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An experimental study of the adjacency constraint on the genitive subject in Japanese

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We present the results of two acceptability judgment and three self-paced reading experiments exploring the source of degradation effects on the acceptability of genitive subjects caused by having them not adjacent to the verb. From a syntactic perspective, Miyagawa (2011) attributes this adjacency constraint to his assumption that the genitive subject is situated in Spec-*v*P, lower than adverbials adjoined to *v*P or higher. This theory thus predicts that adverbials lower than *v*P can intervene between the genitive subject and the verb without degrading acceptability. To test this issue and examine the time course of the intervention effects, our experiments varied the number and the types of interveners. Whereas the results of our acceptability judgment experiments straightforwardly confirmed the purported intervention effects, the self-paced reading experiments provided results that cannot be explained in structural terms alone. First, the reading times of the verb and/or the head noun were greater when the genitive subject was *adjacent* to the verb, an effect that has not been reported in the previous literature. Secondly, the summed reading times of the preverbal regions showed opposite patterns: i.e., the reading times were greater when the genitive subject was *not adjacent*. Finally, regarding the types of interveners, we found that temporal adverbs and locative PPs, but not manner adverbs, were read significantly slower when they followed the genitive subject. We argue that a hybrid account incorporating a syntactic hypothesis with expectation-based incremental processing theories is called for to account for the whole range of data.

1. Introduction

Subjects in Japanese can be marked with either the nominative marker *ga* or the genitive marker *no* in adnominal clauses such as relative clauses, in contrast to other types of subordinate clauses and main clauses, which do not allow genitive subjects, as shown in (1).

(1) a. Naomi-wa [Taro-ga/no kai-ta] hon-o yon-da.
Naomi-Top Taro-Nom/Gen write-Pst book-Acc read-Pst
"Naomi read the book that Taro wrote."

b. Taro-ga/*no hon-o kai-ta.
Taro-Nom/*Gen book-Acc write-Pst
"Taro wrote a book."

c. Taro-ga/*no hon-o kai-te, Naomi-ga sendens-ita.
Taro-Nom/*Gen book-Acc write-Grd Naomi-Nom advertise-Pst
"Taro wrote a book, and Naomi advertised it."

This phenomenon, often called *ga/no conversion*, has been studied in theoretical syntax for many years (Harada 1971; Shibatani 1975; Inoue 1976; Nakai 1980; Miyagawa 1993; 2011; Ura 1993; Watanabe 1996; Ochi 2001; 2017; Kikuta 2002; Hiraiwa 2005; Maki & Uchibori 2008; among others). These theoretical studies mainly concentrate on the syntactic mechanism that should enable the conversion, especially the genitive subject structure. In contrast, what has not been extensively studied is the intervention effect in the genitive subject structure, first pointed out by Harada (1971): the acceptability of a genitive subject is said to be degraded when it is not adjacent to its corresponding predicate, while nominative subjects do not show such an effect, as illustrated below.

(2) Kodomotati-ga/*no minna-de ikioiyoku kakenobot-ta kaidan
children-Nom/*Gen all-with vigorously run.climb.up-Pst stairway
'the stairway that those children ran up together vigorously'
(Harada 1971; Acceptability judgments are those reported in Harada 1971)

One previous study that attempts to give an account for this intervention effect is Miyagawa (2011), who advocates a "D-licensing" theory of the genitive subject structure, which hinges primarily on a structural difference between nominative and genitive subjects (we return to this in Section 3). Even though Harada (1971) observed intervention effects for genitive subjects across Japanese speakers when more than one intervener is present, Miyagawa (2011) argues that such an effect may be found even when there is only one intervener. No formal experimental studies have yet tested the acceptability of non-adjacent genitive subjects such as the one illustrated in (2). Our goal is to examine to what extent non-adjacent genitive subjects are in fact accepted by native speakers of Japanese and explicate the source of degraded acceptability if any. As a working hypothesis, we assume that the results of experimental studies should reflect syntactic properties

of the tested constructions, so we designed and conducted experiments to test the predictions of specific syntactic theories, particularly those of Hiraiwa (2005) and Miyagawa (2011). However, it should be noted that the results of experimental studies do not necessarily stem exclusively from grammaticality issues. For example, even though theoretical linguists tend to make a distinction between grammaticality and acceptability, non-linguists are often not aware of this distinction. Therefore, acceptability judgment studies do not always directly reflect issues of grammaticality. However, even trained linguists may fail to make clearcut grammaticality judgments when it comes to delicate cases,[1] and the present investigation includes such cases: there seem to be no clear judgments in the previous theoretical studies as to the degree of the degradation effect of intervening elements between a genitive subject and its predicate. The aim of the present study is to test whether a specific syntactic theory can fully account for the experimental results regarding intervention effects on genitive subjects. If it can only partially do so, we also attempt to examine what processing theories can account for that syntactic theories cannot.

As the first step, we report in Section 2 the results from two acceptability judgment studies testing the intervention effect. Then in Section 3, we briefly introduce two types of theoretical syntactic accounts of the *ga/no* conversion and discuss the predictions made from these theories regarding the intervention effect on the genitive subject. We also present alternative processing-based theories that may account for the intervention effect. One is a retrieval-based theory and the other is an expectation-based theory. To tease apart these various theories, in Section 4 we present the results of a series of self-paced reading experiments that were designed to (i) dissect the effects of different types of interveners and (ii) pin down the loci of the effects. In Section 5, we discuss the implications of the results for the theoretical accounts and their relations to on-line processing. Section 6 concludes this article.

2. Acceptability judgment experiments #1 and #2

2.1 Procedure

In order to verify the effect of intervening elements, which has not been empirically confirmed in the literature, we conducted two acceptability judgment experiments using a five-point Likert scale (1: very unnatural, 5: natural). The experiments were paper-and-pencil questionnaires. Regarding the target stimuli of the experiment, the Adjacency factor (Adjacent vs. Non-adjacent) and the Case-marking factor (Nominative vs. Genitive) were manipulated in a 2×2 factorial design, yielding a total of four experimental conditions. The Non-adjacent conditions contained two interveners, a temporal adverb and a locative postpositional phrase (locative PP), in the first experiment (AJ1) and one intervener, a temporal adverb, in the second experiment (AJ2). Recall

[1] For debates regarding the tension between linguists' informal judgment studies and large-scale formal judgment studies, see Phillips (2009), Gibson & Fedorenko (2010), Culicover & Jackendoff (2010), Sprouse & Almeida (2013), among others.

that Harada (1971) argues that the intervention effect is strong across Japanese speakers when there are two interveners, whereas Miyagawa (2011) argues that one intervener may be enough to cause such an effect. The Adjacent conditions were constructed by scrambling the interveners of the Non-adjacent conditions to the front of the sentences. The four conditions are exemplified below, where locative PPs, parenthesized, are included in AJ1 but omitted in AJ2.

(3) a. *Adjacent* × {*Nominative ga* | *Genitive no*}
Kyoo (zyuku-de) kodomotati-{ga | no} narat-ta rekisi-wa
today (cram.school-at) children-{Nom | Gen} study-Pst history-Top
Heianzidai-nituite-dat-ta.
Heian.period-about-Cop-Pst
'The history that the children studied at a cram school today was about the Heian period.'

b. *Non-adjacent* × {*Nominative ga* | *Genitive no*}
Kodomotati-{ga | no} kyoo (zyuku-de) narat-ta rekisi-wa
children-{Nom | Gen} today (cram.school-at) study-Pst history-Top
Heianzidai-nituite-dat-ta.
Heian.period-about-Cop-Pst
'*idem*'

Experimental procedures were identical in AJ1 and AJ2. For both experiments, we created 64 target sentences using 16 lexical sets across the four conditions and distributed them into four questionnaires using a Latin Square procedure, so that a participant assigned one of the questionnaires would not see more than one sentence from one lexical set. We included 32 filler items in each questionnaire, which were balanced to ensure an equal number of acceptable and unacceptable sentences in order to lead each participant to make the full range of acceptability judgments. All of the questionnaires started with the same 5 practice items, so that they all consisted of 53 items in total. The order of items within each questionnaire was pseudo-randomized to avoid items with the identical condition presented successively. Then, to control for potential order effects, an additional four questionnaires with the reverse item orders were created, resulting in eight different questionnaires in total.

The participants were 40 native speakers of Japanese in AJ1 and 67 native speakers of Japanese in AJ2, all recruited at a university in Japan.

