Spanish–English L2 speakers' use of subcategorization bias information in the resolution of temporary ambiguity during second language reading

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Abstract

Using a self-paced moving window reading paradigm, we examine the degree to which structural commitments made while 60 Spanish–English L2 speakers read syntactically ambiguous sentences in their second language (L2) are constrained by the verb's lexical entry about its preferred structural environment (i.e., subcategorization bias). The ambiguity under investigation arises because a noun phrase immediately following a verb can be parsed as either the direct object of the verb 'The CIA director confirmed the rumor when he testified before Congress', or as the subject of an embedded complement 'The CIA director confirmed the rumor could mean a security leak'. In an experiment with 59 monolingual English participants, we replicate the findings reported in the previous literature demonstrating that native speakers are guided by subcategorization bias information during sentence interpretation. In a bilingual experiment, we then show that L2 subcategorization biases influence L2 sentence interpretation. The results indicate that L2 speakers keep track of the relative frequencies of verb-subcategorization alternatives and use this information when building structure in the L2.
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1. Introduction

Recent work with monolingual English speakers has attempted to characterize the specific verbal information that forms the basis for structural decisions to explain why parsing certain structures leads to comprehension breakdowns, whereas processing other structures does not cause any measurable comprehension difficulties. Several theorists (e.g., Clifton, Frazier, & Connine, 1984; Ford, Bresnan, & Kaplan, 1982; Holmes, Stowe, & Cupples, 1989; Mitchell & Holmes, 1985; Wilson & Garnsey, 2001, 2004) have reported results that confirm widely held intuitions that sentence parsing can be substantially affected

by probabilistic information associated with verbs. For example, Clifton et al. (1984) found that readers experienced difficulty processing sentences in which optionally transitive verbs were used in a context which turned out to conflict with the verb's dominant usage. Similarly, work by Garnsey and her colleagues (Garnsey, Pearlmutter, Myers, & Lotocky, 1997) provides evidence in favor of their proposal that the likelihood of a particular verb occurring in a specific type of syntactic frame guides the initial selection of a structural analysis. These results indicate that usage-based and exposure-based information associated with verbs is used by the parser and influences comprehension difficulty.

Questions such as how probabilistic verbal information is used, for what purpose, and at what stage of analysis, have been the impetus of much recent psycholinguistic research in the monolingual domain. However, the issue

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of how this information may be related to the processing of constructions in an L2 remains underspecified. Because speakers who are relatively proficient in two or more languages have access to the grammar and lexicon of each language when they comprehend written sentences, one critical question concerns whether the specific semantic and syntactic sub-processes engaged during L2 language comprehension are different when monolingual speakers and second language speakers process input in the target language. The answer to this question has important implications for characterizing speakers of more than one language.

The main objective of this paper is to examine the degree to which structural commitments made while people read sentences in their L2 are constrained by the verb's lexical entry about its preferred structural environment. We term this *subcategorization bias* to distinguish it from *selectional bias* (e.g., the preference for a given verb to take, say, a [+human] subject or complement) or *argument structure/semantic role bias* (which typically involves the mapping from syntactic structures onto conceptual representation and can be regarded as both structural and lexical–semantic in nature).

We have chosen to investigate subcategorization bias information for two main reasons. First, a number of experiments in the monolingual literature have shown that ambiguity resolution processes are sensitive to lexical information about the preferred subcategorization frame of verbs. Native comprehenders have been shown to keep track of the relative frequencies of different subcategorization alternatives for verbs, and to use this information to resolve syntactic ambiguity during reading. This demonstration allows us to ask the question of whether non-native readers also use this same type of information when processing sentences in their second language. To our knowledge, this is an aspect of bilingual language processing that has not been directly addressed in the literature. Second, Clahsen and Felser (2006) have recently argued that the structure-building processes during online L2 sentence comprehension are fundamentally different from the representations built by first language (L1) acquirers. According to their 'shallow structure hypothesis', the syntactic representations that second language learners construct while processing input in their L2 are 'shallower' and less detailed than those computed by adult L1 speakers. In their view, whereas L1 speakers prioritize on 'structure-driven' strategies and syntactic information during sentence processing, second language speakers privilege lexical–semantic and pragmatic information. Given that their argument is based on the examination of a limited number of structures, it remains unclear whether the shallow structure hypothesis is a general property of the way in which L2 speakers parse L2 input or whether it is specific to the cases examined in the literature. Because subcategorization is a property of verbs that is purely structural in nature, the study of subcategorization bias provides a means to test whether second language speakers can use

information other than lexical–semantic information while computing the structure of sentences in their L2.

In the present paper, we examine how Spanish–English speakers process English sentences that contain a post-verbal noun phrase which is temporarily ambiguous between a direct-object reading and an embedded-subject reading, as illustrated below (from Frazier & Rayner, 1982):

(1) I suppose the girl knows the answer to the physics problem.
(2) The girl knows the answer to the physics problem was correct.

After *the girl knows* in (1) and (2), the sentences are structurally ambiguous because the noun phrase (NP) *the answer* can function either as the direct object of *knows*, as in (1), or the subject of the ensuing complement clause, as turns out to be the case in (2). A vast collection of data in the monolingual literature supports the claim that the parser initially takes the structurally simpler path, regardless of lexical (e.g., subcategorization bias) information. For example, Frazier and Rayner (1982) showed that the average reading time per character was longer in (2) than in (1); in addition, participants took longer to process the disambiguating region *was correct* in (2) than in a corresponding control condition for which no structural ambiguity arose (owing to the presence of the complementizer *that*). This finding was taken as evidence that early parsing decisions are determined by phrase-structure rules and simplicity heuristics that refer to those rules, whose function is to increase the speed and efficiency with which the syntactic representation of sentences is built during real-time processing. One such heuristic is *minimal attachment* (Frazier, 1979), which ensures that the parser constructs a structural analysis of a string of words using the smallest permissible number of syntactic nodes. The principle of minimal attachment makes a straightforward prediction regarding the structures in (1) and (2): The direct-object analysis requires the postulation of fewer syntactic nodes than the complement analysis, so the direct-object analysis will be initially adopted to avoid the additional work involved in constructing more complex structures. In (1), this analysis is the correct one, which explains why the readers in Frazier and Rayner (1982) did not experience processing disruption. In (2), the disambiguating region *was correct* makes it clear that the direct-object analysis is not tenable, and reanalysis is necessary.

