Verb Bias and Plausibility in L2 Sentence Processing

Zhiying Qian, Eun-Kyung Lee, Dora Hsin-yi Lu, and Susan Garnsey

Verbs differ in the type of complements that they can take. Consider (1),

(1) The scientist read the article...
   (a) .................................................at lunch time.
   (b) .................................................had been published two months ago.

The syntactic role of the article is temporarily ambiguous. The sentence proceeds with the article having the direct object role in (1a) but having the role of subject of the embedded clause in (1b). Such direct object/sentential complement (DO/SC) ambiguity at the article arises because English allows the complementizer that to be dropped before an embedded clause. Readers typically slow down at reading the first verb in the embedded clause (had in 1b), because they have initially interpreted the article as the direct object of the main clause verb read, and have to revise such analysis at the disambiguating verb had.

In English, sentences with DO/SC temporary ambiguity like (1b) can be disambiguated by adding the complementizer that after the main clause verb, as shown in (2). The use of the complementizer that is optional in English in this type of structure.

(2) The scientist read that the article had been published two months ago.

Another cue that can be used to avoid garden-pathing in sentences like (1b) is verb bias, i.e., the frequency with which a particular verb takes a particular structure. Previous research has found that verb bias influences the garden-path effect (e.g., Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Osterhout, Holcomb, & Swinney, 1994; Pickering, Traxler, & Crocker, 2000; Trueswell & Kim, 1998; Trueswell, Tanenhaus, & Garnsey, 1994; Trueswell, Tanenhaus, & Kello, 1993). In particular, studies have shown that native speakers of English make rapid use of a verb’s DO/SC bias (i.e., the tendency that a verb is more likely to take direct object or sentential complement) to predict the upcoming syntactic structure (Garnsey et al., 1997; Trueswell & Kim, 1998; Wilson &

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Garnsey, 2009). For instance, in (3) and (4), since understand biases towards taking direct objects (DO-bias verb) and admit biases towards sentential complements (SC-bias verb), the parser anticipates a direct object after understood in (3) and an embedded clause after admitted in (4). Thus, readers slow down more at the underlying disambiguating region in (3) than in (4) when the sentences unfold into embedded clauses. One way to reveal garden-pathing is the reading time at the disambiguating region. Longer reading time indicates that the parser has initially committed more to the direct object analysis at the position of the ambiguous noun.

(3) The club members understood the bylaws would be applied to everyone.
(4) The ticket agent admitted the mistake might be hard to correct.

In addition to verb bias and the complementizer that, another cue that native English speakers have been found to rely on to avoid garden-pathing is plausibility (Garnsey et al., 1997; Trueswell, 1996). Garnsey et al. (1997) manipulated the structural biases of the main clause verbs (DO-bias, Equi-bias, and SC-bias) and the plausibility of the ambiguous noun as the direct object of the preceding verb (The club members understood the bylaws…vs. The club members understood the pool…). Equi-bias verbs were those that were used equally often with DO and SC structures (e.g., declare). When verbs did not bias toward either type of continuation, reading time at the disambiguating verb was affected by plausibility. Reading times were faster when the ambiguous noun was implausible as the direct object than when it was plausible, suggesting that the parser committed less to the direct object analysis when such analysis was implausible, leading to the relative ease of recovery at the disambiguating verb. However, when the verb biased towards either direct object or embedded clause, the plausibility manipulation did not show any effect, indicating that plausibility did not have a chance to influence parsing in the presence of verb bias. This effect has also been found in sentences with main clause/reduced relative clause ambiguity, in which the plausibility information appears earlier than verb bias, as in The room searched by the police contained the missing weapon (Trueswell, 1996).

