The object before subject bias and the processing of double-gap relative clauses in Japanese

Michiko Nakamura
University of Hawaii at Manoa

Edson T. Miyamoto
University of Tsukuba

To appear, *Language and Cognitive Processes*

Address correspondence to the second author:
University of Tsukuba, Institute of Literature and Linguistics
Tennodai 1-1-1, Tsukuba, Ibaraki 305-8571 Japan

E-mail: miyamoto@alum.mit.edu
Phone/Fax: +81-29-853-6373

Running head: Double-gap relative clauses in Japanese

Manuscript dated September 29, 2011; comments welcome.
Please do not cite or quote without permission.
Abstract

We report a fragment-completion questionnaire and a self-paced reading experiment investigating relative clauses in Japanese that contain two extraction sites in the same clause. The results indicate that in such double-gap relative clauses there is a preference to fill the object position before the subject position. Previous factors, especially those related to working memory resources, which have often been implicated in extraction preferences, do not predict the patterns observed. The results support the proposal that the accessibility of extraction sites in relative clauses is inversely correlated to the order in which semantic roles are preferentially assigned. We discuss ways of incorporating such a constraint in previous proposals such as expectation-based models.

Key words: relative clauses, accessibility, Japanese, extraction, gap, subject, object
Acknowledgements

The authors would like to thank William O’Grady, Amy Schafer and two anonymous reviewers for helpful discussions on earlier versions of this work. We are grateful to professor Yuji Matsumoto at NAIST for generous support of this research. The experiments were partially supported by the 21st Century Center of Excellence at NAIST while the first author was a postdoctoral fellow and by the following research funds at the University of Hawaii: the Center for the Japanese studies fellowship, the Linguistics Department Endowment Fund and the Arts and Sciences Advisory Awards. All remaining errors are our own. Address correspondence to the second author.
Double-gap relative clauses in Japanese

Introduction

According to work in language typology, the distribution of relative clauses across languages is constrained by an accessibility hierarchy, a language-independent primitive that reflects how easily a grammatical position can serve as the extraction site of a relative clause (Keenan & Comrie, 1977; also Keenan & Hawkins, 1986, for judgement data). We provide evidence supporting accessibility as a factor in the comprehension of double-gap relative clauses in Japanese and we argue for a particular version of accessibility based on an analysis of transitive verbs (Marantz, 1984). Factors previously discussed in the literature (e.g., MacWhinney, 1982; Sheldon, 1974, 1977), especially those related to working-memory resources (e.g., Gibson, 1998; Gordon, Hendrick & Johnson, 2001; King & Just, 1991; Lewis, Vasishth, & van Dyke, 2006), fail to explain the extraction preferences reported. Many aspects of the data are compatible with expectation-based models (Gennari & MacDonald, 2008, 2009; also Hale, 2001; Levy, 2008) and accessibility elucidates alternative ways of interpreting the results within these models.

One of the most well-documented effects in the comprehension of relative clauses is that subject-extracted relatives as in (1a) are easier to understand than object-extracted relatives as in (1b) (Caplan, Hildebrandt & Waters, 1994; King & Just, 1991; Traxler, Moris & Seely, 2002; Wanner & Maratsos, 1978; inter alia; to improve their readability, some relatives are surrounded with square brackets, and the extraction site or gap is coindexed with the modified noun or filler).

(1) a. Subject-extracted postnominal relative clause:

the realtor, [who $gap_i$ was avoiding the landlord]

b. Object-extracted postnominal relative clause:

the realtor, [who the landlord was avoiding $gap_j$]
These constructions in English are *postnominal* in that the relative clause follows the modified noun *realtor*. In *prenominal* relatives in Japanese, which precede the modified noun as shown in (2), subject extraction is favored as well (Ishizuka, Nakatani & Gibson, 2003; Kahraman, Ono & Sakai, 2008; Miyamoto & Nakamura, 2003; Sheldon, 1976; Ueno & Garnsey, 2008).

(2) a. Subject-extracted prenominal relative clause:

\[
\text{[gap}_i\text{ yanusi-o saketeita ] fudosan'ya}_i
\]

landlord-acc avoiding-was realtor

‘the realtor who was avoiding the landlord’

b. Object-extracted prenominal relative clause:

\[
\text{[yanusi-ga gap}_j\text{ saketeita ] fudosan'ya}_j
\]

landlord-nom avoiding-was realtor

‘the realtor who the landlord was avoiding’

We will refer to the constructions in (1) and (2) as *single-gap relative clauses with overt coargument* because the coargument (i.e., the argument other than the extraction site inside the relative clause; ‘landlord’ in the examples) is expressed overtly.\(^1\)

\(^1\)Word order is relatively free in Japanese with the intended interpretation indicated with case markers (nominative for subjects, accusative for objects). The subject-object SOV order is the canonical order (e.g., Tsujimura, 1996, for an introduction on Japanese) but the object-subject OSV order is also possible although rare (less than 5% in a variety of texts, Yamashita, 2002; as well as in a newspaper corpus, Miyamoto & Nakamura, 2005). We assume that the SOV bias extends to relative clauses; thus, the position of the gaps is as indicated in (2), as commonly assumed in the processing of relative clauses in Japanese (e.g., Ueno & Garnsey, 2008) and other languages with verb-final embedded clauses such as Korean (Kwon, Lee, Gordon, Kluender, & Polinsky, 2010) and German (e.g., Schriefers, Friederici & Kuhn, 1995). Even if the OSV order is posited during processing, the main points in the following discussion should hold (but see footnote 4 on working memory factors; also the discussion section of Experiment 2, for crossed and nested dependencies).
According to accessibility, the more accessible the extraction position, the more natural a relative clause is as a statement about the modified (Keenan & Comrie, 1977; Keenan & Hawkins, 1986; see Kuno, 1976, for accessibility in relative clauses and topicalization in Japanese). Because the subject is higher than the object in the accessibility hierarchy (Keenan & Comrie, 1977), the subject-extraction advantage is correctly predicted for the single-gap constructions with overt argument in (1) and (2). Here, we argue for a particular version of accessibility based on an analysis of transitive verbs (Marantz, 1984).

Although often described as taking two arguments, transitive verbs have been claimed to be better represented as a function that takes the direct object as its only argument to yield a one-place predicate, which in turn takes the subject as its argument (Marantz, 1984; also the verb-object bonding principle, Tomlin, 1986). A verb like throw can be represented as $[\text{throw}(y)](x)$ where $x$ stands for the subject, and $y$ for the object.

This type of analysis has been supported by a subject-object asymmetry observed in the way the object chosen modulates the role assigned to the subject. For example, the exact semantic role (agent, experiencer, and so on) of John in the example John threw is not clear until it is determined whether he threw a ball, a party, a fit, the towel. In contrast, the semantic role of the direct object is determined by the verb and is largely independent of the choice of the subject (Marantz, 1984).

Grammatical theories have considerable latitude in the way they implement this type of subject-object asymmetry (e.g., structurally, Saito, 1985; in the lexicon, Ades & Steedman, 1982). But regardless of its exact grammatical underpinnings, this asymmetry is assumed to lead to a processing preference to have the role of the object assigned before the role of the subject (the object before subject bias or ObS; Miyamoto & Nakamura, 2011). This constraint leads to two types of predictions that are relevant in this discussion.
Prediction 1. When the object is undetermined, difficulty is predicted as the semantic role of the subject is prevented or delayed from being fully assigned.

Prediction 2. Assuming that constituents inside the relative clause take precedence over the modified noun when receiving semantic roles from the predicate in the relative clause, there should be a preference to have the object inside the relative clause and the subject as the modified noun.

Prediction 2 assumes that the clause is a crucial domain for semantic role assignment (see Grimshaw, 1990, for discussion), thus constituents in the same clause as the predicate will have precedence receiving roles over constituents outside the clause (for the purposes of this discussion, a clause is assumed to refer to a CP or the equivalent phrase that represents the domain of the relative clause). Intuitively speaking, relative clauses are statements about the modified noun, therefore the reader must understand what the statement means (by, among other things, determining the roles of its internal constituents) to be able to apply this statement to the modified noun. For example, in the subject-extracted the realtor who was avoiding the landlord, the interpretation is straightforward with the predicate assigning a semantic role to the coargument (the object), thus the semantic role assigned to the modified noun coincides in large part with the statement the relative clause makes about this noun.

