Subject/Object Asymmetry in the Comprehension of English Relative Clauses by Japanese Learners of English

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While a considerable number of second language acquisition (SLA) studies have shown that English sentences containing object-extracted relative clauses are more difficult to understand than those with subject-extracted counterparts (e.g., Izumi, 2003), these studies have little to say about where in the sentences learners encounter difficulty and the implication of these difficulties for SLA theory. This exploratory study examines the potential applicability to second language (L2) processing of a theory proposed to predict linguistic complexity in first language (L1) processing, namely Gibson's (1998, 2000) Syntactic Prediction Locality Theory. It considers whether the theory might also account for the processing difficulties encountered by Japanese learners of English when reading sentences containing subject- or object-extracted relative clauses in English. Reading time data obtained from an on-line study will be compared with the reading time differences predicted by Gibson's theory, and it will be considered whether his model of sentence complexity can also hold true of L2 sentence processing difficulty.

Key Words: Relative Clauses, Sentence Processing, Second Language Acquisition

1. English Relative Clauses in Second Language Acquisition Research

A number of SLA researchers have examined the difficulty in the acquisition/learning of English relative clauses by (L2) learners (e.g., Gass, 1979; Izumi, 2003). One issue receiving special attention is the difference in processing difficulty between subject-extracted relative clauses and their object-extracted counterparts, for example, see (1).

(1) a. The reporter who attacked the senator admitted the error. (subject-extracted)
b. The reporter who the senator attacked admitted the error. (object-extracted)
(Gibson, 1998, p.2)

In (1a), the relative clause "who attacked the senator" modifies the immediately preceding noun phrase "The reporter", and its relative pronoun "who" is extracted from the subject position of the clause, so it is called a subject-extracted relative clause. In (1b), on the other hand, the relative clause "who the senator attacked" also modify the preceding noun phrase, but in this case, the relative pronoun is extracted from the object position of the relative clause, thus an object-extracted relative clause.

Analyses of the subject/object asymmetry usually adopt Keenan and Comrie's (1977) *Noun Phrase Accessibility Hypothesis* (hereafter *NPAH*) as the framework of analysis. The

NPAH is an implicational hierarchy which predicts the appearance of various types of relative clauses in a particular language. It reveals that there is a markedness relationship in the construction of relative clauses, which can be applied universally, and predicts following hierarchy.

(2) Accessibility Hierarchy
SU > DO > IO > OBL > GEN > OCOMP (“>” means “is more accessible than”)
(Keenan and Comrie, 1977, p.66)

The hierarchy is implicational in that if a language has OBL type of relative clauses, that language will also have less marked relative clauses than OBL (SU, DO, and IO in this case) but not necessarily more marked ones like GEN and OCOM.

What are crucial in the current study are SU and DO types of relative clauses. SU represents subject-extracted relative clauses, which is exemplified in (1a) above, and DO is (direct) object-extracted relative clauses whose example is shown in (1b).

One important claim of the *NPAH* is that the hierarchy directly reflects “the psychological ease of comprehension” (Keenan and Comrie, 1977, p.88). It is predicted that subject-extracted relative clauses are easier to comprehend than object-extracted relatives. Several experimental studies in the L1 psycholinguistic literature provide empirical support for this prediction (e.g., Brown, 1971).

A number of studies have been conducted to verify the *NPAH* in SLA. Among them is Izumi (2003). The results of his interpretation and grammaticality judgment task provide support for the *NPAH*. In these two comprehension tasks, the participants made more errors in the object-extracted relative clauses than the subject-extracted ones. (Although the difference between subject/object relatives in the interpretation task does not reach significance statistically.) Also, the results of a sentence combining task showed that the participants produced subject relatives more accurately than object counterparts. Schumann (1980) and Gass (1979) provide further supporting evidence from the production data (Schumann from speech production and Gass from a sentence combining task). Additional support for the *NPAH* comes from language instruction studies like Doughty (1991), Eckman *et al*. (1988), Hamilton (1994), and Pavesi (1986) who tested the implicational assumption of the *NPAH*. They examined whether the instruction of one type of relative clauses, say OBL, can be generalized to and lead to the acquisition of other types of relative clauses implicated in the *NPAH*, in this case SU, DO, and IO. Their findings show that this is the case.

