

Expectation-Driven Facilitation in Japanese: Its Independence from Distance *

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1 Introduction

Expectation plays an important role for the incremental processing (Stowe, 1986; De Vincenzi, 1991; Aoshima, et al., 2004; DeLong, et al., 2005, among others). Building on a rich context and more constituents in a structure, the

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parser can sharpen its expectation for what to see in the sentence (the expectation-driven facilitation; Konieczny & Döring, 2003; Hale, 2001; Levy, 2008). In this sense, having more materials at hand is a good thing for the parser to incrementally build a sentence structure in an efficient manner.

Having said that, “more materials” in a sentence usually means that the sentence becomes longer, which in turn suggests that the dependencies established within the sentence get longer, as well. It has been shown that a longer dependency length between the elements increases the integration cost (the locality-driven difficulty, the distance effect; Grodner & Gibson, 2005; Lewis & Vasishth, 2005). Therefore, having “more materials” is good in terms of the expectation, but not so good in terms of the dependency length.

In this paper, we investigate whether and how the expectation and the dependency length interact in sentence processing. There are in fact two critical previous studies concerning these two seemingly conflicting effects. One study, Staub (2010), argues that these two are observed independently; therefore, they do not necessarily interact each other. On the other hand, Husain, Vasishth & Srinivasan (2014) argue that they do. They showed that the distance effect is only observed when the expectation is at work only weakly.

We would like to review each work one after another in the following two sections, and point out that there are some issues that need to be taken care of to see whether their claims can be extended to other paradigms in other languages. Then, we would like to introduce a paradigm in Japanese to examine the expectation and distance effects in a slightly different way. Our experiment showed that those two effects were observed independently, the distance effects in the critical region and the expectation effects in the spill over region. We argue that, as in Staub (2010), those two effects are based on different processing mechanisms and therefore, they do not interact. We further discuss implications and remaining issues in the end.

2 Expectation and Distance Are Independent

Staub (2010) investigated a widely-discussed processing cost of ORCs (object-extracted relative clauses), compared to SRCs (subject-extracted relative clauses), and observed that both expectation and distance effects separately contribute to the processing difficulties of ORCs. In (1a), the subject of the relative clause verb *noticed* is associated to the relative clause head noun *employees*, while in (1b), the object of the relative clause verb is associated to the head noun. It has been observed that SRCs (shown in (1a)) are read faster than ORCs (shown in (1b)) (Gordon, et al., 2001; King & Just, 1991; Traxler, et al., 2002; Mak, et al. 2002, among others). He argued that expectation effects are independent from distance effects because those two

effects were observed separately in different RC regions marked with square brackets in the following example.

- (1) a. The employees [that noticed the fireman] hurried across
the open field.
b. The employees [that the fireman noticed] hurried across
the open field.

First, in his eye-tracking experiment, Staub (2010) observed a reading time slowdown at the NP *the fireman* in (1b), compared to the same NP in (1a). He argued this slowdown is an expectation effect (a surprisal cost; Hale, 2001; Levy, 2008). In (1a), after seeing the relative clause verb *noticed*, the parser can expect an object to appear next; then no difficulty arises upon seeing the object *the fireman*. In (1b), based on the structural preference for SRC, the parser expects a verb to appear after seeing the relative pronoun *that*. A noun phrase *the fireman* appears instead, which violates the parser's expectation, rendering a reading time slowdown. In particular, the effects were observed in the go-past time measure and the rate of regression-out, both of which suggest that the participants made more regressive eye movements and re-read previous portion of the sentence.

Second, comparing the reading times of the verb *noticed* in (1a) and (1b), he also observed a slowdown in (1b), suggesting that the processing cost is associated to the distance between the verb and the relative clause head noun *the employees*. The distance in (1b) is longer than that in (1a), then the encoded information of the head noun has decayed in the working memory. Furthermore, there is an extra noun phrase *the fireman* in (1b), which creates an interference for the retrieval of the true target from the working memory. The effect was pronounced in the gaze duration measure, which suggests that the participants spent more time at the region when they first read the relative clause verb.

The results were very clear, but there are some comments with respect to the claim that the expectation and the distance effects were independent. First, there seems to be a consensus that the reading times get faster as we read further. This speed-up is based on the context build up as we read, and usually it becomes relatively easy to predict how the sentence proceeds (*surprisal*, Hale, 2001). Then, when we compare the reading time of a particular word, it is important that the word is placed relatively in the same position from the beginning of the sentence. In Staub (2010), however, the critical verb *noticed* is placed in slightly different positions depending on the condition. It is desirable that the position of the critical word is nicely aligned.