2.2 Results and analysis

The mean ratings for the four conditions are summarized in **Figure 1**. By comparing the graphical summaries of these two experiments, we can observe the trend that having two adjuncts (AJ1) rather than one (AJ2) decreased the ratings in the genitive subject conditions but not in the nominative subject conditions.

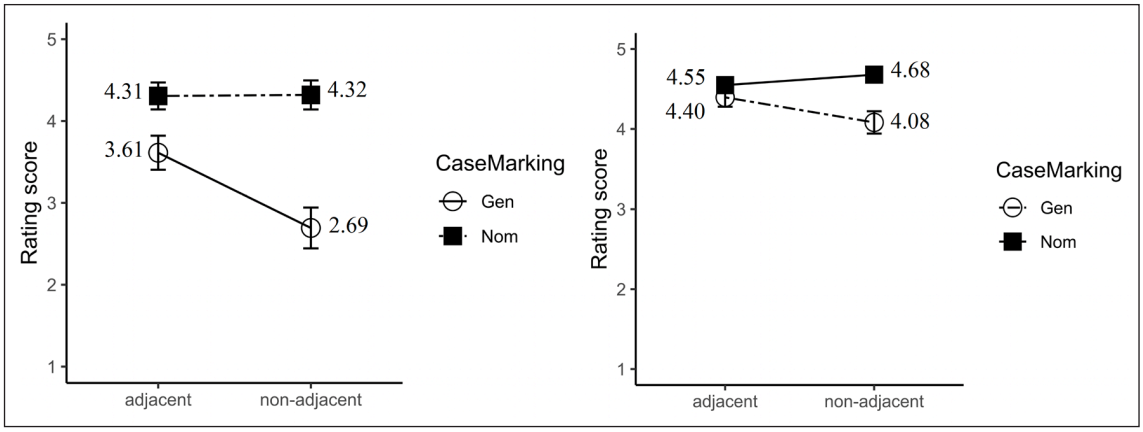


Figure 1: Mean rating scores in AJ1 (left panel) and AJ2 (right panel). Error bars represent 95% confidence intervals.

Prior to the analyses, we transformed the ratings of each participant to z-scores for standardization in order to correct any possible scale bias between participants (Schütze & Sprouse 2013). For each experiment, a linear mixed-effects model was fitted with Case and Adjacency and their interaction (Case × Adjacency) as fixed factors and by-participant and by-item intercepts and slopes as random effects. The analyses were conducted using the lmerTest package for the R statistic program (R core team 2016). For AJ1, we found a significant interaction between Case and Adjacency ($t = 4.80$, $p = .000$) indicating that intervening elements between the subject and the verb degraded the acceptability of the genitive subject but not that of the nominative subject. Planned pairwise comparisons confirmed the trend (the effect of Adjacency on the nominative subject: $t = 0.14$, $p = .887$; on the genitive subject: $t = –5.88$, $p = .000$). We also found a main effect of Case such that the genitive subject was overall rated lower than the nominative subject ($t = 5.25$, $p = .000$) and of Adjacency such that the non-adjacent structure was rated lower ($t = –5.14$, $p = .000$). As for AJ2, we also found an interaction of the two factors ($t = 4.33$, $p = .000$). Planned pairwise comparisons revealed that the intervention effect was detected exclusively on the genitive subject (nominative: $t = 1.16$, $p = .256$; genitive: $t = –3.82$, $p = .000$). A main effect of Adjacency was found such that the non-adjacent structure was rated lower ($t = –3.99$, $p = .000$), as well as a marginal effect of Case such that the genitive subject was rated lower ($t = 1.9$, $p = .060$).

As given in **Table 1**, the observed trends are consistent with the data from written and spoken corpora reported in Nambu (2013b).[2]

[2] Table 1 contains examples of the non-adjacent environment, including cases where elements such as adverbs occur before subjects.

	Adjacent		Non-adjacent	
	Written (MJD)	**Spoken (CSJ)**	**Written (MJD)**	**Spoken (CSJ)**
Nominative	82.9%	88.9%	98.5%	99.8%
subject	(4,371/5,274)	(3,222/3,624)	(2,291/2,326)	(1,318/1,321)
Genitive	17.1%	11.1%	**1.5%**	**0.2%**
subject	(903/5,274)	(402/3,624)	**(35/2,326)**	**(3/1,321)**

Table 1: Frequency of nominative/genitive subject in the adjacent/non-adjacent environment (MJD = Minutes of Japanese Diet, CSJ = Corpus of Spontaneous Japanese) (Nambu 2013b).

Table 1 shows that (i) genitive subjects are overall used less than nominative subjects, and (ii) genitive subjects are used less in the non-adjacent environment than in the adjacent environment, as opposed to nominative subjects, which are not sensitive to adjacency.[3] Importantly, Nambu (2013b) reports that all of the interveners between the genitive subjects and their predicates in the reported data (35 examples in MDJ and 3 in CSJ in **Table 1**) were VP-level adverbs or postpositional phrases.

In summary, the acceptability judgment study quantitatively confirmed the adjacency constraint: the acceptability of genitive subjects was degraded in the non-adjacent condition, as opposed to nominative subjects, which were not sensitive to adjacency. The results also identified the main effect of the case-marking factor as well, in such a way that the nominative subjects were overall rated higher than the genitive ones. Finally, the effect of the adjacency constraint was found even when there was only one intervener, confirming Miyagawa's (2011) argument based on introspection.

3. Syntactic accounts and processing-based accounts

With the adjacency constraint on genitive subjects in Japanese empirically confirmed through the judgment experiments, we attempt to explicate the source of the constraint through self-paced reading experiments. In this section, we first review two major theories of genitive subjects in Japanese proposed in the generative literature, and then introduce processing-based accounts as alternatives. We report our experimental results in the next section.

3.1 Competing theoretical approaches and the adjacency constraint

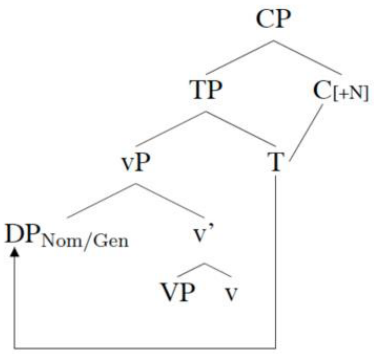
As illustrated in (1), genitive subjects in modern Japanese are predominantly found in adnominal clauses, which strongly suggests that the nominal feature in such clauses is responsible for the

[3] Regarding the inferior status of genitive subjects, see Nambu (2007; 2019) and Ogawa (2018) for discussion in terms of ongoing linguistic change, whereby the use of genitive subjects has been decreasing over time, while the use of nominative subjects has increased.

licensing of the genitive case. Two well-known approaches are the C-licensing theory (Watanabe 1996; Hiraiwa 2005) and the D-licensing theory (Ochi 2001; Miyagawa 2011).

The C-licensing account proposed in Hiraiwa (2005) assigns the same structure, which contains a CP, to both the nominative and genitive subjects. The tree diagram in (4) illustrates the assumption.

(4) C-licensing account (modified from Hiraiwa 2005)

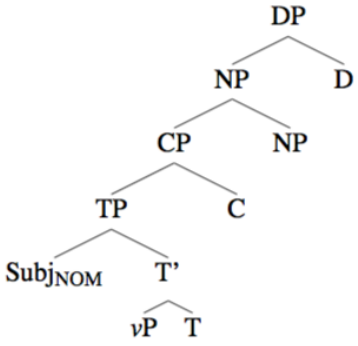


Under this approach, the genitive subject is licensed through the C-T relationship only when C comes with a categorial feature [+N], while the nominative subject is licensed irrespective of this feature (Hiraiwa 2005: 99). This C-licensing theory predicts that the nominative and genitive on a subject are freely interchangeable under the structure with C[+N]. Therefore, this theory does not explain the interaction between adjacency and case marking because both the nominative and genitive subjects under C[+N] have exactly the same structural properties.

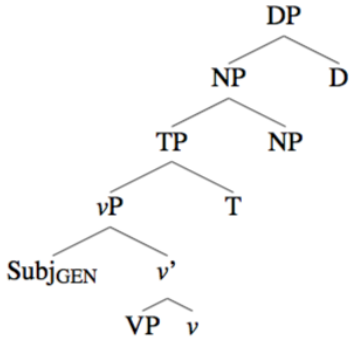
In contrast, under the D-licensing account, the genitive subject must be licensed in the domain of an NP with D, which corresponds to the head noun of the clause. The tree diagrams given in (5) illustrate the structures of the nominative and genitive subjects under Miyagawa's (2011) approach, where the nominative structure contains a CP (5a), in contrast to the genitive subject structure without it (5b).