Although the findings related to the order of difficulty in acquiring and comprehending relative clauses are valuable for understanding the nature of SLA, they tell us little about how these structures are processed. The previous studies provide little information about where in the sentences the learners have the most difficulty in comprehension, that is, what make(s) object-extracted relatives more difficult to comprehend compared with subject-extracted ones. This is partly due to methodological limitations. These studies used “off-line” tasks such as a grammaticality judgment task (Doughty, 1991; Izumi, 2003), an interpretation task (Izumi, 2003), a sentence combination task (Doughty, 1991; Gass, 1979; Hamilton, 1994; Izumi, 2003), and so on. While they give us measures of comprehension or production, it says little about what learners are doing in the course of reading or when and why they, for example, judge a particular sentence as grammatical or ungrammatical.

In view of the goal of SLA theory, namely accounting for the processes responsible for fluent usage of the target language in real time situation, it is important to identify where in the sentence the factor(s) causing the relative difficulty of a particular structure lie(s) and why they are problematic in the real time second language processing. The answers to these questions will also lead us to better understanding of SLA itself.

Possible insights to these problems may be available from L1 research. Gibson (1998, 2000) proposes a processing theory in which linguistic complexity is defined by the distance between two elements integrated and one's working memory capacity. In the next section, I will explain this theory in detail.

2. Gibson's (1998, 2000) Syntactic Prediction Locality Theory

Based on the assumption that sentence comprehension involves constructing syntactic and semantic representation from a series of words, and this construction requires computational resources, Gibson's (1998, 2000) presents a theory which accounts for the relationship between sentence processing mechanism and the computational resources available to comprehenders. The *Syntactic Prediction Locality Theory* (henceforth the *SPLT*) is a model which predicts L1 on-line sentence comprehension difficulty in terms of two cost components both of which consume one shared pool of computational resources (i.e. working memory resources); an integration cost component, which represents what quantities of resources are necessary to integrate new words into the structures constructed so far, and a memory cost component, which indicates the quantity of memory resources needed to store partial structures to complete the sentences.

What is crucial in the current study is an integration cost component. When someone reads through a sentence, all new incoming words must be integrated, syntactically, semantically, or even in the discourse level, to the structures s/he has built so far. These linguistic integrations are assumed to require a fixed amount of computational resources. According to the *SPLT*, the amount of required resources depend on the distance between two elements to be integrated. This means that, all things being equal, the longer the distance between two elements, the more resources that integration requires, hence the more difficult, or more time-consuming, that comprehension process is.

The distance-based integration cost is expressed in terms of a function I(n). Following the assumption that the increase of a substantial integration cost is caused by processing elements which indicate new discourse referents, such as NP and V, the variable "n" is determined by how many such NPs and Vs must be crossed to achieve a successful integration. Also, there are some occasions when more than one integration is conducted at the same point of processing. In that case, more than one I(n) is necessary to express the total quantity of resources required at that point of the comprehension process. The sum of computational resources, or "energy unit", necessary to integrate particular words can be obtained from a simple functional equation $I(n) = n$.[1] Thus, for instance, if there are two integrations of a new incoming word at a particular point of sentence comprehension, and if one of them crosses one new discourse referent and the other crosses two of them to complete each integration, the integration cost here is expressed as $I(1) + I(2)$, and the energy unit needed is 3.

Now let us take a look at how the processing difficulty of subject- and object-extracted relative clauses is described. The integration cost profile of each structure is shown in (3). The relative clauses are in brackets.