In object extraction, as in the realtor who the landlord was avoiding, interpretation proceeds in a more roundabout way as it violates the constraint of using the clause as the initial domain for role assignment. The predicate must first assign a semantic role to realtor (the modified noun outside the clause) before it can assign the subject role to the coargument landlord, and only then based on the relation between the subject and predicate is it possible to understand what the statement in the relative clause says about the modified noun. Crucially, the semantic role of the object (X is being avoided)
differs from the statement that the relative clause makes about the modified noun \((X\ is\ such\ that\ it\ is\ being\ avoided\ by\ the\ landlord)\).

The bias discussed in Prediction 2 should be observable at the final stages of attaching the relative clause when its content is evaluated against the noun. But for postnominal relatives in languages like English, the effects may be more immediate, as soon as enough information (e.g., the verb, the coargument) are available for a tentative semantic role to be assigned to the modified noun. For prenominal constructions in Japanese, the effects will be at the modified noun but processes at the preceding embedded verb may contribute as well (see a later discussion on reactivation in working memory models).

Like traditional accessibility proposals, the ObS assumes an ordering of grammatical functions, which dictates how natural a relative clause is as a statement about the modified noun. In addition, the ObS assumes that the ordering is related to semantic-role assignment. If it is correct to characterize the subject advantage in the relative clauses in (1) and (2) as a preference to assign a role to the object before the subject, then a more direct test is provided by two other constructions in which the ordering of the arguments is more evident. First, in what we will call relative clauses with implicit coargument, the coargument is dropped (i.e., it is left implicit and its referent has to be retrieved from the discourse or the remainder of the sentence; the position of the dropped argument is indicated with pro).

(3) a. Object-extracted relative clause with implicit coargument

\[
[pro\ gap_j\ yoyakusita]\ seki_j
\]

reserved seat

‘the seat that (somebody) reserved’
b. Subject-extracted relative clause with implicit coargument

\[ \text{[gap, pro youyakusita] kyaku,} \]

reserved customer

‘the customer who reserved (something)’

Plausibility is necessary to disambiguate the extraction site in the relatives in (3).

When extraction is from the subject position, the object is dropped. When extraction is from the object position, the subject is dropped. According to traditional definitions of accessibility (Keenan & Comrie, 1977; see O’Grady, 1997, for a model where the structural distance between filler and gap can be interpreted as a measure of accessibility; also Ueno & Garnsey, 2008, for a discussion on structural distance in Japanese relative clauses), the universal preference for subject extraction should hold in this case as well and (3b) should be easier to process.

However, the object remains undetermined in (3b), preventing the semantic role of the subject from being fully specified when ‘customer’ is read, and incurring extra processing cost according to the ObS (see Prediction 1), which therefore predicts that object extraction in (3a) should be favored over subject extraction in (3b).²

In a second type of relatives, double-gap relative clauses, two argument positions in the same clause are relativized as in the examples in Tables 1 and 2 (the object-subject and subject-object labels refer to the order in which the two modified

²The processing cost predicted may be directly related to the difficulty of assigning the subject role without knowing what the object is, but it is also possible that it is caused by expectation failure. In the latter case, the ObS leads to the expectation of an object-extracted relative clause when the verb is read, leading to longer reading times when this predictions proves to be wrong; this would be in-line with expectation-based models (e.g., Gennari & MacDonald, 2008, 2009) discussed later. The ObS is proposed as a constraint, and how or when exactly it applies may depend on the processing model adopted.
nouns come in each sentence at the positions indicated with N1 and N2).

The predicate V1 (‘reserved’ in the examples in Tables 1 and 2) is in the most deeply-embedded clause with two extraction sites. Based on plausibility, the subject position is associated with ‘customer’ and the object position with ‘seat’ (see Nakamura, 2003; Nakamura & Miyamoto, 2006, on the role of plausibility in the processing of these constructions). In the object-subject order in Table 1, the object-extraction position is filled at N1 (‘seat’), and the subject-extraction position at N2 (‘customer’). In the subject-object order in Table 2, the extraction positions are filled in the reversed order. (Note that the intermediate predicate V2 has no extractions in its clause.)

At N1 readers are likely to treat the segment V1 N1 as a relative clause with an implicit coargument, which is reanalyzed as another extraction position when N2 is read (readers’ initial preferences are investigated in Experiment 1).

Traditional accessibility proposals (Keenan & Comrie, 1977; O’Grady, 1997) predict a universal preference for subject extraction, therefore that is the prediction for N1 as well as for N2. In other words, the subject-object order should be easier to understand when N1 is read, while the object-subject order should be easier at N2 (reanalysis to recover from an incorrect initial interpretation could also play a role, and we consider this possibility in the discussion of the speaker as referent factor).

The double-gap relatives provide a particularly clear case to differentiate
traditional accessibility from the ObS because there is a transparent order in which the missing arguments of ‘reserved’ are filled. If the ObS is correct (see Prediction 2), the object-subject order should be favored over the subject-object order when N2 is read.\footnote{Even with strong plausibility bias, there can be semantic indeterminacy for the role of the subject when the object is missing. For example, \textit{man} is more plausible as the subject of the verb \textit{throw} but its exact semantic role will still depend on the object (e.g., experiencer if the object is \textit{a fit}; agent if the object is \textit{a pen}). But if \textit{man} is assigned as the object of \textit{throw}, then its semantic role is determined by the verb even if the subject is not known.}

A point of interest in investigating prenominal relative clauses in Japanese is that their processing preferences can disentangle the predictions of accessibility models in general from other factors, whose predictions we briefly summarize next (see also Table 3). We will suggest that in some cases the ObS can be incorporated into previously proposed mechanisms to either extend their coverage or to clarify their predictions.

\textbf{Working-memory factors} such as decay and interference have often been implicated in the subject-extraction preference observed in the postnominal relatives in (1). It is assumed that difficulty increases as a function of the amount (e.g., number of words, King & Just, 1991; Wanner & Maratsos, 1978; number of discourse referents, Gibson, 1998; \textit{inter alia}) and nature (e.g., similarity of the constituents, Gordon, Hendrick & Johnson, 2001) of the material intervening between the extraction site and its corresponding head noun. These models correctly predict the subject-extraction preference in the English postnominal relatives in (1) because more material intervenes from the modified noun to the object position than to the subject position. However,
the subject-extraction preference reported for single-gap prenominal relatives with overt coargument as in (2) (for results on Japanese, Ishizuka, Nakatani & Gibson, 2003; Kahraman, Ono & Sakai, 2008; Miyamoto & Nakamura, 2003; Sheldon, 1976; Ueno & Garnsey, 2008; for Korean, Kwon et al., 2010; for Turkish, Kahraman, Sato, Ono, & Sakai, in press) cannot be explained by such linear metric models, which rely on the amount and type of material intervening between positions in the sentence.\(^4\)

A variant, temporal metric models, takes into consideration the point in time when a position was first created, the amount of material processed since, and operations such as retrievals that can increase activation levels (Lewis, Vasishth, & van Dyke, 2006). In the Japanese single-gap examples with overt coargument in (2), both subject and object positions should be reactivated at the embedded verb. If reactivation of the two positions occurs simultaneously, their activation levels will not differ when retrieval occurs at the modified noun, and the two types of relative clauses should be equally easy (Kwon et al., 2010, for discussion).

An alternative is to assume that reactivation obeys constraints such as the ObS, so that the object is reactivated before the subject, in which case the gap should be reactivated after the coargument in subject extraction, thus facilitating its association with the modified noun. In object extraction, the coargument (the subject) is the last one to be reactivated, therefore decreasing the activation level of the the gap in object position (Miyamoto & Nakamura, 2011).\(^5\)

\(^4\) The assumption that the subject gap precedes the overt object as indicated in (2a) is crucial for linear metrics. If the gap can be posited either before or after the object (i.e., SOV and OSV orders are both possible), linear metrics should predict no difference in extraction for languages with verb-final embedded clauses, thus failing to explain the subject advantage in German (e.g., Schriefers, Friederici & Kuhn, 1995) as well as Japanese, Korean, Turkish. Similar issues arise if nouns are assumed to be directly associated with the verb (e.g., Pickering & Barry, 1991).

\(^5\) Throughout, ‘gap’ is used as a neutral term to indicate extraction position. For example, reactivation
In sum, previous formulations of working memory factors (using linear as well as temporal metrics) fail to explain the subject preference for the Japanese construction in (2). But temporal metrics may be extended with ObS-based reactivation to account for such a preference.

Double-gap relatives provide an opportunity to further consider the role of accessibility and the different versions of working memory factors. For linear metrics, the amount of material from N1 to either type of gap is the same (just one word, the verb V1, ‘reserved’, intervenes in both cases) and consequently factors such as decay and interference should not favor either type of extraction. Likewise for N2, distance is kept constant in the two constructions, hence neither type of extraction should be favored at this point either.

