Testing and Attesting the Use of Structural Information in L2 Sentence Processing

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1. Introduction

The development of second language (L2) syntax in the framework of generative grammar (Chomsky, 1981, 1986, 1995) has received considerable attention in the past few decades, particularly focusing on whether L2 grammatical representation is constrained by innate universal principles of grammar (for review, see Hawkins, 2001; White, 1989, 2003). However, as Gregg (1996) first pointed out, relatively little L2 research has addressed the developmental problem of language acquisition, i.e., how an L2 learner's grammar changes from one stage to another. A proper treatment of this problem requires an explanation of how L2 learners parse and analyze the target language input since misparsing of the target language input could restructure their L2 grammar in non target-like ways. For example, Fodor (1998b) observes that if one misparses a sentence like "While Mary was mending the sock fell off her lap (p. 354)" and posits a *pro* as the subject of *fell*, then this could incorrectly trigger the positive value of the null subject parameter. In this respect, parsing is a causal process of grammatical change, and it is thus necessary to investigate L2 sentence processing in order to build a transition theory of L2 acquisition (for recent attempts to incorporate processing perspectives into a theory of L2 acquisition, see Carroll, 2001; Truscott & Sharwood-Smith, 2004).

First language sentence processing research has revealed that multiple sources of information, such as syntactic, lexical-semantic, prosodic and discourse information, interact during sentence processing (for review, see Gibson & Pearlmutter, 1998). Of these types of information, it is particularly important for those interested in the development of L2 syntax to examine how the parser utilizes the grammatical information during L2 sentence processing. In this regard, recent research on L2 sentence processing by Felser, Marinis, Roberts & Gross (2003) deserves special attention, as they suggested that the L2 parser does not rely on syntactic information during sentence processing. This hypothesis could potentially have a huge impact on a transition theory of L2 acquisition: How does the parser inform the language acquisition mechanism if the target language is not analyzed based on syntactic information? The present paper addresses the validity of this hypothesis on theoretical and empirical grounds and concludes that this hypothesis is untenable.

The following is the organization of the paper: Section 2 critically reviews the research by Felser et al. (2003) and shows that in order to investigate the above mentioned null hypothesis, it is necessary to examine a phenomenon that shows much clearer structural effects than what they investigated. Section 3 illustrates the experiment, a sentence complexity rating task, which was designed to test whether the L2 parser is sensitive to syntactic information. Section 4 discusses the implications of the findings with respect to the properties of the L2 parser and to the process of L2 acquisition. The final section concludes that the L2 parser is not incapable of using syntactic information.

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2. Does the L2 parser under-use syntactic information?

Recently, The Psycholinguistics Research Group at the University of Essex has conducted a series of studies to investigate sentence processing by L2 learners (Felser et al., 2003; Marinis, Roberts, Felser & Clahsen, 2003; Papadopoulou & Clahsen, 2003), and they drew a conclusion that L2 learners do not use syntactic information to the same extent as native speakers. In this section, we present a critical review of Felser et al. (2003), the most representative of these studies.

Felser et al. (2003) investigated the resolution of relative clause (RC) attachment ambiguity by advanced German and Greek L2 learners of English, and tested whether the L2 parser uses phrase structure and lexical information to the same extent as the L1 parser does. An example of RC attachment ambiguity from Felser et al.'s study is given in (1):

(1) The journalist criticized *the pilot of the traveler* who was drinking too much.

In (1), the RC *who was drinking too much* can modify either NP1 *the pilot* or NP2 *the traveler*, and therefore this sentence is ambiguous with respect to the attachment site of the RC.[1] According to Gibson, Pearlmutter, Canseco-Gonzalez & Hickok (1996), there are two structurally based processing principles that are responsible for the resolution of RC attachment ambiguity: One is the Recency principle (also called Late Closure: Frazier, 1987a), which preferentially attaches incoming lexical items to structures that were built more recently and are structurally local. Another is the Predicate Proximity principle, which attaches incoming lexical items as close as possible to the head of a predicate phrase (Bowers, 1993), i.e., to a non-local structure. The Recency principle derives from a universal short-term memory limitation, and it accounts for the NP2 attachment preference found in languages like English (Carreiras & Clifton, 1999; Cuetos & Mitchell, 1988; Traxler, Pickering & Clifton, 1998), Norwegian, Romanian and Swedish (Ehrlich, Fernández, Fodor, Stenshoel & Vinereau, 1999), whereas in other languages like Spanish (Carreiras & Clifton, 1999; Cuetos & Mitchell, 1988), Dutch (Brysbaert & Mitchell, 1996), Greek (Papadopoulou & Clahsen, 2003), Russian (Sekerina, 1997), or German (Hemforth, Konieczny & Scheepers, 1997, 2000),[2] the Predicate Proximity principle outranks the Recency principle, thus deriving an NP1 attachment preference (for review of crosslinguistic differences in RC attachment preference, see Mitchell & Brysbaert, 1998; Fodor, 2002). In a series of offline questionnaire tasks and online self-paced reading tasks, Felser et al. found that their L2 learners did not show any clear attachment preference for sentences like (1), unlike the English native speaker control group (children and adults) who showed a clear NP2 attachment preference. On the other hand, L2 learners and native speakers behaved alike in the resolution of RC attachment ambiguity in sentences like (2):

(2) The dean liked *the professor with the secretary* who was reading a letter.