These studies revealed that for native English speakers, verb bias plays a larger role than plausibility in predicting the upcoming syntactic structure. What about in L2 sentence processing? Since verb bias is implicit knowledge that is probably hard to be taught in the classroom, but instead can only be acquired through substantial exposure to the target language, whether L2 learners are able to learn verb bias and use it fast enough to guide on-line parsing in the way that native speakers do has attracted some attention in the L2 psycholinguistic literature. A prevailing view claims that L2 learners underuse syntactic information and to compensate that, they rely heavily on lexical-semantic cues such as plausibility (i.e., the Shallow Structure Hypothesis; Clahsen & Felser, 2006). However, what has not been considered on this view is L2 learners’ use of the frequency information about verbs’ subcategorization preference. On the
one hand, verb bias is lexically-associated information that is stored in the lexicon and retrieved when words are recognized. Such information might be considered to be part of the lexical information the Shallow Structure Hypothesis claims that L2 learners rely on. On the other hand, verb bias is about structure, so L2 learners may not use it to the extent that native speakers do. Several studies on L2 learners’ use of verb bias information thus far have revealed that L2 learners are able to learn verb bias that is specific to the L2, and use it fast enough to guide on-line processing (Dussias & Cramer Scaltz, 2008; Frenck-Mestre & Pynte, 1997), even if such information cannot be used in the same way in their L1 because the L1 and L2 use different word orders (Lee, Lu, & Garnsey, 2013).

In a verb bias norming task on English verbs, Dussias and Cramer Scaltz (2008) found that advanced L1-Spanish learners of L2-English were able to learn the biases for English verbs when they conflicted with the biases of Spanish verbs with similar meanings. L2 learners also showed native-like pattern in a self-paced reading paradigm in English, experiencing processing difficulty when the sentence continuation was incongruent with the verb’s bias. Similarly, in Frenck-Mestre and Pynte (1997), L1-English L2-French speakers learned the argument structures (ditransitive vs monotransitive) for French verbs, even when such properties conflicted with their L1 English.

Lee et al. (2013) investigated whether L2 learners were able to learn L2-specific verb bias information if such information was not useful in the same way in their L1. Korean is an SOV language that places verbs at the ends of clauses, and unlike in English, where the complementizer that is optional, a clause-final complementizer particle ko is obligatory. Thus, L1-Korean speakers do not have L1 experience with predicting the upcoming structure based on either verb bias or the complementizer, but they do have experience with an end-of-clause complementizer that is a perfect cue to an embedded clause. In Lee et al., lower- and higher-proficiency groups of L1-Korean L2-English learners read DO/SC ambiguous sentences that manipulated verb bias (DO-bias vs SC-bias) and the presence of the complementizer that. Results showed that lower proficiency L2-learners needed both cues to be present to derive any benefit, while higher proficiency learners were able to derive benefit from each of the cues separately. In addition, the higher proficiency learners were able to combine the cues to some extent, since they gained more benefit from the presence of the complementizer when the verb was DO-biased than when it was SC-biased, but they did not achieve the optimally efficient interactive pattern seen in the native English speakers, for whom either cue alone was entirely sufficient. So, L1-Korean learners of L2-English proved to be able to learn to associate structural biases with verbs in English in spite of the fact that they had no L1 experience with predicting the upcoming structure based on verb bias, and in spite of the fact that in Korean the complementizer is a completely reliable cue while verb bias is less reliable.

The fact that the higher proficiency L1-Korean learners did not achieve the optimal native pattern might well be true for any L2 learners, regardless of the
properties of their L1, simply because they don’t have as much experience as native English speakers. Alternatively, however, it is possible that the fact that verb bias is not available early enough in the sentence to base predictions on in Korean is responsible for the failure to achieve the native pattern, making it important to test L2-English learners whose L1 has a word order placing verbs earlier in the sentence. Mandarin differs from Korean and is similar to English in two important respects. First, Mandarin places verbs early in the sentence, with the same SVO order as English, thus allowing verb bias to be used to develop expectations about the upcoming structure. Second, Mandarin has no complementizer in sentences with verbs taking embedded clause structure, although DO/SC ambiguity can be disambiguated by adding an optional comma after the main clause verb (e.g., 那个售票员承认，错误还没被发现。The ticket agent admitted “that” the mistake had not been caught.). However, the optional comma is used less often in Mandarin than the optional that is in English.

These differences between Korean and Mandarin suggest that L1-Mandarin learners of L2-English might use verb bias and complementizer cues differently from L1-Korean learners. L1-Mandarin learners may find it easier to learn and use the biases of English verbs earlier. As for their ability to use the complementizer that, it is not clear what to predict. Given that they have experience with similar but much less frequent usage of commas, it may be easy for them to learn to rely on the complementizer when it is present. Alternatively, though, the fact that the English cue is a separate word, and furthermore one that has many other usages besides a complementizer (pronoun, demonstrative, relative pronoun,…) may make it a difficult cue for Mandarin-L1 learners to learn to rely on. The present study aims to test these predictions.