For temporal metrics, the two argument positions of V1 (‘reserved’) are first created when this verb is read, therefore there is no reactivation involved. The order in which they are created is likely to be irrelevant because both positions are empty (both arguments are missing from the clause), thus conceivably causing little interference or decay. Therefore, no difference is predicted at N1. For N2 as well, difficulty is predicted not to differ because the intermediate clause (headed by V2) is a statement about N1, therefore not favoring either type of extraction.

Results in English indicate that the difficulty in processing relative clauses may arise from ambiguity as readers have more difficulty predicting the intended interpretation when often-used alternative interpretations are available (Gennari & MacDonald, 2008, 2009; also Hale, 2001; Levy, 2008). Thus, before reading times are discussed, a completion questionnaire (Experiment 1) is reported to measure readers’ expectations and determine the predictions of such expectation-based models.

Another factor that has been proposed to explain extraction preferences is
parallelism, according to which relative clauses are easier to understand when extraction site and modified noun have the same grammatical role in their respective clauses (Sheldon, 1974, 1977). For example, N1 is marked with the nominative particle *ga* (therefore, it is the subject of the clause headed by V2), and parallelism predicts that the extraction position is favored to be the subject of V1. A similar prediction follows for N2 as it will be embedded as the subject of an outer clause.

*Perspective shift* (MacWhinney, 1982) predicts greater difficulty when perspective changes, which occurs when the subjects in consecutive clauses are not the same. In general, difficulty is predicted with object-extracted relatives modifying a noun in subject position. Therefore, when N1 is read, object extraction in the object-subject order is predicted to be harder than subject extraction in the subject-object order. Similarly, when N2 is marked as the subject of its clause, the prediction is for greater difficulty with object extraction (in the subject-object order).

One final factor that we will consider and that may contribute to facilitate object extraction, is that a missing subject can be interpreted as a dropped constituent with the speaker (or the hearer) as its referent whereas a missing inanimate object has no obvious referent in a null context. If the missing subject is initially interpreted as the speaker, it must be reanalyzed as an extraction position when the actual subject is read (i.e., when N1 or N2 is animate). Thus, subject extraction should be harder to process both at N1 (i.e., a slowdown in the subject-object order) as well as at N2 (slowdown in the object-subject order).

Subject-object double-gap relative clauses are notoriously difficult to understand to the extent of being judged unacceptable by some speakers. However, the consensus among linguists seems to be that with strong plausibility biases the construction is grammatical (Haig, 1996; Kornfilt, Kuno & Sezer, 1980; Mihara, 1994; *inter alia*). Converging evidence for the importance of plausibility comes from experimental results
manipulating the plausibility bias constraining the roles of N1 and N2 as the agent or theme of V1 using three levels of plausibility according to independently obtained norming data: strong (for which animacy constrained the roles of the nouns), mild (the two nouns were both animate but one was more felicitous as the subject and the other as the object), and null (both animate nouns were equally plausible as the subject or as the object). With strong bias, there was an advantage for the object-subject order (2.29) over the subject-object order (3.29, on a 5-point scale where 1 is natural, and 5 strange; $P_s < .001$). But similar numerical tendencies were not reliable between the mild-bias conditions (object-subject: 3.38; subject-object: 3.55) or the null-bias conditions (object-subject: 3.55; subject-object: 3.68). Nevertheless, when restricted to the subject-object order, contrast analyses indicated a reliable linear effect for the three levels of plausibility ($P_s < .01$; Nakamura, 2003; also Nakamura & Miyamoto, 2006, Experiment 1).

We report a fragment-completion study (Experiment 1) and a self-paced reading experiment (Experiment 2) confirming the prediction of the ObS that the extraction positions of relative clauses with double-gaps are preferentially filled in the object-subject order.

**Experiment 1**

The constructions investigated are temporarily ambiguous. Therefore, a fragment-completion questionnaire is reported first to determine the interpretations readers favor at crucial points. The results will serve to highlight some confounding factors that need to be addressed in norming studies so that the reading times in Experiment 2 can be interpreted more precisely. The results will also serve to determine the predictions made by expectation-based models (e.g., Gennari & MacDonald, 2008,}
Method

Participants

Forty-two native Japanese speakers, undergraduates at the University of Tsukuba, participated in the study as volunteers.

Materials

Twenty-four sets, each containing three types of fragments, were created. Table 4 contains an example set (see Appendix ??, for the complete list of fragments used).

All three fragments involve the segments immediately preceding the crucial head nouns (N1 and N2 in Tables 1 and 2) so that we can determine the kinds of continuations that readers are likely to expect at those points.

The predictions in Table 3 are for preferences during comprehension, whereas in this experiment the production component is the most prominent. The models discussed earlier are not always explicit about their predictions for production tasks, but for the purposes of the present discussion we will assume that ease in comprehension should correspond to ease in production. Accessibility and the ObS in particular are concerned with the overall naturalness of the relation between relative clause and modified noun, which should be independent of the task performed; hence, their predictions for this experiment are as discussed earlier. For example, the ObS can be understood as a constraint within a constraint satisfaction framework (see, for example,
Gennari & MacDonald, 2008, for a discussion specific to relative clauses). After reading V1 (e.g., “reserved”), there is competition between the subject-extraction continuation (e.g., “client” as in “the client that reserved something”) and the object-extraction continuation (e.g., “seat” as in “the seat that somebody reserved”), but the activation levels of the latter should be boosted because its semantic indeterminacy is lower according to the ObS (in the subject extraction, the role of the subject remains underspecified because the object is missing; but in the object extraction, the role of the object is determined by the verb even in the absence of the subject).

The results expected for the bare-predicate fragment correspond to the predictions for N1 in Table 3. For example, for relatives with an implicit coargument, the ObS predicts that more instances of object extraction than subject extraction should be observed.

The column for N2 in Table 3 contains predictions for the configuration in which double-gap relatives are most likely to be produced for the double-clause fragments. For example, the ObS predicts more object-subject than subject-object double-gap relatives. (Note that the table makes no predictions about other types of continuations and how double-gap relatives would compare to them.)

To reduce the number of fragments per participant, the 24 sets of triplets were divided in two halves of 12 triplets each and distributed according to a Latin Square scheme, yielding 6 sublists of 12 items each. Ten items (see Appendix ?? for a sample set), which are not directly relevant to the discussion, were added to each sublist to increase variability. Each participant saw one single list containing 12 test items (4 of each type) and 10 irrelevant items, which were pseudo-randomly ordered so that similar fragments were not adjacent.
Procedure

Participants were instructed to complete the fragments into full sentences. Each participant saw one list printed with Japanese fonts. Words were shown without intervening blanks as is usual in Japanese writing and were followed by a straight line on which participants wrote the completion in pen or pencil.

Data analysis

Although there are no overt markers associated with relative clauses in Japanese, the configuration is often clear as a predicate in plain form (i.e., not ending in complementizer-like words such as to ‘that’, subordinate inflection such as tara or conjunctions like kedo ‘but’) is followed by a noun phrase (NP).

The extraction position in relative clauses is dependent primarily on the argument structure of the verb and plausibility. The interpretation is often subjective, therefore two native speakers (one was MN) with graduate training in linguistics coded the completions and disagreements (fewer than 3%) were settled after discussion.

Two-tailed Exact Wilcoxon Signed Rank tests (WSRT; function wilcoxsign.test in the package coin in R, R Development Core Team, 2009) are reported for within-subject comparisons on the number of completions.

Results

See Appendix ?? for examples of actual completions produced by participants.

Bare predicates

The following are the results for the bare predicate condition. One completion was ungrammatical and was not included in the counts. Twelve completions out of a total
of 167 (7.2%) were simple clauses (i.e., clauses without filler-gap dependencies, such as subordinate clauses and sentential arguments), including clauses followed by a conjunction (node, ato, ga) or a complementizer-like word (koto, to, nowa). There were no instances of double-gap relative clauses.

Most completions (155 instances, 92.8%) involved relative clauses with implicit coargument, which were classified according to extraction. Six completions were ambiguous because the verb used hiraita or aita ‘opened’ can be transitive (e.g., ‘somebody opened the door’) or intransitive (‘the door opened’; this type of ambiguity is addressed in norming 1 of Experiment 2). The breakdown for the remaining 149 completions confirmed the predictions of the ObS as there were more implicit-coargument relative clauses with object extraction (141 instances, 83.9% of the overall total) than with subject extraction (eight, 4.8%; WSRT, $Z = 5.65$, $P < .001$).