In this example, again, the attachment site of the RC *who was reading a letter* is ambiguous. Frazier & Clifton (1996) claimed that a thematic preposition such as *with* creates its own thematic processing domain, and that once such a thematic domain is projected, it is costly for the parser to attach an ambiguous element (i.e., the RC in (2)) to a structure outside of the domain, hence leading to a local attachment preference. In fact, in Felser et al.'s study, both L2 learners and native speakers showed a clear NP2 attachment preference in sentences like (2).

[1] Notice that this particular example from Felser et al. is pragmatically biased towards NP1 attachment, since too much drinking is very likely to be the cause of criticism by the journalist. Such biasing in experimental stimuli could readily affect overall performance, and hence should be controlled for.

[2] In fact, the RC attachment preference in German seems to depend on the type of genitive construction: Hemforth, Konieczny & Scheepers (1997, 2000) investigated RC attachment preferences in NP1-Gen-NP2 (e.g., *die Lehrerin der Tochter* "the teacher of the daughter") and found an NP1 attachment preference, whereas Augurzky, Alter & Pechmann (2004) found an NP2 attachment preference for the NP1-PP-NP2 construction (e.g., *die Lehrerin von der Tochter*).

Taken together, Felser et al. claimed that "[o]ur results suggest that L2 learners do not rely on phrase-structure information to the same extent that both young and mature native speakers do when processing input from the target language (p. 478)," whereas lexical-semantic information is available to L2 learners as well. A similar pattern of results was found by Papadopoulou & Clahsen (2003) who investigated the same phenomenon in L2 Greek by Spanish, German and Russian speakers.[3]

However, there are at least three problems with the interpretation of the results reported in Felser et al. (2003). Firstly, in the questionnaire study in which subjects were given 10 sentences of the type exemplified in (1) and were asked to choose whether the ambiguous RC attaches to either NP1 or NP2, approximately chance-level performance with a very high standard deviation was found. Table 1, reconstructed from Tables 2 and 5 in Felser et al. (2003), summarizes those results:

Table 1. The percentages of NP2 responses in Felser et al.'s questionnaire studies

	Mean NP2 attachment	Standard Deviation
Advanced German-speaking learners of English (n = 28)	52%	**28.1**
Advanced Greek-speaking learners of English (n = 39)	51%	**25.9**

These high standard deviations indicate, as the authors themselves note (p. 463 and p. 470), that there was a considerable amount of variation within each group of L2 learners. This means that there were, in fact, some individuals who did not behave at chance-level, but rather showed a more or less clear attachment preference as native speakers did. These individual differences are clearly not expected under Felser et al.'s claim that L2 learners do not rely as much on syntactic information as native speakers do.[4]

Secondly, Dussias (2003) showed that L2 learners can show a clear attachment preference, unlike (the grouped results of) the subjects in Felser et al.'s study. Dussias conducted an offline questionnaire task and an online self-paced reading task with Spanish-speaking learners of English and English-speaking learners of Spanish to examine L2 learners' processing of RC attachment ambiguity as in (1). Although no clear attachment preference was attested in the self-paced reading task, Dussias found in the offline task that both groups of L2 learners preferred NP2 attachment in both Spanish and English. Moreover, the performance of the Spanish-speaking learners of English was indistinguishable from that of monolingual English speakers, which clearly shows that L2 learners can in principle behave like native speakers in the resolution of RC attachment ambiguity.[5]

Finally, it is unclear whether the RC attachment preference is in actuality determined solely by phrase-structure based information, as Felser et al. assume. For example, Frazier & Clifton (1996) claim that the NP2 attachment preference in English results from the fact that English has an unambiguous way of modifying NP1, that is, the use of the Saxon genitive. The attachment ambiguity observed in (1) is lost if one changes the Norman genitive, *the pilot of the traveler*, to the Saxon genitive, *the traveler's pilot*, where *pilot* (originally NP1 in the Norman genitive) is the only possible attachment site. For this reason, when a listener is exposed to the Norman genitive construction, s/he

[3] Marinis et al. (2003) investigated whether L2 learners postulate an intermediate gap in processing long-distance *wh*-dependencies. Although their results did not reach statistical significance, it is important to note that at least their Japanese-speaking learners of English showed a trend toward native-like performance.

[4] In footnote 7 (p. 485), Felser et al. report that the questionnaire data from the L2 learners are all normally distributed according to a Kolmogorov-Smirnov test for normality. This normal distribution further indicates the existence of L2 learners whose performance was deviant from the mean.

[5] Similar to Dussias (2003), Fernández (2000) examined the processing of RC attachment ambiguity by English-Spanish and Spanish-English bilinguals. These results are not discussed here since some of the bilinguals were exposed to the second language from their parents as well, so the language profiles of these subjects seem to be quite different from what we normally refer to as L2 learners.

will think that there must be a reason for the speaker to violate the Gricean maxim of "Avoid ambiguity" by choosing this ambiguous construction, and thus construe the RC as modifying NP2 since this is the only way for the RC to modify NP2. On the other hand, Fodor (1998a, 2002) argues that cross-linguistic differences in RC attachment preference are due to language-specific prosody that is projected upon reading this construction. In languages like Spanish that demonstrate an NP1 attachment preference, there is a prosodic break between the NP2 and the RC, whereas other languages that show an NP2 attachment preference have no such prosodic break, and the NP2 and the RC together form a prosodic unit and a predication relation.