As described earlier, native English speakers are more influenced by verb bias than by the plausibility of the temporarily ambiguous noun as the direct object of the preceding verb (Garnsey et al. 1997; Trueswell, 1996). It is possible that the same would not be true for L2 learners because L2 learners have been argued to rely heavily on lexical-semantic information rather than structure. The evidence supporting that argument has come primarily from studies of relative clause attachment ambiguity (Papadopoulou, 2005; Papadopoulou & Clahsen, 2003) and filler-gap dependencies (Dussias & Pinar, 2010; Felser & Roberts, 2007; Williams, Möbius, & Kim, 2001).

With respect to L2-English learners’ processing of DO/SC ambiguous sentences, it is not obvious what to predict about the relative contributions of verb bias and plausibility. Verb bias is lexically specific information about what structures a verb is most likely to appear in. Should that be considered syntactic information that L2 learners might have trouble with, or should it be considered lexical-semantic information that would be easy to use? A verb’s meaning certainly contributes a great deal to its structural biases, but the differences in biases found by Dussias et al. (2010) for English and Spanish verbs with very similar meanings shows that meaning cannot be the only determinant. Lee at al. (2013) has already shown that L1-Korean learners of L2-English did learn to
make use of verb bias in such sentences. However, they did not also consider the role that plausibility might play. In the present study, verb bias and plausibility are both manipulated and pitted against each other to examine the relative importance of plausibility and verb bias in L2-English sentence processing. Native English speakers rely more heavily on verb bias than plausibility, but the opposite might be true for L2-English learners.

1. Method
1.1. Participants

A control group of 65 native English speakers (34 males, mean age 19, range 18-25) and an L2 group of 70 L1-Mandarin L2-English learners participated in the experiment. All were undergraduate and graduate students at the University of Illinois at Urbana-Champaign, had normal or corrected-to-normal vision, gave written informed consent, and received course credit or payment for taking part.

Table 1. Language background information of the L1-Mandarin L2-English learners. Ranges are shown in parentheses.

<table>
<thead>
<tr>
<th></th>
<th>All Learners</th>
<th>Lower Proficiency Group</th>
<th>Higher Proficiency Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Participants</td>
<td>70</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Age</td>
<td>21 (18-33)</td>
<td>21 (18-25)</td>
<td>21 (18-33)</td>
</tr>
<tr>
<td>Proficiency score</td>
<td>34 (25-40)</td>
<td>31 (25-34)</td>
<td>37 (35-40)</td>
</tr>
<tr>
<td>Age at start of English classroom instruction</td>
<td>10 (3-15)</td>
<td>10 (5-15)</td>
<td>9 (3-13)</td>
</tr>
<tr>
<td>Age at first residence in English-speaking country</td>
<td>19 (13-29)</td>
<td>19 (15-23)</td>
<td>19 (13-29)</td>
</tr>
<tr>
<td>Duration of residence in English-speaking country (months)</td>
<td>27 (1-96)</td>
<td>30 (1-96)</td>
<td>26 (1-93)</td>
</tr>
<tr>
<td>Daily use of English (%)</td>
<td>53 (5-95)</td>
<td>50 (10-85)</td>
<td>56 (5-95)</td>
</tr>
</tbody>
</table>

All L2 learners completed at least their middle school education in Mainland China or Taiwan. None of them lived in the U.S. before the age of 13. Additional language background information is summarized in Table 1. Learners’ proficiency was assessed using a cloze test (i.e., fill-in-the-blanks test) that contained forty blanks (adopted from P. Dussias at Pennsylvania State University, personal communication; see Tremblay, 2011, for validity and reliability of using cloze test to assess L2 proficiency). L2 learners were divided into higher and lower proficiency groups based on median split (lower proficiency group<35; higher proficiency group ≥ 35) to examine whether their ability to use verb bias, plausibility and the complementizer that cue improved as their proficiency increased. The proficiency data from two participants were
lost. Their reading times were excluded from any analyses involving the proficiency factor.

