

Locality Effects in the Processing of Negative-Sensitive Adverbials in Japanese*

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1. Introduction

The present study attempts to explicate the use of working memory in integrating grammatical dependencies. Because human language is not necessarily linearly structured, grammatically related items are often not adjacent to each other. However, the presentation and perception of linguistic expressions are time-bound and thus necessarily linear (at least at the surface level), and we often need to deal with incomplete grammatical dependencies while processing an utterance. A simplistic hypothesis is that when we encounter a non-local grammatical dependency chain, we store the head of the dependency chain until we encounter its tail, at which point we retrieve the head of the chain from working memory and integrate the two, and then discharge these items from working memory. This hypothesis predicts that there should be processing costs associated with the length of the dependency chain because the memory load might be greater at the point of retrieval if the item to be retrieved is further away, due to syntactic complexity of the intervening items (Gibson (1998, 2000)), memory decay (Vasishth and Lewis (2006)), similarity interference (Van Dyke and Lewis (2003)), or any combination of these. These hypothesized processing costs are termed *locality effects* in the literature of sentence processing (Gibson (1998)).

As straightforward as the logic behind locality effects seems, experimental

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studies have reported mixed results, especially with respect to head-final (SOV) and verb-final languages (Konieczny (2000) and Konieczny and Döring (2003) for German, Nakatani and Gibson (2008, 2010) for Japanese, Vasishth and Lewis (2006) for Hindi).

Why is this the case? One possibility is that expectation-based facilitation diminishes or even overrides the purported locality effects (Hale (2001), Levy (2008)). The magnitude of expectation-based facilitation should be greater in SOV languages, because the distance between a verb and its arguments tends to be greater in SOV languages than in SVO languages, elevating the expectation for the verb. This would nicely explain the often-reported absence of locality effects in SOV languages.

Another related nontrivial issue is the “position effect,” the effect of having the critical word in different positions across the conditions independently of grammatical dependencies. It is a general tendency that the readers speed up as they proceed through a sentence (Ferreira and Henderson (1993)), which is probably because they obtain more clues about what words should follow as they continue reading the sentence. Simply varying the distance of a dependency by putting more words in between would push the critical word to a later position and might facilitate the reading. This is a confound observed in many of the experimental designs in the previous studies of locality effects, as some researchers have noted (Nakatani and Gibson (2010), Levy and Keller (2013); see Nakatani (2020) for review).

Yet another factor, which has not been fully explored in the literature, concerns the *type* of grammatical dependency involved. Concentrating on those studies of locality effects in SOV languages that had control over position effects, those studies that examined thematic dependencies overall reported lack of locality effects or even anti-locality effects (Konieczny and Döring (2003), Levy and Keller (2013), Nakatani and Gibson (2010)). Other studies on SOV languages have reported locality effects: Vasishth and Drenhaus (2011), for instance, reported slowdown effects with greater distance between relative pronouns and the predicates (or the gaps to be filled by the relative pronouns) in German. Nicenboim et al. (2016) examined relative-pronoun dependencies in German and Spanish and found interactions of locality effects and working memory capacity measures, such that high-capacity readers showed larger locality effects than low-capacity read-

ers. Ono and Nakatani (2014) found locality effects for *wh*-dependencies in Japanese. Finally, Nakatani (2020) compared the effect of locality in processing the dependency between negative-sensitive *X-sika* ‘nobody-but X’ and its obligatory licenser V-Neg, and reported a significant interaction between the reading comprehension accuracies and the locality effects at the V-Neg region, such that the critical V-Neg region was read more slowly when the dependency distance was greater and the reading comprehension accuracy measures were higher.

The constructions tested in studies reporting locality effects all involved extra grammatical dependencies added to predicate-argument relations (relative-pronoun dependencies, *wh*-dependencies, and negative agreement). In contrast, those reporting anti-locality effects or the absence of locality effects examined thematic (predicate-argument) dependencies. This observation conforms to the present assumption that the use of memory resources is dependent on dependency types, such that thematic dependencies constitute the baseline of the comprehensions of the events and thus remain active in the working memory, less likely to decay, while extra grammatical dependencies added to the baseline dependencies are more prone to activation decay. The present study experimentally tests this hypothesis by using a novel type of extra grammatical dependency: the dependency between negative-sensitive contrastive adverbials and Neg.