Many other experiments have confirmed the finding that readers misanalyze such sentences (Ferreira & Henderson, 1990; Mitchell, 1987; Pickering & Traxler, 1998; Rayner & Frazier, 1987), suggesting that there is a *two-stage* process of sentence analysis during which the application of universal parsing strategies such as minimal attachment takes precedence over the application of other potentially relevant sources of information, such as subcategorization bias. Viewed from this perspective, lexical preferences do not guide the initial selection of an analysis, but rather

are used only later, to confirm or disconfirm the current analysis, and to ease the speed with which an incorrect analysis is revised (Frazier, 1987).

Nonetheless, other monolingual work has shown that subcategorization bias can influence initial ambiguity resolution in these structures. For example, Garnsey et al. (1997) investigated the contribution of subcategorization bias[1] to the comprehension of temporarily ambiguous sentences. They constructed stimuli in which verbs that could take either a direct object or a sentential complement, with preference for one over the other, were embedded only in sentential-complement structures with and without the optional complementizer *that*

(3) The CIA director confirmed the rumor could mean a security leak
(direct-object bias verb–ambiguous condition).

(4) The CIA director confirmed that the rumor could mean a security leak
(direct-object bias verb–unambiguous control).

(5) The ticket agent admitted the mistake might not have been caught
(sentential-complement bias verb–ambiguous condition).

(6) The ticket agent admitted that the mistake might not have been caught
(sentential-complement bias verb–unambiguous control).

Garnsey et al. found that at the disambiguation region *could mean*, participants took longer to read (3) than (4), suggesting that participants had initially adopted a direct-object analysis of the post-verbal NP *the rumor*, and were "garden-pathed" upon encountering the embedded auxiliary phrase. This result is consistent with both a minimal attachment account and a lexicalist account (e.g., MacDonald, 1994). According to minimal attachment, the direct-object analysis would be favored because it is the simplest one, requiring the fewest number of syntactic nodes. On the lexicalist account, the direct-object analysis would be pursued because the verb *confirm* is most often followed by a noun phrase that functions as its direct object. In both accounts, when the embedded auxiliary phrase is encountered, participants must relinquish the direct-object interpretation in favor of a sentential-complement analysis. Hence, the additional time spent at the disambiguating region represents the extra processing incurred to reject the initially-adopted direct-object analysis and to establish the sentential-complement analysis. Importantly for constraint-based lexicalist theories, the pattern of results was radically different for constructions containing sentential-complement bias verbs. That is, these sentences caused no significant difficulty for readers at the disambiguation *might not*. In Garnsey et al.'s (1997) account, readers were expecting a sentential-complement in (5), presumably because the verb *admit* is one that most often takes a sentential complement. Because of this, the processing of the post-verbal NP *the mistake* as the subject of the embedded clause was not disrupted. This finding follows directly from the constraint-based lexicalist account: Verb entry information is ordered based on a speaker's prior experience with particular verbs. Given multiple possibilities, the most preferred syntactic frame will be the first attempted parse by the processor.

As noted by Frazier (1995), effects similar to those reported in Garnsey et al. (1997) are not the crucial test for deciding among models, because the findings can be explained as ease of recovery from misanalysis. A more revealing test would be the opposite scenario, in which a direct-object continuation turns out to be difficult to process (i.e., when a sentential-complement bias verb is embedded in a direct-object structure), as exemplified in (7):

(7) The ticket agent admitted the mistake because she had been caught.

Minimal attachment does not predict processing difficulties because the expectation that a noun (in this case, *the mistake*) following a verb is its direct object is not violated in the structure itself. Wilson and Garnsey (2001) tested this hypothesis by presenting participants with sentences in which sentential-complement bias verbs appeared in direct-object continuations. If, as predicted by minimal attachment, the parser constructs the simplest (direct-object) alternative first, and it turns out to be correct, there should be no reason for the parser to try other analyses, and thus no reason for verb bias to influence the parser initially. Contrary to this prediction, they found that verb bias had an equally strong influence in simple and complex sentences, a finding that is consistent with constraint-based lexicalist models (but see Kennison, 2001).

In contrast to the wealth of experiments that have examined lexical influences on parsing while speakers read sentences in their native language, only a handful of studies have been conducted that investigate the degree to which commitments made while individuals read sentences in their second language are constrained by verbal information specific to the L2. Specifically, these studies have considered whether the lexical–semantic properties of verbs affect structural decisions during L2 parsing. Thus far, the available studies yield compatible results: Comprehenders are guided by L2 argument structure and pragmatic information during L2 processing, and indeed parse sentences in the second language in accordance with the lexical–semantic constraints of that language (for reviews, see Clahsen & Felser, 2006; Kroll & Dussias, 2004). For example, Frenck-Mestre and Pynte (1997, Experiment 1) showed that L2 learners use lexical–semantic cues to parse L2 input. They investigated how advanced English learners of French and French native speakers resolved

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[1] Although Garnsey et al. (1997) also examined the role of plausibility information, the findings are not discussed here because they are not directly relevant to the ensuing discussion.

prepositional-phrase attachment ambiguities in sentences such as *They accused the ambassador of espionage (of Indonesia) but nothing came of it.* Eye-movement records revealed that both groups of speakers were more likely to attach the prepositional phrase to the verb phrase if it was a plausible verbal argument, but to the noun phrase when it was a plausible NP modifier. Other findings also indicate that proficiency modulates the ability to access and use syntactic and plausibility information during L2 sentence comprehension in a manner that is similar to native speakers of the target language. For instance, Hopp (2006) found that advanced learners of German displayed the same processing preferences as native Germans when reading subject–object ambiguities, but they did not show differences in response latencies found in native syntactic reanalysis. The near-native speakers, on the other hand, reliably used syntactic features in phrase-structure reanalysis, and also showed evidence of incremental reanalysis patterns typically found in native speakers. Finally, Dussias and Piñar (2007) found that for fluent Chinese–English speakers reading long-distance wh-questions, plausibility information did not prevent an initial misparse, but was found to affect how quickly participants recovered from misanalysis, with implausible information facilitating recovery.