In summary, there have been mixed findings in the L2 processing literature with regard to the resolution of RC attachment ambiguity, and Felser et al.'s claim does not seem to account for their own questionnaire data or Dussias' (2003) findings. These contradicting findings across different studies may be due to various confounding factors (e.g., Norman/Saxon genitive, prosody, etc.) inherent in this phenomenon. Therefore, in order to test whether L2 learners truly rely on syntactic information to the same degree as native speakers, it is essential to examine L2 learners' parsing of constructions that show clear *structural* effects.

In the present study, we examined L2 processing of the RCs that were originally used in Experiment 3 of Traxler, Morris & Seely (2002), as these stimuli allow us to make clear predictions about the use of structural and lexical information. Traxler et al. (2002) examined English native speakers' eye-movement in processing subject relative (SR) and object relative (OR) clauses, where animacy of the first and second noun is manipulated, as shown in (3):

(3) a. *Animate-Inanimate SR*
The musician that witnessed the accident angered the policeman a lot.
b. *Animate-Inanimate OR*
The musician that the accident terrified angered the policeman a lot.
c. *Inanimate-Animate SR*
The accident that terrified the musician angered the policeman a lot.
d. *Inanimate-Animate OR*
The accident that the musician witnessed angered the policeman a lot.

Traxler et al. found a significantly longer eye gaze at the RC region in (3b) (i.e., *the accident terrified*) than in the corresponding regions of the other three conditions, and there was no significant difference for duration of eye fixation at the relevant region across these three conditions. This pattern of results shows that the subjects experienced considerably more processing difficulties in (3b), whereas the other three conditions were fairly easy to process. Traxler et al. interpreted the results in the following way. Roughly speaking, there are two important stages: First, the parser recognizes an incoming RC as it processes the initial noun and the complementizer *that*. The representation of an SR (3a) and an OR (3b), for instance, is illustrated in (4a) and (4b), respectively:

(4) a. The musician$_i$ [$_{CP}$ OP$_i$ that [$_{IP}$ t_i witnessed the accident…]]
b. The musician$_i$ [$_{CP}$ OP$_i$ that [$_{IP}$ the accident terrified t_i …]]

As (4) shows, in English RCs containing a *that* complementizer, a null operator OP is base-generated in the subject or object position and raises to [Spec, CP] where it is co-indexed with the NP that heads the RC (i.e., *the musician*). In sentence processing research, the trace left behind as a result of movement is called a *gap*, and the constituent that is moved is called a *filler*. Assuming that the parser is informed by syntactic knowledge of English RCs, the parser projects a null operator in the [Spec, CP] position as soon as it detects the presence of an RC. Upon encountering a filler, the parser uses a strategy called the Active Filler Strategy (AFS: Frazier, 1987b; Frazier & Flores d'Arcais, 1989; Stowe, 1986) and tries to associate the filler with the earliest gap in order to minimize the durational time over which the constituent needs to be stored in short-term memory. In RCs, the first potential gap position is the subject position (as in (4a)), and therefore the parser assigns the filler to this position and analyzes it as the subject of the RC, even before any lexical item in the IP is processed. Although this initial analysis happens to be correct in the case of SRs as in (3a) and (3c), in ORs as in (3b) and (3d),

this turns out to be incorrect since the subject position is occupied by the true subject of the RCs (i.e., *the accident* in (3b), *the musician* in (3d)). Hence, for ORs the parser needs to reanalyze the OP as the object of the RC, and this process of reanalysis causes processing difficulty. This accounts for the general processing difficulty widely observed in processing ORs as opposed to SRs (e.g., Ford, 1983; Gibson, 1998; King & Just, 1991).

However, as the results show, processing (3d) is easier than (3b) even though they both contain ORs and are structurally identical. Crucially, the only difference between (3b) and (3d) is the animacy of the first noun: Generally speaking, subjects tend to have an Agent theta role rather than Theme or Patient, and hence animate nouns (good thematic Agent) are more likely to be subjects than inanimate nouns (poor thematic Agent: Trueswell, Tanenhaus & Garnsay, 1994). Therefore, Traxler et al. claimed that the incorrect initial analysis in the case of ORs is easy to abandon when the subject is a poor thematic Agent as in (3d). In another words, the use of lexical information facilitates reanalysis in ORs when the sentential subject is inanimate.[6]

In sum, we see that an English native speaker's parser uses syntactic information as well as lexical information such as animacy in processing sentences in (3). Crucially, the AFS-driven parsing of RCs is based on the syntactic information of English RCs, and the facilitation of reanalysis in (3d) results from the lexical information of animacy. As processing of these sentences involve such an interaction of syntactic and lexical information, we can test the use of syntactic and lexical information in L2 sentence processing by comparing the performance by native speakers and L2 learners. The next section illustrates the three predictions based on the stimuli from Traxler et al. (2002), and reports the experimental method and the results of the study.

