

The effect of exposure on syntactic parsing in Spanish–English bilinguals*

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An eye tracking experiment examined how exposure to a second language (L2) influences sentence parsing in the first language. Forty-four monolingual Spanish speakers, 24 proficient Spanish–English bilinguals with limited immersion experience in the L2 environment and 20 proficient Spanish–English bilinguals with extensive L2 immersion experience read temporarily ambiguous constructions. The ambiguity concerned whether a relative clause (RC) that appeared after a complex noun phrase (NP) was interpreted as modifying the first or the second noun in the complex NP (El policía arrestó a la hermana del criado que estaba enferma desde hacía tiempo). The results showed that whereas the Spanish monolingual speakers and the Spanish–English bilinguals with limited exposure reliably attached the relative clause to the first noun, the Spanish–English bilingual with extensive exposure attached the relative to the second noun. Results are discussed in terms of models of sentence parsing most consistent with the findings.

Attachment preferences concerning sentences with a relative clause (RC) preceded by a complex noun phrase (NP) have been found to differ cross-linguistically. To illustrate, the sentence in (1) and its translated equivalent in (2), mean something very different in English and Spanish.

- (1) An armed robber shot the sister of the actor who was on the balcony.
- (2) Un ladrón armado le disparó a la hermana del actor que estaba en el balcón.

In both languages, the relative clause *who was on the balcony/que estaba en el balcón* is temporarily ambiguous because it can modify either the first noun (NP1) or the second noun (NP2) in the complex NP. Therefore, a fully syntactic analysis of this sentence requires the disambiguation of the relative-clause attachment. Where English and Spanish differ is in how each language resolves the ambiguity. In English, the general preference is for attachment to NP2, resulting in the reading “the

actor was on the balcony”. By contrast, in Spanish, readers show a clear preference to attach the relative clause to NP1, giving rise to the interpretation “the sister was on the balcony”.

This cross-linguistic difference, first documented in Cueto and Mitchell (1988), has been studied in a variety of languages, largely because the NP1 attachment preference found in Spanish was at odds with the prevailing structurally-based theories of sentence parsing. For example, one such theory, the Garden-Path Model (Frazier, 1978; Frazier and Rayner, 1982), predicted that new, incoming words should attach to the most recently processed node in the phrase marker (i.e. NP2 in the sentences above), irrespective of the language being processed. However, subsequent cross-linguistic research has provided corroboration of the variability found between English and Spanish, with some languages displaying a preference for NP1 attachment, and others showing a preference for attaching the relative clause to NP2.

Given that a consensus is emerging that native speakers of different language backgrounds employ distinct processing routines when resolving relative-clause attachment ambiguities, it becomes possible to ask whether these same routines can be identified in non-native speakers when processing the relevant structure. Recently, researchers have exploited the existence of cross-linguistic differences in this type of ambiguity to examine whether L2 learners use the parsing mechanisms employed by native speakers of the target language or whether they transfer parsing strategies from their first language to the second language. A number of studies have tackled this question by investigating the role that

* The writing of this paper was supported in part by a Research and Graduate Studies Office Grant from the College of the Liberal Arts, Penn State University, and by NIH Grant HD50629 to Paola Dussias. Portions of this paper were presented at the Colloquium on Language Convergence held during the 4th International Symposium on Bilingualism, Phoenix, Arizona. We thank the colloquium organizer, A. Jacqueline Toribio. Our deepest gratitude to Teresa Bajo, Tracy Cramer, Chip Gerfen, Noriko Hoshino, Judy Kroll, Maya Misra and the attendees of the Language Science Research Group at Penn State for stimulating discussions. We are thankful to the two anonymous reviewers and David Green for their careful reading of the paper and for insightful comments and suggestions. Finally, thanks to Charles Clifton, Jr. and Manuel Carreiras for generously sharing their experimental stimuli with us. All errors are, of course, our sole responsibility.

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exposure to a second language environment has on the acquisition of parsing strategies specific to the L2, although to date, the results are inconclusive. One set of findings suggests that daily exposure to the L2 might have an influential role on the processing routines, whereas other findings argue against this view.