The findings that emerge from these studies indicate that learners resort to lexical–semantic cues to assign structure to a string of words in the L2. In the present work, we examine how a verb's preferred subcategorization frame influences L2 parsing in Spanish–English L2 speakers. Spanish and English are examined here given that the two languages vary with respect to the biases associated with verbs that have been used in prior research with monolingual speakers. Therefore, this provides a fertile testing ground to investigate whether L2 learners transfer L1 subcategorization bias information to the second language. Results indicating that L2 speakers use L1 subcategorization bias while parsing in the L2 would not only inform questions of when and why transfer of information between the bilingual's two linguistic systems occurs, but would also fit well with constraint-satisfaction models, because these models predict that the semantic, phonological, orthographic and morphological information of words in the L1 and the L2, as well as information about their alternative argument structures and frequencies of occurrence, is encoded in the lexicon and is activated to differing degrees during L2 sentence parsing.

2. Method

A reading moving window experiment was conducted to investigate the role of subcategorization bias in the comprehension of sentences with direct- object/sentential-complement temporary ambiguity by Spanish–English L2 speakers. Two verb norming tasks were also carried out. We present the results of the norming study before proceeding to discuss the online experiment.

2.1. Norming task

2.1.1. Participants

One-hundred functionally monolingual Spanish speakers and 60 Spanish–English bilinguals, both residing in Granada (Spain), participated in the norming study. The monolingual Spanish speakers were recruited in order to determine the subcategorization bias of 130 Spanish verbs, among which were the translation equivalents of the English verbs used to construct the stimulus materials for this study. The same 60 Spanish–English bilinguals that participated in the online experiment were administered the norming task to assess whether they had learned the biases of the English verbs used in the moving window experiment.

2.1.2. Materials and procedure

The norming study consisted of a paper and pencil task that instructed participants to provide a completion for a proper noun followed by a verb (for example, *Mary believed* _____). One-hundred thirty verbs were included. One-hundred of the 130 verbs normed in Spanish had been previously normed in English by Garnsey and her colleagues (personal communication). The task was divided into two parts, each consisting of 65 verbs. Participants were asked to complete the first part, take a short break, and then to complete the second part. The administration of the task was counterbalanced so that half of the participants took the first part before the second part, whereas the other half took the second part before the first.

Monolingual Spanish speakers completed the norming task for the Spanish verbs in a quiet room individually. The Spanish–English L2 speakers were given the English norming task after having participated in the online experiment.

2.1.3. Scoring procedure

Following the procedure described in Garnsey et al. (1997), verbs were classified as direct-object bias if they were used twice as often with a noun phrase complement as with an embedded sentential complement. The reverse procedure was followed to classify sentential-complement bias verbs. Verbs that occurred approximately as often with noun phrase objects and with sentential complements were classified as equi-bias verbs.

2.1.4. Results

From the group of 130 normed verbs, we selected the 40 English translation equivalents categorized by Wilson and Garnsey (2001) as direct-object bias or sentential-complement bias, and compared the Spanish and English verbs with respect to subcategorization bias. Of the 40 English verbs, 18 had unique translation equivalents in Spanish and 22 had more than one Spanish translation. A search conducted using the *Larousse Dictionary of Spanish/English* (Cazalaá, Cabot, & Jení-Palac, 1993), showed that 16 of the verbs in this second group had the same dominant meaning in English and Spanish.
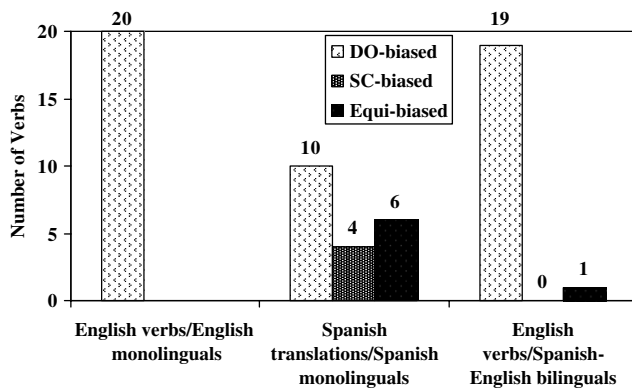
Fig. 1. Norming results for direct-object bias verbs. Monolingual English speakers, monolingual Spanish speakers and Spanish–English bilinguals.
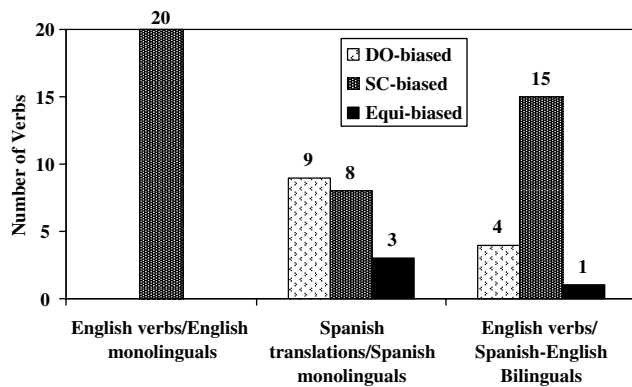

Fig. 2. Norming results for sentential-complement bias verbs. Monolingual English speakers, monolingual Spanish speakers and Spanish–English bilinguals.

As illustrated in Fig. 1, the norming data indicate that of the 20 verbs classified by monolingual English speakers as direct-object bias, half of their translation equivalents were categorized as such by monolingual Spanish speakers. The remaining half was classified either as sentential-complement bias or as equi-bias. In addition, Fig. 2 shows that of the 20 English sentential-complement bias verbs, 8 are also sentential-complement bias in Spanish; 9 are direct-object bias and the remaining 3 are equi-bias.

Turning to the norming data for the Spanish–English L2 speakers, 19 of the 20 English direct-object bias verbs were most often given direct-object NP completions. This indicates that, overall, the L2 speakers had learned the English biases for these verbs.

Finally, the norming data indicate that 15 of the 20 verbs categorized in English as sentential-complement bias were classified as such by the Spanish–English L2 speakers. The remaining 5 were used at least twice as often with a direct object or were followed equally as often by direct objects and sentential complements.

Overall, the results of the norming study indicate that subcategorization biases vary between English and Spanish, and that the Spanish–English bilinguals had learned, for the most part, the subcategorization biases of the English verbs.

