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Introduction

It is well known that *nested* (or *center-embedded*) structures are harder to understand than their right- or left-branching counterparts (Yngve, 1960; Chomsky & Miller, 1963). For example, the right-branching English structure in (1a) is easier to understand than the nested structure in (1b):

(1) a. Mary met the senator who attacked the reporter who ignored the president.

b. # The reporter who the senator who Mary met attacked ignored the president.

These two sentences are identical in respect to the lexical items, the propositional/semantic content, and the grammatical complexity in terms of the depth of structural embedding (i.e., they both involve doubly embedded relative clauses); hence the difference in the processing complexity between (1a) and (1b) cannot be attributed to the differences in syntax or semantics (in a narrow sense), or factors such as event plausibility and lexical frequency. It has thus often been argued in the literature that the contrast between (1a) and (1b) reflects how the process of sentence comprehension is constrained by the available working memory resources. To date, several different hypotheses have been proposed as to how working memory resources constrain on-line sentence comprehension. According to *retrieval-based* hypotheses, processing an incoming word w causes the processor to retrieve relevant pieces of the current structure, so that w can be integrated into this structure. The difficulty of performing a retrieval operation may vary according to several factors, such as how far back the to-be-retrieved element is in the input stream and how well this element matches the cues of the retrieval site. A number of retrieval-based

theories have been proposed in the literature, including the integration component of the dependency locality theory (DLT; Gibson, 1998; 2000), the cue-based retrieval theory of Van Dyke and Lewis (2003) and Van Dyke and McElree (2006), the interference hypothesis of Gordon, Hendrick and Johnson (2001; 2004), and the time-based activation decay model of Lewis and Vasishth (2005) and Vasishth and Lewis (2006). Some of the evidence for the retrieval-based accounts has come from reading studies in which reading times at a verb increase depending on the distance back to verb's dependent(s) (King & Just, 1991; Gibson, 1998; Grodner & Gibson, 2005; Gordon et al., 2001). In doubly-nested structures similar to (1b), for example, Grodner and Gibson (2005) showed that reading times were slowest on the outer verbs in the structure, those which are the endpoints of the longest dependencies, such as *attacked* and *ignored* in (1b).

According to an alternative class of hypotheses – the *expectation-based* hypotheses – processing difficulty is incurred either when a new expectation is added to working memory (e.g., as proposed in the storage component of the DLT; Gibson 1998; 2000), or when the input does not match the comprehenders' expectations (the anticipation hypothesis by Konieczny & Döring 2003; the probabilistic parsers of Hale 2001; Levy 2005, 2008), or both. We will now elaborate on the two different expectation-based accounts. According to the storage component of the DLT (Gibson, 1998; 2000; cf. Chomsky & Miller, 1963; Gibson, 1991), the human sentence processor is sensitive to the number of syntactic heads that are required to form a grammatical sentence at each processing state. Thus, for example, following the words *the reporter who the senator who Mary…* in (1b) there is a cost of five expectation units: one for each predicted verb at this point (three such predictions) and one for each noun phrase (NP) gap position associated with each relative clause pronoun *who*

(two such predictions)[1].   In (1a), the prediction storage cost does not surpass two units (or maybe one) at any point of the sentence, hence the processing load is much smaller than (1b). Chen, Gibson and Wolf (2005) and Gibson, Desmet, Grodner, Watson and Ko (2005) provide evidence for the prediction storage cost from on-line reading experiments in English.   For example, Chen et al. (2005) investigated the processing of embedded English clauses with zero, one or two further verbs pending, as in (2):

(2)

a. 0 expected verbs:

The employee realized that the boss implied that *the company planned a layoff* and so he sought alternative employment.

b. 1 expected verb, late:

The employee realized that the implication that *the company planned a layoff* was not just a rumor.

c. 1 expected verb, early:

The realization that the boss implied that *the company planned a layoff* caused a panic.

d. 2 expected verbs:

The realization that the implication that *the company planned a layoff* was not just a rumor caused a panic.

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[1] The storage component in the original formulation of the DLT includes empty categories corresponding to wh-movement.   The assumption of such empty elements is not crucial in order to explain the storage cost findings that are discussed here with regard to previous work in English or the current experiment in Japanese. Future work is needed in order to determine whether empty elements associated with wh-movement are associated with processing cost independent of other stored predictions (e.g., verbs).

The critical region in this design consists of the embedded clause *the company planned a layoff*, in italics.   Because this clause has the same structure in all conditions, integration costs are identical across the four.   In sentence (2a), the critical material *the company planned a layoff* is embedded as the sentential complement of the verb *implied* which is itself part of a clause embedded as the sentential complement of the matrix verb *realized*.   Because both verbs *implied* and *realized* are encountered immediately after their respective subject nouns, no additional verbs are expected after the critical embedded clause. In sentence (2b), the verb *implied* is nominalized to *implication* with the result that the critical clause is a sentential complement of the noun *implication*.   This change to the embedded subject NP *the implication* results in the requirement for an additional verb following the critical region.   Similarly, in sentence (2c) the matrix verb *realized* is nominalized to *realization*, leading to the expectation for an additional verb after the critical region.   Finally, in sentence (2d), both the verbs *realized* and *implied* are nominalized and two verbs are therefore required following the critical region.   As predicted by syntactic expectation costs, the critical region was read fastest in (2a), slower in (2b) and (2c), and slowest in (2d), with all predicted differences significant.

A second kind of expectation-based cost has been proposed in the literature: the cost for processing a less expected input.   Hale (2001) and Levy (2005, 2008), for example, propose the *surprisal* hypothesis, a theory of expectations based (solely) on structural frequencies.   According to the surprisal hypothesis, all the possible structures compatible with the word string encountered so far ($w_{1...i}$) are allocated memory resources according to their relative frequencies; the next input w_{i+1} may eliminate from consideration some of the structures that are compatible with $w_{1...i}$, updating the probability distribution; w_{i+1} is difficult to process if some structures that are relatively highly frequent given $w_{1...i}$ are rejected by

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w_{i+1} (i.e., w_{i+1} is not highly expected). Under this hypothesis, multiply center-embedded RCs like (1b) are hard because having an object-extracted RC after a subject NP is relatively infrequent, and having such a sequence twice in a row is even more infrequent.

The goal of the present study is to test the predictions of the retrieval-based and the expectation-based hypotheses in Japanese, a strictly head-final language, for processing nested sentences comparable to English (1a) and (1b). Whereas it is known from previous studies of Japanese sentence processing that nested structures are harder to process than less nested ones in off-line acceptability judgment tasks (Babyonyshev & Gibson, 1999; Lewis & Nakayama, 2002; Uehara 1997; Uehara & Bradley 2002), it is not known how nested Japanese structures compare with their non-nested controls in on-line processing. Although both retrieval-based and expectation-based theories predict nested structures to be more complex, the two classes of theories make different predictions as to the locus of the complexity, as we discuss below.

Double nesting in Japanese

Because an object precedes the verb in a head-final language, a complement clause (CC, analogous to the object of a verb) in Japanese comes between the subject and the verb. By recurring this Subject-CC-Verb frame, it is possible to create multiply nested structures.[2] In addition, Japanese allows scrambling of its arguments, so a non-nested control can be created by placing the subject immediately next to the verb, yielding a CC-Subject-Verb order. The present study tested doubly-nested CC structures, which represented the basic

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[2]It is also possible to create multiply nested structures in Japanese by attaching a relative clause (RC) to an object NP. However, such structures involve a lot of temporary ambiguity, which would lead to additional complexity associated with resolving the ambiguity.

word order, against their scrambled variants with single nesting or no nesting, as in (3).