The goal of the present study is to investigate the hypothesis that the syntactic parser tunes to variations in the language to which it is exposed and uses this information to resolve syntactic ambiguity (e.g. Mitchell and Cuetos, 1991; MacDonald, Pearlmutter and Seidenberg 1994a, b; Brysbaert and Mitchell, 1996; Gibson, Pearlmutter, Canseco-Gonzalez and Hickok, 1996; see Mitchell and Brysbaert, 1998, for a more thorough review of the different proposals). In particular, following up on two studies that showed that Spanish-dominant bilinguals¹ reading in Spanish, their dominant language, failed to exhibit the same attachment preference as Spanish monolingual speakers (Dussias, 2003; Fernández, 2003), the present study explores the role of exposure to L2 input by examining whether the L1 comprehension system is permeable. Specifically, by permeable, we refer to the claim that parsing strategies from the L2 affect sentence parsing in the bilingual's primary language. This scenario provides the strongest test of a tuning account of parsing strategies, given that it focuses on the potential effects of L2 exposure on the putatively highly stable L1 parsing mechanism. If L2 is shown to affect L1 parsing, it would suggest that parsing theories must accommodate exposure and experience in their theoretical architectures. In this study, we will focus our attention on Spanish–English bilinguals.

The syntactic construction that will be used to examine our research question contains a complex noun phrase followed by structurally ambiguous relative clause, exemplified in (2) above. This construction is of interest because the cross-linguistic difference in attachment preferences observed for Spanish and English serves as a tool to investigate the influence that parsing routines typically associated with particular constructions from the L2 have on the L1.

The paper is organized as follows. First, we summarize evidence pertaining to the cross-linguistic variability that has been found in the monolingual sentence parsing literature, focusing our attention on Spanish and English. Next we discuss two theoretical explanations, the Tuning Hypothesis and the Construal Theory, that have been proposed to account for the experimental results found

in the literature. We also present recent evidence from the monolingual domain that poses problems for each account. We then discuss how the study of syntactic parsing in bilinguals can serve as a testbed on which to examine predictions made by these two theoretical proposals. We follow with a review of the extant relevant literature on the processing of relative-clause attachment in second language learners which, together with the monolingual findings, motivate this study. The next section states our research questions and predictions, followed by an explanation of our methods. We then present our results and, finally, we discuss our findings in the context of the two models of sentence processing.

Cross-linguistic variation in relative-clause attachment

Well over a decade ago, Cuetos and Mitchell (1988) published a well-known study showing that parsing does not proceed in a similar fashion regardless of the language being processed. In a number of experiments using questionnaire data and self-paced reading, the authors showed that in constructions where a relative clause could be attached to one or the other of two noun phrases, as in (3), monolingual English speakers attached the relative clause to the structurally closer noun (*actress*) but, crucially, monolingual Spanish speakers interpreted the relative clause as referring to the syntactically higher, more distant, noun in the complex NP (*servant*).

- (3) Someone shot the servant of the actress who was on the balcony.

Since then, this cross-linguistic variability has been corroborated by a number of researchers, using a variety of experimental techniques ranging from questionnaire data and self-paced reading studies to eye-tracking experiments and electrophysiological correlates. The preference for NP1 attachment has been well-documented, among other languages, in Spanish (Cuetos and Mitchell, 1988; Mitchell and Cuetos, 1991; Carreiras and Clifton, 1993, 1999; Cuetos, Mitchell and Corley, 1996; Gibson, Pearlmutter and Torrens, 1999; Thornton, MacDonald and Gil, 1999; Dussias, 2003; Carreiras, Salillas and Barber, 2004), Afrikaans (Mitchell, Brysbaert, Grondelaers and Swanepoel, 2000), Dutch (Brysbaert and Mitchell, 1996; Mitchell et al., 2000), German (Hemforth, Konieczny and Scheepers, 2000), French (Zagar, Pynte and Rativeau, 1997; French-Mestre and Pynte, 2000a, b), and Greek (Papadopoulou and Clahsen, 2003). Among the languages for which NP2 attachment is the preferred option are English (e.g. Frazier and Clifton, 1996; Henstra, 1996; Carreiras and Clifton, 1999; Dussias, 2001, 2003; Fernández, 2003), Brazilian Portuguese (Miyamoto, 1998), Arabic (Abdelghany and Fodor, 1999), Romanian, Swedish and Norwegian (Ehrlich, Fernández, Fodor,

¹ Following Kroll & Dussias (2004), we define bilingual as a person who has attempted to master a second language either during early childhood or as an adult, and who possesses knowledge of the second language even to a minimal degree. In this sense, we view bilingualism as a continuum of degrees of accomplishments, which begins at the point where the speaker of one language can use the other language to produce meaningful utterances.

Stenshoel and Vinereanu, 1999), and Italian (De Vincenzi and Job, 1993, 1995; Baccino, De Vincenzi and Job, 2000). However, recent evidence suggests that Italian may also belong to the group of languages for which NP1 attachment is the preferred resolution (e.g. Frenck-Mestre and Pynte, 2000b).