2.2. Online experiment

2.2.1. Participants

The same 60 proficient Spanish–English L2 speakers that were asked to complete the norming study participated in the online experiment. They were between the ages of 20 and 26 and were in their second or third year of study in the translation and interpretation program at the *Universidad de Granada* in Granada, Spain. These L2 speakers were highly skilled in the second language, considered themselves capable of expressing most ideas in both languages equally well, and regarded themselves to have a skillful use of the vocabulary and syntax in the second language. All were native speakers of Spanish and had passed the University of Cambridge Certificate of Proficiency in English before entering the translation and interpretation program. None of the participants had lived in an English immersion environment for more than 9 months. A group of 59 functionally monolingual English speakers residing in the United States also participated in the online portion of the study to provide a baseline for comparison. Participants received payment for their participation.

2.2.2. Materials & design

Seventy-eight experimental sentences were used from Wilson and Garnsey (2001). The experimental stimuli contained 40 English verbs, 20 direct-object bias and 20 sentential-complement bias, that appeared embedded in three sentence types: sentential-complement continuation (ambiguous), sentential-complement continuation (unambiguous) and direct-object continuation. Each verb appeared twice during a list, except for two verbs that only appeared once to allow for the even distribution of the experimental items (78 in total) across the three lists created as a result of counterbalancing. The presentation was counterbalanced so that each verb appeared once in a direct-object continuation and once in a sentential-complement continuation. Each presentation of a particular verb contained a different subject and post-verbal noun. All post-verbal nouns were highly plausible as direct objects of the verbs they followed (see Wilson & Garnsey, 2004 for details on the criterion followed to norm the plausibility of the post-verbal nouns). One-hundred fourteen filler items were also included and were taken from Garnsey et al. (1997). Three 202-item pseudo-randomized lists were created, each containing 78 experimental sentences, the filler items and 10 practice items. Comprehension questions were constructed for each experimental, filler, and practice item. A sample of each condition is provided in (8)–(13).

(8) SC-bias/SC cont. ambiguous: The ticket agent admitted the mistake *might not* have been caught.
(9) SC-bias/SC cont. unambiguous: The ticket agent admitted that the mistake *might not* have been caught.

(10) DO-bias/SC cont. ambiguous: The CIA director confirmed the rumor *could mean* a security leak.
(11) DO-bias/SC cont. unambiguous: The CIA director confirmed that the rumor *could mean* a security leak.
(12) SC-bias/DO cont. The ticket agent admitted the mistake *when he* got caught.
(13) DO-bias/DO cont. The CIA director confirmed the rumor *when he* testified before Congress.

As explained earlier, according to two-stage models, such as the Garden Path Model, the only information that is initially used for interpreting sentences like those in (8–13) above is that *admitted* and *confirmed* are verbs and *mistake* and *rumor* are nouns. Because the simplest interpretation of a noun following a verb is as the verb's direct object, L2 speakers should show an equal amount of difficulty at the disambiguating region (italicized in the examples) in (8) and (10), as compared to (9) and (11). This is so because the correct reading requires that the noun phrase following the verb be interpreted as the grammatical subject of the embedded clause. In addition, L2 speakers are not expected to slow down at the disambiguating region when a direct-object continuation follows the verb (e.g., in (12) and (13) above), but are expected to be slower when a sentential-complement continuation follows the verb (as in (8) and (10)). We note that similar predictions hold if L2 learners are guided by lexical–semantic and pragmatic information during L2 processing. Recall that regardless of verb type (direct-object bias or sentential-complement bias), all temporarily ambiguous nouns are highly plausible direct objects. If learners prioritize on lexical–semantic and pragmatic information over other types of information during L2 comprehension, they should favor a direct-object analysis on the assumption that the constraint imposed by the plausibility information of the noun phrase as a viable direct object will make that alternative more available than the sentential-complement analysis. Conversely, if experience with how particular words are most likely to be used constitutes one important source of evidence, as argued by constraint-based lexicalist models, Spanish–English L2 speakers are expected to show a behavior consistent with biases associated with the L1 or the L2, depending on whether they have learned the relevant information in their second language and can access it during online sentence processing.

2.2.3. Procedure

The stimuli for the online experiment were displayed using a non-cumulative reading moving window technique (Just, Carpenter, & Woolley, 1982). Participants were informed that for each trial, they would see discontinued groups of dashes and that each group represented a word of the sentence. Each click of the space bar would change a group of dashes into the next word and would make the previous word disappear. Each word appeared in its corresponding position within the sentence, while the position of all previous and subsequent words stayed on the screen by the place-holding dashes. For each trial, a fixation sign (+) was presented at the center of the computer screen. At the press of the space bar, the fixation sign disappeared and the first word of the sentence was presented left aligned on the screen. Participants were informed that their task was to read each word silently and to press the spacebar to display each consecutive word on the screen. Participants were able to familiarize themselves with the task through the completion of several practice trials. The time between the appearance of each word and the press of the space bar was recorded. When participants reached the end of each sentence, they were asked to answer a comprehension question, by pressing a YES or a NO button accordingly.

3. Results

Trials on which there was an incorrect response to the comprehension question were omitted from analyses of the reading time data, resulting in an overall loss of 11% of the data. Reading times per word below 200 ms or above 2000 ms were eliminated, resulting in an overall loss of 5% of the data.

The first analysis directly compares the performance of monolingual and bilingual speakers. To analyze the data, three factors were examined: verb bias (direct-object bias verbs vs. sentential-complement bias verbs), ambiguity (ambiguous vs. unambiguous constructions) and sentence continuation (direct-object continuation vs. sentential-complement continuation). Due to the incomplete crossing of the experimental design, two $2 \times 2 \times 2$ analyses of variance (ANOVAs) were run. The first ANOVA crossed subcategorization verb bias with ambiguity and examined the effect of verb bias in sentential-complement constructions. In other words, this ANOVA was conducted on sentences (8) and (10) vs. (9) and (11). The second ANOVA crossed subcategorization bias with sentence continuation to determine the influence of verb bias while speakers read simple, direct-object constructions and complex, sentential-complement constructions. In this second case, the performance on sentences such as (12) and (13) was compared to performance on sentences such as (8) and (10), respectively. In other words, this analysis omitted the unambiguous sentences and compared the ambiguous conditions.

For these analyses, verb bias, ambiguity and sentence continuation were treated as within-participants variables. The group variable (monolingual vs. bilingual participants) was treated as a between-participants variable for the F1 analyses, and as a between-items variable for the F2 analysis (owing to differences in verb biases).