Second, there are a few kinds of "expectations" discussed in the literature.

Staub (2010) discussed expectation in terms of the word category, i.e. between nouns and verbs. In the ORC condition, the participants expect a verb to appear after the relative pronoun, but a noun phrase in fact appeared. On the other hand, Konieczny & Döring (2003) and Husain, et al. (2014) talked about expectation in terms of the lexical content of a verb. For instance, Konieczny & Döring (2003), in their experiment in German, observed that the reading time of the verb *sold* is faster in (2b) than in (2a). They argued that the particular verb *sell* can be easily predicted based on the syntactic and semantic information in (2b). The verb has to be a three-place predicate that assigns theta roles of agent, goal, and theme to its arguments. Then, we have to pay attention to the kind of expectation we are talking about.

- (2) a. ... [the friend of the customer]-NOM [the car]-ACC [sold]
 b. ... [the friend]-NOM [to the customer]-DAT [the car]-ACC [sold]

Third, and finally, in the discussion whether the expectation and distance effects interact or not, the experimental paradigm in Staub (2010) measures those two effects in two different triggers. As we have introduced above, the expectation effects were measured at the RC noun phrase, whereas the distance effects were measured at the RC verb. This may be responsible for the effects observed separately and independently. It seems necessary to examine the effect right at the same region, if possible.

In sum, Staub (2010) observed that the expectation effects and the distance effects in two different positions, suggesting that those independently contribute the processing costs of the relative clauses. Moreover, his results suggest that those two effects in general do not interact. However, we pointed out some issues to be further investigated. We will take care of those points in our experiment, but before that, we will discuss another critical work, Husain, et al. (2014), about the expectation and distance effects.

3 Expectation and Distance Interact

Husain, et al. (2014) found that the strong expectation effect cancels the distance effect in their experiment conducted in Hindi, a head-final language like Japanese and German. They manipulated the expectation strength by changing the object noun phrases; for example, a noun phrase ‘care’ tells the reader that it is likely to see a verb ‘keep’ as shown in (3). Their co-occurrence frequency is really high, and it seems that they are similar to idioms in terms of their compositional meaning. On the other hand, when the object noun phrase is ‘guitar’, a much wider variety of verbs can follow.

(3) Strong expectation condition (Hindi)

| | | |
|---------|-------|----------------|
| khayaal | rakhe | ‘take care of’ |
| care | keep | |

They manipulated the dependency length by adding extra adverbials. Combined with the expectation strength, they used the following four conditions shown below.

- | | | | | |
|--------------------------------------|--------|-------|-------|------|
| (4) Weak expectation, Long distance: | guitar | {adv} | {adv} | keep |
| Weak expectation, Short distance: | guitar | | {adv} | keep |
| Strong expectation, Long distance: | care | {adv} | {adv} | keep |
| Strong expectation, Short distance: | care | | {adv} | keep |

Examining the reading time of the verb, a length-related speed-up effect was found in the strong expectation conditions, meaning that the expectation and distance effects interact. Their observation that the distance effects disappeared when an object strongly tied to the verb was used lead them to argue that, in the strong expectation condition, the verb is integrated into the structure before the readers see the verb, based on the information provided by the object.

Their results suggest that a certain kind of distance-related effects has a lot to do with the expectation emerged from the pre-verbal elements in the structure, but using idiom-like expressions raises some concern with respect to the generality of the claim. Also, Husain, et al. (2014) used different number of adverbial elements in order to manipulate the distance between the object and the verb, but there is a possibility that it influences the prediction of the verb because the contextual information available before the verb is different by conditions. This can be a potential confound for the manipulation in their experiment.

We would like to investigate the expectation and distance effects, following Staub (2010) and Husain, et al. (2014), but it should be done in a design where various concerns and issues are, hopefully, well taken care of. In the next section, we will introduce our experiment conducted in Japanese, which we believe has the same, at least similar, aims as Staub (2010) and Husain, et al. (2014), but with better controls over the design of the experiment.

4 Experiment

4.1 Method

Forty-two students at Tsuda University participated in a self-paced reading experiment. All were native speakers of Japanese. Twenty-four sets of the target sentences were prepared for this experiment, a sample of which is

shown in (5). Two factors with two levels were manipulated in those materials in a factorial design, yielding four conditions.

First, we manipulated types of PP in the embedded clause; the strong expectation condition is shown in (5a) and (5b). Combined with an accusative-marked wh-phrase *dono tebukuro* ‘which glove’, an instrument PP, *boobari-de* ‘by stick needles’, strongly constrains the lexical content of the embedded verb. It should be fairly easy to predict that the embedded verb has something to do with knitting. On the other hand, the weak expectation condition in (5c) and (5d) has a PP, for example *zisitu-de* ‘in (her) own room’, which is compatible with a wide variety of verbs.