It is important to note that not all studies that have investigated relative-clause-modifier attachment using eye tracking records have reported significant effects for measures that are hypothesized to reflect early structural decisions. For example, both Carreiras and Clifton (1999) and Pynte and Colonna (2000) failed to find effects in first-pass reading times when monolingual Spanish and monolingual French speakers, respectively, read complex NPs followed by long relative clauses (e.g. 31.71 characters on average in Pynte and Colonna). In both studies, significant differences emerged in total reading measures. Some researchers have argued that the disruptions observed in total reading times do not necessarily reflect the first syntactic analysis pursued by the parser, but rather may reflect post-syntactic processing, such as more elaborate pragmatic processing (Altmann, Garnham and Dennis, 1992; Hemforth et al., 2000) or aggregate effects that may come about during the reading of several words (Rayner et al., 1989). However, although it is the case that a number of experiments have found significant first-pass effects that seem to reflect the influence of structural information (e.g. Zagar et al., 1997; Frenck-Mestre and Pynte, 2000b), it is also true that many studies show that first-pass reading times also reflect non-structural information (e.g. the verb-bias effects shown in Trueswell, Tanenhaus and Garnsey, 1994; and Garnsey, Pearlmutter, Myers and Lotocky, 1997). Therefore, it has been suggested (e.g. Carreiras and Clifton, 1999) that disruptions in reading manifest themselves at the moment in which the disambiguating information becomes available to the reader. If the disambiguating information is available quickly, the disruption will show up in early measures, such as first-pass reading times; if it does not, it will affect later measures such as total reading times.

Several theoretical proposals have been advanced to explain the cross-linguistic difference in relative-clause attachment. It is beyond the scope of the present paper to provide a comprehensive overview of this work. (A prosodic explanation for relative clause ambiguity resolution is found in Fodor (1998); a discourse-based approach that appeals to the notion of anaphor resolution is discussed in Hemforth et al. (2000); an approach based on the existence of two structural principles – recency and predicate proximity – has been put forth by Gibson et al. (1996); for overviews of the topic see Cuetos et al. (1996) and Mitchell and Brysbaert (1998).) Instead, we focus on two particular proposals that have attracted considerable attention in the monolingual and bilingual literature.

Linguistic tuning

To explain the cross-linguistic findings, Mitchell and Cuetos (1991; see also Mitchell and Cuetos, 1991; Brysbaert and Mitchell, 1996; Cuetos et al., 1996) raised the possibility that the sentence parser is experience-based, and that initial parsing choices are made on the basis of the experience that the individual reader or listener has with the environment. LINGUISTIC TUNING states that in the course of comprehension, the parser's initial analysis of an ambiguous structure is influenced by the reader's (or listener's) previous encounters with ambiguities of the same kind. Every time a person resolves an ambiguous sentence in a given direction successfully, the comprehension system adjusts itself to keep track of the chosen resolution. The result is that on subsequent encounters of comparable ambiguities, the syntactic processor will be more likely to choose that same resolution (Cuetos et al., 1996).

Naturally, the adequacy of this explanation depends, in part, on evidence showing that there is a direct relationship between parsing preferences and linguistic input. If NP2 attachment is a prevalent parsing routine in English, one should be able to find some correspondence between behavioral data and corpus data in English. Mitchell, Cuetos and Corley (1992) report results suggesting that this is the case. A small-scale corpus study of modifier attachment preferences in English, using the million-word Lancaster-Oslo/Bergen (LOB) corpus, found that 62% of the (resolvable) relative-clause attachment constructions were linked to the second noun. Convergent findings are also reported in Gibson and Pearlmutter (1994), who analyzed all occurrences found in the Brown corpus of constructions where a relative clause attached to one of three sites (i.e. NP1, NP2 or NP3) and found that the NP3 was the preferred attachment site. However, as will become evident later, the Tuning account has been criticized on the grounds that it cannot successfully handle a number of recent monolingual findings.

Construal

A second interpretation of the cross-linguistic variation put forth in the monolingual literature is the CONSTRUAL THEORY (Frazier and Clifton, 1996). The theory suggests that comprehension preferences concerning relative-clause modifiers are affected by universal discourse principles as well as by the existence of language specific syntactic options to express genitive relationships. To begin with, Construal suggests that the relative clause in (3) is associated with the last thematic domain. Roughly speaking, because NP2 is not theta marked by the preceding preposition "of", the last thematic domain contains both the NP1 AND the NP2 (for evidence suggesting that NP2 is the thematic domain in sentences