1.2. Materials and Design

Ten DO-bias and ten SC-bias verbs were each used four times to construct 80 sets of sentences, with each set containing four sentences that fully crossed ambiguity and plausibility, as shown in (5). Unambiguous sentences were disambiguated by adding the complementizer that after the main clause verb. In the ambiguous version, the ambiguous noun (e.g., the bylaws) was temporarily ambiguous between being the direct object of the preceding verb (e.g., understood) or the subject of an upcoming embedded clause, whereas in the unambiguous version, such temporary ambiguity was blocked by the presence of that between the verb and the ambiguous noun. All sentences started with a subject noun phrase that contained three words (e.g., the club manager), followed by a main clause verb that was either biased towards taking direct objects or embedded clauses (the bylaws), which were then followed by the disambiguating region that contained the subordinate clause verb and the word immediately following it. Care was taken when selecting the two words for the disambiguating region in each sentence. All disambiguating verbs and the words immediately following them were auxiliary verbs such as were, could, would and had, so that the properties of the disambiguating words did not differ between items with DO-bias and SC-bias verbs. All critical sentences turned out to have the embedded clause structures.

(5) Example stimuli:

**DO-bias verb**

*Plausible:* The club members understood (that) the bylaws would be applied to everyone.  
*Implausible:* The club members understood (that) the pool would be closed on Monday.

**SC-bias verb**

*Plausible:* The ticket agent admitted (that) the mistake might be hard to correct.  
*Implausible:* The ticket agent admitted (that) the kiosk might be difficult to find.

Verbs used in the experiment all met the following criteria: DO-bias verbs were followed at least twice as often by direct object completions as by sentential complement completions in the sentence completion norming task reported in Garnsey et al. (1997), which asked 108 native English speakers to complete 100 sentence fragments that began with a proper name and a verb that could take both direct objects and embedded clauses (e.g., Bill believed…). The reverse was true for SC-bias verbs: there were at least twice as many sentential complement completions as direct object completions generated by participants in the norming task. The ten DO-bias verbs and ten SC-bias verbs used in the present study were matched on the number of letters ($F<1$) and frequency (Francis & Kucera, 1982, $F<1$). Verb properties are summarized in Table 2.
Table 2. Properties of the verbs used in the experiment.

<table>
<thead>
<tr>
<th></th>
<th>DO bias strength (%)</th>
<th>SC bias strength (%)</th>
<th>Mean length</th>
<th>Mean log frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO-verbs</td>
<td>76</td>
<td>13</td>
<td>8.1</td>
<td>1.9</td>
</tr>
<tr>
<td>SC-verbs</td>
<td>17</td>
<td>59</td>
<td>7.9</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Plausible and implausible ambiguous nouns were selected based on the result of a plausibility norming task, which asked 56 native English speakers to rate the plausibility of a sentence in which the noun was the direct object of the verb on a 1 (very implausible) to 7 (very plausible) scale, as shown in (6).

(6) The club members understood the bylaws.
The club members understood the pool.

(7) The club members understood that the bylaws were...
The club members understood that the pool was...

The ambiguous nouns all met the criterion that within any sentence set, the plausible noun was rated at least 2.5 points more plausible than the implausible noun. The properties of the ambiguous nouns are summarized in Table 3. The plausible nouns were rated as significantly more plausible than the implausible ones (6.4 vs 2.1, $F(1,156)=1481$, $p<.001$). Consistent with previous studies reporting that plausibility ratings reflected verbs’ biases, such that nouns tend to be rated as more plausible after a DO-bias verb than after a SC-bias verb (Garnsey et al. 1997), the plausible nouns in sentences with DO-bias verbs were rated slightly more plausible than those in sentences with SC-bias verbs (6.5 vs 6.2, $F(1,78)=5.4$, $p<.05$). In addition, the implausible nouns in sentences with DO-bias verbs were also rated slightly more plausible than those in sentences with SC-bias verbs (2.3 vs 1.9, $F(1,76)=5.4$, $p<.05$), also consistent with previous findings. This raised a possibility that the effects found at the disambiguating region would reflect the combination of the effects from verb bias and plausibility. However, it is unlikely that the small difference in plausibility would have a detectable effect in sentences with strongly biased verbs, given previous findings from studies specifically manipulating plausibility (Garnsey et al. 1997). By mistake, two implausible nouns used in sentences with DO-bias verbs were not rated in the norming study. Plausible nouns in sentences with DO-bias verbs did not differ from those in SC-bias sentences in the number of letters (7.2 vs 7.1, $F<1$) and log frequency (2.9 vs 3.2, $F<1$; from SUBL-EN corpus, Brysbaert & New, 2009). The same was true for implausible nouns (length: 6.1 vs 5.8, $F<1$; log frequency: 3.2 vs 3.0, $F<1$). On average, plausible nouns were about 1 letter shorter than implausible nouns (7.1 vs 6.0, $F(1,79)=11.61$, $p<.01$). If there is any effect of this small difference in length, it could contribute to faster reading times for plausible nouns, but length effects will be removed in the length-corrected residual reading time measure that is submitted to statistical analysis.
A separate norming study that assessed the plausibility of the ambiguous noun as the subject of the embedded clause was conducted with twelve native English speakers, who rated on a 1 (very implausible) to 7 (very plausible) scale the plausibility of sentence fragments such as (7) as the beginning of a sentence. The plausible nouns for DO sentences were rated as equally plausible as the subject of an embedded clause as the plausible nouns for SC sentences (6.1 vs 6.1, \( F<1 \)), and the same was true for the implausible nouns (DO 5.2 vs SC 5.3, \( F<1 \)). Notice that nouns that were implausible as direct objects were also slightly more implausible as embedded clause subjects than were nouns that were plausible as direct objects (5.3 vs 6.1), but this was equally true for both verb types. The properties of the ambiguous nouns are summarized in Table 3.