(3) a. Doubly nested: [NP1 [NP2 [NP3 V3 comp] V2 comp] V1]

[syoki-ga [daigisi-ga [syusyoo-ga utatanesita to] koogisita to] hookokusita]

[secretary-nom [congressman-nom [prime minister-nom dozed comp] protested

comp] reported]

'The secretary reported that the congressman had protested that the prime minister

had dozed.'

b. Singly nested version 1: [NP2 [NP3 V3 comp] V2 comp] [NP1 V1]

[daigisi-ga [syusyoo-ga utatanesita to] koogisita to] syoki-ga hookokusita]

[congressman-nom [prime minister-nom dozed comp] protested comp]

secretary-nom reported]

c. Singly nested version 2: [NP1 [NP3 V3 comp] [NP2 V2 comp] V1]

[syoki-ga [syusyoo-ga utatanesita to] [daigisi-ga koogisita to] hookokusita]

[secretary-nom [prime minister-nom dozed comp] [congressman-nom protested

comp] reported]

d. Non-nested: [NP3 V3 comp] [NP2 V2 comp] [NP1 V1]

[syusyoo-ga utatanesita to] [daigisi-ga koogisita to] [syoki-ga hookokusita]

[prime minister-nom dozed comp] [congressman-nom protested comp]

[secretary-nom reported]

The structure in (3a) is a doubly-nested, non-scrambled (default) word order for the clause 'the secretary reported that the congressman protested that the prime minister dozed'. The other three word orders are scrambled versions of (3a), which are less nested but have the identical propositional content. In (3b), the highest level subject NP (NP1) and the

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embedded complex sentence ([NP2 [NP3 V3 comp] V2 comp]) are scrambled from their default positions as arguments of V1, so that the subject NP1 is now adjacent to its thematic-role assigning verb V1. In (3c), the middle subject NP (NP2) and the sentential complement ([NP3 V3 comp]) are scrambled from their default positions, so that NP2 is now adjacent to its role-assigning verb V2. In (3d), both of the preceding scramblings take place, resulting in a fully non-nested structure, in which all arguments are adjacent to their role-assigning verbs.[3, 4]

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[3] A reviewer has observed that there is a fifth scrambled version of this structure, as in (i) below, in which the most deeply embedded clause is fronted to the beginning of the sentence:

(i) [syusyoo-ga utatanesita to] [syoki-ga [daigisi-ga *t* koogisita1to] hookokusita]
    [primeminister-nom dozed comp] [secretary-nom [congressman-nom *t* protested comp] reported]

The dependencies in (i) are unlike those in (3a)-(3d) in that some are crossed, as opposed to nested. In particular, the predicate-argument dependency headed by *koogisita* ('protested') is interrupted by *syoki-ga* ('secretary-nom'), an argument of the higher verb *hookokusita* ('reported'). Because there is evidence that processing crossed dependencies causes processing difficulty independent of other language processing factors (Gibson & Breen, 2004; Gibson, Fedorenko & Breen, 2006; Levy, Gibson & Fedorenko, 2008), we limited our study here to the four nested structures in (3).

[4] An additional factor that has been shown to affect the complexity of nested structures in Japanese is whether or not the first subject is marked as the topic, using the case-marked "wa". In particular, several previous studies have shown that the difficulty of having a sequence of multiple nominative-marked NPs in Japanese can be reduced by marking the first subject NP with "wa" (Uehara, 1997; Uehara & Bradley, 2002; Miyamoto, 2002). One possible explanation for this effect is that processing wa-marked NPs may simply be generally easier than processing ga-marked NPs (possibly because the frequency of wa-marked NPs). A second possibility is that the sequence NP-wa NP-ga may be more frequent than the sequence NP-ga NP-ga, and hence easier to comprehend. A third possibility is that there may be less similarity-based interference in comprehending the sequence NP-wa NP-ga than the sequence NP-ga NP-ga, independent of the production frequencies (Uehara & Bradley, 2002). Because we included no "wa"-marked NPs in our materials, we do not address these issues

An advantage of comparing nested to non-nested CC structures in Japanese over comparing nested to non-nested RC structures in English is that the clausal embedding position of the different NPs is better controlled in Japanese than in English.   That is, the main clause subject NP is the same in all versions of the Japanese sentences, as are the embedded subject and the most embedded subject.   In contrast, the embedding status of the verbs and NPs differs across the English structures being compared in (1) (e.g., *Mary met the senator …* is the top-level clause in (1a), whereas *The reporter … ignored the president* is the top-level clause in (1b)).

Predictions

First, consider the predictions of the retrieval-based hypothesis for (3a-d).   For simplicity, consider Gibson's (1998) linear distance-based hypothesis, whereby retrieval cost increases by one unit for each non-pronominal noun phrase and verb intervening between the retrieval site and the to-be-retrieved word (see Table 1; other retrieval-based hypotheses make essentially the same predictions).   Specifically, Gibson (1998) proposes a retrieval cost metric such that each new word incurs a cost of one unit if it is the head of a noun phrase or verb phrase which corresponds to a new discourse referent, and then one additional unit for each new NP or verb between the retrieval site and the to-be-retrieved element(s) in the structure for the input.   For example, at regions 1, 2, and 3 of structure (3a), a new NP is connected to the structure for the input.   In each case, the NP is connected immediately following the structure for the preceding word in the input.   Thus the total cost of each of these integrations is one unit, corresponding to the new NP in each case.   At region 4, V3 is connected to NP3, corresponding to another local integration of cost one unit.   The

here.

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complementizer integrates following V3, also locally (no new NPs or verbs intervene), so this connection is cost-free according to this metric. The average cost over this region is therefore 0.5 units. At region 5, V4 is connected to NP2 at a cost of 3 units: one for each of V4, V3 and NP3, all which come between V4 and NP2. There is no cost for the local integration of the complementizer, and thus the average integration cost in this region is 1.5 units. The calculation of integrations costs proceeds similarly for the remainder of the positions in the table.

According to this metric, in (3a) integration costs should be largest at the outermost verb, V1, and progressively smaller on the more embedded verbs. Note that V1 is contained in the final region (region 6) in all four conditions, making the cross-condition comparisons straightforward at this region. The processing of V1 in (3c) should be as complex as V1 in (3a), because it integrates with N1, which is the sentence-initial argument, just as in (3a). Region 5 of (3a) and region 4 of (3b) are predicted to have the same retrieval costs (2 units for a verb and a noun). All other verbs are integrated locally, causing no distance-based integration costs.

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Insert Table 1 about here

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Now consider the two types of expectation-based theories: storage and surprisal. According to the syntactic storage cost hypothesis of Gibson (1998, 2000), each new

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nominative NP is associated with the expectation of a verb to come.[5]   The detailed

expectation predictions for (3a)-(3d) according to this hypothesis are provided in Table 2.

