 課長に / 新製品を / インターンが / 上手に / 披露したと / 伝えた。

‘The employee relayed that the intern advertised the new product skillfully (to the chief).’

TV 披ってたと; Adv1 会議で; Adv1 若い; Adj2 さん新な; Adv2 悔しそうに。

15a. 老人は / 一人娘に / 土地を / 親戚が / 密かに / 残したと / 白状した。

‘The old man confessed that the relative left the land secretely (to the only daughter).’
Reanalysis of clause boundaries

TV 使ったと; Adv1 農家で; Adj1 へんくつな; Adj2 広い; Adv2 やっと。

16a. 店員は / 女の子に / 洋服を / 高校生が / ふさけて / 見せたと / しゃべった。

‘The shop keeper said that the student showed the clothes jokingly (to the girl).’

TV 試着したと; Adv1 デパートで; Adj1 うまい; Adj2 派手な; Adv2 べらべら。

17a. 奥さんは / お母さんたちに / お餅を / 子供たちが / 全部 / 焼いたと / 言った。

‘The wife said that the children baked the rice cakes in their entirety (to/for their mothers).’

TV 食べたと; Adv1 バザーで; Adj1 活発な; Adj2 おいしい; Adv2 嫉しそうに.

18a. 秘書は / 校長に / ピアノを / 調律士が / 素早く / 届けたと / 知らせた。

‘The secretary informed that the tuner delivered the piano efficiently (to the principal).’

TV 直したと; Adv1 広島で; Adj1 陽気な; Adj2 高い; Adv2 気さくに.

19a. 音楽家は / 踊子に / 花束を / 知人が / 聖かしそうに / あげていたと / 言ってしまった。

‘The musician blurted that the acquaintance was giving the bouquet shyly (to the dancer).’

TV 持っていたと; Adv1 バーで; Adj1 貧しい; Adj2 美しい; Adv2 皮肉に.

20a. 少女は / お父さんに / おみやげを / お姉さんが / 確実に / 頼んだと / 嘘をついた。

‘The girl lied by saying that the elder sister requested a present for a fact (to the father).’

TV 喜んだと; Adv1 長崎で; Adj1 明るい; Adj2 珍しい; Adv2 あっさり.

21a. 男性は / 恋人に / 指輪を / 売り子が / 確かに / おくったと / 安心させた。

‘The man reassured by saying that the shop assistant sent the ring to his lover for sure.’

TV 鑑定したと; Adv1 レストランで; Adj1 頼もしい; Adj2 豪華な; Adv2 そっと.

(The matrix verb in this item was included by mistake, it cannot take the dative lover as an argument.)

22a. 男の子は / 両親に / キャンディを / 仲良しが / 何回も / ねだったと / 叫んだ。

‘The boy shouted that his friend asked for the candy many times (to the parents).’

TV 試食したと; Adv1 公園で; Adj1 小さい; Adj2 大きな; Adv2 泣き声で.
23a 先輩は / 教授に / 壺を / 後輩が / 先週 / 作ったと / 認めた。

‘The senior student admitted that the junior student made a jar last week (for/to the professor).’

TV 割ったと: Adv1 研究室で; Adj1 やり手の; Adj2 赤い; Adv2 しぶしぶ.

24a. 女優は / 母親に / 車を / 男性が / 自慢気に / 見せたと / 言った。

‘The actress said that the man showed the car boastfully (to the mother).’

TV 止めたと: Adv1 横浜で; Adj1 美しい; Adj2 かっこいい; Adv2 苦々しく.

25a. 本屋さんは / 小学生に / 本を / お母さんが / 本当に / 買ったと / 言ってあげた。

‘The bookshop owner said that the mother bought the book for sure (to/for the student).’

TV 忘れたと.
Table 1: Experiment 1: ANOVAs for the ditransitive conditions

<table>
<thead>
<tr>
<th>Region</th>
<th>By subjects</th>
<th>By items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F₁(1, 37)=</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.45</td>
<td>5.09</td>
</tr>
<tr>
<td>2</td>
<td>3.85</td>
<td>3.55</td>
</tr>
<tr>
<td>3</td>
<td>12.56</td>
<td>15.64</td>
</tr>
<tr>
<td>4</td>
<td>11.53</td>
<td>16.78</td>
</tr>
<tr>
<td>5</td>
<td>0.09</td>
<td>0.01</td>
</tr>
<tr>
<td>6</td>
<td>9.00</td>
<td>7.26</td>
</tr>
<tr>
<td>7</td>
<td>0.04</td>
<td>0.45</td>
</tr>
</tbody>
</table>
Table 2: Experiment 1: ANOVAs for the transitive conditions