(3) a. subject-extracted relative clause

	INPUT WORD								
INTEGRATION	The	Reporter	[who	attacked	the	senator]	admitted	the	error.
COST (IN EUS)	-	I(0)	[I(0)	I(0)+I(1)	I(0)	I(0)+I(1)]	I(3)	I(0)	I(0)+I(1)

(Gibson, 1998, p.20)

b. object-extracted relative clause

	INPUT WORD								
INTEGRATION	The	Reporter	[who	the	senator	attacked]	admitted	the	error.
COST (IN EUS)	-	I(0)	[I(0)	I(0)	I(0)	I(1)+I(2)]	I(3)	I(0)	I(0)+I(1)

(Gibson, 1998, p.21)

A sharp contrast can be found at the last word of each relative clause. In (3a), the last word of the subject-extracted relative clause is a noun "senator". This noun must be integrated into the developing interpretation in two ways. First, it must be integrated to the immediately preceding article "the" to form a noun phrase. This integration does not cross any new discourse referent (Note that what is crossed here is a noun, not a noun phrase, which can be a new discourse referent.), so the integration cost necessary to form this noun phrase is described as I(0). The second integration is to link the noun phrase "the senator" to the preceding verb "attacked". This linkage requires crossing one new discourse referent, namely a noun phrase "the senator". Thus, the integration cost spent here is I(1). The total quantity of the integration cost needed at this point of the sentence is I(0) + I(1). Following the assumption that the sum of computational resources required at a particular point of the on-line comprehension is obtained from the functional equation I(n) = n, the total energy unit required at the processing of the word "senator" in (3a) is 1.

In (3b), on the other hand, the integration of the last word of the relative clause, namely a verb "attacked", seems to require more computational resources than "senator" in (3a). It is same that there are two integrations at this point, but is different in what kind of integrations take place. The first is that the verb is attached to the structure as the verb of the preceding subject noun phrase "the senator". This integration of the verb and the noun phrase crosses one new discourse referent, the verb "attacked", so the integration cost for this process is I(1). Another integration involves identifying the object gap position and relating it to the relative pronoun "who". There are two new discourse referents between the relative pronoun and the object gap, the noun phrase "the senator" and the verb "attacked". This integration process, therefore, spends I(2) integration cost. An integration cost of I(1) + I(2) is required at this word in the sentence, and it amounts to 3 energy units.

Although (3a) and (3b) are different in the processing difficulty of the last word of each relative clause, they appear to require the same amount of resources to integrate the main verb of each sentence. This integration here involves the verb "admitted" and the main subject noun phrase "The reporter". To integrate these two elements, three new discourse referents must be crossed in each case, the main verb "admitted", the embedded verb "attacked", and the embedded subject noun phrase "the senator". Thus, the integration cost here is I(3), and the energy unit required is 3.

Now a question arises as to how the difference of the integration cost of each relative clause affects the on-line comprehension process. Following Just and Carpenter (1992), the SPLT assumes shared working memory capacity. It is hypothesized that the time taken to conduct a linguistic integration "is a function of the ratio of the integration cost required at that state to the space currently available for the computation" (Gibson, 1998, p.16). Simply saying, this means that the more the integration cost (or energy units) is, the longer it takes to perform the integration, which means that comprehension is more difficult.

Figure 1 below illustrates the reading time differences for subject- and object-extracted relative clauses under discussion here.[2]