For the first analysis, the disambiguating region was read more slowly in ambiguous sentences without 'that' than in unambiguous controls, resulting in a main effect of ambiguity ($F1(1, 117) = 43.16$; $MSE = 3090.13$, $p < 0.01$; $F2(1, 152) = 37.40$; $MSE = 2501.36$, $p < 0.01$). There was also an interaction between verb bias and ambiguity that was significant by participants ($F1(1, 117) = $

7.24; MSE = 2554.02, $p < 0.01$) and marginally significant by items ($F2(1, 152) = 3.81$; MSE = 9540.96, $p = 0.053$). Finally, the interaction among bias, ambiguity and group was marginally significant in the participants analysis ($F1(1, 117) = 3.35$; MSE = 8238.27, $p = 0.069$) and significant in the item analysis ($F2(1, 152) = 4.86$; MSE = 12165.52, $p < 0.05$).

For the second analysis, which crossed verb bias and sentence continuation, the only significant findings were an interaction between bias and continuation type ($F1(1, 117) = 17.21$; MSE = 3209.83, $p < 0.01$; $F2(1, 152) = 10.25$; MSE = 35593.98, $p < 0.01$), and an interaction among bias, continuation type and group that was not significant by participants ($F1(1, 117) = 2.08$; MSE = 6684.38, $p = 0.15$) but approached significance by items ($F2(1, 152) = 3.11$; MSE = 10800.09, $p = 0.08$).

The overall pattern of results indicates that the monolingual and bilingual speakers are more similar than dissimilar in the processing of the ambiguity under investigation; however, the marginal interaction effects reported above suggest that there may be some subtle processing differences between the monolingual and bilingual groups. To explore this hypothesis further, separate analyses will be presented for the native speaker data and the L2 participant data. We begin by presenting the results of the English monolingual experiment, which was conducted with the goals of replicating the findings reported in Wilson and Garnsey (2001) and of providing a baseline for comparison for the Spanish–English L2 speakers. Subsequently, we present the bilingual results.

3.1. Monolingual English speakers

Trials on which there was an incorrect response to the comprehension question were omitted from analyses of the reading time data, resulting in an overall loss of 4% of the data. Reading times per word below 200 ms or above 2000 ms were eliminated, resulting in an overall loss of 2% of the data. We first report the results for the disambiguating region of the sentence and subsequently report the findings for other critical regions of the sentence.

3.1.1. Disambiguating region

Mean reading times for all conditions in all regions are shown in Table 1. The first ANOVA revealed a main effect of ambiguity ($F1(1, 58) = 27.36$; MSE = 4477, $p < 0.01$; $F2(1, 76) = 34.98$; MSE = 2450, $p < 0.01$) and small main effect of bias that approached significance only by participants ($F1(1, 58) = 3.36$; MSE = 9016, $p = 0.07$). Crucially, there was also a significant interaction effect between ambiguity and bias ($F1(1, 58) = 8.736$; MSE = 2052, $p < 0.01$; $F2(1, 76) = 8.82$; MSE = 2450, $p < 0.01$), such that for sentences with direct-object bias verbs, the disambiguating region was read significantly more slowly in ambiguous sentences (451 ms) than in unambiguous controls (385 ms) ($t1(58) = 5.3$, $p < 0.01$; $t2(77) = 5.63$, $p < 0.01$). No such difference was found in constructions with sentential-complement

Table 1
Mean reading times in milliseconds at the disambiguating region

	Monolingual English speakers			Spanish–English speakers		
	SC-continuation (ambiguous)	SC-continuation (unambiguous)	DO-continuation	SC-continuation (ambiguous)	SC-continuation (unambiguous)	DO-continuation
DO-bias verbs						
Matrix verb	M = 474; SD = 160	M = 476; SD = 138	M = 464; SD = 117	M = 531; SD = 139	M = 541; SD = 140	M = 556; SD = 149
Ambiguous NP	M = 409; SD = 96	M = 405; SD = 117	M = 414; SD = 111	M = 438; SD = 106	M = 419; SD = 102	M = 435; SD = 102
Disambiguation	M = 451; SD = 143	M = 385; SD = 87	M = 413; SD = 123	M = 446; SD = 102	M = 421; SD = 94	M = 427; SD = 97
SC-bias verbs						
Matrix verb	M = 470; SD = 135	M = 471; SD = 141	M = 477; SD = 136	M = 568; SD = 167	M = 561; SD = 164	M = 566; SD = 166
Ambiguous NP	M = 437; SD = 111	M = 399; SD = 107	M = 430; SD = 126	M = 433; SD = 97	M = 417; SD = 102	M = 430; SD = 119
Disambiguation	M = 418; SD = 112	M = 393; SD = 91	M = 438; SD = 134	M = 438; SD = 92	M = 421; SD = 93	M = 447; SD = 113

Monolingual English speakers and Spanish–English bilinguals.

bias verbs (418 ms vs. 393 ms; $p > 0.1$). This indicates that readers had difficulty when a noun phrase following a direct-object bias verb turned out not to be the direct object. If the noun phrase followed a sentential-complement bias verb, participants did not seem to have such difficulty, suggesting that they had analyzed the post-verbal noun phrase as the subject of the embedded clause.

The next ANOVA, which crossed subcategorization bias with sentence continuation, showed a significant interaction between verb bias and sentence continuation type that was significant by participants ($F1(1, 58) = 11.64$; $MSE = 4274$, $p < 0.01$) and by items ($F2(1, 76) = 11.51$; $MSE = 3715$, $p < 0.01$). The nature of the interaction confirms that participants were slowed down whenever there was a mismatch between verb bias and sentence continuation, and this was confirmed in pairwise comparisons. Participants read the disambiguating region more slowly when direct-object bias verbs appeared in sentential-complement constructions than when they appeared in direct-object constructions (451 vs. 413 ms; $t(58) = 2.47$, $p < 0.01$). In addition, they were slower at the disambiguating region when sentential-complement bias verbs appeared in direct-object constructions than when they appeared in sentential-complement structures (438 vs. 418 ms; $t(58) = 2.04$; $p < 0.05$). Taken together, these results replicate previous findings in the monolingual literature and demonstrate that subcategorization bias is used during sentence parsing.