in which the preposition assigns a thematic role, see Frazier and Clifton, 1996 and references therein; Frenck-Mestre and Pynte, 2000b). As a result of discourse-based influences (i.e. the principle of Relativized Relevance), NP1 will be the last discourse entity in focus. Hence, all languages should display a broad preference to construe NP1 as the host of the relative clause. This is, precisely, what we observe in Spanish. However, this preference is overridden and a tendency for attachment to the second noun prevails if the language has at its disposition two or more syntactic constructions to express possessive relationships, one of which unambiguously conveys the intended attachment to the first noun. This is the case in English, which has two genitive forms, the so-called Saxon genitive (e.g. the actor's sister), which can be used to unambiguously modify the first noun in the complex NP, and the Norman genitive (e.g. the sister of the actor). According to the Construal theory, a speaker of English intending association of the relative clause to the first NP would choose the Saxon genitive over the Norman genitive, because it is the grammatical option that best conveys the intended meaning. It follows that if the Norman genitive is used instead, it is because the reader/listener intended an interpretation where the relative-clause modifies the second NP. This explains the NP2 preference found in English for this type of construction.

To summarize the Construal account, in English and Spanish, a relative-clause modifier preceded by complex head will associate with the entire NP, in cases where the second noun is an argument of the first. The parser's final choice to attach the relative clause high or low will depend on semantic and interpretative considerations. It will also depend on whether the grammar of the language has a grammatical option to block one of the two available interpretations. In English, but not in Spanish, the parser chooses the lower host in a complex NP as the attachment site because English offers a grammatically unambiguous option to convey interpretation to the first NP.

It is important to note that both the Construal theory and the Tuning hypothesis have been questioned on the grounds that they are unable to satisfactorily account for a number of recent experimental findings from the monolingual literature. For instance, Brysbaert and Mitchell (1996; see also Mitchell and Brysbaert, 1998) discuss evidence from Dutch which is damaging to the construal account. These authors explain that Dutch is similar to English in that the Norman genitive co-exists with two other genitive forms: the Saxon form (comparable to English) and a possessive pronoun form (e.g. *vader zijn hoed*, translated as "father his hat"). As in English, the use of the Norman genitive results in an ambiguous sentence, but the use of the two other forms forces attachment of the relative clause to the second NP. Following the arguments presented above to explain the

NP2 bias found in English, Dutch readers should interpret the speakers' choice of the Norman form as a sign that the relative clause is intended to modify the second NP. However, as it turns out, Dutch shows a preference for NP1 attachment (Brysbaert and Mitchell, 1996). In a similar vein, Mitchell et al. (2000) provide evidence from Afrikaans against the proposal, developed in the Construal theory, that the presence of an unambiguous alternative genitive structure is responsible for the cross-linguistic difference. An analysis of questionnaire data in Afrikaans, which like English has a frequently used Saxon genitive form, revealed a reliable NP1 preference for sentences in which a complex noun phrase was followed by a relative clause. Taken together, the results of both studies indicate that speakers do not capitalize on the presence of more than one genitive form to resolve relative clause modifier ambiguity (see Kamide, 1998, for similar evidence from Japanese).

There are also some exceptions to the correspondence between corpus statistics and parsing data that are not expected if the Tuning hypothesis is correct. For example, Gibson et al. (1999; see also Gibson, Schütze and Salomon, 1996) showed that for stimuli involving two or three potential attachment sites, Spanish readers had a preference for NP1 attachment when only two sites were present. However, low (NP2) attachment was preferred over high (NP1) attachment, which was in turn preferred over middle attachment, when three sites were present. This suggests, contrary to the claim made by Cuetos and Mitchell (1988), that attachment preferences are determined in part by a preference to attach recently.

Along these same lines, Gibson et al. (1996) examined conjunctions of noun phrases to complex heads that contained three noun phrases (e.g. *The salesman ignored a customer with a child with a dirty face and a wet diaper* (low attachment); *The salesman ignored a customer with a child with a dirty face and one with a wet diaper* (middle attachment); *The salesman ignored a customer with a child with a dirty face and one with a baby with a wet diaper* (high attachment)). Analyses of corpus searches revealed that middle-attached examples were more frequent than high-attached examples. However, results of a survey showed that low attachments were rated as least complex, followed by high attachments, with middle attachments rated as most difficult. This finding contrasts with the prediction of the Tuning hypothesis that middle attachments should have been rated as easier to process because they were more frequent in the corpus. Finally, Mitchell and Brysbaert (1998) also discuss evidence from Dutch which shows that NP2 attachment of relative clauses is more frequent in corpora, whereas NP1 attachment prevails in on-line data, a finding that is problematic for the Tuning hypothesis.