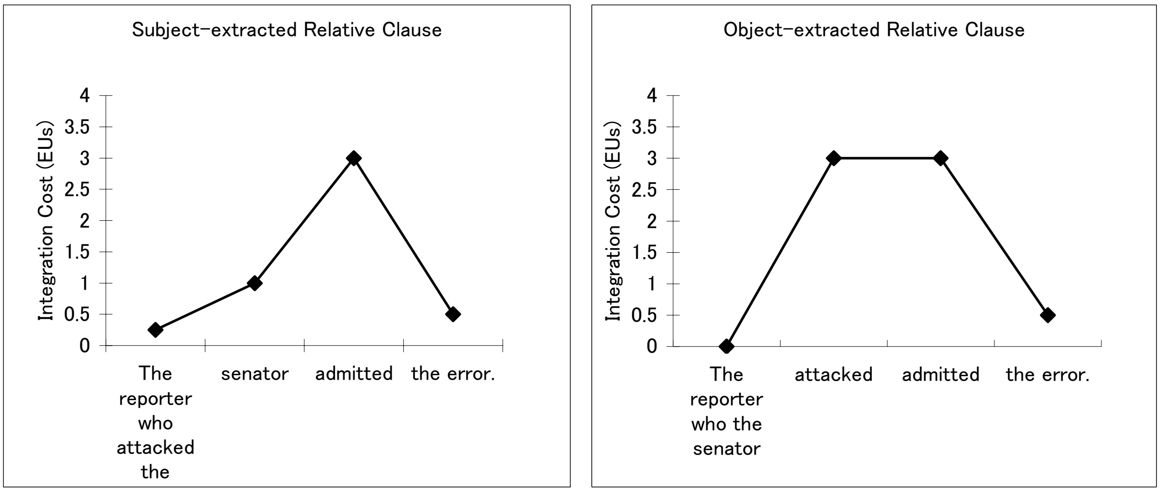

Figure 1. Word-by-word reading time based on the integration costs predicted by the *SPLT*. (Gibson, 1998)

What these two figures show is that, in a sentence containing an object-extracted relative clause, there are two points where the reading time is slow. Compared with other parts of the sentence, the comprehension of two verbs (in the case of the example raised here, “attacked” and “admitted”) takes longer time. In contrast, in the reading of a sentence involving a subject-extracted relative clause, they encounter only one such comprehension difficulty, namely at the main verb “admitted”.

These reading times fit well with findings reported by King and Just’s (1991) on-line reading study. Results from a moving window self-paced reading task revealed that the reading time of two verbs in the object-extracted relative clause sentences was longer than that of other words in the sentence, whereas in sentences with a subject-extracted relative clause, the processing difficulty is not so severe, and the reading time of the main verb (and the last word of the relative clause) is slightly higher compared with other parts of the sentence. The high correlation between the reading time which the *SPLA* predicts and that of King and Just’s (1991) experiment suggests the integration cost account is valid.

In L1 and L2 studies, it has been argued that object-extracted relative clauses are more difficult to comprehend than subject-extracted counterparts, and possible causes of such difficulty have been suggested especially in the literature of working memory capacity theory (Just and Carpenter, 1992; King and Just, 1991). Gibson’s (1998, 2000) *SPLT* provides a formal model of why this is the case by quantifying the memory resources which the processing of each word consumes and predicts where in the sentence the difficulty lies.

Assuming that the *SPLT* can account for the on-line comprehension difficulty of L1 native speakers of English, a natural question arises as to whether this theory also predicts processing difficulties in the L2. This is of interest because it is widely recognized that word integration processes are the source of important differences in L2 processing ability (Fender, 2001). In the next section, I will discuss L2 reading time data obtained from a larger study conducted by me and my co-researcher. The reading time data will be considered in light of the SPLT, with the goal being to assess how well the account fits the L2 data.

The underlying assumption in the *SPLT* is that all the native speakers have full competence of that language; they should have complete grammatical (phonological, morphological, syntactic, and semantic) knowledge and rich vocabularies of the language. It is also assumed that, partly because the grammatical knowledge they possess, they all have a complete and fully automatized processing ability for the lower processes like letter recognition, word recognition, access to mental lexicon, and so on. These sub-processes consume working memory capacity, but for native speakers, the memory resources required to perform such processes are usually minimal. In contrast, in L2 learners, there is much variability in grammatical knowledge and processing ability.[3] Accordingly, L2 learners differ in terms of efficiency of various sub-processes. Some may have quite limited word recognition ability, and others may be poor in accessing mental lexicon. These not automatized processes are said to consume much working memory capacity.