In (3a), one verb is predicted at the NP1-nom region. Then NP2-nom triggers the prediction

of another verb, adding to the expectation cost. Furthermore, another verb is predicted at

NP3-nom, augmenting the expectation cost to 3 units. At the following regions, the storage

cost decreases as the predicted heads are encountered.   In the singly-nested conditions (3b)

and (3c), on the other hand, the expectation cost never elevates to 3 units. At the first region,

one verb is predicted, and at the second region, another verb is predicted, increasing the

expectation cost to 2 units; however, at the following verb region, the cost is reduced to 1 unit

because one of the two predicted heads is encountered. In (3b), V2 at the following region

further reduces the expectation cost to 0; the complementizer at the same region, however,

triggers a new prediction for a new verb.[6]   The complementizer was presented in the same

region as the preceding verb.   As a simplifying assumption, we quantify the expectation cost

of a region containing two words (e.g., a verb and a following complementizer) as the

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[5] Because some Japanese predicates (mostly stative ones) allow nominative objects in addition to subjects, it is

possible that only one verb will follow the second nominative NP.   However, the case marker "ga" marks a

nominative subject much more often than it marks a nominative object, perhaps especially for a human NPs.

Because it is known that lexical frequencies, when heavily biased, can outweigh syntactic expectations (Gibson,

1998; 2006; MacDonald, Pearlmutter & Seidenberg, 1994), we assume that each nominative human NP is

preferentially analyzed as a subject, and thus induces an expectation for a new verb.   In support of this

hypothesis, see Miyamoto (2002) which demonstrates that a second Japanese nominative NP tends to be

interpreted as a clause boundary during on-line processing.

[6] Processing the complementizer after V2 in (3b) also causes the expectation for a subject noun phrase, but

subjects are often null for S-complement verbs in natural discourse, so a null subject may also be posited here,

and no storage cost should be incurred.

average expectation cost across the two words. Thus, the cost for the fourth region of condition (3b) is $(0+1)/2 = 0.5$, as shown in Table 2.

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Insert Table 2 about here

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Finally, let us consider the predictions of the surprisal hypothesis (Hale, 2001; Levy, 2008). The predictions of relative difficulty are generally similar to the predictions of the storage hypothesis, especially at the NP regions, although they may be somewhat different at some V regions. According to the surprisal hypothesis, each of the possible structures compatible with the partial string that has been encountered so far is allocated a certain amount of memory resources in accordance with its probability relative to the others. Because Japanese is an SOV language and because CC-taking verbs such as *omow* 'think' are frequent, the nested structure frame in the form of S-CC-V is a frequent structure. However, a structure containing two consecutive phonetically-overt nominative NPs is not so frequent, because embedded CC structures may be scrambled and / or they may include phonetically null pronouns. According to a corpus count we conducted on the 23,788 occurrences of non-null nominative nouns in the Kyoto Text Corpus (a tagged corpus from the newspaper Mainichi Shimbun from 1995, consisting of about 40,000 sentences), a nominative-marked noun was immediately followed by another noun (rather than a verb, adjective etc.) in linear order 6722 times (28.3%), and among these cases, it was immediately followed by another nominative-marked noun only 60 times = 0.9% of all nouns following a

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nominative noun.[7] There were no cases of three consecutive nominative nouns (0%).[8]

Thus it is probably safe to assume that the surprisal hypothesis would predict a slowdown

effect when a nominative NP in (3) is immediately followed by another nominative NP, and a

greater slowdown when two consecutive NPs are followed by yet another nominative NP in

(3a).

As for the V regions, the surprisal hypothesis predicts that all of the V regions are

easier to process than the second of the consecutive nominative NPs, because each of the Vs

are preceded by at least one of their arguments, which should create an expectation for the

Vs, whereas there is no structural factor triggering an expectation of a nominative NP coming

immediately after a nominative NP.   This prediction is similar, but not identical, to that of

the storage hypothesis: in contrast, the latter predicts that one V region, namely V3 in (3a),

should be as hard to process as the second of the consecutive nominative NPs, because in

both cases, 2 predictions are not yet matched.   Furthermore, the surprisal hypothesis may

predict that the V3 region in (3a) has lower surprisal than the V3 regions in the other

conditions (3b-d), because it is preceded by more context (3 NPs) compared to V3 in (3b,c)

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[7] This figure includes only instances in which the *word* immediately following the nominative noun is a

nominative noun, and excludes the instances in which the *phrase* following and hierarchically closest to the

nominative noun is a nominative NP pre-modified by a genitive NP, an adjective, a demonstrative, etc., in

which case the word string would be something like N-nom N-gen N-nom, N-nom Adj N-nom, etc.   If such

instances were included, the figure would be greater by approximately 40.   There were also about 100

instances in which two nominative NPs were separated by an adverb or a dative NP.

[8] No instances of three consecutive nominative phrases or nominative words were encountered.   There were

only two instances in the corpus of three nominative phrases before their predicates, but these had other phrases

intervening.

(preceded by 2 NPs) and V3 in (3d) (preceded by 1 NP and thus predicted to be the hardest);[9] the storage hypothesis, on the other hand, predicts the opposite: V3 in (3d) (2 storage units) should be harder than the other V3 regions (0.5 storage unit).

In summary, for the NP regions, the retrieval-based theories do not predict differences, whereas the expectation-based theories predict increasing reading times as nominative NPs stack up.   For the V regions, the retrieval-based theories predict increasing reading times in longer distance connections, whereas the expectation-based theories do not predict such increasing reading times: the storage hypothesis predicts speedup at the V regions as more verbs are encountered, irrespective of dependency length.   The surprisal hypothesis predicts that all V regions, including V3 in condition (3a), are easier than the second of the consecutive NPs, whereas the storage hypothesis predicts that V3 in (3a) is as hard as the NP regions with the storage cost of 2 units.   The storage hypothesis also predicts that V3 in (3a) is harder to process than the other V3 regions, whereas the surprisal hypothesis predicts that V3 in (3a) may be the easiest among all the V3 regions because it has more preceding context and that V3 in (3d) may be the hardest among them.

Experiment

Method

Participants

45 adult native speakers of Japanese in the Boston area participated in the experiment. They were each paid five dollars for participation in the experiment, which took about 20

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[9] We thank a reviewer for bringing up this point.

minutes per session.

Materials

A sample set of the four target conditions described above is shown in (3) above. Because people typically read the final region of a sentence more slowly than other regions, we did not want to compare end-of-sentence regions to non-sentence-end regions. Consequently, the materials in the experiment included an additional clause following the sentences in (3), initiated by a conjunction such as *node* 'because' (see the Appendix for a list of the materials). There were six regions of interest in the experiment, corresponding to the three subject nouns and their corresponding verbs. Bound morphemes such as case-markers, complementizers, and conjunction markers were grouped with preceding words such as nouns and verbs.

Procedure

The experiment was conducted with Linger, a sentence processing experimental presentation program written by Douglas Rohde, using Apple PowerBook computers on Mac OS X. The program presented one sentence at a time on the computer monitor, left to right, word by word in a noncumulative, moving-window manner as a participant pushed the space bar (Just, Carpenter & Woolley, 1982). The 20 sets of 4 target conditions were distributed in a Latin Square design, resulting in 4 lists. 72 filler items were added to each list, including 48 items from two unrelated experiments and 24 items which were unrelated to any of the experimental items in any of the sub-experiments. The 92 sentences in a list were presented in a different pseudo-random order for each participant, such that no two target items were presented consecutively. The participants were asked to read the sentences as naturally as

possible. The experiment was preceded by brief instructions and nine practice items. Each stimulus was immediately followed by a yes-no question (e.g., "Was it the congressman that protested?" for (3) above) regarding the content of the sentence was presented, with feedback for wrong answers.