(5) D-licensing account (modified from Miyagawa 2011)

a. Nominative subject



b. Genitive subject



Miyagawa (2011) argues that the nominative subject is licensed by T in conjunction with C but not by D because CP is a phase and blocks the D-licensing due to a violation of the Phase Impenetrability Condition (Chomsky 2001). On the other hand, the genitive structure does not contain a CP, which would block the D-licensing. According to Miyagawa, the absence of CP in the genitive structure is supported by its incompatibility with CP-level adverbs such as speech act, evaluative, and evidential adverbials. This is illustrated below.

(6) a. [kitto Taro-ga/-no yon-da] hon
probably Taro-Nom/Gen read-Pst book
'the book that Taro read for certain'

b. [saiwaini Taro-ga/*-no yon-da] hon
fortunately Taro-Nom/Gen read-Pst book
'the book that Taro fortunately read'

The TP-level adverb *kitto* 'probably' in (6a) is compatible with both the nominative and genitive subjects, whereas the CP-level adverb *saiwaini* 'fortunately' in (6b) is not acceptable with the genitive subject, which can be accounted for under the assumption that the genitive structure lacks a CP.

Furthermore, according to Miyagawa (2011), this D-licensing theory is advantageous in that it can account for the intervention effect (adjacency constraint) on the genitive subject. T without C in the genitive structure fails to inherit any formal grammatical features from C and thus lacks an EPP feature, which is assumed to be the trigger for movement of the subject to Spec-TP (Chomsky 1995); as a result, there is no formal motivation to move the genitive subject into Spec-TP. Therefore, the genitive subject preferably stays at Spec-*v*P, in contrast to the nominative subject, which must move to Spec-TP due to the EPP feature. This approach can provide an account for the intervention effect, according to Miyagawa, because the genitive subject is closer to V than the nominative subject is. In other words, genitive subjects are "more adjacent" to the predicate by default, so making them non-adjacent to it would necessitate some

extra “unmotivated” and “uneconomical” operations. Miyagawa (2011: 1274) attributes the contrast between the following examples to this structural position of the genitive subjects.

(7) [Koozi-no mattaku sir-ana-i] kakudo
Koji-Gen at.all know-Neg-Prs angle
‘an angle that Koji doesn’t know at all’

(8) ??[kodomotati-no minna-de kake-nobot-ta] kaidan
children-Gen all-with run-climb.up-Pst stairwary
‘the stairway which those children ran up together’

According to Miyagawa, *mattaku* ‘at all’ is a VP-adverb that sits lower than *v*P, and thus, there is no need to move the genitive subject to derive the surface order in (7). In contrast, the degraded acceptability of (8) indicates that the genitive subject *kodomotati* ‘children’ must undergo “unmotivated” and “uneconomical” movement (Miyagawa 2011: 1274), leading to degraded naturalness. Although Miyagawa (2011) does not explicitly state so, it implies that he assumes that *minna-de* ‘all-with (=together)’ in (8) is situated above *v*P.

Miyagawa’s (2011) discussion on the intervention effect for genitive subjects is rather brief, and there are some issues left open. Although Miyagawa’s theory makes clear predictions regarding the interaction between the structural positions of adjuncts relative to *v*P and the possibility of intervention in the genitive subject structure, no detailed discussion is provided regarding which adjuncts are assumed to be placed above *v*P or under *v*P. Miyagawa discusses *saiwai* ‘fortunately’, which is a CP-level adverb, *kitto* ‘probably’, which is a TP-level adverb, *minna-de* ‘together’, which Miyagawa regards as an adjunct attached to *v*P, and *mattaku* ‘at all’, which Miyagawa regards as a VP-level adverb. What then of other adverbs such as locative PPs and manner adverbs? This issue is worth examining.[4]

In summary, the interaction between case-marking and adjacency is straightforwardly given a structural account from Miyagawa’s D-licensing theory, according to which genitive subjects stay under *v*P unlike nominative subjects. Then, can we conclude that the D-licensing theory is more tenable than the C-licensing theory on the grounds that it can account for the intervention effect (adjacency constraint)? More specifically, are the predictions of Miyagawa’s D-licensing theory regarding the intervention effect in relation to the structural positions of the interveners empirically supported? In the experiments we conducted, we investigated the online processing of the intervention effects on genitive subjects, varying the type of intervener to test Miyagawa’s

[4] On another matter, if Miyagawa’s account based on “uneconomical” movement is correct, it seems to predict that having *v*P- and VP-adjuncts to the left of nominative subjects would also incur an effect similar to the intervention effect for genitive subjects, because in such a case, the adjuncts should undergo “uneconomical” movements.

structural hypothesis. The adverbial interveners we used in the experiments were (i) temporal adverbs, (ii) locative PPs, and (iii) manner adverbs.

It seems plausible and uncontroversial to assume that temporal adverbs are TP-level adjuncts and that manner adverbs are VP-level adjuncts. If so, Miyagawa's D-licensing theory predicts that temporal adverbs would cause intervention effects for genitive subjects, whereas manner adverbs would not. The structural position of locative PPs, however, is far from obvious. It seems that there is a consensus in the theoretical literature that cross-linguistically, locative PPs are situated somewhere between temporal and manner adverbials (Cinque 1999; 2006; Maienborn 2001; Ernst 2002; 2004; Frey 2003; Pittner 2004). For example, Cinque (2006: 154) suggests that "a unique (universal) order of merge" is "Temp > Loc > Mann > complements > VP". As for Japanese, Takamine (2010) demonstrates that the syntactic domain of locative phrases is higher than that of manner adverbs. In the experimental literature, Tamaoka et al. (2004) and Koizumi & Tamaoka (2006) measured reaction times of sentences with various adverbs including manner adverbs and locative phrases in Japanese, and conclude that the canonical word order of a transitive structure with a manner adverb is either *Subject-Adverb-Object-Verb* or *Subject-Object-Adverb-Verb*, whereas that with a locative phrase is *Subject-Adverb-Object-Verb*. All these studies suggest that manner adverbs are placed close to the verb, and locative PPs are placed higher than manner adverbs. However, the position of locative PPs relative to *v*P is not clear. Takamine (2010) argues that locative phrases and temporal adverbs behave similarly in terms of scope relations, which may or may not show that locative phrases are syntactically as high as temporal adverbs. Frey (2003) and Pittner (2004) claim that "event-related adverbials" including temporals are structurally higher than the highest argument, "process adverbials" including manner adverbials are situated lower than the other arguments, and "event-internal adverbials" including instrumentals and locatives are situated lower than the highest argument and higher than the other arguments. Maienborn (2001) investigates locatives in detail, suggesting that locatives could be either frame-setting modifiers, external modifiers or internal ones:

(9) a. In Argentina, Eva still is very popular. (Frame-setting modifier)
b. Eva signed the contract in Argentina. (External modifier)
c. Eva signed the contract on the last page. (Internal modifier)

Based on binding and other data, Maienborn (2001) concludes that the base position of frame-setting modifiers is higher than the subject, that of internal modifiers is lower than the object, and that of external modifiers is between the subject and the object. For example, the following set of German data regarding the coindexing between fronted referential expressions and pronouns convincingly shows the base positions of locatives relative to subject and object (Maienborn 2001: 12, 14).

(10) Object > Internal modifier
*[In Peters$_i$ Auto]$_j$ hat der Chef ihn$_i$ t_j nach hause gefahren.
[in Peter$_i$'s car]$_j$ has the boss him$_i$ t_j at home driven.
(Intended) 'In Peter$_i$'s car, the boss drove him$_i$ home.'

(11) a. External modifier > Object
[In Peters$_i$ Büro]$_j$ hat der Chef t_j ihm$_i$ die Akten gezeigt.
[in Peter$_i$'s office]$_j$ has the boss t_j him$_i$ the files shown
'In Peter$_i$'s office, the boss showed him$_i$ the files.'

b. Subject > External modifier
*[In Peters$_i$ Büro]$_j$ hat er$_i$ t_j dem Chef die Akten gezeigt.
[in Peter$_i$'s office]$_j$ has he$_i$ t_j the boss the files shown
(Intended) 'In Peter$_i$'s office, he$_i$ showed the boss the files.'

(12) Frame-setting modifier > Subject
[In Peters$_i$ Firma]$_j$ entscheidet t_j er$_i$ allein über die Ausgaben.
[In Peter$_i$'s business]$_j$ decides t_j he$_i$ alone about the expenses.
'In Peter$_i$'s business, he$_i$ decides about the expenses alone.'