The *SPLT* predicts syntactic complexity and resulting processing difficulties in terms of memory resources which processing of a particular word requires. Therefore, if there are other sources which consume working memory capacity, the theory may not be able to predict the processing difficulty correctly. The data presented below was obtained from 15 Japanese university students, but it must be noted that there should be variability in their competence or processing ability. Thus, applying a theory which assumes automatized processing directly to L2 learners may be dangerous. Factors which affects on processing outcomes, like speed of word recognition, should be controlled, but in the study reported in the next section, this was not done. This is a limitation of the study reported below.

3. Data from Japanese Learners of English

The reading time data presented here was originally collected for a larger study (Hashimoto and Hirai, 2006). The aim of that study was to examine the relative order of difficulty in processing encountered by Japanese EFL learners when reading various kinds of relative clause structures. I will present the reading time data relevant to the present discussion, namely subject- and object-extracted relative clauses, modifying the subject in the main clause. The procedure is described below.

Participants

Participants in this experimental study are 15 Japanese university students majoring in English.[4] As an index of the participants' English proficiency, we asked them to report their TOEIC score. The average of their score is 457, and their score ranges from 336 to 565.

Methodology

The participants' reading time was obtained from a self-paced reading task using the psychological software program *Super Lab* Version 2.0.4. In this task, each participant sits in front of the computer screen and reads sentences which appear on the screen. The experimental sentences are divided into some parts to measure more detailed reading time within the sentence. Sample sentences are described in (4). (Note that RP stands for "relative pronoun".)

(4) a. Subject-extracted relative clause
The nurse / who / kisses / the doctor / treats / the patient.
first NP / RP / first V / second NP / second V / third NP
b. Object-extracted relative clause
The nurse / whom / the doctor / kisses / treats / the patient.
first NP / RP / second NP / first V / second V / third NP

In the beginning, a series of asterisk appears in the centre of the screen, which indicates where each part of the experimental stimuli appears. Once s/he presses the spacebar, the first word (the first NP, "The nurse", in the case of both (4a) and (4b)) appears. When s/he presses the spacebar again, the first word disappears, and the second word (RP "who" or "whom") appears instead. This procedure continues until the end of the sentence. After reading each sentence, participants are asked to answer the true-false questions to confirm that they read for understanding the sentence. Their reading time of each part of the sentence is obtained by the millisecond in terms of the latency between each two pressing of the spacebar. Each sentence type has four experimental sentences, and there are ten sentence types including ones shown in (4a) and (4b). In total, there are forty test sentences, and sixty-two filler sentences are included in a test set. To complete the whole experimental procedure, they took twenty to thirty minutes depending on the participant.

Results

The structures in question, subject-extracted relative clauses and object-extracted relative clauses, will be considered separately. The average reading times and the standard deviations (SD) of each part of the experimental sentences are shown in Table 1 below.

Table 1.
The average reading time and the standard deviation of each part of the sentences

	Subject-extracted relative clause					
	The nurse	who	kisses	the doctor	treats	the patient
Reading Time	853.222	882.2549	950.9067	1554.897	1287.451	1253.535
SD	334.0414	580.6291	509.931	1249.814	984.7175	1009.815
	Object-extracted relative clause					
	The nurse	whom	the doctor	kisses	treats	the patient
Reading Time	818.8599	956.8875	2016.176	1839.908	1817.337	1000.477
SD	319.3945	552.7904	1702.753	1753.212	1429.566	723.5551

First, the average reading time of each part of the sentences containing a subject-extracted relative clause is presented in Figure 2.