Results

Comprehension performance

Because the nature of our materials (three clauses, many doubly-embedded) made them difficult to comprehend, participants achieved a relatively low overall accuracy rate of 72.2%. Broken down by conditions, the comprehension question response accuracy rates were 77.3% (SE 2.8) for (3a), 70.7% (SE 3.0) for (3b), 69.8% (SE 3.1) for (3c), and 71.1% (SE 3.0) for (3d). A repeated measures one-way ANOVA revealed no significant differences among the four conditions ($Fs < 2$, $ps > .2$). It should be noted that the accuracy on the 24 filler sentences that were not part of any sub-experiment was much higher than in the target sentences, at 87.0% across the experiment. This higher accuracy rate demonstrates that the participants were making an effort to comprehend the items. The low comprehension accuracy rate of the target items probably reflects the complexity of the items rather than the negligence of the participants.

Reading times

In order to reduce reading time differences due to region length and to diminish reading time differences among participants, length-adjusted (residual) reading times (Ferreira and Clifton, 1986), were calculated per region. It should be noted that the

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Japanese orthography consists of two types of characters: kana and kanji. Kana are mostly moraic, with each kana character usually corresponding to a single mora (a phonological unit determining syllabic weight in Japanese); on the other hand, kanji (Chinese characters) used in the Japanese orthography may represent several morae (ranging from one to three morae in the majority of cases). Because of this property of the Japanese orthography, a simple count of the characters used may not be a good estimate of how long people take to read the character, if there is phonological component to reading. Some previous experimental studies have shown that both the number of characters and the number of morae have an effect in reading sentences in Japanese (e.g., Mazuka, Itoh, Kondo & Brown, 2000). We thus calculated the residual reading times for each participant using a linear regression equation involving both the number of characters and the number of morae as variables (following Mazuka, Itoh & Kondo, 2002). The analyses of the raw reading times and of the residual reading times based solely on the character count showed similar patterns as the analyses of the dual-factor residuals (based on the mora count and the character count). We present the analyses of the dual-factor residuals here.

In addition, the residual reading times were trimmed so that data points beyond five standard deviations from the relevant condition x region cell mean were discarded, corresponding to less than 1.0% of the data. We also excluded the data from one participant whose comprehension accuracy rate was below 65%. We analyzed all the other trials, whether the comprehension question was answered correctly or not. The analyses without the incorrect responses showed very similar statistical patterns.

The mean residual RTs per region for the four conditions are illustrated in Figure 1. The residual RTs and the predictions of the retrieval-based integration and the syntactic prediction storage cost hypotheses are summarized in Table 3.

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Insert Figure 1 about here

Caption:

Figure 1: Mean residual reading times for all conditions

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Insert Table 3 about here

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Correlational analyses conducted between the predicted costs and the overall condition mean RTs in each region (obtained by simply averaging the RTs for all trials in a region, for all participants and all items) across the four conditions support the expectation-based storage cost hypothesis. We found a highly reliable correlation between the mean residual RTs and the predicted costs of expectation ($r^2 = .80$; $p < .001$; see Figure 2).   On the other hand, when the mean residual RTs were compared to the retrieval-based integration predictions, no correlation was found ($r^2 = .01$; $p > .6$).   Because the retrieval-based integration hypothesis does not make predictions for the noun regions, we also analyzed the verb regions alone, but again no correlation was observed ($r^2 = .05$; $p > .4$; see Figure 3).   In fact, the numerical trend of the direction of the correlation was in the reverse of the predicted direction.

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Insert Figure 2 about here

Caption:

Figure 2: Correlation between the mean RTs and the syntactic prediction storage

cost predictions

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Insert Figure 3 about here

Caption:

Figure 3: Correlation between the mean RTs of the verb regions and the

retrieval-based integration cost predictions

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Having found a significant correlation between prediction storage costs and the RTs,

we also performed planned comparisons of all pairs of prediction storage cost regions that

differed minimally, i.e., 0.5 vs. 1 unit of prediction storage cost; 1 vs. 2 units of prediction

storage cost; and 2 vs. 3 units.   ANOVAs confirmed that there were statistically significant

differences depending on the prediction storage cost factor: 0.5 vs. 1 unit: $F_1(1,43) = 9.09$, p

$< .005$; $F_2(1,19) = 8.19$, p $< .02$;[10] 1 vs. 2 units: $F_1(1,43) = 41.16$, p $< .001$; $F_2(1,19) =$

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[10] The reading time of region 5 in condition (2b), which was predicted to have a storage cost of 1 unit, was

unexpectedly slow.   However, even without this slow region, there was a statistically significant difference

between 0.5 and 1 units of storage in the participants analysis ($F_1(1,43) = 5.03$, p $< .03$) and a strong tendency

toward a difference in the items analysis ($F_2(1,19) = 4.16$, p $= .055$).

79.43, p < .001; 2 vs. 3 units: F1(1,43) = 7.66, p < .01; F2(1,19) = 4.22, p = .054.   The mean

reading times are summarized in Table 4.

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Insert Table 4 about here

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We also performed the same comparisons within the NP regions and within the V

regions.   As for the NP regions, the prediction storage cost factor yielded significant

differences: 1 vs. 2 units: F1(1,43) = 28.49, p < .001; F2(1,19) = 39.57, p < .001; 2 vs. 3

units: F1(1,43) = 8.98, p < .006; F2(1,19) = 4.69, p < .05.   As for the V regions, the

difference between the regions with 0.5 units and those with 1 unit was not significant (Fs <

1.6, ps > .2).   The small prediction storage cost difference (0.5 units) might not have been

large enough to yield a difference, for the fewer trials in comparison to when NP regions

were also considered.   The difference between 1 and 2 units in the V regions, on the other

hand, turned out to be statistically significant (F1(1,43) = 19.13, p < .001; F2(1,19) = 19.96, p

< .001).

Finally, we performed comparisons between the V regions in order to test the

following predictions of the surprisal hypothesis and the storage hypothesis: (i) the surprisal

hypothesis predicts that all V regions, including V3 in (3a), are easier than the second of the

two consecutive nominative NPs, whereas the storage hypothesis predicts that V3 in (3a) is as

hard as them; (ii) the surprisal hypothesis predicts that V3 in (3a) may be the easiest and V3

in (3d) may be the hardest among the V3 regions, whereas the storage hypothesis predicts

that V3 in (3a) is harder than the others.   As for (i), a simple comparison among all the V

regions and all the regions containing the second of the two consecutive nominative NPs

supported the prediction that the V regions are faster (mean RTs: 41.2 msec (SE 12.4) vs.

295.0 msec (SE 24.0); F1(1,43) = 32.45, p < .001; F2(1,19) = 49.29, p < .001); however, V3

in condition (3a) was not faster than the second of the two consecutive NPs (mean RTs: 307.7

msec (SE 55.0) vs. 307.3 msec (SE 39.5); Fs < .1, ps > .9), which was not predicted by the

surprisal hypothesis and was predicted by the storage hypothesis. As for (ii), the comparison

between the V3 regions with regard to the number of preceding words (V3 in (3a) preceded

by 3 NPs; V3 in (3b,c) preceded by 2 NPs; V3 in (3d) preceded by 1 NP) revealed a

significant difference (F1(2,86) = 12.97, p < .001; F2(2,38) = 10.98, p < .001), though in the

opposite direction of the prediction, with V3 in (3a) being much slower than the others (mean

RTs: (3a) 307.7 msec vs. (3b,c) 18.1 msec vs. (3d) 52.6 msec).   This difficulty of V3 in (3a)

is predicted by the storage hypothesis, because its predicted storage cost is 2 units while the

other V3 regions are associated with 0.5 storage unit.