2. Negative-Sensitive *Wa*-Marked Adverbials in Japanese

Japanese has a wide variety of (negative) polarity-sensitive adverbials that must be licensed by Neg: these include *kessite* ‘never,’ *mattaku* ‘not at all,’ and *mettani* ‘rarely,’ none of which can be used unless the negative morpheme *-na(i)* is suffixed to the predicate. Unlike English negative polarity items such as *ever* and *any*, these adverbials cannot be licensed in conditional or interrogative contexts, or by Neg in a higher clause. However, these adverbial NPIs, being lexicalized items, are not suitable for our intended experimental design where the effect of locality should be compared between negative-sensitive conditions and neutral controls, because they do not have corresponding non-negative counterparts that can be compared with them.

However, there exist some adverbial suffixes in Japanese that can function

as negative-sensitive markers, and which are usable in the present context: they are the contrastive markers *-mo* and *-wa*. By using these markers, we can construct minimal pairs of items contrasting a negative-sensitive condition and its non-negative-sensitive, neutral counterpart.

Let us consider *-wa*, which is well known for its use as a topic marker and a contrastive marker. This suffix can be attached not only to NPs but also to other syntactic projections, including adverbs. If the adverb carries a maximally positive connotation on a scale, such as “clearly,” “perfectly,” and “promptly,” the contrastive marker *-wa* turns the adverb into a “near” negative-polarity item (Hara (2006), Sawada (2013)). For example, the manner adverb *hakkirito* ‘clearly’ can be used in either an affirmative context or a negative context, as shown in (1a, b); however, when *-wa* is attached (*hakkirito-wa*), a negative reading is strongly expected, as illustrated in (2a, c):

- (1) a. Kare-wa hakkirito soo it-ta.
 he-Top clearly so say-Past
 ‘He said so clearly.’
 b. Kare-wa hakkirito soo iwa-nakat-ta.
 he-Top clearly so say-Neg-Past
 ‘He didn’t say so clearly.’ (= ‘He said so but not clearly.’)
- (2) a. #Kare-wa hakkirito-wa soo it-ta.
 he-Top clearly-WA so say-Past
 #‘He said so, but clearly.’
 b. Kare-wa aimaini-wa soo it-ta.
 he-Top vaguely-WA so say-Past
 ‘He said so, but vaguely.’
 c. Kare-wa hakkirito-wa soo iwa-nakat-ta.
 he-Top clearly-WA so say-Neg-Past
 ‘He said so, but not clearly.’

(2a) is very unnatural—if not completely ungrammatical—because *-wa* functions as a contrastive marker when attached to a degree adverb, conventionally implicating (like English *but*) that there could have been a better situation. Thus, when the *wa*-marked degree adverb is maximally positive, it is difficult to imagine a proper context in which it could be used. For this reason, when a maximally positive adverb is marked with *-wa*, negation is

required to make the sentence sound natural, as in (2c). In this sense, *-wa* functions as a negative-sensitive marker when it is attached to such an adverb, almost obligatorily requiring Neg suffixed to the theta-assigning verb. Note that when the *wa*-marked degree adverb is not maximally positive, it *can* be used in an affirmative context, as shown in (2b).

We conducted a self-paced reading experiment using the former kind of *wa*-marked adverbials to test if this dependency would incur locality effects. An immediate advantage of this experimental design over Nakatani's (2020) study, which tested locality effects in the processing of nominal negative-sensitive marker *-sika*, 'no ... but,' is that the truth-conditional semantics can be kept constant across the conditions. That is, in Nakatani (2020), the target condition NP-*sika* V-Neg 'Nobody but NP did V' and its nominative control NP-*ga* V-Neg 'NP did not do V' were truth-conditionally opposed. In the present design, however, the absence/presence of *-wa* did not affect the truth conditions.