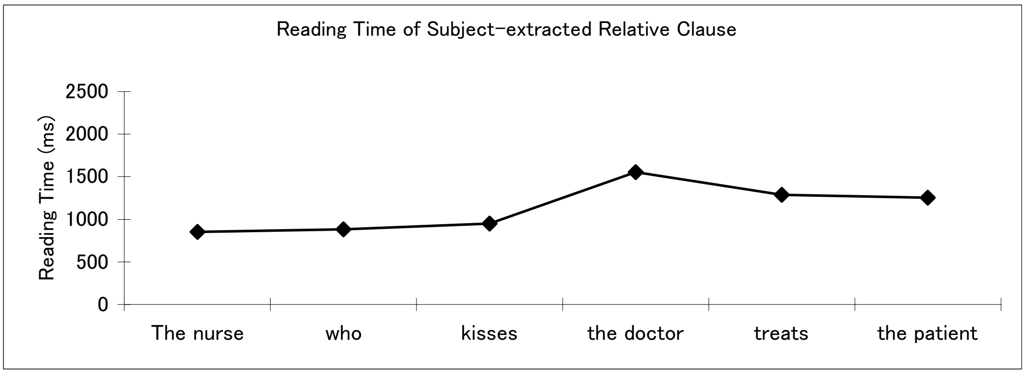

Figure 2. Average reading time of each part of the sentences containing a subject-extracted relative clause

Two things should be noted from this data. First, the reading time at the point where the *SPLT* predicts the most difficulty, the main verb, was slightly longer compared with other parts of the sentence. This result is, though not completely, consistent with the prediction of the *SPLT*. Secondly, contrary to the prediction, the participants took longer to read the last part of the relative clause. A possible reason of this can be a reading strategy the participants adopted. Since they have relatively low English proficiency, they might have processed each experimental sentence in shorter units. It is possible that, at the end of each relative clause, they might have performed some other processes like trying to remember the subject NP of the main clause. In other words, what made the reading time of the object NP of relative clauses might have been the reactivation process of the subject NP. Following this explanation, the relatively weak effect of the expensive integration cost at the main verb may be also accounted for. Since the element which will be linked to the main verb is reactivated, the integration process which occurs at the main verb could be easier compared with the prediction of the *SPLT*.

Figure 3 illustrates the average reading time of each part of the sentences containing an object-extracted relative clause.

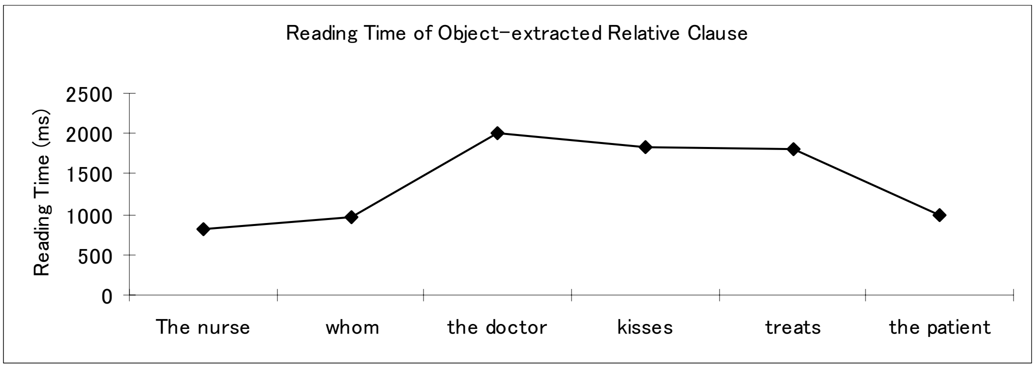

Figure 3. Average reading time of each part of the sentences containing an object-extracted relative clause

This result appears to be consistent with the *SPLT*. As predicted, the reading time of two verbs is clearly longer than other parts of the sentence.[5] One exception is the reading time of the second NP (i.e. the subject NP of the relative clause). The integration cost at this point of the sentence predicted by the *SPLT* is I(0)s, so following the assumption that the more the integration cost is, the longer it takes to perform the process, the long reading time here is unexpected. Also, it is not the end of the sentence, so the "wrap-up" effect would not be expected. One possibility is that there might have been an ambiguity effect at this point.