### Table 3. Properties of the ambiguous nouns.

<table>
<thead>
<tr>
<th></th>
<th>Mean length</th>
<th>Log frequency</th>
<th>Plausibility as the direct object</th>
<th>Plausibility as the clause subject</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO-items</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plausible Noun</td>
<td>7.2</td>
<td>2.9</td>
<td>6.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Implausible Noun</td>
<td>6.1</td>
<td>3.2</td>
<td>2.3</td>
<td>5.2</td>
</tr>
<tr>
<td><strong>SC-items</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plausible Noun</td>
<td>7.1</td>
<td>3.2</td>
<td>6.2</td>
<td>6.1</td>
</tr>
<tr>
<td>Implausible Noun</td>
<td>5.8</td>
<td>3.0</td>
<td>1.9</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Critical sentences were distributed over four lists according to a Latin Square design, so that all participants saw an equal number of trials of each condition and never saw two versions from the same sentence set. A total of eighty distractors was added to each list for a total of 160 trials per list. In twenty distractors, the noun phrase immediately following the main clause verb turned out to be the direct object. The rest of the sixty distractors had various syntactic structures. All sentences were followed by a comprehension question that targeted the content of various parts of the sentences (e.g., *Were the bylaws applied fairly?*). The comprehension questions to critical sentences did not probe the initial misanalysis (e.g., *Did the club members understand the bylaws*?). All sentences were pseudo-randomized once so that no two critical sentences from the same condition appeared consecutively and were presented to all participants in the same order in all lists.

### 1.3. Procedure

Participants sat in a dimly lit and sound-attenuated booth in front of a 23-inch LCD monitor. A total of 160 sentences was presented word by word in white 26-point Arial font on a black background in a non-cumulative moving window self-paced reading paradigm, controlled by the Presentation software package. Each trial began with a trial number that stayed at the left side of the screen for
one second. The participant then pressed a button on a Cedrus-830 response box to read each word successively at their own speed. Each time they pressed the button, the next word appeared and the previous word reverted to the mask character. All sentences were presented on a single line. Following each sentence, a comprehension question was presented and participants pressed yes or no buttons to indicate their answers. Feedback about question response accuracy was given after each trial. A “Too Slow” message was presented when participants did not make a response within four seconds. Sentences were divided into four blocks with forty sentences each, and participants took a break after each block. A practice block of five trials was added at the beginning. The entire experiment took 30-45 minutes to complete.

2. Results
2.1. Comprehension Accuracy

Trials for which participants pressed the yes or no button before the comprehension questions were displayed, and trials for which participants did not make a response within the four second limit were excluded from the analysis of comprehension accuracy. On average, the accuracy rate for native English speakers was 93% and for L1-Mandarin learners of L2-English was 87%. Higher proficiency L2 learners were more accurate than lower proficiency L2 learners (89% vs 85%, p<.01).

2.2. Reading Times

Prior to data analysis, word-by-word reading times that were faster than 100 milliseconds (ms) or slower than 2000 ms were excluded, leading to a loss of 0.6% of the native speakers’ data and 1.4% of the L2 data. To remove individual differences in reading speed, statistical results reported below were based on length-corrected residual reading times computed separately for each participant (Ferreira & Clifton, 1986; Trueswell et al., 1994). In Table 4 below raw reading times at the disambiguating region are reported.