Maienborn (2001: 14) further points out that the base order of Subject > External modifier holds even with unaccusative predicates:

(13) *[In Peters$_i$ Büro]$_j$ ist er$_i$ t_j eingeschlafen.
[In Peter$_i$'s office]$_j$ has he$_i$ t_j fallen.asleep
(Intended) 'In Peter$_i$'s office, he$_i$ fell asleep.'

Taking into consideration all these observations and the standard assumption that R-expressions must not be bound (Chomsky 1981), it seems unlikely that locative PPs as external modifiers are situated above *v*P at least in German and possibly in English and in Japanese if the base order is assumed to be universal (Cinque 1999; 2006). As we will see in Section 4, the locative PPs used in our experimental materials are external modifiers, and thus the prediction according to Miyagawa's D-licensing theory would be that these locatives should not cause intervention effects for genitive subjects.

3.2 Processing-based accounts

Note that Miyagawa's account regarding the potential intervention effects of genitive subjects does not hinge upon the categorical distinction between grammaticality and ungrammaticality, but rather resorts to the relative notion of derivational economy (Miyagawa 2011: 1274). From a processing perspective, it can be assumed that structures associated with less economical

derivations would be less preferred, yielding experimental results indicating degradedness such as lower acceptability rates and slower reaction times. Alternatively, different types of factors that are independent of Miyagawa's structural hypothesis may influence the processing of genitive subjects. At least two processing-based possibilities can be thought of: a cue-based retrieval account and an anticipatory, expectation-based account. The former is concerned with the processing cost of retrieving a stored item from working memory. According to a cue-based retrieval theory (Van Dyke & Lewis 2003; Lewis et al. 2006), the items stored in working memory are represented as "feature bundles", and thus the retrieval cues are also feature-based. For example, when a verb is encountered, it triggers a cue-based search for its subject. Because this search attempts to tap into an item with a nominal feature, the presence of nominal items intervening between the subject and the verb is expected to incur some processing complexity at the verb, a variant of what is often called a locality effect (cf. Gibson 2000). Thus, the search should be easier when the subject is placed right next to the verb than when it is placed far from the verb. Also, the search may be more difficult if the subject is genitive-marked because genitive case is not a prototypical subject-marker. This may explain the adjacency constraint on the genitive subjects.

Another processing account would be based on a proactive, anticipatory search for specific features to come (Hale 2001; Konieczny & Döring 2003; Levy 2008). Genitive-marked NPs themselves are ambiguous between an adnominal-modifier analysis and a subject analysis; the former is attained when the genitive NPs are successfully integrated with nominal heads, while the latter is attained when they are integrated with verbs or adjectives. According to Levy's (2008) expectation-based, fully parallel parsing theory (a theory of surprisal), the parser computes possible continuations to the inputs encountered so far, and it allocates different amounts of processing resources to different possible continuations *in proportion to their probabilities*. The processing difficulty of the actual continuation would then be in proportion to the degree to which this resource allocation has to be revised: if the actual continuation turns out to be a less expected one, the probabilistic resource allocation will have to be revised to a greater extent, and hence leads to a difficulty. From this perspective, the subject analysis of a genitive NP would be more difficult than the adnominal analysis because it is less probable. Nambu (2013a) explored the probability of possible interpretations of genitive-marked NPs using a sentence completion task and found that the adnominal completion is more dominant.

Therefore, it is predicted that some processing load is incurred when a genitive NP is not followed by a nominal element but is followed by an adverbial because it will raise the probability of the less expected continuation, i.e., the subject analysis. However, it should be noted that the mere presence of an adverbial or a predicative element immediately following a genitive NP does not completely rule out an adnominal analysis. Consider the following set of examples:

(14) a. boku-no [totemo omosiro-i] hanasi
I-Gen [very interesting-Prs] story
'a very interesting story of mine'

b. [boku-no totemo hoshi-i] kuruma
[I-Gen very want-Prs] car
'the car I really want'

c. boku-no kyonen kat-ta ie
I-Gen last.year buy-Pst house

c'. Subject analysis: [boku-no kyonen kat-ta] ie 'the house I bought last year'

c". Possessive analysis: $boku_i$-no [pro_i kyonen kat-ta] ie 'my house I bought last year'

The genitive NP in (14a) must eventually be analyzed as an adnominal, possessive modifier even if it is followed by an adverbial *totemo* 'very' and a predicate *omosiroi* 'interesting', because the subject of the predicate is the head noun *hanasi* 'story'; in contrast, in (14b), the same genitive NP must be analyzed as the subject of the predicate of the relative clause because pragmatically, the head noun *kuruma* 'car' cannot be the subject of the predicate *hosii* 'want'. Finally, (14c) is an ambiguous case, for which both subject and possessive readings are possible: although the subject reading is probably the preferred one, it is also possible to set up a null subject within the relative clause, especially if we put a pause after the genitive NP, forcing the genitive NP out of the relative clause, in which case the genitive NP is interpreted as an adnominal, possessive modifier for the head noun. This ambiguity is subtle because in either case, the interpretation will be almost identical (i.e., '(the) house I bought last year' vs. 'my house (I) bought last year'). Note that the latter type of analysis is not possible for (14b), because it is pragmatically anomalous to interpret it as 'my car I really want' (because the car I really want is not yet possessed by me).

These examples show that the ambiguity of the genitive NP will not be resolved unless a proper thematic relation is computed between the genitive NP and the predicate. To make the situation even more complicated, the ambiguity resolution may be postponed until the head noun is encountered. Consider the following pair:

(15) a. [boku-no ason-dei-ru] basyo
[I-Gen play-Prg-Prs] place
'the place where I'm playing around'

b. boku-no [ason-dei-ru] inu
I-Gen [play-Prg-Prs] inu
'a dog of mine that is playing around'

Because Japanese lacks relative pronouns, the computation of the thematic relation between the head noun and the predicate of the relative clause must be done by considering the thematic fit

between the two. For this reason, the syntactic status of the genitive NP in (15) cannot be fully determined until the thematic relation between the head noun and the predicate is computed. In (15a), the head noun *basyo* 'place' is not a plausible subject of the predicate *asondeiru* 'playing around', and thus, the genitive NP should be regarded as the subject of the relative clause; in contrast, the head noun *inu* 'dog' in (15b) is a plausible subject and an implausible adjunct for the predicate, and thus the subject analysis of the genitive NP is rejected and its adnominal analysis is forced.

All these considerations lead to the conclusion that in online incremental processing, neither adnominal nor subject analyses of a genitive NP in Japanese can be fully discarded until the predicate or the head noun is encountered. If so, both adnominal and subject analyses of a genitive NP should be kept active during the processing of the relative clause, while different amounts of processing resources are allocated to them in proportion to their likelihood. This can be a possible account for the intervention effect.

Finally, it should be noted that as for the retrieval region, namely the verb region, an expectation-based account predicts an effect in the opposite direction of that predicted by the cue-based retrieval theory discussed earlier. Because genitive case is more frequently used as an adnominal marker, a surprisal effect is predicted at the verb if the genitive subject is immediately followed by the verb. On the other hand, if adverbial items follow the genitive NP, they should elevate the probability of genitive subject structures. Thus, the presence of interveners should facilitate the processing of the verb, contrary to the prediction of cue-based retrieval theories.

The present study attempts to tease apart these structural and processing accounts for the intervention effect of the genitive subject in Japanese. To sum up, the predictions from the various theories would be the following. (i) Miyagawa's D-licensing theory predicts that the intervention effect is a function of the type of intervener: adjuncts whose base positions are higher than *v*P (such as temporal adverbials) should induce an intervention effect on genitive subjects, while those lower than Spec *v*P (such as manner adverbs and possibly locative PPs) should not. (ii) As for processing-based accounts that do not hinge upon a particular theory of syntactic derivation, cue-based retrieval theories assume that intervention effects on genitive subjects are incurred by the presence of nominal features between the target of the retrieval (the genitive subject) and the retrieval site (the verb); thus, it is predicted that intervention effects should be found at the verb regions. (iii) Expectation-based theories predict processing load when a genitive NP is followed by an adverbial intervener because such a continuation is less probable. (iv) Finally, expectation-based theories in general predict an advantage of interveners when it comes to the processing of the verb region, contrary to the cue-based theories. In the next section, we present a series of self-paced reading studies to dissect the effects of various types of interveners and pin down the loci of the effects.