3. Experiment

This experiment employed the sentence complexity rating task in order to investigate whether the L2 learners of English rely on syntactic and lexical information in the same way as the English native speakers do. In this task, subjects were asked to read the four types of RCs exemplified in (3) and rate their complexity.

There are two reasons for choosing this task: First, the complexity rating reflects the maximum intuitive complexity incurred during sentence processing. Since the RC region contains an unbounded dependency which increases syntactic complexity (e.g., Gibson, 1998), the rating is therefore likely to reflect the parsing processes in the RC region, which is the critical region where we expect an interaction of syntactic and lexical information. Second, despite being an offline task, the task gives us a good estimate of what happens in online processing, since findings in the sentence complexity rating task are often replicated in online processing experiments (e.g., Warren & Gibson, 2002).

3.1. Predictions

There are three possibilities with respect to the use of syntactic and lexical information.[7] Let us consider each prediction in turn.

(5) **Prediction 1: Syntactic information only**

If L2 learners use only syntactic information in parsing the RCs in (3), L2 learners will process SRs (3a) and (3c) more easily than ORs (3b) and (3d).

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[6] Traxler et al. (2002) argue that other theories of RC processing, such as memory-based accounts (e.g., Gibson, 1998; Gordon, Hendrick & Johnson, 2001) or a perspective-shifting account (MacWhinney & Pleh, 1988) cannot account for these results (see Traxler et al. for a detailed discussion).

[7] The fourth logical possibility is that L2 learners do not use either syntactic or lexical information, but this possibility is not considered here since it is hard to predict how this would be reflected in the present experiment. One might argue that this would predict no difference between the four conditions, but such null results could be a consequence of some flaw in the experimental procedure.

The first possibility is exactly the opposite of Felser et al.'s claim that L2 learners under-use syntactic information but are able to use lexical information to the same extent as native speakers do. Under this prediction, the parser initially analyzes the null operator co-indexed with the head noun as the subject of the RC due to AFS. SRs (3a) and (3c) would be both equally easy to process because this initial analysis by AFS happens to be correct, whereas ORs (3b) and (3d) would be difficult since the initial misanalysis induces reanalysis of the parse.[8] However, there is no facilitation of reanalysis in (3d) as lexical information is unavailable, and therefore (3d) will be as difficult as (3b).

(6) **Prediction 2: Lexical information only**

If L2 learners use only lexical information in parsing the RCs in (3), L2 learners will process RCs with an animate external argument (3a) and (3d) more easily than RCs with an inanimate external argument (3b) and (3c).

This prediction is compatible with Felser et al.'s (2003) claim, and under this prediction the difference in structure type (i.e., SR versus OR) would not be associated with any processing difficulty. Instead, the parser should be sensitive to the difference in animacy of the first and second nouns in the sentences in (3). As noted before, animate nouns are good thematic Agents and therefore likely to be subjects, in contrast to inanimate nouns which are poor Agents. Therefore, for a parser that relies exclusively on lexical information, it is predicted that (3a) and (3d) will be easy to process since the verb in the RC region (i.e., *witnessed*) has an animate external argument, *the musician*. On the other hand, the verb *terrified* in the RC region of (3b) and (3c) has an inanimate external argument, *the accident*, and therefore processing (3b) and (3c) is predicted to be more costly than processing (3a) and (3d)[9]. Since the animacy of the external argument is the only variable predicted to affect the processing of experimental sentences, no difference in processing difficulty is expected between (3a) and (3d) as well as between (3b) and (3c).

(7) **Prediction 3: Syntactic and Lexical information**

If L2 learners use both syntactic and lexical information in parsing the RCs in (3), L2 learners will process SRs (3a) and (3c) as well as an OR with an inanimate subject (3d) more easily than an OR with an animate subject (3b).

This prediction is based on the findings in Traxler et al. (2002). First, the parser analyzes the first noun as the subject of the RC due to AFS, which is a correct analysis for SRs (3a) and (3c), so these sentences should be easy to process. This is also expected under prediction 1, but prediction 3 crucially differs from prediction 1 in that the reanalysis induced in the OR in (3d) is facilitated by the lexical information of the sentential subject, as the inanimate subject is a poor Agent and therefore this

[8] Two caveats are in order here: First, this prediction relies on the assumption that L2 learners of English can in fact apply AFS in processing RCs, but nothing ensures that the subjects in our study can. Moreover, the L1 of our subjects is Japanese, which does not have obligatory *wh*-movement, so one might wonder if their parser is equipped with a parsing strategy that applies to English-type *wh*-constructions. However, Miyamoto & Takahashi (2003) and Aoshima, Phillips & Weinberg (2003) showed that even in a *wh*-in-situ language like Japanese, the parser does use AFS in processing scrambled *wh*-word and tries to complete the *wh*-dependency between the *wh*-word and the question particle at the earliest point. Thus, it is not the case that their parser does not have the AFS itself. With respect to the status of AFS in L2 processing, Williams, Möbius & Kim (2001) showed that Korean, Chinese & German learners of English all showed filled-gap effects, i.e., garden-path effects due to AFS. Thus, it seems that advanced L2 learners do seem to apply AFS in processing filler-gap dependencies, so we will assume here that our advanced L2 learners are also capable of using AFS. As we will see, the pattern of results in our experiment does seem to indicate that this is in fact the case.