Statistical analyses were performed on the disambiguating region and the ambiguous noun region, since these two regions reflected the parser’s commitment to the initial misanalysis and the ease of recovery from such misanalysis. Reading times at the disambiguating region were obtained by averaging across the reading times of the disambiguating verb (e.g., would) and the word immediately following it (e.g., be) to capture spill-over effects that often occur in self-paced reading experiments. Similarly, reading times at the ambiguous noun region were calculated by averaging across the reading times of the determiner and the head noun (e.g., the bylaws). Reading times in each region were then analyzed using linear mixed-effect models in R (R Development Core Team, 2008). For all analyses, the initial model included a maximal random effects structure that included all fixed effects and interactions among them, random intercepts and random slopes for all fixed effects and their interactions for both subjects and items (Barr, Levy, Scheepers, & Tily, 2013).
The final models reported here were the most complex model that converged. All categorical fixed effects were coded using contrast coding and continuous fixed effects were centered to avoid colinearity. Estimates, standard errors, and $t$-values were reported, with $t>2$ being interpreted as significant.

Table 4. Raw reading times at the disambiguating region.

<table>
<thead>
<tr>
<th></th>
<th>DO-bias verbs</th>
<th>SC-bias verbs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ambig</td>
<td>Unambig</td>
<td>Ambig Effect</td>
</tr>
<tr>
<td>Raw RT (ms)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1-English</td>
<td>364</td>
<td>351</td>
<td>13</td>
</tr>
<tr>
<td>L1-Mandarin</td>
<td>462</td>
<td>431</td>
<td>31</td>
</tr>
</tbody>
</table>

Disambiguating region. Analysis on the residual reading times at the disambiguating region for native speakers revealed a main effect of ambiguity, with ambiguous sentences read more slowly than unambiguous sentences (356 vs 349 ms; $\beta=8$, $SE=3$, $t>2$), and an interaction between verb bias and ambiguity ($\beta=13$, $SE=5$, $t>2$). The interaction resulted because ambiguous sentences were read more slowly than unambiguous sentences only after DO-bias verbs (364 vs 351 ms, $\beta=20$, $SE=7$, $t>2$) but not after SC-bias verbs (348 vs 347 ms; $\beta=2$, $SE=4$, $t<1$), as shown in Figure 1. There was no effect involving the plausibility factor ($ts<1.6$). This is consistent with a previous finding that plausibility of the noun as a direct object had no effect on disambiguation region reading times in native English speakers when verbs were strongly biased (Garnsey et al., 1997). Also replicating previous studies was the pattern that native speakers achieved the optimal pattern of using verb bias and the complementizer that cue interactively, such that either cue was sufficient enough to guide readers away from garden-pathing.

The linear mixed-effect model with maximal random effect structures performed on L1-Mandarin L2-English speakers that included proficiency as a categorical predictor variable (higher proficiency group vs lower proficiency group) revealed the same pattern as native speakers. There was a main effect of ambiguity, with ambiguous sentences being read more slowly than unambiguous sentences (447 vs 425 ms; $\beta=21$, $SE=4$, $t>5$), a main effect of proficiency, with the higher proficiency group reading faster than the lower proficiency group (421 vs 451 ms; $\beta=16$, $SE=5$, $t>3$), and an interaction between verb bias and ambiguity ($\beta=18$, $SE=8$, $t>2$), which was caused by the ambiguous sentences being read more slowly than unambiguous sentences after DO-bias verbs (462 vs 432 ms; $\beta=40$, $SE=9$, $t>4$), but not after SC-bias verbs (433 vs 419 ms; $\beta=13$, $SE=7$, $t<2$), as shown in Figure 1. There was no effect involving the plausibility factor ($ts<2$). Although L2 learners displayed the interaction between verb bias and ambiguity similar to that of native speakers, they did not reach the optimal pattern of combining the two cues. They benefited the most when both verb bias and the complementizer that cue were present, as shown by the fastest reading
time at the disambiguating region in the unambiguous condition of SC-bias items.

![Figure 1](image1.png)

**Figure 1.** Residual reading times at the disambiguating region collapsing over plausibility.

There was a numeric pattern in both the native speakers and the L2 learners’ data that reading times were slower on the disambiguation following a DO-bias verb and an implausible noun, as seen in Figure 2. This tendency was not significant in either language groups ($t$s<1.6), and this effect was hypothesized to be spill over from reading the implausible noun itself.