3.1.2. Temporarily ambiguous NP

The ambiguous NP (e.g., *the mistake* in (8) and *the rumor* in (10)) was read more slowly in ambiguous sentences (423 ms) than in unambiguous controls (402 ms; $F1(1, 58) = 7.75$; $MSE = 3382.48$, $p < 0.01$; $F2(1, 76) = 4.22$; $MSE = 5471.493$, $p < 0.05$). There was also an interaction between bias and ambiguity that was significant only by participants ($F1(1, 58) = 4.41$; $MSE = 4134.09$, $p < 0.05$; $F2 < 1$). The interaction effect was such that encountering the word *that* decreased reading times on the NP more in sentences with sentential-complement bias verbs (by 38 ms) than in sentences with direct-object bias verbs (by 4 ms). As discussed in Wilson and Garnsey (2001), this suggests that the presence of a direct-object bias verb created an expectation that a direct-object noun phrase would be encountered. The presence of the complementizer, however, clearly contradicted this expectation, resulting in the observed delay when readers reached the following NP in sentences with DO-bias verbs.

ANOVAs examining the combined effect of bias and continuation, did not reveal any significant differences (all $Fs < 1$). This finding was expected because the materials used to conduct the analyses were identical up to the point of disambiguation.

3.1.3. Reading times at the verb

None of the analyses carried out at the main verb revealed any significant effects (all $Fs < 1$).

3.2. Spanish–English-L2 speakers

Trials on which there were incorrect responses to the comprehension questions were omitted from analyses of the reading time data, resulting in an overall loss of 7% of the data. Reading times per word below 200 ms or above 2000 ms were eliminated, resulting in an overall loss of 3% of the data. As in the previous case, two analyses were conducted. In the first one, mean reading times at the disambiguating region were submitted to participant- and item-based 2 (verb bias) × 2 (ambiguity) ANOVAs. In the second analysis, reading times were submitted to participant- and item-based 2 (verb bias) × 2 (sentence continuation) ANOVAs.

3.2.1. Disambiguating region

Results of the ANOVA examining the contribution of bias and ambiguity indicate a main effect of ambiguity that was significant by participants ($F1(1, 59) = 15.90$, $MSE = 1727$, $p < 0.01$), and by items ($F2(1, 76) = 6.67$; $MSE = 1651$, $p < 0.05$). Thus, just like the monolingual English results, ambiguous constructions were read significantly slower than unambiguous constructions (Fig. 3). However, unlike the monolingual results, verb bias and ambiguity did not interact (all $Fs < 1$).

The next ANOVA, which crossed verb bias and sentence continuation, revealed no main effect of verb bias or sentence continuation type (all $Fs < 1$), but showed a reliable interaction between verb bias and sentence continuation ($F1(1, 59) = 5.48$; $MSE = 2163$, $p < 0.05$; $F2(1, 76) = 6.59$; $MSE = 3656$, $p < 0.05$). Pairwise comparisons confirmed that this interaction effect came entirely from sentences with direct-object bias verbs ($t(59) = 2.48$, $p < 0.05$). The difference between the two means for sentential-complement bias verbs was not statistically significant ($t(59) = 1.03$, $p > 0.10$). The results are depicted in Fig. 4.

At first glance, the findings from both analyses indicate that highly proficient Spanish–English L2 speakers do not use subcategorization bias information in the same way as monolingual English speakers. The bias × ambiguity results suggest that L2 speakers may have an overall preference for interpreting a noun phrase following a verb as its direct
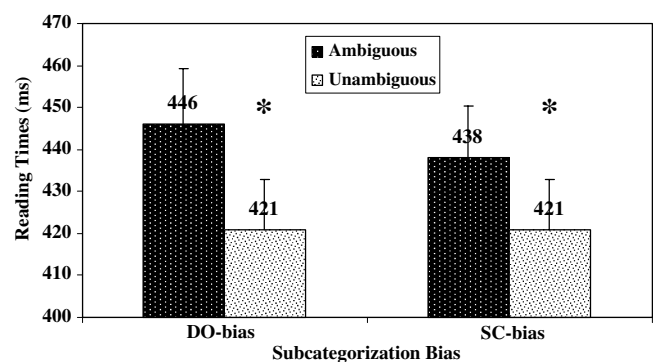

Fig. 3. Reading times at the disambiguating region (bias × ambiguity). Spanish–English bilinguals.

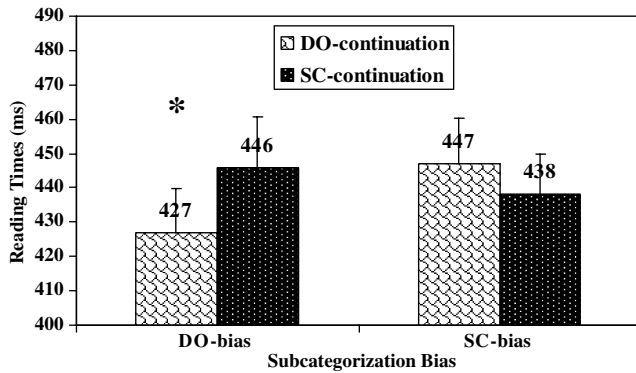Fig. 4. Reading times at the disambiguating region (bias × continuation type). Spanish–English bilinguals.

Fig. 5. Reading times at the disambiguating region. Fifteen verbs (bias × continuation type). Spanish–English bilinguals.

object, which hints to the possibility that L2 speakers prefer to build a structurally simple syntactic tree. As discussed elsewhere (Frenck-Mestre & Pynte, 1997; Gillon-Dowens & Carreiras, 2006), building such representations may represent a less costly but effective alternative for second language speakers, given that reading in a second language imposes higher cognitive demands on the processing system.