Double clauses

There was a numerical tendency for more double-gap relative clauses to be produced with the object-subject order (13) than with the subject-object order (7) but the difference was not statistically reliable (WSRT $Z = 1.3$, $P > .3$).

Most completions (300 instances, 90.1%) started with a conjunction (node, tame, tameni, ga), a complementizer or a nominalizer (koto, to, nowa), of which 147 instances were with the object-missing condition and 153 were with the subject-missing condition. In other words, in all those cases, the most deeply-embedded clause (headed by V1) was a relative clause with implicit coargument, not a double-gap relative; whereas the clause containing it (headed by V2) was usually a subordinate clause or sentential argument.

There was another type of relative clause, with extraction from the clause headed by V2 (i.e., the clause immediately preceding the head noun N2), as in the following example.
(4) Nakusita shogakusei-ga \([gap_i\) tugino-hi nanorideta] / kurasumeito\(_i\)-ni lost student-nom next-day self-introduced classmate-dat uwagutu-o kaesitemoratta.

shoe-acc returned-got

‘The student who lost (it\(_i\)) got the classmate who made a self-introduction the following day, to return the shoe\(_i\).’

In the completion above it is implied that the student lost the shoe mentioned in the matrix clause. Instead of a double-gap relative clause, the completion has the object ‘classmate’ modified by a relative clause (‘who made a self-introduction the following day’) in a center-embedding configuration. This type of structure is sometimes favored over more complex double-gap constructions especially with the subject-object order (Nakamura & Miyamoto, 2006). There were 11 center-embedded completions in the object-missing condition, and 2 in the subject-missing condition. (Norming 3 addresses the possibility of such an alternative interpretation being pursued during reading.)

There were also three fragments that were left blank by the participants in the subject-missing condition.

**Discussion**

The results can be summarized as follows. First, when reading a bare transitive verb (e.g., *yoyakusita* ‘reserved’), the preference is to assume that this is the beginning of a relative clause with implicit coargument. The large number of object extractions (83.9%) is compatible with the ObS.

Out of the 24 verbs used, 16 were composed of a noun of Chinese origin plus a light verb (e.g., *yoyaku-suru* “reserve-do”), which are ambiguous between a transitive (‘to reserve’) and an intransitive reading (‘to make a reservation’), but even restricted
to those 16 items, the preference for object extraction in the completion data remains high (86.6%). When occurrences of such types of verbs in sentence-initial position immediately followed by a modified noun were counted in the 38,383 sentences of a manually-tagged newspaper corpus (Kurohashi & Nagao, 1997), a similar preference for object extraction (8 instances) over subject extraction (1 instance) was observed. Therefore, the completion results could be a reflection of the frequency distributions that readers are exposed to (see, for example, Mitchell, Cuetos, Corley, & Brysbaert, 1995) and the effects of the ObS could be indirect as it may contribute to originate such distributions.

Second, in over 90% of the completions for the double-clause fragments, the most deeply-embedded clause was interpreted as a relative clause with implicit coargument. However, despite the complexity of double-gap relative clauses, 20 instances (6%) were produced spontaneously. The low frequency of double-gap relatives may be due to the difficulty in positing two extraction positions in succession when the first verb is read. Such similar dependencies starting from inside the same clause may be particularly confusing to maintain in working memory.

Based on those results, expectation-based models (Gennari & MacDonald, 2008, 2009; also, Hale, 2001; Levy, 2008, for related discussions) predict that object extractions should be read faster at N1 where such completions were favored. At N2, there was no difference between the two types of double-gap relatives, but competition from an alternative interpretation (see (4), for an example) tended to be greater in the subject-object order, and this type of double-gap relative should be harder to process.
Experiment 2

A reading time experiment was conducted to test the predictions of the ObS for double-gap relative clauses.

Method

Participants

A new group of 32 native speakers of Japanese at NAIST (Nara Institute of Science and Technology) were paid to participate in the experiment.

Materials

Twenty-four sets of items were created using the fragments in Experiment 1. Each set consisted of four sentences that varied according to two factors: clause type (double-gap relative clause or subordinate clause) and order of the head nouns N1 and N2 (subject-object or object-subject). Table 5 contains examples of double-gap relative clauses (see Appendix ?? for the complete list of items used).

<table>
<thead>
<tr>
<th>Insert Table 5 (page 54) About Here</th>
</tr>
</thead>
</table>

The subordinate-clause conditions are exactly the same as the double-gap conditions, except that there is a conjunction (e.g., node ‘because’) as a suffix to the predicate V2. The conjunction is the head of a subordinate clause (because Japanese is a consistently head-final language, the conjunction comes at the end of the subordinate clause) that provides a purpose or a justification for the matrix clause that follows it. Hence, there is only one extraction position in the clause headed by V1, the other
position in this clause is left implicit and its antecedent is determined when the matrix subject N2 is read. There is no filler-gap dependency created at N2 in these conditions, therefore they provide a baseline for the processing of the double-gap conditions.

The results of Experiment 1 indicate that the segment V1-N1 is likely to be interpreted as relative clauses with implicit coargument. The cost of interpreting such structures should be observed at N1, where the relative clause headed by ‘reserved’ is attached to this noun. The ObS predicts an object-extraction preference at this point, whereas traditional accessibility models favor subject extraction (see Table 3 for the predictions of other models).

According to Experiment 1, double-gap relatives are rarely anticipated. Therefore, the cost of processing these constructions is likely to be observed only at N2 where it becomes clear that this is the interpretation intended. At this point, the implicit coargument is reanalyzed as an extraction site, and thereby the relation between the relative clause and N2 is determined. This attachment operation is predicted to be easier when N2 is associated with the subject position either because subject positions are always more accessible (e.g., Keenan & Comrie, 1977) or because the object-subject order is a more natural way of providing the arguments of a transitive verb (according to the ObS; see also Table 3).

Twenty-four items were distributed into four presentation lists using a Latin Square design. Each participant saw one of the lists. Sixty foil sentences were inserted into each list in pseudo-random order so that at least one foil sentence intervened between any two test items.

**Procedure**

The experiment used a phrase-by-phrase self-paced reading with non-cumulative moving-window presentation (Just, Carpenter & Woolley, 1982). Sentences were
presented on a single line using Japanese characters with the fixed-width Osaka Toohaba font.

In self-paced reading experiments, reading times per segment for Japanese tend to be markedly slower than for English, but that is expected because segments used for Japanese are not words but rather bunsetsus, that is, a content word plus functional material (e.g., case markers, postpositions, complementizers) corresponding to roughly two words in English.

After each item, a simple yes/no comprehension question appeared on a new screen. Instructions and eight practice trials preceded the experimental trials.

Data analysis

Analyses of variance were conducted using the means for participants (participant analysis, $F_1$) and for items (item analysis, $F_2$). Analyses were conducted on the responses to the comprehension task (analyses on arcsine-transformed scores revealed trends similar to the raw-score analyses reported) and on the reading times to the test items for which participants responded the comprehension task correctly.

Residual reading times were used to adjust for differences in the number of characters between the regions compared across conditions (Ferreira & Clifton, 1986). Residual reading times beyond three standard deviations from all participants’ condition $\times$ region means were discarded, which affected 2% of the data.

The analyses conducted with raw reading times revealed trends similar to the ones reported with residual reading times. The only exception was the region containing V2, for which the subordinate-clause conditions (which contained an extra word, a conjunction such as ‘because’) were slower than the double-gap conditions in the raw reading time analyses but not in the residuals analyses.

Mean squared errors in the participant analyses were used to calculate 95%
confidence intervals for differences between means (95% CIs, for short), which provide a lower bound for pairwise comparisons (Loftus & Masson, 1994).

**Norming study 1 for N1**

Norming 1 was conducted to guarantee that the plausibility of each individual noun in relation to V1 had been effectively manipulated. Each relative clause (V1 N1) was shown and a new group of 24 native Japanese speakers judged which of two paraphrases was more natural on a scale from 1 to 5, with each extreme indicating the preference for one of the interpretations. For the items in Table 5, the pairs in Table 6 were created.

In the paraphrases, the case-marked noun precedes the verb in canonical order (the nominative marker *ga* indicates that the noun is the subject, and the accusative marker *o* indicates that the noun is the object). Order of presentation for the two paraphrases was included as a factor without any reliable effects on the judgements (main effect and interaction with animacy: all $F$s < 1). The 24 sets of items were distributed into four lists according to a Latin Square design.