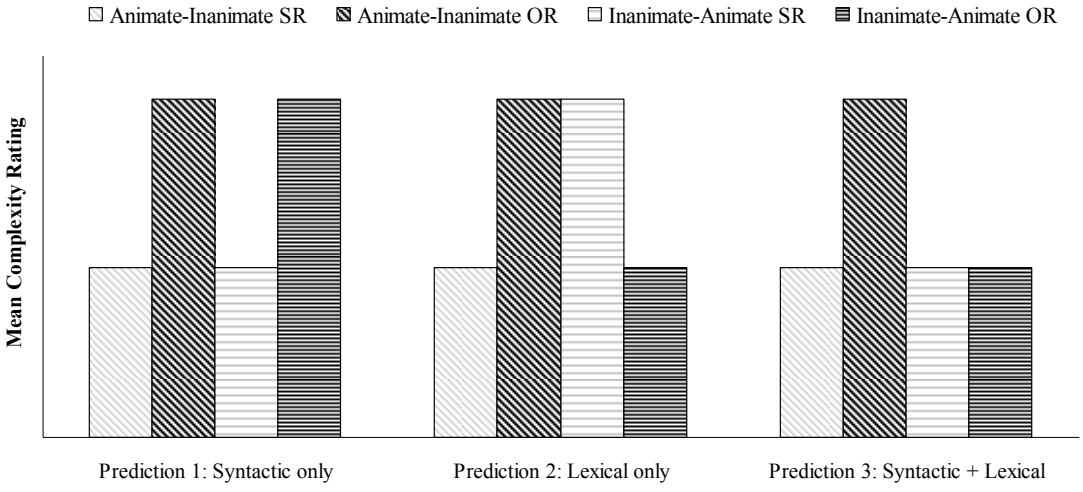
The second caveat is that the prediction 1 also assumes that these learners do have target-like grammatical knowledge of English RCs, despite the fact that the RCs in their L1 do not involve operator movement (e.g., Hoji, 1985). No independent measure of their grammatical knowledge is reported in this paper, but again, the results of the study seem to suggest that they do have target-like knowledge of English RCs (cf. Hawkins & Chan, 1997).

[9] Note that the animacy of the external arguments of the verbs in the RCs should not be confused with the animacy of the external arguments of the matrix verbs.

misanalysis is easy to abandon. On the other hand, there is no lexical information that aids the reanalysis in (3b), and hence this will be more difficult than (3d). Since the reanalysis induced in the processing of (3d) is not costly, it is expected that (3a), (3c) and (3d) are all equally easy to process.

The patterns of results associated with each prediction in the present study are summarized in Figure 1 below. As Figure 1 shows, these three predictions lead to clearly different patterns of results and thus allow us to examine precisely what kind of information is available for the L2 parser.

Figure 1. Predictions for the sentence complexity rating task



3.2. Method

3.2.1. Participants

Two groups of Advanced Japanese-speaking learners of English and a native speaker control group (n =16) participated in the present study. The first L2 group consists of 44 advanced Japanese-speaking learners of English who are studying at Sophia University in Tokyo, Japan. These students were in either the Department of English Language and Studies or the Department of Comparative Culture where a majority of the courses are taught in English. All of the subjects in this group had relatively high TOEFL scores, ranging from 550 to 613. However, even though these subjects appear to be quite proficient, their use of English in daily life is still limited in comparison to Japanese, and the dominance of Japanese could potentially affect their L2 processing behaviors in an unpredicted way (see discussions in Fernández, 2000). For this reason, we conducted the same experiment with another L2 group which consists of 24 advanced Japanese-speaking learners of English in graduate programs at the University of Hawai'i at Mānoa. These learners are (apparently) 'immersed' in an English-speaking environment both in and out of school; thus it is reasonable to assume that they use English to a much greater extent than the subjects in the first L2 group. All subjects in the second group also had high TOEFL scores, ranging from 580 to 627.[10]

All subjects were paid $4 for their participation and were naive to the purpose of the experiment.

3.2.2. Materials

Twenty experimental sentences with RCs of the types shown above in (3) were selected from the stimuli used in Experiment 3 of Traxler et al. (2002).[11] Each item consisted of a subject-modifying RC,

[10] The smaller range in the TOEFL scores of the second group suggests that the second group may be more homogeneous in terms of proficiency.

[11] Traxler et al. (2002) had 28 experimental sentences, but we selected 20 of the sentences that seemed to contain lexical items that would be familiar to L2 learners.

and four conditions were created for each item by systematically changing the RC type (SR versus OR) and the animacy of the first and second noun (Animate-Inanimate order or Inanimate-Animate order). Half of the materials consisted of SRs as in (3a) and (3c) and the other half ORs as in (3b) and (3d), and two conditions had an animate sentential subject and an inanimate noun within the RC as in (3a) and (3b), whereas the other two conditions had an inanimate sentential subject and an animate noun inside the RC, as in (3c) and (3d). These sentences in the four conditions contained the same lexical items, such that they were matched for the length and frequency across conditions. All experimental stimuli used in this experiment are presented in the Appendix.