Because the relative pronoun “which” was used in both subject- and object-extracted relative clauses in some test sentences, it might have been ambiguous for the participants as to which type of relative clause is coming after that relative pronoun, and that might have led to the longer reading time at the position immediately after the relative pronoun. However, this possibility is also eliminated since detailed analysis of the four experimental sentences of this type revealed that the longer reading time actually happened only in one sentence, and the relative pronoun of that sentence was “whom”, which clearly indicated that the relative clause was object-extracted. At this stage, no answer can be provided to account for this deviance. However, the pattern of the remaining part of the sentence is in accordance with the prediction of the *SPLT*.

To sum up, the results of our reading time study are mainly consistent with the predicted reading time predicted by the *SPLT*. Thus, the account may be applicable to SLA.

4. Conclusion

This study considers whether Gibson’s (1998, 2000) *Syntactic Prediction Locality Theory* might also account for the subject/object asymmetry of processing difficulty in sentences containing relative clauses in L2 processing. The results of the self-paced reading task mostly fit well with the predicted reading time of the *SPLT*. Participants took longer to comprehend portions of the sentence where the theory predicts to be most demanding in terms of computational resources. Since some effects which are not predicted by the *SPLT* are also found, however, we cannot strongly argue that the *SPLT* can be applied to processing of second language learners. Besides, there are some limitations in this experimental study. First, as mentioned in the previous section, a number of individual factors which may have an effect on the on-line sentence comprehension are not taken into account in this study. Especially, whether lower level processes, such as word recognition and access to mental lexicon, are automatized or not is crucial because such sub-processes consume substantial amount of working memory capacity, if it is not automatized and cost-free, and one’s memory resource is a crucial part of the *SPLT*. Such factors should be controlled in the future studies. Secondly, presentation of experimental sentences can be problematic. The *SPLT* predicts the processing difficulty of each word in a sentence. However, the presentation unit in this study is either a word or phrase. Further, it is often criticized that presenting each part of the sentence in sequence in the centre of the display is not a natural reading. To examine the applicability of the *SPLT* fully, future studies should obtain word-by-word reading time by adopting, for example, King and Just’s (1991) moving window technique, which is said to be a more authentic reading. Finally, the experimental stimuli should receive greater attention. As mentioned before, the original aim of this reading time study is to examine the relative order of difficulty of various post-modification structures in English. There are ten types of post-modification structures, and the test sentences of each type are derived from four sentence templates (Thus, forty test sentences as a whole). This means that participants encounter sentences containing, for instance, “the doctor”, “the nurse”, and “the patient” as arguments ten times in the experiment. It is possible that there is a practice effect in this study. Future studies need to devise more appropriate experimental stimuli.

In spite of these limitations, this study seems to succeed in demonstrating a possibility to apply a sentence processing theory proposed in the field of L1 psycholinguistics to second language acquisition. Additional studies are definitely necessary to further investigate the applicability of the theory.

Notes

[1] This is a simplified version to calculate total computational resources. In section 2.6.7 of Gibson(1998), it is shown that the integration cost (and the memory cost also) is actually not a linear function. But for the present discussion, the simplified function will do.

[2] The predicted reading time here does not take memory costs into account. Also, it is possible that the integration cost is influenced by the intervening integrations. It should be noted that, in the real time comprehension, these factors interact, and it is unlikely that the actual reading time fits with the predicted time perfectly. Thus, for example, though the predicted integration costs of the main verb “admitted” are the same in both the subject- and object-extracted relative clauses, the cost of the object-extracted relative clause might be more expensive, due to the higher integration cost required at the previous word “attacked” compared with the cost at the corresponding position in the subject-extracted relative clause (i.e. “senator”). This leads to the prediction that the reading time of the main verb “admitted” might be longer in the object relative clause.

[3] This learners’ variability is one of the reasons why we have lacked real time (i.e. on-line) comprehension studies in SLA. See Juffs (2001).

[4] At first, 18 students took part in the study. Due to some statistical problems, however, three participants were excluded from this reading time analysis.

[5] It is assumed that there is no reactivation process suggested in the discussion of subject-extracted relative clauses, since, due to the high integration cost at the embedded verb, there should be few computational resources left for other processes.

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