Although the intended interpretations (animate as subject, $M = 1.34$; inanimate as object, $M = 1.07$, where 1 is the intended interpretation) were clearly favored, the preference was stronger for inanimate nouns than for animate nouns ($F_1(1,23) = 21.65$, $MSe = 0.0855, P < .001$; $F_2(1,23) = 10.66$, $MSe = 0.1737, P < .01$). This is probably because the unintended interpretation for the animate nouns is not entirely ruled out in some cases (e.g., *keiji-o sousasita* ‘somebody investigated the detective’). To factor out possible effects on the reading times, a second analysis with a subset of
the items will also be reported for the main experiment.

**Norming studies 2 and 3 for N2**

Another study (including normings 2 and 3) was conducted with a total of forty-eight sets of sentences (24 sets for each norming) distributed into two presentation lists using a Latin Square design so that each list contained one item of each set from each norming study. A new group of twenty-eight native speakers of Japanese rated each sentence on a 5-point scale from 1 (natural) to 5 (strange).

**Norming 2**

Norming 2 tested whether the preferred interpretation at N2 was as intended (i.e., animate noun as subject, inanimate noun as object). Two versions (intended or reversed) of a simple transitive sentence were created using N1, N2, and V1 from each test item (see (5) for the sentences created for the items in Table 5).

(5) a. Intended:

Kyaku-ga seki-o yoyakusita.

customer-nom seat-acc reserved

‘The customer reserved the seat.’

b. Reversed:

Seki-ga kyaku-o yoyakusita.

seat-nom customer-acc reserved

‘The seat reserved the customer.’

Results were as follows. The intended conditions were rated as being more natural (1.16) than the reversed conditions (4.74; $F_1(1,27) = 2277.61$, $MSe = 0.0785$, $P <$
Double-gap relative clauses in Japanese

0.001; $F_2(1,23) = 4718.42, MSe = 0.0325, P < .001), suggesting that the roles of the nouns were strongly constrained by plausibility.

Norming 3

When the noun N2 in the double-gap conditions is read, it should be associated with one of the extraction sites inside the clause headed by V1. However, an alternative interpretation may be pursued as readers can create a gap in the intermediate clause headed by V2. Some constructions of this type were produced in Experiment 1 as exemplified in (4) (also Nakamura & Miyamoto, 2006, for related experimental results). To prevent readers from pursuing this interpretation, it is necessary to ensure that N2 is incompatible with V2. For this purpose, a simple sentence was created using N2 and V2 of each test sentence. A sample set is shown below (in (6a) 'existed' can only be used with inanimate entities; see Nicol, 1998, for few production errors with such animacy agreement features in Japanese).

(6) a. V2 with the animate noun

Kyaku-ga kituenseki-no tonari-ni-atta.

customer-nom smoking-area-gen next-to-exist

‘A customer existed next to the smoking section.’

b. V2 with the inanimate noun

Seki-ga jikan-ni okureta.

seat-nom time-for late-was

‘The seat was late for the appointed time.’

The rating for the clauses using the inanimate noun (4.11) and for the ones using the animate noun (4.23) did not differ ($F(1,27) = 2.1, MSe = 0.0852, P > .1;
$F_2(1,23) < 1)$. Therefore, V2 is equally incompatible with the two head nouns, and the competing interpretation is unlikely to be considered at this point.

Note that this norming measured the availability of the competing interpretation after N2 is read. It does not say anything about what happens before N2; thus, expectation-based models (e.g., Gennari & MacDonald, 2008, 2009) may still predict difficulty depending on how much this interpretation is expected as N2 is about to be read.

**Results**

The reading-time experiment involved a $2 \times 2$ design, where the two factors manipulated were clause type (double-gap relative or subordinate) and order of the nouns (subject-object or object-subject).

Performance in the comprehension task that followed each sentence in the self-paced presentation was reliably better in the object-subject conditions (94.3%) than in the subject-object conditions (88.3%; $F_1(1,31) = 8.65, MSe = 67, P < .01; F_2(1,23) = 5.24, MSe = 93, P < .05$). Neither the main effect of clause type ($P_s > .1$) nor the interaction between relative clause type and order of the nouns ($F_s < 1$) was significant.

**Results for N1 and N1+1**

This section reports the results for the residual reading time analyses for the first crucial region (N1) and its succeeding region (N1+1; see Figure 1 and Table 7 for the results for all regions).

Insert Figure 1 (page 47) About Here

Insert Figure 1 (page 47) About Here
At N1, there was a main effect of extraction as object extraction (in the object-subject order conditions) was faster than subject extraction (in the subject-object conditions; $F_1(1,31) = 12.34, MSe = 48,937, P < .01; F_2(1,23) = 11.67, MSe = 32,924, P < .01$). A spill-over effect was observed in the following region, N1+1 ($F_1(1,31) = 28.78, MSe = 28,079, P < .001; F_2(1,23) = 9.79, MSe = 50,542, P < .01$). None of the other effects was reliable in these two regions (all $P$s > .15).

The relative clauses were created so that the transitive verb in the relative clause (V1; e.g., ‘reserved’) was favored to have the animate noun (‘customer’) as its subject and the inanimate noun (‘seat’) as its object. However, according to Norming 1, the plausibility bias for the animate nouns was less constraining than for the inanimate nouns (see the row labelled Norming 1 on Table 8 for the means).

Moreover, two types of frequency biases could also have favored object extraction. The first one was the frequency of the head nouns. Number of hits on the Internet search engine Google indicated that the animate nouns were less frequent than the inanimate nouns (see the row $N$ frequency on Table 8 for the means; on the raw number of hits: $F_2(1,23) = 6.35, MSe = 834 \times 10^{12}, P < .05$; on the logarithm of the number of hits: $F_2(1,23) = 6.51, MSe = 1.405, P < .05$; on the use of Internet search engines to evaluate frequency, see Keller & Lapata, 2003, for English; Miyamoto, 2006, for Japanese). Moreover, the verb (e.g., $yoyakusita$ ‘reserved’) was less likely to cooccur with the animate noun ($kyaku$ ‘client’) than with the inanimate noun ($seki$ ‘seat’) although only the analysis with the log number of hits was reliable ($F_2(1,23) = 7.76, P < .05$; raw number of hits on Google: $F_2(1,23) < 1$; row $V-N$ frequency on Table 8).
Because plausibility or either type of frequency bias could have contributed to the difficulty observed with the animate nouns at N1, another analysis was conducted eliminating the 12 items with the largest biases. Restricted to the remaining 12 items (see the first 12 items in Appendix ?? and Table 8 for the means), there was no reliable bias in plausibility (norming 1: \( F_1(1,23) = 2.29, \text{MSe} = 0.082, P > 0.14; F_2(1,11) < 1 \)) or frequency (raw and log number of hits on Google for the head nouns and for verb-noun cooccurrences: all \( P_s > 0.2 \)). Nevertheless, residual reading times for this set of 12 items revealed the same patterns reported for the 24 items. Most crucially, object extraction was read faster than subject extraction at N1 (\( F_1(1,31) = 7.89, \text{MSe} = 55,733, P < .001; F_2(1,11) = 11.59, \text{MSe} = 12,759, P < .001 \)) and at N1+1 (\( F_1(1,31) = 18.83, \text{MSe} = 23,936, P < .001; F_2(1,11) = 6.78, \text{MSe} = 20,266, P < .05 \)).

**Results for N2 and N2+1**

In the second critical region (the second head noun, N2), the main effect of clause type was reliable (\( F_1(1,31) = 42.96, \text{MSe} = 112,331, P < .001; F_2(1,23) = 121.88, \text{MSe} = 28,126, P < .001 \)) indicating that the conjunction ‘because’ in the previous region (V2) had the desired effect on the subordinate-clause conditions as they were easier to understand than the double-gap conditions. When the conjunction is present, the missing coargument is treated as a dropped argument whose antecedent is provided by N2. When the conjunction is absent, a double-gap relative clause is built.

More crucially, there were a main effect of noun order (\( F_1(1,31) = 11.97, \text{MSe} = 51,047, P < .01; F_2(1,23) = 10.07, \text{MSe} = 46,995, P < .01 \)) and an interaction
between clause type and noun order \( F_1(1,31) = 8.34, MSe = 60,613, P < .01; F_2(1,23) = 7.65, MSe = 53,458, P < .05 \). The interaction occurred because the slowdown in the subject-object order compared to the object-subject order was not reliable in the subordinate-clause conditions (12 ms; 95% CI = 126) but it was reliable for the double-gap conditions (264 ms).

Two points are worth noting in relation to this interaction. First, because the object-subject order was faster than the subject-object order at N1, it could be argued that its advantage at N2 in the double-gap conditions is only a reflection of that earlier effect; however, the lack of difference between the two subordinate-clause conditions provides evidence that this is unlikely to be the case.