4. Self-paced reading experiments #1, 2, 3

We conducted a series of self-paced reading experiments to progressively identify the source of the intervention effect, investigating whether the effect can be boiled down to the syntactic properties proposed in Miyagawa's D-licensing theory or whether it calls for a processing-based explanation. In the literature, Kahraman (2012) reports that in the adjacent condition, there was no significant difference in reading times between sentences with nominative and genitive subjects. However, it is yet to be understood how the non-adjacent conditions are processed, especially in terms of the type of interveners.

In a self-paced reading task, a participant silently reads a given sentence with a relevant linguistic condition on a computer screen, region by region in a noncumulative, moving-window manner as the participant pushes the space bar (Just et al. 1982). In our experiments, each region contained one free morpheme (such as verbs, adjectives, and adverbs) as well as bound morphemes attached to it (such as case markers, postpositions and conjunctions). Assuming that a slowdown in reading time represents a cost in sentence comprehension, identifying which element of a sentence induces the cost may uncover the source of the intervention effect. To this end, we manipulated the types of interveners to see which adverbials would or would not incur intervention effects and to what magnitude.

All three self-paced reading experiments (henceforth, SPR1, SPR2, SPR3) were based on the same 2 × 2 factorial design, crossing the Adjacency factor (Adjacent vs. Non-adjacent, varied by scrambling) and the Case factor (Nom(inative) subjects vs. Gen(itive) subjects). Thus, the target items in all SPRs we conducted share the same sentential frames as illustrated below:

(16) a. *Adjacent* × {*Nom* | *Gen*}
[Adv1] [Adv2] NP-{Nom | Gen} V HeadN ...

b. *Non-adjacent* × {*Nom* | *Gen*}
NP-{Nom | Gen} [Adv1] [Adv2] V HeadN ...

Adv1 and Adv2 were selected from temporal adverbs (Temp), locative PPs (Loc) and manner adverbs (Mann). The combinations of the two adverbs were <Temp, Loc> in SPR1, <Mann, Loc> in SPR2, and <Temp, Mann> in SPR3. We could not put Loc in the Adv1 position because the adnominal, non-subject analysis of NP-Gen was grammatically possible in the Non-adjacent condition (NP-Gen NP-P).[5]

[5] An anonymous reviewer suggests a possible experimental design in which the locative consists of a proper name or adverbial pronoun. In this design, we might be able to put the locative PP immediately after the genitive subject without letting the participants choose the adnominal analysis of NP-Gen. Although we still worry about the possibility that such a design induces a temporary confusion due to the matching of the nominal features between NP-Gen and the locative, this might be worth pursuing in future research.

4.1 Method

4.1.1 Participants

Native speakers of Japanese participated in the experiments, and the number of participants were 67 for SPR1, 86 for SPR2, and 68 for SPR3. They were mainly recruited at a university in Japan, and were paid 1,000 yen or received course credit for participation. None of them participated in more than one experiment.

4.1.2 Materials

As mentioned earlier, all three SPRs had a 2 × 2 factorial design crossing the Adjacency factor and the Case factor, showing the sentential frames illustrated in (16). As for lexicalization, the target items for SPR1 adopted the same 16 lexicalized sets as the ones tested in the first acceptability judgment experiment (ADJ1 in Section 2). The target items in SPR2 were based on those in SPR1 with slight modifications apart from varied adverbs to adjust plausibility, and those in SPR3 were based on those in SPR2. Thus, lexicalizations were slightly different among the three SPR experiments, but they were mostly similar to each other. Sample materials are shown below, where slashes indicate region boundaries for SPR presentation. The translations of the Non-adjacent conditions are identical to the Adjacent ones and thus are omitted in what follows.

(17) SPR1: ＜Temp, Loc＞

a. *Adjacent* × {*Nom* | *Gen*}
Kyoo / juku-de / kodomotati-{ga | no} / narat-ta / rekisi-wa
today / cram.school-at / children-{*Nom* | *Gen*} / learn-Pst / history-Top
/ Heianzidai-nituite / dat-ta.
/ Heian.period-about / Cop-Pst
'The history that the children learned at a cram school today was about the Heian period.'

b. *Non-adjacent* × {*Nom* | *Gen*}
Kodomotati-{ga | no} / kyoo / juku-de / narat-ta / rekisi-wa
children-{*Nom* | *Gen*} / today / cram.school-at / learn-Pst / history-Top
/ Heianzidai-nituite / dat-ta.
/ Heian.period-about / Cop-Pst

(18) SPR2: ＜Mann, Loc＞

a. *Adjacent* × {*Nom* | *Gen*}
Sibusibu / juku-de / kodomotati-{ga | no} / narat-ta
grudgingly / cram.school-at / children-{*Nom* | *Gen*} / learn-Pst
/ eikaiwa-wa / ryokoosaki-de / yaku-ni / tat-ta.
/ conversational.English -Top / travel.destination-at / role-Dat / rise-Pst
'The conversational English that the children grudgingly learned at a cram school turned out to be useful at the travel destination.'

b. *Non-adjacent* × {*Nom* | *Gen*}
Kodomotati-{ga | no} / sibusibu / juku-de / narat-ta
children-{*Nom* | *Gen*} / grudgingly / cram.school-at / learn-Pst
/ eikaiwa-wa / ryokoosaki-de / yaku-ni / tat-ta.
/ conversational.English -Top / travel.destination-at / role-Dat / rise-Pst

(19) SPR3: <Temp, Mann>
a. *Adjacent* × {*Nom* | *Gen*}
Sensyu / sibusibu / kodomotati-{ga | no} / narat-ta
last.week / grudgingly / children-{*Nom* | *Gen*} / learn-Pst
/ eikaiwa-wa / ryokoosaki-de / yaku-ni tat-ta.
/ conversational.English -Top / travel.destination-at / role-Dat rise-Pst
'The conversational English that the children grudgingly learned last week turned out to be useful at the travel destination.'

b. *Non-adjacent* × {*Nom* | *Gen*}
Kodomotati-{ga | no} / sensyu / sibusibu / narat-ta
children-{*Nom* | *Gen*} / last.week / grudgingly / learn-Pst
/ eikaiwa-wa / ryokoosaki-de / yaku-ni tat-ta.
/ conversational.English -Top / travel.destination-at / role-Dat rise-Pst

In each SPR, the 16 item sets were distributed into four lists using a Latin Square procedure. Filler items were added to each list; the number of fillers was 90 in SPR1 (of which 66 were items for other unrelated experiments), 64 in SPR2 (of which 32 were items for other unrelated experiments), and 56 in SPR3 (of which 24 were items for another unrelated experiment). One list was assigned to each participant, and the target and filler sentences in a list were presented in a pseudo-random order for each participant, such that no two target items were presented consecutively.

4.1.3 Procedure

All three experiments were conducted with Linger (v.2.88), a Tcl/Tk sentence presentation program written by Douglas Rohde, using Apple Mac mini computers on Mac OS X and 17-inch TFT displays. In all three SPRs, participants were asked to read the sentences silently, not aloud. The experiment was preceded by brief instructions and 9 practice items. Each stimulus was immediately followed by a simple sentence that may or may not have matched the content of the sentence that was presented, and the participants were instructed to push either the F key (for yes) or the J key (for no) on a keyboard depending on the match. Visual feedback was provided for wrong answers only. An opportunity for a break was given after every 20 trials.

4.1.4 Analysis

For analyses, we trimmed the data to eliminate noise using four procedures. First, we excluded participants who had correct answers for less than two thirds of the comprehension questions;

three, zero, two participants were excluded by this criterion for SPR1, SPR2, SPR3, respectively. Second, we excluded the data points from the incorrectly answered trials, which corresponded to 5.3%, 8.8%, 19.3% of the target data points in SPR1, SPR2, and SPR3, respectively. The size of the trimmed data based on the comprehension question responses was notably larger in SPR3 than in SPR1 or SPR2, for which we could not figure out the reasons. However, the mean comprehension accuracy rate for the target items in SPR3 was still reasonably high ($>80\%$), so we assumed that the participants were making fair efforts in this experiment. Third, we interpreted reading times shorter than 150 ms to be missteps and excluded them, which corresponded to less than 1% of the data. Finally, after removing the data points exceeding 10,000 ms, we calculated the z-scored reading times of each region for each condition, and excluded the data points whose z-scores were greater than 3 as outliers.

For statistical analyses, linear mixed-effects models were fitted using the lmerTest package in statistical software R4.1.1 (2021-08-10). We fitted the models with Case and Adjacency as fixed effects, and by-participant and by-item intercepts and slopes as random effects; then the random effects structure was simplified from a maximal model (which often led to singular fit warnings) using backwards step- wise regression using the step function from lmerTest to avoid overparameterization (Bates et al. 2015).