3. Experiment

As mentioned above, we were able to construct minimal pairs whose members only contrasted in the presence or absence of the polarity inducing particle *-wa*. In order to double-check whether this requirement for the negative element be induced by *-wa* is significant compared to the same adverbs without *-wa*, we conducted a forced-choice sentence completion questionnaire as a norming study. We prepared 16 items that were simplified versions of the Local condition items (illustrated in (3b) below), where all the items included a maximally positive adverbials, either marked with *-wa* or not. The participants' task was to judge which of the two continuations—1. affirmative or 2. negative—would most naturally complete the given sentences. The 16 items were distributed in a Latin Square design into two lists. 16 unrelated filler items were added to each list. The participants in the study were 109 self-declared native speakers of Japanese, recruited via *Lancers*, an online crowd-sourcing service (<https://www.lancers.jp/>): the participants received 30 yen (approximately 25 cents) for judging sentences from one of the two lists. The sentences were pseudo-randomly presented by Ibex Farm, an online experiment hosting service (<https://spellout.net/>

ibexfarm/). In the results, where the choice of an affirmative predicate was converted to 0 and the choice of a negative predicate to 1, the overall mean rating was 0.27 for the adverbs without *-wa* and 0.87 for the *wa*-marked adverbs. The fitted mixed effects logistic regression model revealed a main effect of *-wa* marking ($z=10.34$, $p<.001$). These results confirm the negative-sensitive property of the *wa*-marked adverbs under investigation.

Using slightly more complex versions of these 16 items, the effects of locality were tested in a self-paced reading experiment.

3.1. Method

The experiment involved a 2×2 factorial design, crossing the Locality factor with Neg-Sensitivity. As for the Locality factor, the distance was manipulated by scrambling. The Neg-Sensitivity factor was varied by the presence/absence of *-wa*. A sample set of materials is shown below, with presentation regions being indicated by slashes (/).

(3) a. {Neutral | Neg-sensitive} \times Local

Purodyusaa-ga /AD-no /gakuya-de-no /nusumi-o
 producer-Nom /AD-Gen/backstage-at-Gen/theft-acc
 /{**hakkirito** | **hakkirito-wa**}/**syoogensi-nakat-ta** node
 /{**clearly** | **clearly-WA**} /**testify-neg-past** because
 /zawameki-ga /okot-ta.
 /murmur-Nom/occur-Past

b. {Neutral | Neg-sensitive} \times Distant

Purodyusaa-ga /{**hakkirito** | **hakkirito-wa**}/AD-no
 producer-Nom /{**clearly** | **clearly-WA**} /AD-Gen
 /gakuya-de-no /nusumi-o/**syoogensi-nakat-ta** node
 /backstage-at-Gen/theft-acc /**testify-neg-past** because
 /zawameki-ga /okot-ta.
 /murmur-Nom/occur-Past

‘Because the producer did not clearly testify the theft in the dressing room by the assistant director, murmurs (of surprise) were heard.’

Whereas the adverbials were adjacent to the verbs they modify in the Local condition (3a), three words intervened between them in the Distant con-

dition (3b). The positions of the critical verb region were kept constant across conditions. The truth-conditional interpretations were held constant across all conditions. 16 item sets were prepared, and 64 filler items were added.

The experiment was conducted using Linger 2.94, a sentence processing experimental presentation program written by Douglas Rohde, using Apple Mac mini computers on Mac OS X and 17 inch LCD monitors. The program presented one sentence at a time on the monitor, using a Latin Square design, in a different pseudo-random order for each participant. Sentence segments were presented from left to right, region by region in a noncumulative manner as the participant pressed the space bar. Each item trial was followed by a comprehension question. 86 native speakers of Japanese, mostly undergraduate students at Konan University, participated, either for a course credit or for payment of 900 yen.

3.2. Results and Discussion

In order to eliminate the effect of outliers due to noise, data points beyond 3 SDs from the relevant condition \times region cell mean were discarded. We also excluded data from the participants whose comprehension accuracy scores on the target items fell below 70%. Analyses were based on the remaining data.