Second, it is possible that the missing subject of V1 is interpreted as the speaker, therefore reanalysis should occur whenever an animate noun (i.e., the actual subject) is read leading subject extraction to be slower than object extraction (what we called the speaker as referent factor). Although this could have explained the object-extraction advantage seen at N1, it is unlikely to be crucial as it fails to explain the subject-extraction advantage in the double-gap relatives observed at N2.

In region N2+1 (the region following N2), the double-gap conditions were read more slowly than the subordinate-clause conditions \( F_1(1,31) = 8.15, MSe = 7,096, P < .01; F_2(1,23) = 4.35, MSe = 12,347, P < .05 \). Neither the main effect of noun order \( Ps > .1 \) nor the interaction \( Fs < 1 \) was reliable.

**Discussion**

The results indicate that object extraction is easier than subject extraction at N1. In contrast, at N2, subject extraction was easier than object extraction. In short, both at N1 and at N2, the object-subject order is easier to process than the subject-object order (see Nakamura & Miyamoto, 2006, for similar trends although some differences were
delayed possibly because of the various plausibility manipulations included). The ObS explains these results based on the preference to specify the object before the subject.

The preference for subject extraction at N2 could also be explained by traditional accessibility proposals (Keenan & Comrie, 1977; O’Grady, 1997), but they fail to provide an account for the object-extraction preference at N1. Accessibility hierarchies for grammatical roles (Keenan & Comrie, 1977), structural models (O’Grady, 1997), parallelism accounts (Sheldon, 1974, 1977) and perspective shift (MacWhinney, 1982) all favor subject extraction, hence they cannot explain the object-extraction preference observed at N1. Working-memory factors (Gibson, 1998; Gordon, Hendrick & Johnson, 2001; King & Just, 1991; Lewis, Vasishth, & van Dyke, 2006; Wanner & Maratsos, 1978; inter alia) also fail to explain the results.

The predictions of expectation-based models (Gennari & MacDonald, 2008, 2009; Hale, 2001; Levy, 2008) are compatible with various aspects of the data reported. For N1, the majority of the completions in Experiment 1 involved the interpretation that was also read the fastest at that point, namely the object-extracted relative with implicit coargument. For N2, the double-gap with subject-object order was read the slowest and it is the interpretation that is likely to suffer from more competition (see example (4)). This last point underscores a difficulty in this type of explanation, namely, the direction of causality. It is possible, as expectation claims, that the alternative interpretation causes interference making the intended interpretation harder; but it is also possible that difficulty in understanding the intended interpretation leads the reader to seek alternative interpretations. The ObS is compatible with both alternatives. It is possible that the ObS affects the frequency of production patterns, which in turn modulates expectations that determine comprehension difficulty. Another possibility, which would be incompatible with expectation, is that the ObS affects production and comprehension independently, while the latter two do not have a direct
causal relation between them.

For relative clauses in English as in (1), it has been suggested that expectation fails to explain where difficulty takes place (Grodner & Gibson, 2005; Levy, 2008; but see Gennari & MacDonald, 2008). Results for the Japanese single-gap constructions with overt coargument in (2) are not compatible with expectation either. While completion data favor object extraction, reading times and brain responses favor subject extraction (Ueno & Garnsey, 2008; and Appendix ?? for related discussion).

In some formulations, expectation has been suggested not to be relevant for long-distance dependencies, only to local ones (Levy, 2008). Such definitions of surprisal (Levy, 2008; also Hale, 2001), in which greater difficulty is predicted the more a word modifies previously held expectations, may still be a factor at N1 but less so at N2 in double-gap relative clauses. Under some interpretations, surprisal should predict that, after V1 (‘reserved’), the object ‘seat’ should take longer to process than the subject ‘customer’ because the object is more likely to prune the range of expectations previously available. There are at least two scenarios that could justify this claim. First, when the object is read, it restricts the type of semantic role the verb can assign to the missing subject; but when the subject is read, it in large part leaves open the role for the missing object (Marantz, 1984). Second, 16 out of the 24 verbs used were made of a noun of Chinese origin plus a light verb (e.g., *yoyaku-suru* “reserve-do”), which are ambiguous between a transitive (‘to reserve’) and an intransitive reading (‘to make a reservation’); crucially, both readings remain possible after the subject is read, whereas the object forces the transitive reading. In both scenarios, the subject is likely to have a smaller impact on earlier expectations, therefore according to surprisal it should be read faster, the opposite of what we reported. Note that this type of prediction requires assuming that the subject and the object are equally likely after V1, but this is probably not true. It is possible that the ObS is already affecting expectation after V1.
is read, thus making the object the more expected alternative at the next word.

In sum, the results for double-gap relatives at N1 and N2 are compatible with some expectation-based models (Gennari & MacDonald, 2008, 2009) although some aspects of the explanation (such as direction of causality) need further scrutiny. Formulations that assume expectation to be relevant only for local attachments (roughly the association of neighbouring words as in N1, rather than the attachment of a clause as in N2; Levy, 2008) are compatible with the results at N1 if one assumes that a factor like the ObS favors the object continuation as soon as V1 is read. But expectation seems to fail to explain single-gap relative clauses with overt coargument in Japanese (see Appendix ??).

**Crossed versus nested dependencies**

In this section we discuss a further factor that under some assumptions may be relevant in the processing of the constructions discussed. If we assume that the order of the gaps in the clause headed by V1 are in the SOV order (and not in the OSV order, perhaps because of grammatical constraints or a frequency bias favoring SOV), then one potentially relevant factor is that the dependencies are nested in the object-subject order and crossed in the subject-object order as schematically represented in Figures 2 and 3.

---

Insert Figure 2 (page 48) About Here

---

---

Insert Figure 3 (page 49) About Here

---
One first problem with this kind of comparison is that there is no overt difference between the two types of dependencies (e.g., words intervening between the two gaps), therefore working memory related constraints are unlikely to play a role. Moreover, comparison with results in Dutch and German suggests that dependency type is unlikely to play a role in the Japanese constructions. Crossed dependencies in Dutch have been reported to be easier to understand than nested dependencies in German, and the explanation raised at the time was that, in the German construction, the most deeply embedded clause would be built but remain unattached until the clause containing it was completed (Bach, Brown & Marslen-Wilson, 1986; also Joshi, 1990, for a formalization using tree-adjoining grammars). According to this characterization, the nested versus crossed difference is irrelevant in double-gap relatives because the attachment to higher clauses proceeds in a similar manner in the subject-object and object-subject versions.

The advantage for crossed dependencies has also been explained as a preference to minimize the amount of time that incomplete structures have to remain stored (Joshi, 1990) or the amount of intervening material until the dependency is completed (e.g., Frazier, & Clifton, 1989). If these can be subsumed under working memory models (as claimed in Gibson, 1998), then the predictions should be as discussed for working-memory factors (i.e., no difference for the two types of double-gap relatives). But if there is an overall crossed-over-nested preference across natural languages, then the prediction for the Japanese constructions should be that the crossed subject-object order is easier than the nested object-subject order. But this is the opposite of what we found in Experiment 2.
General discussion

Since the proposal of accessibility more than 30 years ago, a pressing issue has been to explain its underlying mechanisms. Although a few suggestions were made at the time (see Keenan & Comrie, 1977; also Comrie, 2007, for a more recent discussion), to our knowledge none of them has led to further developments. The ObS is an attempt to provide one such mechanism to explain the accessibility hierarchy in terms of more basic concepts.

According to the ObS, the hierarchy is closely related to the mechanisms of assigning semantic roles because the roles of positions higher in the hierarchy are dependent on lower positions. A position low in the hierarchy is hard to extract from (i.e., it is less accessible) because all positions above it on the hierarchy depend on it for their semantic roles. In general, precedence in semantic-role assignment is inversely correlated to accessibility. If extraction is from a low position, then all positions above it inside the relative clause will have their semantic roles underspecified. In particular, the subject is easy to extract because there is no position above it, therefore no element is left with an underspecified role in subject extraction. In object extraction, the role of the coargument (the subject) remains unclear until the relation between relative clause and modified noun is established because only then the verb and object can assign a role to the subject.

Such underspecified semantic roles have to be computed when the relative clause is associated with the modified noun. It is possible that readers assign semantic roles in anticipation even when all information is not yet available (see the introduction for a discussion on how Prediction 2 may apply early in English), but we assume that at some point they will have to compute the exact semantic role. The ObS may have an effect at either stage depending on how it is implemented in a general model of sentence
comprehension.