In addition, for comparisons where the immediately preceding regions were not constant across the conditions (such as the analysis of Region 4, the verb region, which was preceded either by the subject NP (the Adjacent conditions) or by one of the interveners (the Non-adjacent conditions)), the centered and scaled RTs of the immediately preceding regions were included as another fixed effect labeled “spillover”.

4.2 Results

Our interest is in the reading times in the first five regions of the stimuli, i.e., up to the head noun of the embedded clause, as shown in (17-19). Two critical regions were the verb region (R4) and the head noun region (R5). We were also interested in how adverbial regions were incrementally processed, especially in the Non-adjacent conditions (R2, R3). Mean reading times of the first five regions plus two spillover regions are graphically summarized in **Figure 2** for Non-adjacent conditions and **Figure 3** for Adjacent conditions.

4.2.1 R4 (Verb region) and R5 (Head noun region)

We first report the analyses of the interaction between the Adjacency and Case factors in the verb region (R4) and the head noun region (R5). The mean reading times for the combinations of the two factors are graphically summarized in **Figures 4** and **5**, and a summary of the results from the best-fitting LME models is shown in **Table 2**. In the verb region (R4), no interaction

was found in SPR1 (t = –0.66, p = .507) or in SPR2 (t = –1.12, p = .276), but a significant interaction was found in SPR3 (t = –2.80, p = .006) in the direction that the genitive subject condition was significantly slowed down when the genitive subject was adjacent (pairwise comparisons in SPR3: the effect of the Adjacency factor was significant for the Gen conditions (t = –4.51, p = .000), while not significant for the Nom conditions (t = –0.61, p = .542)). In the head noun region (R5), no interaction was found in SPR1 (t = –0.73, p = .463) or in SPR3 (t = –1.48, p = .141), while a significant interaction was found in SPR2 (t = –2.24, p = .027) in the same direction as the interaction found in R4 in SPR3 (pairwise comparisons: the effect of the Adjacency factor for the Gen conditions: t = –3.38, p = .001; for the Nom conditions: t = –0.04, p = .967). In summary, the slowdown effect from having the genitive subject adjacent to the verb was found in SPR2 and SPR3, but the effect was delayed in SPR2 until R5. No interaction was found in SPR1.

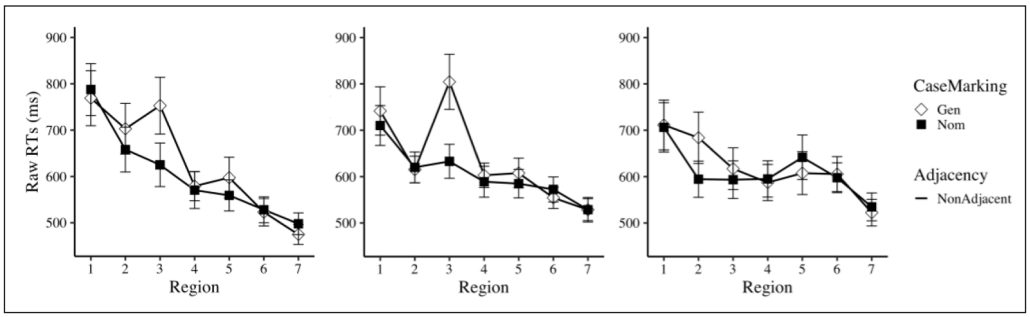


Figure 2: The mean reading times in milliseconds in the Non-adjacent conditions in SPR1 (left), SPR2 (middle), and SPR3 (right), with error bars representing 95% confidence intervals. Regions 2 and 3 were the intervener regions (<Temp, Loc> in SPR1, <Mann, Loc> in SPR2, <Temp, Mann> in SPR3), and Regions 4 and 5 were the verb and head noun regions.

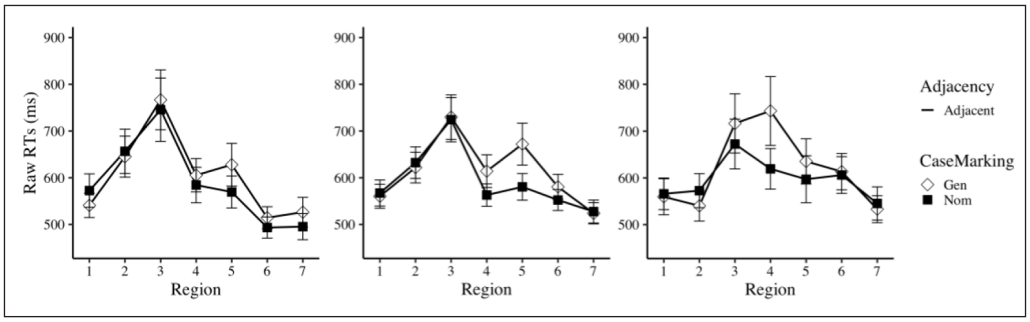


Figure 3: The mean reading times in the Adjacent conditions in SPR1 (left), SPR2 (middle), and SPR3 (right), with error bars representing 95% confidence intervals. Regions 1 and 2 were the intervener regions (<Temp, Loc>, <Mann, Loc>, <Temp, Mann>), R3 was the subject region, and Regions 4 and 5 were the verb and head noun regions.

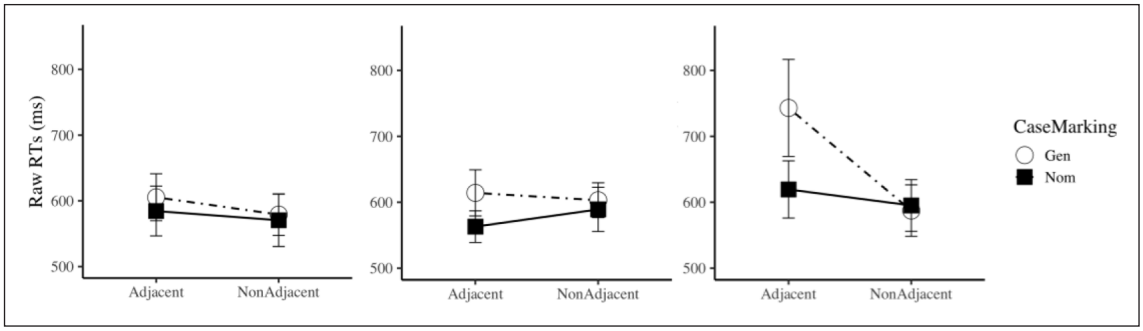


Figure 4: The mean reading times in the verb regions (R4) in SPR1 (left), SPR2 (middle), and SPR3 (right), with error bars representing 95% confidence intervals.

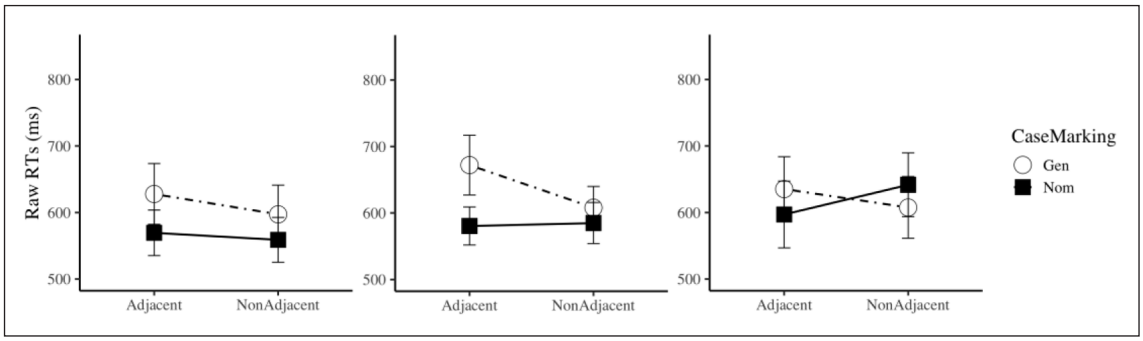


Figure 5: The mean reading times in the head noun regions (R5) in SPR1 (left), SPR2 (middle), and SPR3 (right), with error bars representing 95% confidence intervals.