Discussion

Overall, the results support the predictions of the expectation-based theories: the

participants slowed down as nominative NPs stacked, and read faster at the verb regions, as

both the storage and the surprisal hypotheses predicted.   The correlational analyses also

strongly supported the expectation cost hypothesis. Before proceeding to discuss the results

in more detail, it is worth pointing out that there may be some cost associated with processed

scrambled word orders in a null context, such as in our singly-nested and non-nested

conditions.   However, even if scrambling does adversely affect reading times, it appears that

expectation costs play a larger role in the processing of these materials, because the default

(doubly-nested) word order condition is slowest to process.

As for how well the two expectation-based hypotheses predicted reading times at the V regions, the results were mixed. The storage predictions were supported when all the regions were compared, when the NP regions were compared, and when the V regions with the storage cost of 2 and the V regions with the cost of 1 were compared, except that there was only a numerical (non-significant) difference between the V regions with the storage cost of 1 and those with the storage cost of 0.5. Turning to the predictions of the surprisal hypothesis, the prediction that each V region should be easier than the second of the consecutive NPs was not supported because the V3 region in condition (3a) did not conform to this prediction; this finding, however, was predicted by the storage hypothesis. Also, among all the V3 regions, the surprisal hypothesis predicts that V3 in (3a) may be the easiest, whereas the storage hypothesis predicts that it should be the hardest; the results from our study supported the latter prediction. Thus overall, the comparisons between the V regions appear to be more supportive of the storage hypothesis than the surprisal hypothesis. However, a caveat is in order here: although the observed difficulty at V3 in condition (3a) was crucial in favoring the storage hypothesis over the surprisal hypothesis, the slowness of this particular V3 might have been due to a spillover from the previous region, which was the slowest of all the target regions. Furthermore, it should be noted that the storage effects and the surprisal effects are not mutually exclusive from each other: it could be the case that both affect processing.

In contrast, the results did not support the retrieval-based theories at all: we found no evidence that the distance between a verb and its arguments affected the complexity of processing the verb. Note that the absence of the retrieval-based effects has often been pointed out in the previous studies of head-final languages: Nakatani and Gibson (2008) in

Japanese; Konieczny (2000) and Konieczny and Döring (2003) in German; Vasishth (2003) and Vasishth and Lewis (2006) in Hindi.   The results from the present study are particularly robust in pointing to the absence of locality effects, because the semantics, the lexical choice, and the embedding order of the propositions were kept constant across all the conditions. Although the lack of retrieval-based effects is technically a null result, the fact that we could not find a main effect of locality in such well-controlled materials should be taken seriously, especially in the presence of large differences predicted by expectation-based accounts.

We will now discuss the implications of the current results for theories of sentence complexity more generally.   In particular, how do we reconcile the current results with the abundant evidence of retrieval effects in other structures and/or languages?   Levy (2008), for example, has suggested that all kinds of processing difficulty effects may be interpreted as surprisal: there is no cost incurred by prediction storage, or by retrieval.   The nesting difficulty, according to Levy, is then caused by the infrequency of the nested structures.

However, as Levy (2008) himself notes, there are instances of attested locality effects that cannot be interpreted as surprisal effects.   For example, Grodner and Gibson (2005) found that the verb *supervised* in (4a-c) below was read slower when more words intervened between the subject *the administrator* and the verb:

(4)   a. The administrator who the nurse *supervised ...*

b. The administrator who the nurse from the clinic *supervised ...*

c. The administrator who the nurse who was from the clinic *supervised ...*

The locality effect found here runs contrary to the surprisal prediction because the surprisal hypothesis predicts that the more words precede the verb, the more the processor expects the

verb because the number of all the possible structures compatible with the partial string processed so far generally decreases as more words have been encountered, which in turn leads to the increase of the memory allocation for the target structure (the verb continuation). See also Levy, Fedorenko and Gibson (2007), who presented two experiments, directly comparing the predictions of surprisal and retrieval-based accounts in Russian relative clause structures, and demonstrated that the results are best explained by retrieval difficulty.

If the retrieval locality effects are found in English and Russian, why are they not found in Japanese and other head-final languages? One possibility is that the processing strategy is parameterized depending on language-dependent parameter settings, such as the order of a head and its arguments. For example, it might be the case that the processor is heavily expectation-oriented in head-final languages so that there is no cost associated with long-distance retrieval at head positions, while it may be more retrieval-based in head-initial languages. However, evidence against this hypothesis is provided by Jaeger, Fedorenko, Hofmeister and Gibson (2008), who found evidence for anti-locality effects even in English, for subject-verb relationships.

Another possibility is that the observed difference regarding the presence of locality effects is dependent on the type of retrieval, rather than the type of language, as suggested in Grodner and Gibson (2005) and Levy (2008). In particular, the locality effects discussed above were found for filler-gap relations (between a relative pronoun such as *who* and its gap position) in relative clauses. On the other hand, the lack of locality effects and / or the presence of surprisal effects reported in the studies of head-final languages, including ours, were observed in the constructions involving dependencies between predicates and arguments / adjuncts. It is therefore possible that the retrieval locality applies only in filler-gap and other "non-canonical" head-dependency relations. Future research on

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materials with filler-gap dependencies in head-final languages will help to evaluate this

hypothesis.

References

Babyonyshev, M., & Gibson, E. (1999).   The complexity of nested structures in Japanese. *Language, 75*, 423–450.

Chen, E., Gibson, E., & Wolf, F. (2005). Online syntactic storage costs in sentence comprehension.   *Journal of Memory and Language, 52,* 144–169.

Chomsky, N., & Miller, G.A. (1963). Introduction to the formal analysis of natural languages. In R.D. Luce, R.R. Bush, & E. Galanter (Eds.), *Handbook of mathematical psychology, volume 2* (pp. 269–321). New York, NY: Wiley.

Ferreira, F., & Clifton, C., Jr. (1986). The independence of syntactic processing. *Journal of Memory and Language, 25,* 348–368.

Gibson, E. (1991). *A computational theory of human linguistic processing: Memory limitations and processing breakdown.*   Unpublished doctoral dissertation, Carnegie Mellon University, Pittsburgh, PA.

Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition, 68,* 1–76.

Gibson, E. (2000).   The dependency locality theory: A distance-based theory of linguistic complexity.   In Miyashita, Y., Marantz, A., & O'Neil, W. (Eds.), *Image, language, brain* (pp. 95–126). Cambridge, MA: MIT Press.

Gibson, E. (2006). The interaction of top-down and bottom-up statistics in the resolution of syntactic category ambiguity.   *Journal of Memory and Language, 54,* 363-388.

Gibson E., Desmet, T., Grodner, D., Watson, D., & Ko, K. (2005). Reading relative clauses in English.   *Cognitive Linguistics, 16*, 313-354

Gibson, E. & Breen, M. (2004). Processing crossed dependencies in English. Poster

presented at the 17th Annual CUNY Conference on Human Sentence Processing, University of Maryland, March, 2004.