<table>
<thead>
<tr>
<th>Region</th>
<th>By subjects $F_1(2, 74) =$</th>
<th>p $&lt;$</th>
<th>By items $F_2(2,48) =$</th>
<th>p $&lt;$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.84</td>
<td>0.17</td>
<td>1.65</td>
<td>0.21</td>
</tr>
<tr>
<td>2</td>
<td>3.64</td>
<td>0.05</td>
<td>4.02</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>21.74</td>
<td>0.01</td>
<td>16.98</td>
<td>0.01</td>
</tr>
<tr>
<td>4</td>
<td>14.62</td>
<td>0.01</td>
<td>15.71</td>
<td>0.01</td>
</tr>
<tr>
<td>5</td>
<td>0.63</td>
<td>0.54</td>
<td>0.62</td>
<td>0.55</td>
</tr>
<tr>
<td>6</td>
<td>1.75</td>
<td>0.19</td>
<td>1.98</td>
<td>0.16</td>
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<tr>
<td>7</td>
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<td>0.36</td>
<td>1.99</td>
<td>0.15</td>
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</tbody>
</table>
Table 3: Experiment 1: pairwise results for the transitive conditions

<table>
<thead>
<tr>
<th>Region</th>
<th>Conditions</th>
<th>By subjects</th>
<th>By items</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>AT, TC (9a,b)</td>
<td>$F_{1}(1, 37)$= 5.75, p&lt; 0.05</td>
<td>$F_{2}(1, 24)$= 7.35, p&lt; 0.05</td>
</tr>
<tr>
<td>2</td>
<td>AT, STC (9a,c)</td>
<td>0.13, p&lt; 0.73</td>
<td>0.01, p&lt; 0.96</td>
</tr>
<tr>
<td>2</td>
<td>TC, STC (9b,c)</td>
<td>7.84, p&lt; 0.01</td>
<td>6.78, p&lt; 0.05</td>
</tr>
<tr>
<td>3</td>
<td>AT, TC (9a,b)</td>
<td>26.82, p&lt; 0.01</td>
<td>20.23, p&lt; 0.01</td>
</tr>
<tr>
<td>3</td>
<td>AT, STC (9a,c)</td>
<td>35.50, p&lt; 0.01</td>
<td>30.47, p&lt; 0.01</td>
</tr>
<tr>
<td>3</td>
<td>TC, STC (9b,c)</td>
<td>3.17, p&lt; 0.09</td>
<td>2.00, p&lt; 0.18</td>
</tr>
<tr>
<td>4</td>
<td>AT, TC (9a,b)</td>
<td>19.66, p&lt; 0.01</td>
<td>19.11, p&lt; 0.01</td>
</tr>
<tr>
<td>4</td>
<td>AT, STC (9a,c)</td>
<td>13.47, p&lt; 0.01</td>
<td>20.55, p&lt; 0.01</td>
</tr>
<tr>
<td>4</td>
<td>TC, STC (9b,c)</td>
<td>0.55, p&lt; 0.47</td>
<td>0.02, p&lt; 0.89</td>
</tr>
</tbody>
</table>
Figure Captions

Figure 1: Experiment 1: residual reading times for the ditransitive conditions.

Figure 2: Experiment 1: residual reading times for the transitive conditions.

Figure 3: Experiment 2: difficulty and attachment preference (means and standard errors).

Figure 4: Experiment 1 and *ni* classification: average RRT and standard errors at the embedded verb of 16 items.
Figure 1: Experiment 1: residual reading times for the ditransitive conditions.
Figure 2: Experiment 1: residual reading times for the transitive conditions.
Figure 3: Experiment 2: difficulty and attachment preference (means and standard errors).
Figure 4: Experiment 1 and ni classification: average RRT and standard errors at the embedded verb of 16 items.
Contents

1 INTRODUCTION 3

2 A MINIMAL CHANGE RESTRICTION DURING REANALYSIS 5

3 REANALYSIS AS A CONSTRAINT-DRIVEN PROCESS 7

3.1 Attachment Preference and Optionality of Dative NPs 8

3.2 A Non-Vacuous Extra Change 9

3.3 Alternatives to NP-lowering 10

4 EXPERIMENT 1 12

4.1 Method 12

4.1.1 Participants 12

4.1.2 Materials 12

4.1.3 Procedure 15

4.1.4 Data analysis 16

4.2 Results 17

4.2.1 Comprehension Task 17

4.2.2 Reading Times 17

4.3 Discussion 18

5 EXPERIMENT 2 20

5.1 Method 21

5.1.1 Participants 21

5.1.2 Materials 22

5.1.3 Procedure 24

5.2 Results 25
5.2.1 Difficulty Rating ........................................... 25
5.2.2 Attachment Preference ..................................... 25
5.3 Discussion ......................................................... 25

6 DEGREES OF OPTIONALITY OF *ni*-MARKED NPS .... 26

7 GENERAL DISCUSSION ........................................... 28
   7.1 Further on-line evidence for NP-lowering ............... 29
   7.2 Reanalysis with and without a predicate ................. 30

8 REFERENCES ......................................................... 34

Appendix A. ........................................................... 39