Notwithstanding the notable differences between corpus frequencies and parsing data, recent findings

reported in Desmet, Brysbaert and De Baecke (2002) provide some indication that the differences in the literature between corpus materials and comprehension data can be accounted for when considering variables that had been previously overlooked. For example, Desmet and his colleagues found that the overall NP2 attachment preference in the Dutch corpus was due to a mismatch between the types of complex NPs that prevail in corpus data and the ones often used in reading experiments. Specifically, in reading experiments, the complex noun phrase always consists of two human nouns (e.g. servant of the actor), but complex NPs of this type turn out to be very rare in Dutch corpus materials. Moreover, Desmet et al. showed when NP1 did not refer to a human entity, the preference in the Dutch corpus was for NP2 attachment. However, this preference was reversed, and an NP1 attachment preference emerged, when the first noun in the complex noun phrase referred to a human. Thus, this variable not considered in previous corpus studies accounts for the apparent contradiction between corpus data and sentence comprehension results, at least in the Dutch cases.

In spite of the large number of cross-linguistic studies that have examined relative-clause-attachment preferences, there is still considerable debate about what this structure really tells us about models of the architecture of the human sentence processing mechanism. Although some models are able to afford the kinds of tests that allow researchers to discriminate between opposing accounts of ambiguity resolution, it is often difficult to distinguish between competing proposals because the available methodological tools do not unequivocally allow researchers to distinguish the sources of information that influence initial parsing decisions from those that become available during subsequent stages of reanalysis. In addition, to conduct experiments that investigate parsing preferences in reading, researchers need to construct materials that have been carefully controlled to allow for an adequate comparison between the different experimental conditions. In the case of RC ambiguity resolution, this has resulted in the majority of studies being based on sentences with complex NPs containing two human entities, partly because this allowed researchers to disambiguate the relative clause on the basis of the semantic gender of the nouns (Desmet et al., 2002). However, as mentioned earlier, this has also led to distorted conclusions about the processes underlying relative-clause attachment.

In this respect, bilingual sentence parsing research becomes particularly revealing. Thus, for example, a prediction that stems from the Construal theory is that knowledge of the existence of the Saxon genitive in English should impinge on how Spanish L2 learners of English parse English relative clauses preceded by complex NPs. If L2 speakers are like native speakers

in that they use the same discourse information (i.e. interpretive and discourse principles) and language-specific information (i.e. knowledge of different genitive constructions in the languages involved) when parsing sentences containing a complex genitive NP followed by an RC, then we expect Spanish-dominant bilinguals reading in Spanish and in English to show language dependent parsing preferences. That is, the bilinguals should favor NP1 attachment when reading Spanish and NP2 attachment when reading English (so long as they are sufficiently proficient in English to know of the existence of alternative genitive constructions). Experimental findings congruent with these predictions would provide evidence in favor of the Construal proposal.

To illustrate further how research on bilingual sentence parsing provides an important tool for revealing constraints within the cognitive architecture (Frenck-Mestre, 2005; Kroll and de Groot, 2005), a model such as Linguistic Tuning predicts that parsing preferences should change if, during an extended period of time, speakers are exposed to large amounts of one particular attachment resolution over the other. As Cuetos et al. (1996) discuss, testing this hypothesis with monolingual speakers can prove to be difficult. This is because outside of an experimental setting, monolingual participants continue to be exposed to the attachment biases that exist in their environment. Hence, the lack of a change in parsing preferences cannot be interpreted as disfavoring the Tuning hypothesis. This obstacle can potentially be overcome with bilingual research, because depending on the language background and the discourse community that bilingual speakers come into contact with most frequently, they may be naturally exposed to different types of biases. The goal of the present paper is precisely to test the impact that immersion in the second language environment has on syntactic parsing. Before launching into a description of the present study, however, it is useful to provide a review of the studies that have investigated ambiguity resolution of relative clause modifiers in bilinguals.

Relative clause ambiguity resolution in L2 speakers

One of the recurring issues in the L2 processing literature concerns whether the same routines and strategies that have been identified during monolingual syntactic processing are also found in non-native learners who appear to know the relevant structures. By and large, this question has been investigated by examining non-native sentence processing in five linguistic domains: main verb vs. reduced relative clause ambiguities (e.g. Juffs, 1998a; Frenck-Mestre, 2005), subject vs. object ambiguities (e.g. Juffs and Harrington, 1996; Frenck-Mestre and Pynte, 1997; Juffs, 1998b), gap processing (e.g. Juffs and Harrington, 1995; Hoover and Dwivedi, 1998, Williams,

Möbius and Kim, 2001; Marinis, Roberts, Felser and Clashen, 2005), object relative constructions (e.g. Love, Mass and Swinney, 2003), and relative-clause attachment ambiguities (e.g. Frenck-Mestre, 1997, 2002; Fernández, 1999, 2003; Dussias, 2001; 2003; Felser, Roberts, Gross and Marinis, 2003; Papadopoulou and Clashen, 2003). Of these, the resolution of relative clause ambiguities has received the most attention, partly because the cross-linguistic differences in relative-clause attachment provide a fertile ground to test whether sentence parsing in the L2 is influenced by the reader's native language.