The hierarchy is assumed to rank grammatical functions although the ranking itself is determined by semantic-role assignment. An immediate question is whether accessibility is truly a hierarchy of grammatical functions (as originally proposed in Keenan & Comrie, 1977) or whether it could be a hierarchy of semantic roles (see Grimshaw, 1990; Jackendoff, 1972, for hierarchies that could be extended to cover the basic predictions of accessibility so that, for example, agent roles are predicted to be easier to extract than patients). However, semantic-role hierarchies have difficulty explaining constituents that are promoted to higher grammatical positions. For example, languages that do not allow object extraction in relative clauses can circumvent such a grammatical restriction by promoting the object to subject position (e.g., by using passive constructions) and then extract the former object from its new position as a subject even though the semantic role remains unchanged (Keenan & Comrie, 1977). A related argument can be made for passives in languages where subject extraction (e.g., the student that was seen by the woman) is more natural than extraction from the by phrase (e.g., the woman that the student was seen by); in other words, the patient role in subject position is more accessible than the agent role in the by-phrase.

Although we have concentrated on subject and objects, we view the ObS as a general constraint in which semantic roles for lower positions have to be assigned before roles for higher positions in the syntactic representation (for a related proposal see Grimshaw, 1990). In this case, research on the ease of relativizing a given position becomes part of a more general research project on how the order in semantic role assignment is constrained.

The ObS is not only more desirable for such conceptual reasons, but the results reported suggest that it also improves the empirical coverage of previous accessibility proposals by explaining the preference in the processing of double-gap relative clauses.
As predicted by the ObS, there is a preference in such constructions to furnish the missing arguments in the object-subject order rather than in the subject-object order. Reading time data (Experiment 2) detected an advantage for the object-subject order at both points when a modified noun was read.

The results of the fragment-completion study (Experiment 1) were also compatible with the ObS (although the effects could be mediated by a learning mechanism as in Mitchell et al., 1995). When a bare predicate missing both of its arguments (e.g., ‘reserved’) was presented, participants could have either produced a subject (in a subject-extracted relative clause with implicit object; e.g., ‘reserved client’ in the sense of ‘the client that reserved something’) or an object (in an object-extracted relative clause with implicit subject; e.g., ‘reserved cake’ in the sense of ‘the cake that someone reserved’). However, the vast majority of the completions (83.9%) were of the latter type as object-extracted relative clauses with implicit coargument, suggesting that there is a preference to provide the object rather than the subject first.

Regardless of how exactly it is employed, the ObS seems to be involved in the comprehension of single-gap relative clauses with overt coargument (as in (2)) and those with double gaps. For double-gap relatives, the results can be understood as the ObS affecting the distribution of the constructions, which in turn may affect reading times according to expectation-based models (Gennari & MacDonald, 2008, 2009; Hale, 2001; Levy, 2008). But expectation-based models are not compatible with results reported for single-gap relative clauses with overt coargument in Japanese (see Ueno & Garnsey, 2008; also Appendix ??). These constructions cannot be explained by previous formulations of working memory factors either (e.g., Gibson, 1998; Gordon, Hendrick & Johnson, 2001; Lewis, Vasishth, & van Dyke, 2006), but reactivation (as in Lewis, Vasishth, & van Dyke, 2006) guided by the ObS may explain the subject-extraction preference in those constructions (Miyamoto & Nakamura, 2011) as discussed in the
introduction section. In sum, the ObS can augment previous models to account for the comprehension of relative clauses in Japanese (working-memory reactivation for single-gap relatives with overt coargument; expectation models for double-gap relatives).

The experiments reported only deal with animate subjects and inanimate objects, thus the results could be narrowly construed as a preference to have the inanimate noun receive its role as soon as possible, rather than a preference to prioritize the object as proposed by the ObS. But when taken together with past results, we believe the experiments reported here provide evidence for a more general principle affecting the processing of relative clauses at large. For example, such a narrow generalization based on animacy would fail to explain the subject-extraction preference in relatives with overt argument when both nouns are animate (as in (1) and (2)). Our assumption is that, despite their complexity, double-gap relatives are not to be taken in isolation but rather they provide an opportunity to expand the discussion of previous literature on relative clauses.

**Causative constructions**

Testing animacy contrasts in Japanese as has been done in other languages (e.g., Dutch: Mak, Vonk & Schriefers, 2002; English: Traxler, Moris & Seely, 2002; also Slobin, 1966, for related discussion on animacy effects) can be problematic because it is often difficult to create sentences that sound natural with an inanimate noun as the subject of a transitive verb. But this may be circumvented with causative-marked verbs as in the following examples.
(7) a. Basic causative construction

Shacho-ga shain-o nayamaseta.

company president-nom employee-acc worry-made.

‘The company president worried the employee.’

(lit.: ‘The company president made the employee worry.’)

b. Matrix-subject extraction

\[
\begin{align*}
\text{gap}_i \quad & \text{shain-o} \quad \text{nayamaseta} \quad \text{shacho}_i \\
& \text{employee-acc} \quad \text{worry-made} \quad \text{company president}
\end{align*}
\]

‘the company president that gap$_i$ made the employee worry’

c. Embedded-subject extraction:

\[
\begin{align*}
\text{shacho-ga} \quad & \quad \text{gap}_j \quad \text{nayamaseta} \quad \text{shain}_j \\
& \text{company president-nom} \quad \text{worry-made} \quad \text{employee}
\end{align*}
\]

‘the employee that the company president made gap$_j$ worry’

An inanimate subject (e.g., kaisha-no keei ‘management of the company’ where ‘management’ is the action of running the company, not the personnel running it) would be natural with such constructions (e.g., ‘management of the company made the employee worry’) and would allow new animacy configurations to be tested in Japanese relative clauses. Regardless of the animacy of the subject (‘company president’ or ‘managing the company’), the ObS would predict that subject extraction should be more natural and native speakers’ judgements tend to support this prediction.

Causatives also suggest ways of generalizing traditional definitions of accessibility. Although the predicate in (7) is a single word nayamaseta ‘made worry’, this type of construction is usually assumed to be biclausal with the causative sase heading the matrix clause and ‘worry’ heading an embedded clause (see Harley, 2008, for a recent
summary of extensive literature on the syntax of causative constructions; also Sato et al., 2009, for data on related types of relative clauses). More interestingly, the second noun 'employee' retains many of the properties associated with subjects. To the extent that such a position can be characterized as a subject, traditional accessibility approaches would have difficulty making any predictions because both positions are subjects and should be equally accessible. The ObS, in contrast, predicts that extraction from the matrix clause in (7b) should be easier because it is more natural to determine the role of the constituents inside the embedded clause in order to interpret this clause in relation to the matrix subject. Native speakers’ judgements suggest that the prediction is likely to be correct. If this discussion is correct, it would suggest that the hierarchy can be dispensed with completely and that the ObS is a generalization rather than just a special type of accessibility hierarchy.

Clearly, traditional definitions of accessibility could be expanded by assuming that positions inside embedded clauses are less accessible than those in the matrix clause. Or more generally, that outer clauses are more accessible than inner clauses (assuming that the semantic roles of constituents in the outer clause depend on the inner clause but not vice-versa). This in effect would admit the structural representation of sentences as a component of accessibility and it would perhaps even suggest a definition based entirely on syntactic representations without referring to an accessibility hierarchy (thus, incorporating some aspects of structural distance models, O’Grady, 1997). It would also in particular bring the predictions of traditional accessibility closer to those of the ObS.

Conclusion

We reported a fragment-completion questionnaire and a self-paced reading experiment providing evidence for a preference to fill the object position before the subject position
in double-gap relative clauses in Japanese. The results support the proposal that accessibility for extraction sites in relative clauses, is related to the order in which semantic roles are preferentially assigned by transitive verbs. We then suggested ways of incorporating such a constraint within models of sentence comprehension.

References


Language and Cognitive Processes, 6, 229-259.


Figure Captions

Figure 1: Residual reading times and standard errors per region.

Figure 2: Nested filler-gap dependencies in the object-subject order.