![Figure 2](image2.png)

**Figure 2.** Ambiguity effect at the disambiguating region. Plausibility effect was not significant in any comparisons.

*Ambiguous noun.* Native English speakers showed a main effect of ambiguity, with unambiguous sentences being read faster than ambiguous sentences (ambiguity effect 20 ms; $\beta=20$, $SE=3$, $t>6$). There were no effects involving plausibility ($t$s<1.2). L1-Mandarin speakers of L2-English showed a main effect of ambiguity (ambiguity effect 25 ms, $\beta=25$, $SE=5$, $t>5$) and an interaction between ambiguity and verb bias ($t>2$), which resulted because there was an
ambiguity effect after SC-bias verbs (ambiguity effect 34 ms; $\beta$=34, $SE$=7, $t$>4) but not after DO-bias verbs ($\beta$=14, $SE$=7, $t$<2). There were no effects involving the proficiency or plausibility factors ($t$s<2). The ambiguity effect at the ambiguous noun region is plotted in Figure 3.

**Figure 3.** Ambiguity effect at the ambiguous noun region.

### 3. Discussion

The present study manipulated the plausibility of the ambiguous noun as the direct object of the main clause verb together with the structural biases of the verbs and complementizer presence to examine the relative importance of plausibility, verb bias, and complementizer cues in the processing of English DO/SC sentences by native speakers and L1-Mandarin learners of L2 English. The comparison of plausibility effects between native and L2 speakers was of particular interest, given proposals that L2 learners tend to rely more heavily on plausibility than on other more syntactic cues in L2 sentence processing (e.g., Clahsen & Felser, 2006). A previous study of native English speakers had found that plausibility had no effect when verbs were strongly biased (Garnsey et al., 1997), but it seemed possible that non-native speakers might. The absence of plausibility effects in native English speakers was replicated here, and somewhat surprisingly the same pattern was found for non-native speakers. Contrary to expectation, L2 learners were just as unaffected by plausibility as the native speakers. Thus, the results provide no evidence supporting the claim that non-native speakers rely on plausibility more than other kinds of cues.

Garnsey et al. (1997) argued that a possible reason that native speakers rely more on verb bias than on plausibility is that verb bias is retrievable information that comes with recognizing the verb and is thus available very rapidly, while plausibility must be computed online for particular verb-noun combinations and so may not be available quickly enough to influence reading times at the disambiguating region. The same is apparently true for those learning English as a second language.
Consistent with previous findings (e.g., Garnsey et al., 1997; Lee et al., 2013), both native speakers and L2 learners were affected by the presence of the complementizer that and the structural biases of verbs. Also consistent with those studies, native English speakers showed the optimally efficient use of verb bias and complementizer cues, while non-native speakers showed additive effects of both cues.

4. Conclusion

The present study investigated L1-Mandarin L2-English learners’ use of verb bias, complementizer that, and plausibility cues to predict upcoming syntactic structure. Mandarin follows SVO word order to place verbs early in the sentence and so verbs are useful in constraining expectations about upcoming structures. The complementizer that cue, on the other hand, is not an available cue in Mandarin to signal an upcoming embedded clause. Thus, it was possible that L1-Mandarin speakers would be able to use the verb bias cue but not the complementizer cue when processing sentences in L2 English. Results showed that L1-Mandarin speakers combined the verb bias and complementizer cues interactively, though they did not reach the optimally efficient pattern seen in native speakers. In addition, L1-Mandarin learners of L2-English learned the verb bias and complementizer cues even when their proficiency was lower. Such results contrast with those in Lee et al. (2013), which found that the use of verb bias by L1-Korean learners of L2-English was dependent on the presence of the complementizer in the lower proficiency group, but approached native-like interactive pattern in the higher proficiency group. Taken together, the difference between L1-Mandarin and L1-Korean learners suggests that L1 word order influences how quickly L2 learners learn word-order-dependent cues about structures in L2. Moreover, just like native speakers, L2 learners did not use plausibility in their processing of DO/SC ambiguous sentences used here, contrasting the claims that L2 learners rely heavily on semantic cues. It was suggested that it may simply take too long, even for native speakers, to put the verb and noun meanings together in the way that is required for it to influence parsing decisions.

References