These 20 sentences were counter-balanced using the Latin Square design and assigned to one of four lists so that each subjects did not see more than one condition of each sentence. Each list also contained 84 fillers that were unrelated to the purpose of the present study. All items were pseudo-randomized within each list.

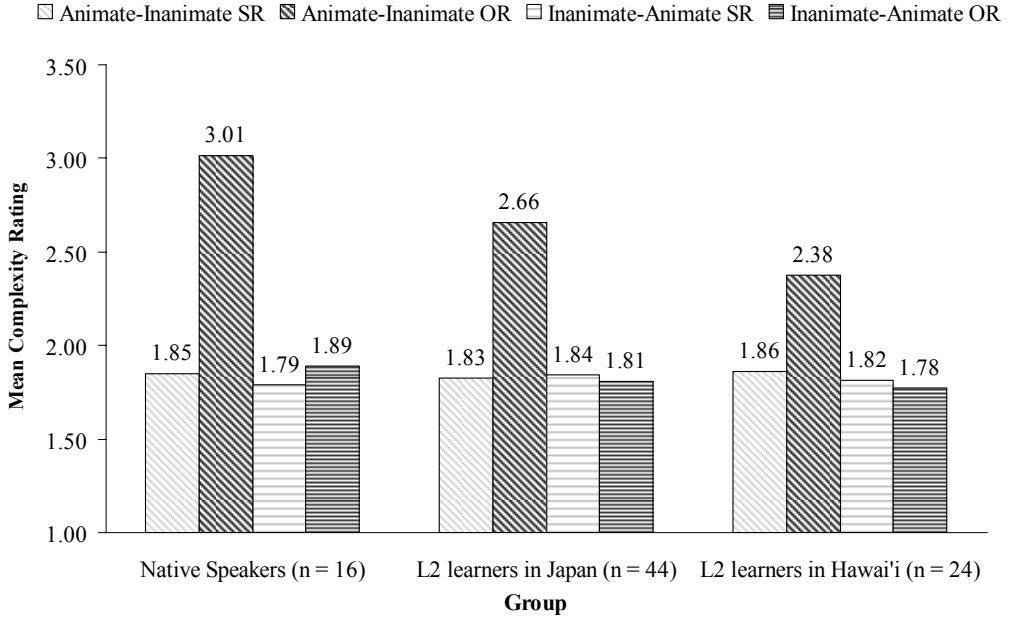
3.2.3. Procedure

Participants were asked to rate the complexity of the English sentences using a 5-point scale, 1 being "easy to understand" and 5 being "hard to understand." The first page of the questionnaire contained instructions stating that the subjects should make judgments based on their first impression when they read the sentences, and they were told not to read a sentence more than once. On the same page, they were given six examples with suggested ratings in order to ensure subjects' understanding of the task. None of the examples contained the experimental sentences. After the examples were given, it was emphasized that individuals vary in their judgments and that they should be confident in their answers. At the end of the task, they were given a language background questionnaire to complete.

3.3. Results

The mean complexity ratings of the experimental sentences by each group are graphically summarized in Figure 2:

Figure 2. **The results of the sentence complexity rating task**



Repeated measures ANOVAs with RC type (SR versus OR) and animacy of the first noun (animate versus inanimate) as within-group factors show that exactly the same pattern of results was obtained in each group.[12] First, the data from the native speaker control group showed, in both subject analysis and item analysis, main effects of RC type [OR greater than SR: $F1$ (1, 15) = 68.823, $p < .001$, MS = 5.641; $F2$ (1, 19) = 24.514, $p < .001$, MS = 7.051] as well as animacy [animate greater than inanimate: $F1$ (1, 15) = 25.886, $p < .001$, MS = 6.376; $F2$ (1, 19) = 51.837, $p < .001$, MS = 7.970] and interaction of RC type and animacy [$F1$ (1, 15) = 50.012, $p < .001$, MS = 4.516; $F2$ (1, 19) = 21.201, $p < .001$, MS = 5.645]. Second, the data from L2 learners in Japan also produced main effects of RC type [OR greater than SR: $F1$ (1, 43) = 58.816, $p < .001$, MS = 7.695; $F2$ (1, 19) = 27.046, $p < .001$, MS = 3.498], animacy [animate greater than inanimate: $F1$ (1, 43) = 45.590, $p < .001$, MS = 7.040; $F2$ (1, 19) = 28.816, $p < .001$, MS = 3.200], and interaction [$F1$ (1, 43) = 52.850, $p < .001$, MS = 8.205; $F2$ (1, 19) = 30.163, $p < .001$, MS = 3.729]. Finally, the data from the L2 group in Hawai‘i similarly produced main effects of RC type [OR greater than SR: $F1$ (1, 23) = 15.962, $p < .001$, MS = 2.470; $F2$ (1, 19) = 13.992, $p < .001$, MS = 2.059], animacy [animate greater than inanimate: $F1$ (1, 23) = 10.255, $p < .005$, MS = 1.354; $F2$ (1, 19) = 6.216, $p < .05$, MS = 1.128] and interaction of RC type and animacy [$F1$ (1, 23) = 14.735, $p < .001$, MS = 1.870; $F2$ (1, 19) = 7.125, $p < .05$, MS = 1.559]. The interaction of RC type and animacy observed in all groups indicates that subjects in each group rated Animate-Inanimate OR (3b) as more complex than the other three conditions. No significant difference was observed between the two SR conditions, (3a) and (3c), or between the two inanimate conditions, (3c) and (3d) [both $F < 1$]. These results are fully compatible with the prediction 3, which is based on both syntactic and lexical information.