Figure 3: Crossed filler-gap dependencies in the subject-object order.
Figure 1: Residual reading times and standard errors per region.
Double-gap relative clauses in Japanese

Figure 2: Nested filler-gap dependencies in the object-subject order.
Figure 3: Crossed filler-gap dependencies in the subject-object order.
<table>
<thead>
<tr>
<th>V1</th>
<th>N1</th>
<th>V2</th>
<th>N2</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[gap_i gap_j yoyakusita] seki_j-ga kituenseki-no tonari-ni-atta] kyaku_i</td>
<td>reserved seat-nom smoking-area-gen next-to-was customer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‘the customer that reserved a seat which was next to the smoking area’

(Literal: ‘the customer, [that a seat, [that gap_i reserved gap_j] was next to the smoking section]’)

Table 1: Double-gap relative clause with object-subject order
Table 2: Double-gap relative clause with subject-object order

<table>
<thead>
<tr>
<th>V1</th>
<th>N1</th>
<th>V2</th>
<th>N2</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[gap_i gap_j yoyakusita] kyaku_i-ga jikan-ni okureta] seki_j</td>
<td></td>
<td>reserved customer-nom time-to late-was seat</td>
<td></td>
</tr>
</tbody>
</table>

‘the seat that a customer who was late for the appointed time reserved’
(Literal: ‘the seat_j [that a customer_i [that gap_i reserved gap_j] was late for the appointed time]’)

Table 3: Predictions for the extraction preferences at N1 and at N2

<table>
<thead>
<tr>
<th>Factors</th>
<th>N1</th>
<th>N2</th>
</tr>
</thead>
<tbody>
<tr>
<td>object before subject bias (ObS); expectation-based models (e.g., Gennari &amp; MacDonald, 2008) according to the completions of Experiment 1</td>
<td>object</td>
<td>subject</td>
</tr>
<tr>
<td>accessibility (Keenan &amp; Comrie, 1977); structural distance (O’Grady, 1997)</td>
<td>subject</td>
<td>subject</td>
</tr>
<tr>
<td>working memory (Gibson, 1998; Gordon, Hendrick &amp; Johnson, 2001; King &amp; Just, 1991; Lewis, Vasishth, &amp; van Dyke, 2006; Wanner &amp; Maratsos, 1978; inter alia)</td>
<td>no difference</td>
<td>no difference</td>
</tr>
<tr>
<td>parallelism (Sheldon, 1974, 1977), perspective shift (MacWhinney, 1982) when both N1 and N2 are marked as subjects</td>
<td>subject</td>
<td>subject</td>
</tr>
<tr>
<td>speaker as referent</td>
<td>object</td>
<td>object</td>
</tr>
</tbody>
</table>
Table 4: Example set of items for Experiment 1

<table>
<thead>
<tr>
<th>Condition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare predicate</td>
<td>V1</td>
</tr>
<tr>
<td>(subject and object missing)</td>
<td>Yoyakusita reserved</td>
</tr>
<tr>
<td></td>
<td>‘(Somebody) reserved (something)…’</td>
</tr>
<tr>
<td>Double clause</td>
<td>V1</td>
</tr>
<tr>
<td>with missing object missing</td>
<td>Yoyakusita kyaku-ga jikan-ni okureta</td>
</tr>
<tr>
<td></td>
<td>reserved customer-nom time-dat late</td>
</tr>
<tr>
<td></td>
<td>‘The customer that reserved (something) was late for the appointed time…’</td>
</tr>
<tr>
<td>Double clause</td>
<td>V1</td>
</tr>
<tr>
<td>with missing subject missing</td>
<td>Yoyakusita seki-ga kituenseki-no tonari-ni atta</td>
</tr>
<tr>
<td></td>
<td>reserved seat-nom smoking section next to was</td>
</tr>
<tr>
<td></td>
<td>‘The seat that (somebody) reserved was next to the smoking section…’</td>
</tr>
</tbody>
</table>
Table 5: Example set for Experiment 2

<table>
<thead>
<tr>
<th>Double-gap relative clause with object-subject order</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 N1 N1+1 V2 N2 N2+1 matrix V</td>
</tr>
<tr>
<td>Yoyakusita seki-ga kituensekino tonarini-atta kyaku-wa hokanoseki-ni kaesasetā. reserved seat-nom smoke-area next-was customer-top other-seat-to changed</td>
</tr>
<tr>
<td>Lit.: ‘The customer that the seat that (he/she) reserved was next to the smoking section made (them) change to another seat.’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Double-gap relative clause with subject-object order</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 N1 N1+1 V2 N2 N2+1 matrix V</td>
</tr>
<tr>
<td>Yoyakusita kyaku-ga jikan-ni okureta seki-wa hokanokyaku-ni mawasareta. reserved customer-nom time-to late-was seat-top other-customer was-given</td>
</tr>
<tr>
<td>Lit.: ‘The seat that the customer that reserved (it) was late was given to another customer.’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subordinate clause with object-subject order</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 N1 N1+1 V2-conjunction N2 N2+1 matrix V</td>
</tr>
<tr>
<td>Yoyakusita seki-ga kituensekino tonarini-atta-node kyaku-wa hokanoseki-ni kaesasetā. reserved seat-nom smoke-area next-was-because customer-top other-seat-to changed</td>
</tr>
<tr>
<td>‘Because the seat that (he/she) reserved was next to the smoking section, the customer made (them) change to another seat.’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subordinate clause with subject-object order</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 N1 N1+1 V2-conjunction N2 N2+1 matrix V</td>
</tr>
<tr>
<td>Yoyakusita kyaku-ga jikan-ni okureta-node seki-wa hokanokyaku-ni mawasareta. reserved customer-nom time-to late-was-because seat-top other-customer was-given</td>
</tr>
<tr>
<td>‘Because the customer that reserved (it) was late, the seat was given to another customer.’</td>
</tr>
</tbody>
</table>
Table 6: Example of items for norming 1

| Inanimate yoyakusita seki | Fragment: reserved seat |
|---------------------------------------------------------------|
| Paraphrases: seki-o yoyakusita 1 2 3 4 5 seki-ga yoyakusita   |
| seat-acc reserved seat-nom reserved                           |
| ('seat' as object)                                             |
| ('seat' as subject)                                            |

| Animate yoyakusita kyaku | Fragment: reserved customer |
|---------------------------------------------------------------|
| Paraphrases: kyaku-ga yoyakusita 1 2 3 4 5 kyaku-o yoyakusita |
| customer-nom reserved customer-acc reserved                    |
| ('customer' as subject)                                        |
| ('customer' as object)                                         |
Table 7: Analysis of variance results for the residual reading times per region

<table>
<thead>
<tr>
<th>Region</th>
<th>Effect</th>
<th>By participants</th>
<th>By items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$F_1(1,31)$</td>
<td>$P &lt;$</td>
</tr>
<tr>
<td>V1</td>
<td>(all $Ps &gt; .15$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N1</td>
<td>noun order</td>
<td>12.34 .01</td>
<td>11.67 .01</td>
</tr>
<tr>
<td></td>
<td>(all other $Ps &gt; .15$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N1 +1</td>
<td>noun order</td>
<td>28.78 .001</td>
<td>9.79 .01</td>
</tr>
<tr>
<td></td>
<td>(all other $Ps &gt; .4$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2</td>
<td>(all $Ps &gt; .2$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td>noun order</td>
<td>11.97 .01</td>
<td>10.07 .01</td>
</tr>
<tr>
<td></td>
<td>clause type</td>
<td>42.96 .001</td>
<td>121.88 .001</td>
</tr>
<tr>
<td></td>
<td>interaction</td>
<td>8.34 .01</td>
<td>7.65 .05</td>
</tr>
<tr>
<td>N2 +1</td>
<td>clause type</td>
<td>8.15 .01</td>
<td>4.35 .05</td>
</tr>
<tr>
<td></td>
<td>(all other $Ps &gt; .1$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>matrix V</td>
<td>(all $Fs &lt; 1$)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8: Mean plausibility ratings (Norming 1) and mean frequency (number of hits on the Google search engine; mean log in parentheses) for all 24 items and a subset of 12 items

<table>
<thead>
<tr>
<th></th>
<th>24 items</th>
<th>12 items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>‘reserved seat’</td>
<td>‘reserved client’</td>
</tr>
<tr>
<td>Norming 1</td>
<td>1.07</td>
<td>1.34</td>
</tr>
<tr>
<td>N frequency</td>
<td>$38 \times 10^6$ (16.8)</td>
<td>$17 \times 10^6$ (15.9)</td>
</tr>
<tr>
<td>V-N frequency</td>
<td>225,000 (11.5)</td>
<td>183,000 (10.6)</td>
</tr>
<tr>
<td></td>
<td>1.09</td>
<td>1.18</td>
</tr>
<tr>
<td>N frequency</td>
<td>$90 \times 10^6$ (16.98)</td>
<td>$36 \times 10^6$ (16.26)</td>
</tr>
<tr>
<td>V-N frequency</td>
<td>125,000 (10.9)</td>
<td>187,000 (10.5)</td>
</tr>
</tbody>
</table>