A number of studies have examined this question using different language pairs (e.g. Spanish–English, German–English, Spanish–Greek, Spanish–French), but the findings are inconclusive. For example, some studies show that learners transfer strategies from the L1 when processing the L2 and others find evidence against the transfer of L1 processing strategies. Factors known to modulate this finding are level of proficiency and years of exposure to the second language as well as similarities between L1 and L2 parsing strategies. For example, Frenck-Mestre (1997) examined RC ambiguity resolution in non-proficient learners of French (a language where NP1 is the preferred attachment site) by considering whether attachment preferences in the L1 and the L2 were congruent. The findings showed that in the congruent case (i.e. L1 Spanish–L2 French), learners showed a preference for NP1 attachment. However, for the incongruent case (i.e. L1 English–L2 French), the trend was towards NP2 ambiguity resolution. Frenck-Mestre attributed this pattern of results to the influence of the native language on second language processing (but see Felser et al. (2003) and Papadopoulou and Clashen (2003) for evidence against an L1 transfer account in proficient L2 learners whose L1 and L2 favor the same attachment site). A subsequent study (Frenck-Mestre, 2002) found that English–French speakers who were proficient in their L2 French resolved the ambiguity in favor of NP1 attachment, the same pattern found in the French monolingual group. Frenck-Mestre suggested that the differences in parsing preferences between the two groups of non-native French speakers could be due to their linguistic histories. The English–French speakers in the earlier study had approximately nine months of French immersion experience and were less proficient in the L2 (i.e. they rated their overall proficiency in French at a level of 5 on a ten-point scale). In contrast, the bilinguals in Frenck-Mestre (2002) were more proficient (the average self-rating was 7 or better) and had lived in France for an average of three years. This suggests that differences in L2 linguistic abilities were responsible for the observed parsing preferences (see also Fernández, 1995). However, because the studies examined the combined effects of exposure to the second language environment and proficiency in the second language, the findings need to

be supplemented with additional evidence that separates each of these variables to obtain a more complete picture of the factors responsible for the patterns observed during L2 syntactic parsing.

Recently, Fernández (2003, Experiment 3) used an unspeeded questionnaire to investigate relative-clause attachment preferences in monolingual and bilingual speakers of English and Spanish. The important variable in this experiment was the manipulation of the length of the relative clause, which is known to influence relative clause ambiguity in monolingual sentence parsing (Fodor, 1998; Pynte and Colonna, 2000). Accordingly, sentences either had a short relative clause (e.g. *the nephew of the teacher that was divorced*) or a long relative clause (e.g. *the nephew of the teacher that was in the communist party*). Consistent with the proposal advanced in Fodor (1998) that the parser has a tendency to equalize the prosodic weight size of constituents (so, long RCs should “attract” NP1 and short relative clauses should attract NP2 attachment), Fernández found overall higher rates of NP1 attachment with long vs. short relative clauses for Spanish monolingual speakers. The bilingual data revealed that Spanish–English bilinguals were sensitive to the length of the relative clause when reading in English. However, these same speakers failed to exhibit length effects with Spanish materials, despite the fact that Spanish was their dominant language. To explain the finding in Spanish, Fernández hypothesizes that sensitivity to length emerges more clearly in the language that the participants read more frequently. In the case of the Spanish–English bilinguals, the fact that they were more frequent readers of English may have contributed to the lack of a length effect.

Similar findings are reported in Dussias (2003), who also tested Spanish–English bilinguals in their two languages. As in previous studies, the construction examined contained a complex noun phrase followed by a relative clause (e.g. *El perro mordió al cuñado de la maestra que vivió en Chile con su esposo* “The dog bit the brother-in-law of the teacher (fem.) who lived in Chile with her husband”). Findings for the control groups (i.e. Spanish and English monolinguals) showed the conventional bias for NP1 and NP2 (respectively) reported in the literature. However, for the Spanish-dominant bilinguals, the prevailing strategy was NP2 attachment regardless of whether they were reading Spanish or English materials. To account for the findings, Dussias suggested that the amount of exposure to the second language by these speakers could have played a role. The Spanish–English participants had lived in the second language environment for approximately eight years and had been under intense contact with English. It could have been that exposure to a large number of English complex NP-*of*-RC constructions resolved in favor of NP2 may have rendered this interpretation more

available, ultimately resulting in the preference for NP2 attachment observed in the results.