One might notice that there is a numerical difference in the rating of (3b) across groups, which seems to suggest that the L2 learners in Japan look more native-like than L2 learners in Hawai‘i. However, such numerical differences between the two L2 groups may be caused by the difference in the number of subjects, so this should not be taken as evidence that the L2 learners in Japan performed ‘better’ than those in Hawai‘i. Alternatively, one might infer that L2 learners were not as sensitive to syntactic and lexical information as native speakers, given the numerical differences between, on the one hand, the native speaker group and, on the other, the two L2 groups. However, this inference is not warranted either, since it could be the case that native speakers are simply more confident in their judgments than L2 learners and thus fully use the 5-point scale (Amy J. Schafer, personal communication, March 2004). Also, if one were to take the differences in ratings across groups as reflecting the differences in the magnitude of processing difficulty, then this would mean that native speakers experienced *more* processing difficulty than L2 learners, which is very implausible. Therefore, the numerical differences between groups are not important: What is crucial is that all groups showed a pattern of results that is expected under prediction 3, that is, syntactic as well as lexical information is available to the parser.

4. Discussion

The results of the sentence complexity rating task support prediction 3, indicating that (a) both native speakers and L2 learners parsed the RCs in (3) by initially analyzing the first noun as the subject of the RC due to the syntactic knowledge of English RCs and AFS, and (b) the reanalysis induced in (3d) was facilitated by the use of animacy information. These findings are compatible with the eye-tracking data reported in Traxler et al. (2002), and the fact that the pattern of results found in the L2 learners’ performance is identical to that of native speakers’ shows that L2 learners are indeed as sensitive to syntactic and lexical information as native speakers, in contrast to Felser et al.’s claim.

[12] We did not examine between-group differences here, since this is meaningless for two reasons: First, the important point is the contrast between (3b) and other three conditions, and as long as the same pattern is observed in both native speakers and L2 learners, we can claim that L2 learners are as sensitive to syntactic and lexical information as native speakers are. Second, even if one finds a significant difference in the ratings across groups, it is not clear what the difference arises from. As discussed in the results section, it could merely be the case that native speakers are simply more confident than L2 learners in their judgments.

Assuming our results are valid, what then accounts for the mixed findings in the previous questionnaire studies on L2 RC attachment preference? As previously pointed out, the resolution of RC attachment is influenced by various factors, such as the presence of alternative genitive construction, prosody, etc., so it is likely that one of these factors, or potentially an interaction of these various factors, complicates L2 learners' ambiguity resolution.[13] It is thus necessary to design an experiment that singles out each of these factors and to examine how L2 learners react.[14] Another possible explanation for the mixed findings may be the proficiency of the subjects: Irrespective of what kind of information the parser has access to, low proficiency learners will have general processing difficulties in overall comprehension processes. For example, Perani et al. (1998) conducted a series of fMRI studies and showed that only high proficient L2 learners had brain cortical activation in the same area as native speakers. In this way, proficiency could easily mask the real properties of the L2 parser (for review see Abutalebi, Cappa & Perani, 2001).

It is important to note that, in contrast to the mixed findings in the questionnaire studies, none of the previous online self-paced reading experiments with L2 learners has found a clear RC attachment preference (Dussias, 2003; Felser et al., 2003; Papadopoulou & Clahsen, 2003). This may indicate that L2 learners have general processing difficulties under the time pressure of online processing, such that they fail to use various types of information (including syntactic information).[15] In a similar vein, Hahne (2001) reported that highly proficient L2 learners did not show an ERP pattern called early anterior negativity, which is considered to reflect an automatic, first-pass syntactic parsing, even though they were able to show an ERP pattern called P600, which is associated with late syntactic processes (e.g., Hahne & Friederici, 1999). Despite the fact that the present study indicated that the L2 parser uses syntactic information in its first-pass parsing, this pattern of results may not be retained if we were to examine the same phenomenon in online processing. In order to investigate this question, a self-paced reading study with the same materials and the same participants is currently under way (Omaki & Ariji, in progress).[16]

Finally, we should ask what our findings tell us about L2 acquisition of syntax. Certainly it brings us good news that the parser is able to use syntactic information to analyze the target language input, which will in turn contribute to the acquisition of the target grammar. However, since the subjects in our study were quite proficient, it is an open question whether the L2 parser is able to use syntactic information at earlier stages of L2 acquisition.[17] We are currently planning to investigate whether lower proficiency learners of English would behave in the same way as the advanced learners in the present study.