However, this explanation seems unlikely when considering the results of the second analysis (bias × continuation). There was a numerical cost when a sentential-complement continuation appeared after a direct-object bias verb; however, no such pattern was observed when a sentential-complement continuation appeared after a sentential-complement bias verb. This pattern of results is not expected if the bilingual parser favors the construction of syntactically simpler representations. So, what might account for this finding? One possibility is that the L2 speakers' prior experience with both the L1 *and* the L2 is guiding the interpretation of these sentences. Fig. 1 shows that overall, the Spanish–English L2 speakers had learned the English biases for direct-object bias verbs, which could feasibly account for the significant reading time difference obtained when direct-object bias verbs appeared with different continuation types. On the other hand, the norming data indicate that only 15 of the 20 sentential-complement bias verbs in English were preferentially used with a sentential complement by the Spanish–English bilinguals (Fig. 2). This raises the possibility that reading times for constructions containing sentential-complement bias verbs reflect the joint contribution of Spanish and English verbal information. To further test this hypothesis, an analysis was conducted that included only the 15 sentential-complement bias verbs for which the English biases had been learned by the bilingual speakers. If the lack of a significant interaction between bias and continuation type was due to the transfer of verb bias information from the L1, in addition to the implementation of verb bias cues specific to the L2, the crucial interaction should emerge once the L1 information is removed. As shown in Fig. 5, once this procedure was followed, there was a significant main effect of bias
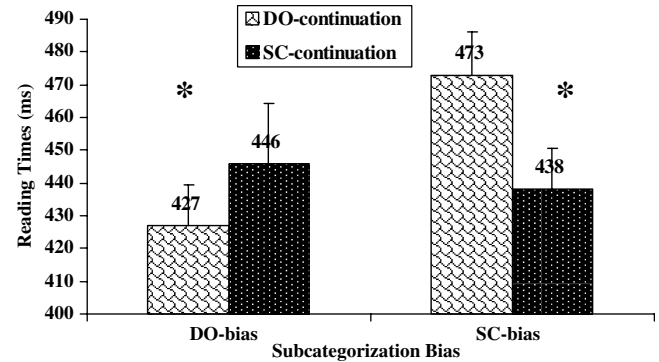
$(F1(1, 59) = 5.4$; MSE $= 3937$, $p < 0.05$; $F2(1, 66) = 5.6$; MSE $= 2451$, $p < 0.05$) and a significant interaction between verb bias and sentence continuation $(F1(1, 59) = 8.92$; MSE $= 5066$, $p < 0.01$; $F2(1, 66) = 8.83$; MSE $= 2205$, $p < 0.01$).

The nature of the interaction between verb bias and sentence continuation was such that reading times were longer when verb bias and continuation type did not match (mismatch $M = 473$, SD $= 142$; match $M = 427$, SD $= 97$), and this pattern was confirmed in pairwise comparisons for the direct-object bias verbs ($t (59) = 2.48$, $p < 0.05$) as well as for the sentential-complement bias verbs ($t (59) = 2.26$, $p < 0.05$).

Next, we conducted an analysis that only included the five verbs whose subcategorization biases appeared not to have been learned by the Spanish–English bilinguals. These were among the 12 verbs whose translation equivalent were classified by the Spanish monolinguals as something other than sentential-complement bias. If we are correct in assuming that the initial lack of a significant interaction between bias and continuation type was due to the transfer of verb bias information from the L1, this hypothesis should be confirmed in the analyses. Pairwise comparisons revealed that the disambiguating region was read more slowly when the verbs were embedded in sentential-complement constructions than when they appeared in direct-object constructions (440 ms vs. 400 ms; $t (58) = 2.21$, $p < 0.05$). This suggests that the Spanish–English bilinguals preferentially analyzed these verbs as direct-object biased.

3.2.2. Temporarily ambiguous NP

At the NP, the only significant finding was a main effect of ambiguity by participants, such that more time was spent reading the ambiguous NP when it appeared in ambiguous constructions (436 ms) than when it was embedded in unambiguous ones (418 ms; $(F1(1, 59) = 7.94$; MSE $= 2301.81$, $p < 0.05$; all other $Fs < 1$).

3.2.3. Reading times at the verb

Analyses carried out at the main verb did not reveal any significant effects (all $Fs < 1$).

4. Discussion

Current findings within the bilingual domain suggest that proficient L2 speakers are not very different from L1 speakers of the target language in their use of lexical–semantic information to compute structural relations among different words in a sentence. These studies indicate that lexical–semantic processing in L2 speakers parallels that of monolingual speakers, and that any differences observed between the two groups arise because processing is slowed down during L2 reading. In contrast, L1 and L2 speakers appear to show qualitative differences in their ability to employ structural information and phrase-structure based on locality principles. Recently, Clahsen and Felser (2006) captured this difference in their "shallow structure hypothesis", which states that the parsing operations in a second language do not reflect the interaction between syntactic and lexical processing that is characteristic of adult monolingual speakers. However, as the authors themselves indicate, the available evidence in support for their claim derives from a limited number of studies investigating L2 sentence processing. One way to put the claims made in Clahsen and Felser on more secure footing is to demonstrate that they hold across different structures. With this in mind, the present study examined whether the syntactic representations that proficient Spanish–English L2 speakers build during L2 sentence processing are constrained by the verb's subcategorization bias. As stated earlier, because subcategorization is purely structural in nature, its study provides a means to test whether second language speakers use other sources of information, in addition to lexical–semantic information and pragmatic information, during L2 sentence processing or whether they essentially compute structural representations of the input from aspects of lexical–semantic structure and pragmatic information.

To establish whether bilingual speakers are sensitive to verbal information specific to the second language, we conducted a norming study to determine the existence of cross-linguistic differences in subcategorization bias and to verify that our bilingual participants possessed the relevant information about the constraints associated with the specific lexical items employed in this study. A comparison between the monolingual Spanish data collected for the present experiment and monolingual norms collected by Garnsey and her colleagues (personal communication) demonstrated the existence of cross-linguistic differences between English and Spanish in subcategorization bias. It also confirmed that the Spanish–English L2 speakers had learned the subcategorization biases associated with the English verbs, although they were less successful at learning these biases if the verb's relative frequencies favored a sentential-complement analysis. We speculate that this difficulty is attributable to grammatical differences between Spanish and English. Spanish grammar requires that subordinate clauses be headed by a complementizer. By comparison, in English the complementizer can often be omitted. It is

possible that L2 speakers may take longer to learn that certain verbs prefer the embedded sentence alternative because the input is ambiguous when the complementizer is absent in English. In sum, however, the results of the norming study show that L2 speakers are able to track structural differences in the input and are sensitive to the statistical properties of the L2 linguistic environment to which they were exposed. The fact that our L2 speakers were able to extract information about the preferred subcategorization frame of verbs from the L2 input suggests that the L2 processing mechanism searches for potentially useful sources of information to reduce uncertainty in the input. One way to do this is to seek sources of predictability by capitalizing on the information that is likely to be the most statistically reliable, as is the case with subcategorization bias.