As has been suggested elsewhere (Fernández, 2003; Papadopoulou, 2005), to develop a more complete account of bilingual sentence processing, it becomes necessary to supplement the existing findings with evidence from other bilingual populations. In this respect, comparing bilinguals who live in an environment where English is the dominant language to bilinguals in an environment where Spanish is the dominant language should be especially useful to investigate whether the effects reported for the Spanish-dominant bilinguals in Fernández (2003) and Dussias (2003) are indeed linked to language exposure. The experiment that motivates this study examines the role that extensive exposure to the second language has on sentence parsing in the bilingual's first language.

The present study

The critical question addressed in this study is whether immersion in the L2 environment affects the processing of ambiguous relative clause constructions in the primary language of Spanish–English bilinguals. If exposure to the L2 plays a role in determining parsing preferences in the L1, we predict that Spanish–English bilinguals who have been living in an environment where the second language is the dominant language and who have had intense contact with the second language should show evidence of using parsing strategies typically associated with the L2 when resolving temporarily ambiguous constructions in their L1. In the context of relative clause ambiguity resolution, this effect should manifest itself as a reading time advantage for sentences favoring NP2 attachment. This prediction follows from the literature on ambiguity resolution of relative clauses in English showing that structures that force an NP2 interpretation are read significantly faster than constructions disambiguated toward NP1 attachment. In addition, if the Language Exposure Hypothesis is correct, proficient Spanish–English bilinguals with little exposure to the second language should behave like Spanish monolingual speakers. In other words, both groups are expected to prefer NP1 attachment.

Method

Participants

Twenty-eight native Spanish speakers who had lived in an English environment for an extended period of time (henceforth, bilinguals with extensive exposure), 30 native Spanish speakers who had lived in an English environment for a limited amount of time (henceforth, bilinguals with limited exposure) and 54 functionally monolingual speakers of Spanish participated in this study for payment.

The bilinguals with extensive exposure were born in Spain and had learned English during adulthood. Therefore, acquisition of the first language had been completed both through formal and informal input before the onset of second language acquisition.² Three participants were excluded from all analyses because they reported being proficient speakers of a third language. Five additional participants were excluded due to response biases on a set of comprehension questions that was included in the experiment proper to ensure that participants were reading the sentences as expected. Thus, 20 participants were included in the data analyses. At the time of data collection, the participants were completing graduate coursework either in the humanities or in the sciences at a large American university. The bilinguals with limited exposure were born in Granada (Spain). At the time of data collection, these participants were undergoing rigorous training in the translation and interpretation program at the Universidad de Granada. Two participants were excluded from the analyses because they reported being proficient speakers of a third language. Thus, 28 subjects were included in the data analyses. Finally, the functionally monolingual speakers of Spanish, also from the Universidad de Granada, served as the control group. These participants were native speakers of Spanish and were born and raised in Granada. Two participants were excluded because they reported overall proficiency in a second language higher than 2 on a scale from 1 to 10 (with 1 being not fluent at all and 10 being very fluent). Three participants were eliminated because technical problems with the eye-tracking equipment resulted in data loss. Five other participants were excluded due to response biases on the comprehension questions. Thus, 44 participants were included in the data analyses.

To assess the functional proficiency in the first and second language, the Spanish–English bilinguals completed a language history questionnaire designed to tap into several aspects of language proficiency and use by self-report (e.g. language dominance, level of proficiency in the four language areas, number of years the second language was studied, length of stay in a country where the second language was spoken, degree of acculturation/integration in the second language environment). The self-rated proficiency measure was a ten-point scale with 1 being the lowest score and 10 being the highest score.

² The participants came from the original pool of 99 subjects recruited in Dussias (2003). A number of common features characterized this pool of subjects, which were considered important for the purpose of this study, e.g. ease with which the participant reported communicating in Spanish and English, length of stay in the USA, level of formal schooling, age at which L1 and L2 language acquisition began, and degree to which participants felt acculturated in the society where the second language was spoken.

Table 1. *Comparison of bilinguals' Spanish and English language proficiency, measured by the Language Background Questionnaire; 10 = highly proficient, 1 = minimal ability.*

	Means for Spanish (L1)	Means for English (L2)	Standard Deviation	<i>p</i> value t-test
<i>Bilinguals with extensive exposure</i>				
Reading	9.2	9.3	1.12	>.1
Listening	9.8	9.1	.94	<.05
Speaking	9.8	8.7	1.27	<.05
Writing	9.4	8.5	1.31	<.05
<i>Bilinguals with limited exposure</i>				
Reading	9.6	8.2	.67	<.05
Listening	9.9	8.0	.91	<.05
Speaking	9.6	7.8	.72	<.05
Writing	9.2	7.4	.50	<.05