Mean raw RTs for all regions are summarized in Figure 1. As for statistical analyses, linear mixed effects models were fitted for the raw reading times at the critical verb region (Region 6), using the lmerTest package in R (version 3.6.2 (2019-12-12)). We fitted the models with the Locality and Neg-sensitivity factors as fixed effects. Because the words in the region immediately preceding the critical region were not constant between the Local and Distant conditions, we also included the centered and scaled reading times in the pre-critical region as a fixed effect (spillover) in the models; see Vasishth and Lewis (2006). Participants and items intercepts were included in the model as random effects. We also attempted to include random slopes as well, but were forced to simplify the random effects structure step-by-step until convergence failure and singularity warnings disappeared; eventually we ended up by including Locality for items as the sole random slope. However, models with more complex random structures showed very

similar statistics. A summary of the results from the best-fitting model is shown in Table 1. Main effects were found for both the Locality factor (Distant slower: $t=2.83, p=.016$) and the Neg-sensitivity factor (Neg-sensitive faster: $t=-2.04, p=.041$). Most importantly, a significant interaction was observed between the two factors ($t=2.41, p=.016$). Planned pairwise comparisons revealed a robust main effect of Locality for Neg-sensitive conditions ($t=3.70, p=.001$), compared to no such effect for Neutral conditions ($t=0.65, p=.521$).

These results strongly indicate both expectation-based facilitation effects and distance-based slowdown effects for Neg-sensitive adverbials. The critical verb region in the Neg-sensitive \times Local condition was read significantly faster than other conditions, indicating the facilitation effect triggered by negative-sensitive *-wa*. However, the observed interaction of the two factors indicates that negative-sensitive adverbials not only triggered a proactive facilitation effect, but also incurred a retroactive locality effect at the point of retrieval. This interaction is best accounted for by memory-based decay theories such as Vasishth and Lewis (2006) if we assume that the head of an extra dependency chain added to the base-line thematic interpretation is more prone to memory decay.

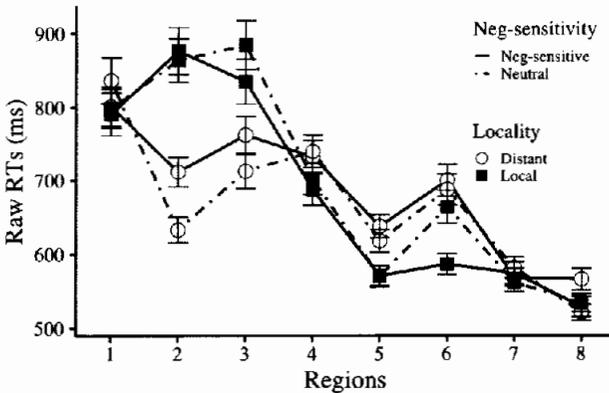


Figure 1: The mean raw RTs for all regions in all conditions with error bars representing standard errors. Region 6 is the critical verb region.

	Estimate	SE	t-value	Pr(> t)
(Intercept)	682.3	21.4	31.90	.000 ***
Locality	28.8	10.2	2.83	.016 *
NegSensitivity	-17.2	8.4	-2.04	.041 *
spillover	111.6	14.1	7.90	.000 ***
Locality:NegSensitivity	20.3	8.4	2.41	.016 *

Signif. codes: 0 '***' .001 '**' .01 '*' .05 '.' 0.1 ' ' 1

Table 1: Results of linear mixed effects model analysis

4. Concluding Remarks

The present study addressed the hypothesis that the magnitude of a given locality effect is dependent on the type of dependency. The working assumption was that base-line thematic, predicate-argument dependencies tend to be kept activated in the working memory, thus showing less locality effects or even anti-locality effects due to elevated expectations, whereas extra dependencies added to the base-line thematic dependencies may be more prone to memory decay, more likely to show locality effects. We tested this hypothesis using a peculiar property of *wa*-marked adverbials, which incur negative polarity-like sensitivity when the adverbials are maximally positively evaluative. The results of the experiment confirmed locality effects induced by the negative-sensitive adverbials. This finding is significant, not only because this is one of the first studies that have attested locality effects in adverbial integration, but also because the use of *-wa* enabled us to control for the truth-conditional semantic differences between the target conditions and their controls: the attachment of *-wa* could drive negative polarity-like sensitivity without causing a change in the truth-conditional interpretation of the sentence at hand. It was revealed that the attachment of *-wa* to a maximally positive adverbial not only triggered an expectation for a negative element to come (thus speeding up the processing of the critical region), but also incurred memory load at the point of retrieval, proportional to the dependency length (thus showing locality effects). The results confirm the type-based theory of locality effects, also conforming to the previous studies of SOV languages, where locality effects were found when non-thematic dependencies were involved.

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