Second, we manipulated the distance between the accusative-marked wh-phrase and the verb. In the local condition (5b) and (5d), there is just a VP-adverb between the wh-phrase and the verb. In the distant condition (5a) and (5c), on the other hand, there is an additional temporal adjunct clause, shown in (6), so that there were five words between the wh-phrase and the verb.

(5) a. STRONG EXPECTATION, DISTANT/LONG

Sobo-wa gikei-ga boobari-de dono-tebukuro-o
 grandma-TOP sister.inlaw-NOM stick.needle-by which-glove-ACC
 [adjunct clause] yorokonde andano-ka magomusume-ni tazuneta
 happily knitted-Q grand.daughter-to asked
 ‘When the marriage of the relative gets closer, the grandma asked to her
 granddaughter which gloves her sister-in-law knitted by the stick needle.’

b. STRONG EXPECTATION, LOCAL/SHORT

Sobo-wa gikei-ga [adjunct clause] boobari-de
 grandma-TOP sister.inlaw-NOM stick.needle-by
 dono-tebukuro-o yorokonde andano-ka magomusume-ni tazuneta
 which-glove-ACC happily knitted-Q grand.daughter-to asked

c. WEAK EXPECTATION, DISTANT/LONG

Sobo-wa gikei-ga zisitu-de dono-tebukuro-o
 grandma-TOP sister.inlaw-NOM own.room-in which-glove-ACC
 [adjunct clause] yorokonde andano-ka magomusume-ni tazuneta
 happily knitted-Q grand.daughter-to asked
 ‘When the marriage of the relative gets closer, the grandma asked to her
 granddaughter which gloves her sister-in-law knitted in her own room.’

d. WEAK EXPECTATION, LOCAL/SHORT

Sobo-wa gikei-ga [adjunct clause] zisitu-de
 grandma-TOP sister.inlaw-NOM own.room-in
 dono-tebukuro-o yorokonde andano-ka magomusume-ni tazuneta
 which-glove-ACC happily knitted-Q grand.daughter-to asked

(6) Inserted adjunct clause

[sinseki-no kekkon-ga tikazuita tokini]
 relative-GEN marriage-NOM get.close when
 ‘when the marriage of the relative gets closer’

A self-paced reading experiment was conducted with Linger, an experimental presentation program developed by Douglas Rohde. The program presented one sentence at a time with a word-by-word non-cumulative matter. Words or regions were displayed from left to right as a participant pressed a space bar (Just, Carpenter & Woolley, 1982).

Twenty-four sets of items were distributed into four lists in a Latin Square design, and forty-eight filler sentences were added to each list. The participants were asked to read the sentences as naturally as possible, and each sentence was followed by a yes-no comprehension question about the content of the stimulus sentences. A feedback was given when the participants answered incorrectly.

4.2 Results

The overall mean accuracy rate was 73 percent, and there was an interaction between distance and expectation strength ($F(1, 41)=9.44, p<0.05$; $F(1, 23)=9.41, p<0.05$), showing that the accuracy rate for the strong/long condition (77 percent) was significantly higher than the strong/short condition (68 percent), and that the accuracy rate for the weak/local condition (77 percent) was significantly higher than the weak/long condition (71 percent).

We excluded data from five participants and five items whose mean accuracy rates were low (less than 60 percent for the participants, and less than 55 percent for the items). For the rest of the participants and target items, we eliminated the reading time data points which were more than three standard deviations away from the mean reading time in each region. We also eliminated data from the trials where the participants wrongly answered comprehension questions.

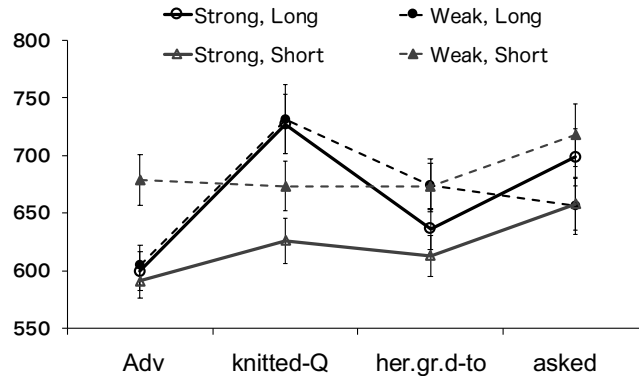


Figure 1. Mean reading times (ms) per region for four conditions.