As for main effects of the factors, main effects of the Case factor were found in all three experiments (R5 in SPR1, R4 and R5 in SPR2, R4 in SPR3) such that the Gen conditions were read slower on average. In some cases, these effects were found even when there were no significant interactions (R5 in SPR1, R4 in SPR2), indicating that genitive-marked subjects generally tended to cause greater reading times at the verb and/or head noun regions. Main effects of the Adjacency factor were also found in some regions (R5 in SPR2, R4 in SPR3) in the direction that the Adjacent conditions were read slower. These effects are likely by-products of the significant interactions in which the Gen $\times$ Adjacent conditions were read considerably slowly.

4.2.2 Sum of the preverbal regions R1-3

Our next step was to examine the effects in preverbal regions. Because the words in the first three regions were not lined up across the conditions (due to the Adjacency factor, which varied the word order), we collapsed the first three regions into one and analyzed the summed reading times of the three regions. The results are graphically summarized in **Figure 6**. The fitted linear mixed-effects models, summarized in **Table 3**, showed not only constant main effects of the

R4 (Verb)					R5 (Head N)				
SPR1	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**		**SPR1**	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**	
(Intercept)	580.1 (20.8)	28.89	.000	***	(Intercept)	593.2 (25.1)	23.67	.000	***
Case	12.1 (16.3)	0.74	.458		Case	51.7 (21.2)	2.44	.018	*
Adjacency	–19.2 (16.3)	–1.18	.240		Adjacency	–22.5 (17.4)	–1.30	.195	
Case:Adjacency	–21.7 (32.6)	–0.66	.507		Case:Adjacency	–25.46 (34.7)	–0.73	.463	
spillover	32.9 (7.7)	4.30	.000	***					
SPR2	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**		**SPR2**	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**	
(Intercept)	586.5 (18.5)	31.64	.000	***	(Intercept)	617.6 (27.8)	22.22	.000	***
Case	28.6 (13.2)	2.17	.030	*	Case	58.2 (20.0)	2.91	.007	**
Adjacency	5.3 (15.0)	0.35	.730		Adjacency	–35.4 (15.1)	–2.34	.020	*
Case:Adjacency	–45.4 (40.4)	–1.12	.276		Case:Adjacency	–70.3 (31.3)	–2.24	.027	*
spillover	20.4 (4.4)	4.58	.000	***					
SPR3	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**		**SPR3**	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**	
(Intercept)	632.5 (25.9)	24.42	.000	***	(Intercept)	628.9 (33.1)	19.0	.000	***
Case	51.4 (23.6)	2.18	.032	*	Case	0.3 (19.9)	0.02	.987	
Adjacency	–81.3 (25.2)	–3.22	.002	**	Adjacency	–1.9 (20.1)	–0.10	.924	
Case:Adjacency	–122.6 (43.7)	–2.80	.006	**	Case:Adjacency	–58.7 (39.8)	–1.48	.141	
spillover	90.8 (10.9)	8.33	.000	***					

Table 2: Results of linear mixed effects model analyses of the RTs in the verb region (R4) and the head noun region (R5) for SPR1, SPR2, SPR3.
Signif. codes: 0 '***' .001 '**' .01 '*' .05 '.' 0.1 ' ' 1.

Adjacency factor (in contrast with the verb and head noun regions, the Non-adjacent conditions were slower: $t = 4.03, p = .000$ in SPR1; $t = 2.41, p = .017$ in SPR2; $t = 2.20, p = .028$ in SPR3) but also interactions of the two factors in the direction that having the subject non-adjacent to its verb incurred a greater load when the subject was genitive-marked ($t = 1.83, p = .071$ in SPR1; $t = 2.75, p = .006$ in SPR2; $t = 2.03, p = .043$ in SPR3). Thus, overall, a slowdown was incurred in the pre-verbal regions when the genitive subject was not adjacent to its verb, but it should be noted that an opposite pattern tended to emerge in the verb region or the head noun region.

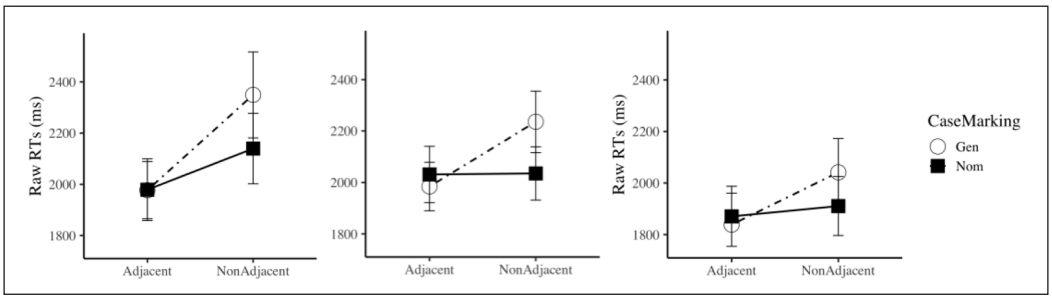


Figure 6: The mean reading times of the sum of the first three regions in SPR1 (left), SPR2 (middle), and SPR3 (right), with error bars representing 95% confidence intervals.

SPR1	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**	
(Intercept)	2133.4 (94.33)	22.62	.000	***
Case	120.0 (58.59)	2.05	.043	*
Adjacency	236.5 (58.8)	4.03	.000	***
Case:Adjacency	223.9 (122.6)	1.83	.071	.
SPR2	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**	
(Intercept)	2065.7 (72.5)	72.5	.000	***
Case	69.4 (46.8)	1.49	.140	
Adjacency	115.29 (47.8)	2.41	.017	*
Case:Adjacency	229.3 (83.5)	2.75	.006	**
SPR3	**Estimate (SE)**	***t*-value**	**Pr(>|t|)**	
(Intercept)	1938.9 (88.0)	22.03	.000	***
Case	17.9 (43.2)	0.41	.679	
Adjacency	95.3 (43.4)	2.20	.028	*
Case:Adjacency	174.7 (86.3)	2.03	.043	*

Table 3: Results of linear mixed effects model analyses of the summed RTs of the preverbal, first three regions for SPR1, SPR2, SPR3.
Signif. codes: 0 '***' .001 '**' .01 '*' .05 '.' 0.1 ' ' 1.

4.2.3 R1, R2, and R3 in the Non-adjacent conditions

Finally, to pin down the locus of the pre-verbal slowdowns in the Genitive × Non-adjacent conditions, we conducted pairwise comparisons between the two Non-adjacent conditions in each of the first three regions (see **Figure 2**). The transitions of the mean reading times across the regions are graphically shown in **Figure 2** above. No effect of Case was found in R1, the nominative/genitive subject region in any of the three experiments (SPR1: $t = –0.62$, $p = .536$; SPR2: $t = 0.93$, $p = .353$; SPR3: $t = –0.38$, $p = .706$). In R2, the first adverbial region, a main effect of Case was found only in SPR3 ($t = 3.16$, $p = .002$), where the adverbial was a temporal adverbial, such that the Genitive conditions were read slower, but no such effect was found in SPR1 ($t = 1.57$, $p = .121$), where the adverbial was also a temporal adverbial, nor in SPR2 ($t = –0.52$, $p = .607$), where the adverbial was a manner adverbial. As for R3, the second adverbial region, a strong main effect of Case was found when this region was a locative PP (SPR1: $t = 3.31$, $p = .002$; SPR2: $t = 4.88$, $p = .000$) in the direction that the Genitive conditions were read slower than the Nominative conditions, while no such effect was found when this region was a manner adverb (SPR3: $t = 0.84$, $p = .361$).

In sum, from the perspective of the type of interveners, (i) post-subject temporal adverbs tended to be read slower when the subject was genitive-marked (in SPR3 but not in SPR1), (ii) post-subject locative PPs were consistently read considerably slower in the Genitive conditions (SPR1 and SPR2), and (iii) post-subject manner adverbs did not show any such effect (SPR2 and SPR3).

4.3 Discussion

Through the three self-paced reading experiments varying (i) the case-marking of the subject of the relative clause (the Case factor: Nominative vs. Genitive), (ii) the distance between the subject and the predicate (the Adjacency factor: Adjacent vs. Non-adjacent), and (iii) the types of the adverbials (SPR1: a temporal adverb and a locative PP; SPR2: a manner adverb and a locative PP; SPR3: a temporal adverb and a manner adverb), we found the following.