Gibson, E., Fedorenko, E. & Breen, M. (2006). Processing extraposed structures in English: grammatical and processing factors. Poster presented at the 19th Annual CUNY Conference on Human Sentence Processing, CUNY, New York, March, 2006

Gordon, P.C., Hendrick, R., & Johnson, M. (2001). Effects of noun phrase type on sentence complexity. *Journal of Memory and Language, 51,* 97–114.

Gordon, P.C., Hendrick, R., & Johnson, M. (2004). Memory interference during language processing. *Journal of Experimental Psychology: Learning, Memory and Cognition, 27,* 1411–1423.

Grodner, D., & Gibson, E. (2005). Consequences of the serial nature of linguistic input. *Cognitive Science*, *29*, 261–291.

Hale, J. (2001). A probabilistic Earley parser as a psycholinguistic model. In *Proceedings of North American Association for Computational Linguistics*.

Jaeger, T.F., Fedorenko, E., Hofmeister, P. & Gibson, E. (2008). Expectation-based Syntactic Processing: Anti-locality outside of Head-final Languages. Paper presented at the 21sh CUNY Conference on Human Sentence Processing, U. North Carolina, Chapel Hill, NC.

Just, M.A., Carpenter, P.A., & Woolley, J.D. (1982). Paradigms and processing in reading comprehension. *Journal of Experimental Psychology: General, 111,* 228–238.

King, J. & Just, M.A. (1991) Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language, 30,* 580–602.

Konieczny, L. (2000). Locality and parsing complexity. *Journal of Psycholinguistic Research, 29*, 627–645.

Konieczny, L., & Döring, P. (2003). Anticipation of clause-final heads: Evidence from eye-tracking and SRNs. In *Proceedings of the 4th International Conference on Cognitive Science*, 330–335. Sydney: University of New South Wales.

Levy, R. (2005). *Probabilistic models of word order and syntactic discontinuity.* Ph.D. thesis, Stanford University.

Levy, R. (2008). Expectation-based syntactic comprehension. *Cognition, 106*, 1126–1177.

Levy, R., Fedorenko, E., & Gibson, E. (2007) The syntactic complexity of Russian relative clauses. Paper presented at the 20th CUNY Conference on Human Sentence Processing, UC San Diego.

Levy, R., Gibson, E. & Fedorenko, E. (2008). Expectation-Based Processing of Extraposed Structures in English, Poster presented at the 21st CUNY conference on sentence processing, University of North Carolina.

Lewis, R., & Nakayama, M. (2002). Syntactic and positional similarity effects in the processing of Japanese embeddings. In Nakayama, M. (Ed.) *Sentence Processing in East Asian Languages*. Stanford, CA: CSLI Publications (pp. 85–110).

Lewis, R. & Vasishth, S. (2005). An activation-based model of sentence processing as skilled memory retrieval. Co*gnitive Science, 29,* 1-45.

MacDonald, M.C., Pearlmutter, N. & Seidenberg, M.S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review, 101,* 676--703.

Mazuka, R., Itoh, K., Kondo, T, & Brown, J.S. (2000) Phonological processing in reading Japanese sentences silently. Presented at the 13th Annual CUNY Conference on Human Sentence Processing, University of California, San Diego, 2000.

Mazuka, R., Itoh, K., & Kondo, T. (2002) Costs of scrambling in Japanese sentence processing. In Nakayama, M. (Ed.) *Sentence Processing in East Asian Languages*.

Stanford, CA: CSLI Publications (pp. 131166).

Miyamoto, E. T. (2002). Case markers as clause boundary inducers in Japanese. *Journal of Psycholinguistic Research*, 31, 307–347.

Nakatani, K., & Gibson, E. (2008). Distinguishing theories of syntactic expectation cost in sentence comprehension: Evidence from Japanese. *Linguistics, 46*, 63−87.

Uehara, K. (1997). Judgments of processing load: The effect of NP-*ga* sequences. *Journal of Psycholinguistic Research, 26,* 255–263.

Uehara, K., & Bradley, D. (2002). Center-embedding problem and the contribution of nominative case repetition. In Nakayama, M. (Ed.) *Sentence Processing in East Asian Languages*. Stanford, CA: CSLI Publications (pp. 257–287).

Van Dyke, J. & Lewis, R. L. (2003). Distinguishing effects of structure and decay on attachment and repair: A retrieval interference theory of recovery from misanalyzed ambiguities. *Journal of Memory and Language, 49:285-413*.

Van Dyke, J. & McElree, B. (2006). Retrieval interference in sentence comprehension. *Journal of Memory and Language, 55:157-166*.

Vasishth, S. (2003). *Working memory in sentence comprehension: Processing Hindi center embeddings*. New York, NY: Routledge.

Vasishth, S. & Lewis, R. L. (2006). Argument-head distance and processing complexity: Explaining both locality and antilocality effects. *Language, 82*, 767–794.

Yngve, V.H. (1960). A model and an hypothesis for language structure. In *Proceedings of the American Philosophical Society, 104* (pp. 444–466).

Region	1	2	3	4	5	6
(3a)	[NP1	[NP2	[NP3	V3 comp]	V2 comp]	V1 conj]
New NP/verb	1	1	1	1 0	1 0	1 0
Integration distance	0	0	0	0 0	2 0	4 0
Total cost (per region)	1	1	1	0.5	1.5	2.5
(3b)	[NP2	[NP3	V3 comp]	V2 comp]	[NP1 t	V1 conj]
New NP/verb	1	1	1 0	1 0	1	1 0
Integration distance	0	0	0 0	2 0	0	0 0
Total cost (per region)	1	1	0.5	1.5	1	0.5
(3c)	[NP1	[NP3	V3 comp]	[NP2 t	V2 comp]	V1 conj]
New NP/verb	1	1	1 0	1	1 0	1 0
Integration distance	0	0	0 0	0	0 0	4 0
Total cost (per region)	1	1	0.5	1	0.5	2.5
(3d)	[NP3	V3 comp]	[NP2 t	V2 comp]	[NP1 t	V1 conj]
New NP/verb	1	1 0	1	1 0	1	1 0
Integration distance	0	0 0	0	0 0	0	0 0
Total cost (per region)	1	0.5	1	0.5	1	0.5

Table 1: Predictions of retrieval-based accounts

Region	1	2	3	4	5	6
(3a)	[NP1	[NP2	[NP3	V3 comp]	V2 comp]	V1 conj]
Predicted heads	V1	V1,V2	V1,V2,V3	V1,V2 V1,V2	V1 V1	- V
Cost (per region)	1	2	3	2	1	0.5
(3b)	[NP2	[NP3	V3 comp]	V2 comp]	[NP1	V1 conj]
Predicted heads	V2	V2,V3	V2 V2	- V1	V1	- V
Cost (per region)	1	2	1	0.5	1	0.5
(3c)	[NP1	[NP3	V3 comp]	[NP2	V2 comp]	V1 conj]
Predicted heads	V1	V1,V3	V1 V1	V1,V2	V1 V1	- V
Cost (per region)	1	2	1	2	1	0.5
(3d)	[NP3	V3 comp]	[NP2	V2 comp]	[NP1	V1 conj]
Predicted heads	V3	- V2	V2	- V1	V1	- V
Cost (per region)	1	0.5	1	0.5	1	0.5