For subcategorization bias to guide the online processing of ambiguous constructions, L2 learners must not only possess the relevant knowledge, but they must also be able to access it quickly enough to constrain sentence interpretation. Demonstrating that L2 speakers can access this source of knowledge in the L2 is important because studies of comprehension and production in L2 speakers have shown that the slower time course associated with the L2 can result in greater vulnerability to interference from competing information, including information from the L1 (Costa & Caramazza, 1999; Van Heuven, Dijkstra, & Grainger, 1998). To examine the possibility that subcategorization bias was used during online L2 sentence processing, we conducted a reading moving window experiment with the same L2 speakers that participated in the norming study. At the first glance, the findings suggested that the L2 speakers were different from the monolingual readers in their processing of the ambiguity. That is, unlike the monolingual speaker behavior reported in Wilson and Garnsey (2001) and replicated in this study, a comparison of the reading times for ambiguous sentence-complement constructions with their unambiguous controls suggested that the L2 speakers had adopted a strategy of constructing the structurally simplest direct-object interpretation, regardless of whether the constructions contained verbs that were biased toward a direct-object or a sentential-complement interpretation. However, the reading patterns exhibited at the disambiguating region when verb bias was not congruent with sentence continuation, although not statistically significant at first, suggested that the comprehension system of bilingual speakers did not analyze every noun following a verb as its syntactic direct object, even when plausibility information provided supports this analysis. If this had been the case, then direct-object continuations should have been read as quickly following a direct-object bias verb as with a sentential-complement one. The fact that this was not the case indicates that the L2 speakers were not favoring the simplest structural analysis, as would be expected if they applied universal parsing strategies, nor were they prioritizing on plausibility information, as suggested in Clahsen and Felser (2006). Rather, these L2 speakers were more likely using a combination of

verbal information from the L1 and the L2 to resolve the ambiguity. In fact, once the English verbs for which the L2 speakers had not learned the L2 biases were removed from the analysis, the behavior of L2 speakers closely resembled that of native speakers of the target language.

Our finding that the plausibility of the noun phrase as a viable direct object did not prevent a garden path effect, is congenial with the results in Garnsey et al. (1997). A range of results in that study revealed that monolingual English speakers displayed significant difficulties reading sentential complements when the preceding verb was one that most often took a direct object, and this was true even when the post-verbal noun phrase was implausible as a direct object for the verb. However, plausibility effects were found at the disambiguation if verbs were unbiased toward a direct-object or a sentential-complement reading, as was the case with equi-bias verbs. To explore further the contribution of plausibility information to the comprehension of the ambiguous constructions in L2 speakers would require additional experimentation in which plausibility is more closely examined to include plausible and implausible post-verbal noun phrases to the experimental design used here. The next phase of studies should also be directed at replicating and extending the findings reported here with other methodologies. Although the self-paced moving window technique employed in this study was important in revealing the online processes that L2 speakers engage in while reading in their second language, because the task does not impose time constraints on readers, the results can not clearly discriminate between initial processing decisions and later processes; hence, the precise time course by which *initial* parsing decisions were made was not captured. In this respect, the recording of eye-movements during reading provides greater technical detail, as it fractionates reading times into distinct components (e.g., first fixation, gaze duration, regressions, and so forth), which combined with theoretical analysis of how the measures might be linked to underlying processing, can provide useful hints about the processes that are occurring at particular points in time during reading (Carreiras & Clifton, 2004).

The present study exploited a formal linguistic difference that exists in the bilingual's two languages (i.e., the difference in subcategorization bias information between Spanish and English) as a means to determine whether the variables purported to affect monolingual syntactic parsing also impact L2 speakers when processing sentences in their second language. Our findings support the notion that L2 learners are able to extract subtle information from the input, such as the statistical frequencies with which verbs are used with different subcategorization frames, and use this information during L2 sentence processing. One important point to note is that the type of ambiguity examined in the present study is cross-linguistically asymmetrical in the Spanish–English comparison. That is, the ambiguity arises only in English, where the deletion of the complementizer *that* is possible in subordinate clauses, but not in Spanish, where the corresponding complementizer *que* cannot be omitted. It is possible, then, that the asymmetrical status of the ambiguity might render transfer of verbal information from L1 less likely. A logical extension that follows from this hypothesis is that when the temporal ambiguity is symmetrical between two languages, one should observe widespread transfer from the L1 to the L2. However, research on bilingual relative clause ambiguity resolution suggests that this is not the case. This ambiguity is symmetrical across a number of language pairs studied so far (e.g., Spanish–English; French–English; Greek–English), yet during relative clause ambiguity resolution, bilinguals have been shown to move along a continuum that ranges from transfer of information from the L1 to the L2 (Frenck-Mestre, 1997) to transfer of information from the L2 to the L1 (Dussias & Sagarra, 2007; Fernández, 2003). Within this continuum, there is also evidence of language-dependent processing (Frenck-Mestre, 2002) and language-independent processing (Clahsen & Felser, 2006; Fernández, 2002; Papadopoulou & Clahsen, 2003). The first case refers to instances in which bilinguals use different processing strategies that correspond to each of the input languages. The second one denotes cases in which bilinguals use a combination of processing strategies from the L1 and the L2 with different input languages. Given this collection of evidence, it is clear that transfer of information from the L1 to the L2 is modulated by a range factors (level of proficiency in the L2, years of immersion in the L2 environment, time constraints imposed by the task, and so forth) and that the cross-linguistic structural (a)symmetry of the construction is just one of these factors.

To conclude, it is possible that L2 readers capitalize on the same types of structural cues that characterize skillful L1 reading, but at the same time may resort to the L1 to compensate for the absence of knowledge in the second language. The available findings lead us to postulate that L2 speakers recruit information from the various sources stored for each of the two languages, depending on the nature of the structure being processed and of the characteristics of the input. A model such as the one proposed by constraint-based lexicalist theorists (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell, Tanenhaus, & Garnsey, 1994), which assigns an important role to adjustments made by the parser as it is exposed to language can best account for the results reported here. Proponents of such models assume that there are no architectural restrictions – as those underlying the Garden Path Model – on the use of particular sources of information during sentence parsing. Consequently, readers or listeners are expected to use multiple sources of information interactively (e.g., syntactic category information, plausibility information, verb-bias, information, frequency information, etc.) throughout processing. Such a model can also account for a number of findings stemming from the bilingual sentence parsing literature that have shown

clear effects of exposure on the development of parsing strategies (e.g., Dussias & Sagarra, 2007; Frenck-Mestre, 2005).

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