First, at the loci of the thematic integrations, namely the verb region (R4) and the head noun region (R5), the main effects of Case were overall constantly found (R4 in SPR2 and SPR3; R5 in SPR1, SPR2) such that the Genitive conditions were read slower, which conforms to the results of the acceptability judgment experiments (Section 2), those of Nambu's (2013a) sentence-completion study, and those of a corpus frequency study (Nambu 2013b). However, the interaction between the Case and Adjacency factors in these regions emerged in the opposite direction to these off-line studies: the Genitive conditions were read more slowly when the genitive subjects were adjacent to the verb while no such effects were found for nominative subjects. The disadvantage of having a predicate immediately follow a genitive subject can be accounted for in terms of expectation-based surprisal models such as Hale (2001) and Levy (2008), because a genitive-marked NP is much more frequently understood as an adnominal element than as a

subject (Nambu 2013a, b). Having a predicate immediately follow a genitive NP would defy this expectation, inducing a surprisal, while distancing the genitive NP away from the predicate and inserting adverbial elements in between would significantly facilitate the subject analysis of the genitive NP before the parser encounters the predicate. One may object that an adverbial following a genitive NP should also incur a processing difficulty. However, it is not the case that an adverbial and a verb should cause the same level of processing load. An adverbial merely triggers a revision of the processing resource allocation such that the expectation for a genitive subject structure is elevated. In contrast, an encounter with a verb works differently because it is a theta assigner searching for an argument. The verb that immediately follows the genitive NP does not merely elevate the possibility of the genitive subject analysis, but it forces the parser to reject the highly frequent adnominal analysis of the genitive NP. This should cause a greater processing load than having an adverbial following the genitive NP.

Interestingly, the interactions were only found in SPR2 (a significant interaction in R5) and in SPR3 (a significant interaction in R4), but not in SPR1. If we compare what preceded the verb region in the Adjacent conditions, both SPR2 (＜manner, locative ＞) and SPR3 (＜temporal, manner ＞) had a manner adverb in one of the pre-subject regions whereas SPR1 (＜temporal, locative ＞) did not. It might be the case that the presence of a manner adverb led to a stronger surprisal effect when processing the genitive NP that came after it. Under the assumption that a manner adverb is generated lower than the subject in syntactic structure, an “unmotivated” movement must be set up to yield a ‘manner-adverb subject’ word order (Miyagawa, 2011). Therefore, the presence of a manner adverb preceding a genitive NP in SPR2 and SPR3 may have driven the adnominal analysis of the genitive NP more strongly than in the case where a manner adverb is not involved (i.e., SPR1). This stronger preference driven by a manner adverb may have yielded greater surprisal effects, leading to significant slowdown in the Genitive × Adjacent conditions in SPR2 and SPR3, in contrast with SPR1. Therefore, even though the disadvantage of putting a genitive subject adjacent to the verb, found in the verb and head noun regions, does not follow from Miyagawa’s structural hypothesis, the negative effect of putting a manner adverb before the genitive subject may necessitate a hierarchical structural assumption like Miyagawa’s.

Second, the disadvantage of separating the genitive subject from the predicate was found in the pre-verbal regions. When the summed reading times of the pre-verbal regions were compared, interactions of the two factors were found in the direction that the Genitive × Non-adjacent conditions were read slower. This conforms to the results of the acceptability judgment experiments (Section 2), those of Nambu’s (2013a) completion study, and those of a corpus frequency study (Nambu 2013b), as well as what has been pointed out in theoretical studies (Harada 1971; Miyagawa 2011, among others).

Third, regarding the type of adverbials responsible for intervention effects, we found the Non-adjacent × Genitive disadvantage in the temporal adverb regions (though not consistently),

and particularly in the locative PP regions, but not in the manner adverb regions. The contrast between temporal adverbs and manner adverbs seems to conform to the prediction of Miyagawa's (2011) D-licensing theory coupled with the syntactic hierarchical analyses of adverbials in the previous syntactic literature (Cinque 1999; 2006; Maienborn 2001; Ernst 2002; 2004; Frey 2003; Pittner 2004; etc.), where manner adverbs are assumed to be syntactically situated very low while temporal adverbs are assumed to be very high. Specifically, Miyagawa (2011) hypothesizes that genitive subjects are base-generated syntactically higher than manner adverbs and lower than temporal adverbs, and thus, having a temporal adverb follow a genitive subject is expected to cause some processing load while having a manner adverb follow it is not.

In contrast, notable slowdowns found in the locative PP regions in the Genitive × Non-adjacent conditions in SPR1 and SPR2 are unlikely to be attributable to Miyagawa's structural hierarchy because there seems to be no strong evidence that locative PPs are base-generated syntactically higher than the Spec of *v*P, where genitive subjects are supposed to be situated. Particularly, our findings that the slowdowns in locative PP regions were even stronger than those in temporal adverb regions are inexplicable in terms of relative structural height because the consensus in the syntactic literature seems to be that locative PPs should be generated somewhere closer to *v*P than temporal adverbs and thus their intervention effects on genitive subjects should be smaller than those of temporal adverbs, a prediction not supported in our experimental studies. The reason for a seemingly huge disadvantage of a locative intervener is not entirely clear, but we speculate that this could be accounted for by a version of an expectation-based theory. Although an adverbial immediately following a genitive NP drastically elevates the possibility of its subject analysis, its adnominal analysis still has a chance, as we saw in (14a) and (14c) of Section 3.2 where genitive NPs must be adnominal even though immediately followed by an adverbial. Thus, we assume that the parser retained both the subject analysis, probing for a verbal feature, and the adnominal analysis, probing for a nominal feature, even after an adverbial was encountered. When a locative PP followed, it also triggered an expectation for a verbal feature (because the postpositions used in our experiments were always morphologically adverbial). However, the NP in the PP might have sidetracked the parser into the adnominal analysis because of its nominal feature matching the adnominal expectation. This analysis was ungrammatical because of the presence of an adverbial between the genitive NP and the PP. We conjecture that this ungrammatical attraction from the nominal feature of the locative PP was the source of the elevated reading times.

5. General discussion and conclusion

The present article reported several important empirical findings on the intervention effect on genitive subjects. First of all, against the background of some disagreement regarding the magnitude of the intervention effect that was often documented in theoretical studies based on

introspection, the present study is the first to present evidence of this purported intervention effect using both off-line and on-line experiments. Our acceptability judgment studies revealed that the presence of interveners worsened the acceptability of the genitive subject sentences to a statistically greater extent compared with the nominative subject sentences, even when only one intervener was present. Our three self-paced reading experiments also showed consistent and robust interaction between the Adjacency factor and the Case-marking factor such that there was an intervention effect for the genitive subject, but not for the nominative subject, when the sum of the reading times of the first three pre-verbal regions were compared. Interestingly, the effect was reversed in the verb and/or head noun regions such that the Genitive conditions were read slower when the genitive subject was adjacent to the verb. This goes against the prediction based on hierarchical structural complexity or cue-based retrieval, but it can be accounted for in terms of surprisal (Hale 2001; Levy 2008). Additionally, our study suggests a negative effect of placing the manner adverb immediately before the genitive subject, which may be explained by a combination of surprisal and Miyagawa's (2011) structural hierarchy.

Furthermore, the series of self-paced reading studies designed to identify the loci of the intervention effects with reference to structural and processing-based accounts revealed effects of temporal adverbs and locative PPs but not that of manner adverbs. The results are not compatible with the view that any type of intervener is harmful for the genitive subject or the hypothesis that having one intervener is tolerable but having a second intervener is harmful. We have shown that the intervention effect for the genitive subject is clearly sensitive to intervener types. Regarding the loci of the effects, the contrast between temporal and manner adverbs lends support to Miyagawa's syntactic hypothesis on the genitive subject structure in comparison to other syntactic hypotheses that do not assume any structural difference from the nominative subject structure. However, our finding that the slowdown effects at locative PPs were even stronger than those at temporal adverbials is not accountable by Miyagawa's D-licensing hypothesis. We suggest that this finding may be accounted for by a version of an expectation-based theory: that is to say, the nominal feature of a locative PP may interfere with the parser's proactive search for a verbal feature triggered by the genitive subject. All in all, these fine-grained findings suggest that the intervention effects require a hybrid account grounded in theories of syntactic derivation and of expectation-based processing.

Data accessibility statement

Analysis scripts and raw data for the acceptability judgment and self-paced reading experiments are available in the supplementary materials at Open Science Framework: https://osf.io/v9ery/?view_only=8af6791cf8c847df96e0cfde0300a485

Abbreviations

Acc = accusative, Cop = copula, Dat = dative, Gen = genitive, Neg = negation, Nom = nominative, Prg = progressive, Prs = present, Pst = past, Top = topic, Grd = gerundive

Ethics and consent

The study was approved by Monash University Human Research Ethics Committee (Project number 14343).

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Competing interests

The authors have no competing interests to declare.

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