Table 2: Predictions of the syntactic prediction storage cost account

(3a)	[NP1	[NP2	[NP3	V3 comp]	V2 comp]	V1 conj]
RTs (SE)	83.9 (33.1)	307.3 (39.5)	496.8 (75.6)	307.7 (55.0)	1.2 (39.6)	37.2 (41.0)
Retrieval-based integration cost	1	1	1	0.5	1.5	2.5
Prediction storage cost	1	2	3	2	1	0.5

(3b)	[NP2	[NP3	V3 comp]	V2 comp]	[NP1 t	V1 conj]
RTs (SE)	68.5 (31.4)	280.8 (37.5)	-3.0 (38.0)	-78.7 (36.3)	237.4 (54.0)	48.5 (42.4)
Retrieval-based integration cost	1	1	0.5	1.5	1	0.5
Prediction storage cost	1	2	1	0.5	1	0.5

(3c)	[NP1	[NP3	V3 comp]	[NP2 t	V2 comp]	V1 conj]
RTs (SE)	75.0 (32.3)	296.9 (47.1)	39.3 (39.2)	106.3 (35.8)	70.0 (49.0)	12.8 (44.8)
Retrieval-based integration cost	1	1	0.5	1	0.5	2.5
Prediction storage cost	1	2	1	2	1	0.5

(3d)	[NP3	V3 comp]	[NP2 t	V2 comp]	[NP1 t	V1 conj]
RTs (SE)	51.1 (30.4)	52.6 (38.0)	65.7 (37.4)	-15.3 (38.5)	29.1 (29.7)	-54.7 (31.9)
Retrieval-based integration cost	1	0.5	1	0.5	1	0.5
Prediction storage cost	1	0.5	1	0.5	1	0.5

Table 3: Mean residual reading times in msec and predicted costs

Prediction storage cost	0.5	1	2	3
Mean RT (SE)	0.4 (14.8)	65.4 (11.6)	259.7 (19.6)	496.8 (75.6)

Table 4: Predicted prediction storage costs and mean residual reading times in msec

Acknowledgments

Appendix

In the following, all the items used in the experiment for the unscrambled condition are shown with their romanized transcripts, glosses, and translations. The other three conditions were the same as this condition, except for the word order. The slashes indicate region boundaries, and the brackets mark the target regions; the slashes and brackets were not presented in the actual experiment.

1 a. [書記が / 代議士が / 首相が / うたた寝したと / 抗議したと / 報告したので] / 週刊誌や / 新聞が / 騒ぎ / たてた。

[syoki-ga / daigisi-ga / syusyoo-ga / utatanesita to / koogisita to / hookokusita node] / syuukansi-ya / sinbun-ga / sawagi / tateta.

[secretary-nom / Diet_member-nom / prime_minister-nom / dozed comp / protested comp / reported because] / weekly_magazine-and / newspaper-nom / make_a_fuzz / stirred_up

'[Because the secretary reported that the Diet member protested that the prime minister dozed], weeklies and newspapers made a big fuzz.'

2 a. [相撲協会が / 行司が / 力士が / 負傷したと / 判断したと / 発表したので] / その / 力士は / 安心して / 休場した。

[sumookyookai-ga / gyoozi-ga / rikisi-ga / husyoosita to / handansita to / happyoosita node] / sono / rikisi-wa / ansinsite / kyuuzyoosita.

[Sumo_Association-nom / referee-nom / wrestler-nom / got_injured comp / judged comp / announced because] / that / wrestler-topic / feel_relieved / was_absent_from_games.

'[Because the Sumo Association announced that the referee judged that the wrestler got injured], that wrestler felt relieved and took a leave.'

3 a. [黒幕が / 社長が / 責任者が / 自白したと / 知ったと / 確認したため]/事態は / や
やこしい / 方向へ / 進んだ。

[kuromaku-ga / syatyoo-ga / sekininsya-ga / zihakusita to / sitta to / kakuninsita tame] / zitai-wa /
yayakosii / hookoo-e / susunda.

[man_behind_the_scene-nom / boss-nom / person_in_charge-nom / made_confession comp / learned
comp / confirmed because] / situation / complicated / direction-toward / proceeded

'[Because the man behind the scene confirmed that the boss learned that the person in charge made a
confession], the situation became complicated.'

4 a. [設計者が / 大工が / 水道屋が / ヘマしたと / 勘違いしたと / もらしたので]/ もめ
ごとの / 新たな / タネと / なった。

[sekkeesya-ga / daiku-ga / suidooya-ga / hemasita to / kantigaisita to / morasita node] /
momegoto-no / aratana / tane-to / natta.

[designer-nom / carpenter-nom / plumber-nom / made_a_mistake comp / misunderstood comp /
murmured because] / trouble-gen / new / cause / became.

'[Because the designer murmured that the carpenter misunderstood that the plumber made a mistake],
it caused a new trouble.'

5 a. [ディレクターが / 司会者が / 歌手が / 失踪したと / 発表したと / つぶやいたので]
/ とりまきが / たいそう / 心配した。

[direkutaa-ga / sikaisya-ga / kasyu-ga / sissoosita to / happyoosita to / tubuyaita node] / torimaki-ga /
taisoo / sinpaisita.

[director-nom / show_host-nom / singer-nom / disappeared comp / publicized comp / murmured
because] / followers-nom / very much / were worried.

'[Because the director murmured that the show host publicized that the singer disappeared], the

people around the her were worried.'

6 a. [脚本家が / マネージャーが / 主役が / 降板したと / 嘆いたと / 吐露したため] /舞台裏では / 大変な / 争いと / なった。

[kyakuhonka-ga / maneezyaa-ga / syuyaku-ga / koobansita to / nageita to / torosita tame] / butaiura-de-wa / taihenna / arasoi-to / natta.

[playwright-nom / manager-nom / leading_actor-nom / quit_the_show comp / griped comp / confided because] / backstage-at-topic / serious / dispute / became.

'[Because the playwright confided that the manager griped that the leading actor quit the show], a serious dispute was caused at the backstage.'

7 a. [電機屋が / 問屋が / 製造元が / 倒産したと / 考えていると / 弁解したため] /顧客から / 問い合わせの / 電話が / 殺到した。

[denkiya-ga / ton'ya-ga / seezoomoto-ga / toosansita to / kangaeteiru to / benkaisita tame] / kokyaku-kara / toiawase-no / denwa-ga / sattoosita.

[electric_appliance_shop-nom / wholesaler-nom / manufacturer-nom / bankrupted comp / thought comp / explained because] / clients-from / inquiry-gen / phone_call-nom / rushed.

'[Because the electric appliance shop explained that the wholesaler thought that the manufacturer bankrupted], phone calls of inquiry from the clients poured in.'

8 a. [不動産屋が / 大家が / 店子が / 夜逃げしたと / 決めつけていると / 推測したので] / まわりは / みな / 不安な / 思いに / かられた。

[hudoosan'ya-ga / ooya-ga / tanako-ga / yonigesita to / kimetuketeiru to / suisokusita node] / mawari-wa / mina / huanna / omoi-ni / karareta.

[realtor-nom / landlord-nom / tenant-nom / disappeared comp / stubbornly_assume comp / assumed

because] / people_around-topic / all / anxiuse / thought-dat / was_seized.

'[Because the realtor assumed that the landlord stubbornly assume that the tenant disappeared], everybody was worried a lot.'

9 a. [指揮者が / 聴衆が / ピアニストが / 間違えたと / 信じていると / 感じたため] /指揮に / 思わぬ / 乱れが / 出てしまった。

[sikisya-ga / tyoosyuu-ga / pianisto-ga / matigaeta to / sinziteiru to / kanzita tame] / siki-ni / omowanu / midare-ga / detesimatta.