We calculated the mean reading time for each condition and region. Figure 1 shows that the mean reading times from the pre-verb adverb region to the final matrix verb region. We found that there was a significant main effect of distance at the embedded verb region ‘knitted-Q’, the mean reading times in the distance conditions being slow, compared to those in the local conditions ($\beta=39.39$, $t=2.62$, $p<0.02$). There was no significant main effect of expectation, nor interaction. At the spillover region ‘to her grand-daughter’, there was a significant main effect of expectation; the mean reading times in the strong expectation conditions were faster than those in the weak expectation conditions ($\beta=21.58$, $t=2.73$, $p<0.01$). There was no significant main effect of distance, nor interaction of the factors.

5 Discussion and Conclusion

The result clearly indicated that the two factors, distance and expectation, manipulated in our experiment did not interact, but were independent from each other. The distance effect was found in the embedded verb region, while the expectation effect was found in the spill over region.

The separation suggests that the parser handles the relevant information separately, probably under different processing mechanisms. Based on the presence of the wh-phrase, the parser has to incrementally build a structure where the wh-phrase is syntactically licensed. Upon encountering the verb with the licensing Q-particle, the parser has to retrieve the wh-phrase from the working memory. It is more costly to retrieve the information when the wh-phrase is linearly far from the verb, which is the source of the distance effect (Phillips, Kazanina & Abada, 2005, Ono & Nakatani, 2014). On the other hand, the expectation effect observed in the current experiment is based

on the lexical information. Based on the lexical meaning of the element in the structure, especially based on the lexical content of the PP, the parser predicts a particular lexical item, a verb in our case, to show up. Due to the observation that the expectation effect is independent from the distance effect, we suggest that this meaning-based prediction mechanism runs independently from any encoding/retrieving processes from the working memory.

In section 2, we raised a small concern with respect to Staub (2010). He observed distance and expectation effects in different regions in his relative clause experiment. More specifically, he observed distance effects at the relative clause verb, and expectation effects at the subject NP after the relative pronoun. There seems to be a possibility that two separate effects were observed because the two effects were triggered by different words. Based on the our current results, however, the two effects were observed independently, i.e., with different timing, even when the single word, the verb with the Q-particle, triggers the effects. Our current finding more strongly shows that processing mechanisms responsible for the distance and expectation effects are different in nature.

The above discussion leads us to argue that the integration-in-advance approach discussed in Husain, et al. (2014) is not applicable at least for our current paradigm. Recall that they observed a facilitation effect just for the strong expectation conditions, and they argue that the parser established a dependency before it actually encounters the verb. Such an integration process seems to be responsible for a facilitation effect. However, it seems that the manipulation by expectation in their material has something to do with very restricted idiom-like expressions, which involves a special syntactic / lexical property. Outside of those limited environments, the expectation and distance does not interact in a significant manner.

Although we found a clear independence of the expectation effects from the distance effects, there are some remaining issues to be investigated in future research. In our current experiment, the distance effect was found at the embedded verb with the Q-particle, and the expectation effect showed up in the spill over region. At this point, it is still unclear why those two effects showed up in that particular order. Assuming that the expectation manipulated in the current experiment is about the lexical content of the verb, one may suppose that the effects show up earlier than the distance effects which involve structural integration with a question-related licensing mechanism.

We do not have a full account about the current finding, but we can note that the relative ordering between the distance and expectation effects has already been suggested in Staub (2010). Recall that, in Staub (2010), the distance effect was observed at the relative clause region, and the effect showed up in the first fixation and the gaze duration measures, which are

categorized as early measures. On the other hand, the expectation effect was observed at the noun phrase region, and the effect showed up in the go-past time and the regressive eye movement rate. Those eye movement measures are known to reflect some late processing mechanism (Clifton, Staub & Rayner, 2007). If it is possible to consider an effect in the spill over region in our experiment as a late processing cost, our finding is at least compatible with the findings in Staub (2010).

Finally, we should note another issue which we would like to examine in future. In the relative clause paradigm in Staub (2010), the expectation effect was observed at the RC noun phrase, e.g. *the fireman*, that appears immediately after the relative pronoun. The processing cost for the noun phrase was large, because the parser expected a verb, not a noun phrase, to appear after the relative pronoun. The increased processing cost emerged due to the categorial mismatch. Turning to the experimental paradigm in our case, the expectation mismatch was not about the lexical category, i.e. noun, verb, etc., but it was more about the lexical/semantic content of the verb. In the strong expectation conditions, the reading time of the verb was fast, because the previous context “primed” the particular verb. Therefore, the expectation effect discussed here is slightly different from the one in Staub (2010). Whether and how this different types of “expectation” should be modeled needs to be asked in future research.

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