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[13] With respect to the influence of the Saxon/Norman genitive constructions on L2 learners' RC attachment preferences, it is possible that the syntactic knowledge of genitive constructions in their L1 affects the application of Gricean maxim of "Avoid Ambiguity." For example, German also has two types of genitive expressions (see footnote 2) but both of them allow modifications by a following RC. Thus, if German-speaking learners of English transfer this property of L1, then the Gricean maxim would not be applicable in their L2 since they would consider that the Saxon genitive is as ambiguous as the Norman genitive.

[14] In an on-going study, Hwang (2004) investigated the resolution of RC attachment ambiguity in both comprehension and production by advanced Korean-speaking learners of English. The preliminary results indicate that at least some of the L2 learners seem to be influenced by the prosody they project upon processing this construction.

[15] Felser et al. (2003) rejected the possibility that the lack of clear RC attachment preferences in online self-paced reading experiments is due to the processing difficulties under time pressure, since their own subjects failed to show any clear RC attachment preference in an offline questionnaire task as well. However, the questionnaire study by Dussias (2003) and our present findings show that L2 learners are able to use syntactic information in offline processing.

[16] One interesting implication of the current study is that the L2 parser uses syntactic and lexical information at different stages, which has not been addressed in previous L2 processing research. However, in order to confirm this, we need a solid measure of reanalysis, such as eye regression as measured in eye-tracking studies. Therefore, it would be interesting to conduct a true replication of Traxler et al.'s study using an eye-tracker.

[17] See Friederici, Steinhauer & Pfeifer (2002) for a report that subjects who learned an artificial language started to produce P600 after several training sessions.

5. Conclusion

In this study, we investigated advanced L2 learners' processing of RCs and found that L2 learners do in fact use both syntactic and lexical information during L2 sentence processing. This finding constitutes counter-evidence to Felser et al.'s claim that the L2 learners are less sensitive to syntactic information than native speakers are, and rather indicates that the L2 parser behaves very similarly to the L1 parser with respect to the use of syntactic and lexical information.

Appendix

The following 20 sets of materials were selected from stimuli used in Experiment 3 of Traxler et al. (2002).

1a/1b The musician that witnessed the accident/the accident terrified angered the policeman a lot.
1c/1d The accident that terrified the musician/the musician witnessed angered the policeman a lot.

2a/2b The contestant that misplaced the prize/the prize delighted made a big impression on Mary.
2c/2d The prize that delighted the contestant/the contestant misplaced made a big impression on Mary.

3a/3b The cowboy that carried the pistol/the pistol injured was known to be unreliable.
3c/3d The pistol that injured the cowboy/the cowboy carried was known to be unreliable.

4a/4b The scientist that studied the climate/the climate annoyed did not interest the reporter.
4c/4d The climate that annoyed the scientist/the scientist studied did not interest the reporter.

5a/5b The director that watched the movie/the movie pleased received a prize at the film festival.
5c/5d The movie that pleased the director/the director watched received a prize at the film festival.

6a/6b The student that attended the school/the school educated was visited by the governor.
6c/6d The school that educated the student/the student attended was visited by the governor.

7a/7b The teacher that watched the play/the play angered upset a few of the students.
7c/7d The play that angered the teacher/the teacher watched upset a few of the students.

8a/8b The woman that reported the accident/the accident bothered caused a number of serious injuries.
8c/8d The accident that bothered the woman/the woman reported caused a number of serious injuries.

9a/9b The banker that refused the loan/the loan worried created a problem for the mayor.
9c/9d The loan that worried the banker/the banker refused created a problem for the mayor.

10a/10b The lawyer that reviewed the trial/the trial confused was covered by the national media.
10c/10d The trial that confused the lawyer/the lawyer reviewed was covered by the national media.

11a/11b The psychologist that printed the notes/the notes annoyed got lost somewhere in the basement.
11c/11d The notes that annoyed the psychologist/the psychologist printed got lost somewhere in the basement.

12a/12b The child that loaded the revolver/the revolver scared injured the teenage babysitter.
12c/12d The revolver that scared the child/the child loaded injured the teenage babysitter.

13a/13b The golfer that mastered the game/the game excited was ignored by most sportswriters.
13c/13d The game that excited the golfer/the golfer mastered was ignored by most sportswriters.

14a/14b The salesman that examined the product/the product excited was mentioned in the newsletter.
14c/14d The product that excited the salesman/the salesman examined was mentioned in the newsletter.

15a/15b The fireman that fought the fire/the fire burned caused only a small amount of damage.
15c/15d The fire that burned the fireman/the fireman fought caused only a small amount of damage.

16a/16b The farmer that purchased the tractor/the tractor impressed arrived at the store late last night.
16c/16d The tractor that impressed the farmer/the farmer purchased arrived at the store late last night.

17a/17b The gardener that trimmed the plants/the plants pleased helped make the house more attractive.
17c/17d The plants that pleased the gardener/the gardener trimmed helped make the house more attractive.

18a/18b The actor that rehearsed the play/the play delighted was given first prize at the awards dinner.
18c/18d The play that delighted the actor/the actor rehearsed was given first prize at the awards dinner.

19a/19b The student that practiced the instrument/the instrument frustrated had been around for a few months.
19c/19d The instrument that frustrated the student/the student practiced had been around for a few months.

20a/20b The journalist that composed the article/the article bothered caused a big scandal.
20c/20d The article that bothered the journalist/the journalist composed caused a big scandal.

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