[conductor-nom / audience-nom / pianist-nom / missed comp / believe comp / felt because] / conduct-dat / unexpectedly / disorder-nom / emerged.

'[Because the conductor felt that the audience believe that the pianist made an mistake], the conductor's performance went awry.'

10 a. [おばあさんが / 占い師が / 孫が / 昇進すると / 告げたと / 自慢したので] / 親類たちは / なんだか / 良い / 気が / しなかった。

[obaasan-ga / uranaisi-ga / mago-ga / syoosinsuru to / tugeta to / zimansita node] / sinruitati-wa / nandaka / yoi / ki-ga / sinakatta.

[grandma-nom / fortune_teller-nom / grand_son-nom / get_promoted comp / told comp / boasted because] / relatives-topic / somehow / good / feeling-nom / did_not.

'[Because the grandma boasted that the fortune teller told that the grand son would get promoted], the relatives felt uncomfortable.'

11 a. [官房長官が / 国民が / 大臣が / 失脚したと / 思い込んでいると / ぼやいたため] / 首相が / 確認の / 電話を / 入れた。

[kanbootyookan-ga / kokumin-ga / daizin-ga / sikkyakusita to / omoikondeiru to / boyaita tame] /

syusyoo-ga / kakunin-no / denwa-o / ireta.

[Chief_Cabinet_Secretary-nom / the_people-nom / minister-nom / fell_from_power comp / assume

comp / complained because] / prime_minister-nom / confirmation-gen / phone_call-acc / put_in.

'[Because the Chief Cabinet Secretary complained that the the people assume that the minister fell

from power], the prime minister called for confirmation.'

12 a. [隣人が / メードさんが / 強盗が / 侵入したと / 偽証したと / ささやいたので] /
おじさんは / びっくりして / 飛びあがった。

[rinzin-ga / meedosan-ga / gootoo-ga / sin'nyuusita to / gisyoosita to / sasayaita node] / ozisan-wa /

bikkurisite / tobiagatta.

[neighbor-nom / maid-nom / burglar-nom / broke_in comp / gave_false_testimony comp / whispered

because] / uncle-nom / surprised / jumped_up

'[Because the neighbor whispered that the maid gave a false testimony that the burglar broke in], the

old man was very surprised.'

13 a. [裁判官が / 刑務所長が / 囚人が / 造反したと / 訴えたと / 理解したため] /判決が
/ 予想に / 反した / ものに / なった。

[saibankan-ga / keemusyotyoo-ga / syuuzin-ga / zoohansita to / uttaeta to / rikaisita tame] /

hanketu-ga / yosoo-ni / hansita / mono-ni / natta.

[judge-nom / warden-nom / prisoner-nom / rebelled comp / complained comp / undertood because] /

judgment-nom / expectation-dat / oppose / thing-dat / became.

'[Because the judge undertood that the warden complained that the prisoner rebelled], the court's

decision eventually turned up to be something unexpected.'

14 a. [党首が / マスコミが / 支持者が / 離反したと / 喧伝したと / 非難したため] /その

ことが / 大きく / ニュースで / とり / あげられた。

[toosyu-ga / masukomi-ga / sizisya-ga / rihansita to / kendensita to / hinansita tame] / sono-koto-ga /

ookiku / nyuusu-de / tori / agerareta.

[party_leader-nom / mass_media-nom / supporters-nom / left comp / widely_announced comp /

criticized because] / that-thing-nom / to_a_great_extent / news-at / take / raised.

'[Because the party leader criticized that the mass media widely announced that the supporters left],

it made the headlines.'

15 a. [学科長が / 指導教官が / 学生が / 落第したと / 公表したと / 白状したため]/その

/ 教官の / 処遇が / 教授会で / 討議された。

[gakkatyoo-ga / sidookyookan-ga / gakusee-ga / rakudaisita to / koohyoosita to / hakuzyoosita tame]

/ sono / kyookan-no / syoguu-ga / kyoozyukai-de / toogisareta.

[chairperson-nom / advisor-nom / student-nom / failed comp / publicized comp / confessed because]

/ that / professor-gen / treatment-nom / faculty_meeting-at / was_discussed.

'[Because the chairperson confessed that the advisor publicized that the student failed], they

discussed at the faculty meeting what to do with this professor.'

16 a. [船長が / 航海士が / 潜水夫が / 溺れたと / 思ったと / 言い訳したので]/ ますま

す / 責任の / なすりつけあいが / ひどく / なった。

[sentyoo-ga / kookaisi-ga / sensuihu-ga / oboreta to / omotta to / iiwakesita node] / masumasu /

sekinin-no / nasuritukeai-ga / hidoku / natta.

[captain-nom / ship's_mate-nom / diver-nom / drowned comp / thought comp / excused because] /

increasingly / responsibility-gen / rubbing-nom / terrible / became.

'[Because the captain excused that the ship's mate thought that the diver drowned], they tried to lay

the blame on each other, more than ever.'

17 a. [刑事が / 目撃者が / 容疑者が / 逃走したと / 錯覚したと / 推理したため] /簡単な / 事件が / 迷宮入り / した。

[keezi-ga / mokugekisya-ga / yoogisya-ga / toosoosita to / sakkakusita to / suirisita tame] / kantanna / ziken-ga / meekyuuiri / sita.

[detective-nom / witness-nom / suspect-nom / ran_away comp / had_wrong_impression comp / inferred because] / easy / case-nom / labyrinth_into / did.

'[Because the detective inferred that the witness had a wrong impression that the suspect ran away], the case which had been thought to be easy to solve eventually went unsolved.'

18 a. [駅員が / 通行人が / 酔っぱらいが / 寝ていると / 通報したと / 述べたので] / おまわりさんが / それを / 書きとった。

[ekiin-ga / tuukoonin-ga / yopparai-ga / neteiru to / tuuhoosita to / nobeta node] / omawarisan-ga / sore-o / kakitotta.

[station_worker-nom / passer-by-nom / drunk_person-nom / is_sleeping comp / reported comp / said because] / police_officer-nom / that-acc / wrote_down.

'[Because the station worker said that the passer-by reported that the drunk person was sleeping], the police officer wrote that down.'

19 a. [ドアマンが / 清掃員が / 受付けが / サボっていたと / 暴露したと / 聞いたので] / ビルの / オーナーは / 苦笑いした。

[doaman-ga / seesooin-ga / uketuke-ga / sabotteita to / bakurosita to / kiita node] / biru-no / oonaa-wa / nigawaraisita.

[doorman-nom / janitor-nom / receptionist-nom / was_goofing_off comp / exposed comp / heard because] / building-gen / owner-topic / smiled_wryly.

'[Because the doorman heard that the janitor exposed that the receptionist was goofing off], the owner of the building smiled wryly.'

20 a. [テレビ局が / 登山者が / パートナーが / 遭難したと / 知らせたと / 報じたため] / 知り合いが / みな / 心配した。

[terebikyoku-ga / tozansya-ga / paatonaa-ga / soonansita to / siraseta to / hoozita tame] / siriai-ga / mina / sinpaisita.

[TV_station-nom / climber-nom / partner-nom / got_lost comp / informed comp / reported because] / acquaintances-nom / all / was_worried.

'[Because the TV station reported that the climber informed that the partner got lost], the people knew them were all worried.'