The questionnaire indicated that the bilinguals with extensive exposure had been living in the U.S. for an average of 7.1 years. As Table 1 shows, these participants rated their L1 proficiency in the four language areas (i.e. reading, listening, speaking and writing) higher in Spanish than in English, though it is clear that English was scored high as well. This suggests that the speakers viewed themselves as proficient users of English. A paired sample t-test performed on the scores assigned by the participants to the four language areas revealed a significant difference between the scores given to speaking, listening and writing, with Spanish being better than English, and no significant differences between the scores assigned to reading in both languages. The questionnaire also revealed that English was chosen as the language most frequently read by the participants. On average, English was read for well over two hours daily, whereas Spanish was read for a little over one hour. The reading materials were also more diversified in English than in Spanish. For example, whereas 77% of the bilinguals reported reading magazines, textbooks, research articles, literary works, and newspapers in English, only 33% reported reading the same type of materials in Spanish. For most of the bilinguals, Spanish reading materials were restricted to either magazines or newspapers. The questionnaire also uncovered a number of similarities between the use of Spanish and English in the lives of the participants. All participants reported using Spanish and English in their daily lives and in a variety of contexts, both formal and informal. For example, the participants used Spanish for academic purposes (i.e. in pursuit of graduate degrees) and at the work environment, as well as with colleagues, family and friends. At the same time, all reported feeling integrated and acculturated in the L2 environment (an

average of 8.9 out of a possible 10) and valued the attainment of high proficiency in English. In all, the results of the language history questionnaire, coupled with the fact that the participants were highly successful at using English for intellectual and professional advancement, indicated that these bilinguals felt more dominant in their L1 for some language areas, but nonetheless were proficient in the L2.

The questionnaire also revealed that the Spanish–English bilinguals with limited exposure had learned English during adulthood and had lived in the second language environment for an average of 8.5 months prior to participating in this study. Fifteen participants reported having knowledge of English at level “A” as measured by the Cambridge Certificate of Proficiency and the remaining thirteen reported English proficiency at level “B”.³ The participants’ level of proficiency in both languages, as measured by self-ratings, was overall higher in Spanish than in English. A t-test performed on the scores assigned by the participants to the four language areas revealed a significant difference between the scores given to Spanish and those assigned to English.

To determine whether the two groups of bilinguals were comparable in terms of L2 proficiency, an additional t-test was performed on the scores assigned by each group to the four language areas in English. The results showed that self-rating of reading and speaking abilities differed significantly between the two proficiency groups ($p < .05$), but the differences in writing and listening were marginally significant ($p = .07$ and $p = .11$, respectively). These findings suggest that the bilinguals with limited exposure were somewhat less proficient English speakers than the bilinguals with prolonged L2 immersion experience.

Naturally, differences in L2 proficiency between the two groups of bilinguals are likely to affect parsing decisions. That is, because the bilinguals with limited exposure are also less proficient in English, differences in proficiency can potentially compromise the claim that exposure is an important factor. To ensure that both groups of participants were similarly proficient in English, we first matched the groups using the subjective scores assigned by the participant to their English language skills (see Table 2). This procedure resulted in the elimination of four subjects from the group with limited English proficiency.

³ The Cambridge Certificate of Proficiency reflects the highest level of Cambridge exams in English for speakers of other languages. The test is composed of five sections (Reading, Writing, Use of English, Listening and Speaking) and only candidates with pass scores of A, B, and C are awarded the certificate by University of Cambridge ESOL Examination. Candidates who achieve these three levels are considered to have a high level of language skill, approaching a standard of English similar to that of a native speaker.

Table 2. *Matched Comparison of Bilinguals' English language proficiency, measured by the Language Background Questionnaire; 10 = highly proficient, 1 = minimal ability.*

Self-ratings (10-point scale)	Bilinguals with limited exposure		Bilinguals with extensive exposure		<i>p</i> value t-test
	Mean	Standard Deviation	Mean	Standard Deviation	
Reading	8.8	.78	9.3	1.16	>.05
Listening	8.4	.93	9.1	.99	>.05
Speaking	8.4	.71	8.7	1.2	>.05
Writing	8.1	.55	8.5	1.41	>.05

Next, to obtain a more objective measure of English proficiency, we compared the groups using two measures: (a) the total time it took participants to read the 114 filler items included in an unrelated eye tracking experiment that examined the contribution of L1 verb bias information to the reading of ambiguous sentences in English, and (b) the percentage of correct responses to the comprehension questions for the same filler items. Examples of the filler items and their corresponding comprehension questions are provided in (4)–(6).

- (4) The warning from the experts was a shock to the residents for the city.
Was the warning a surprise?
- (5) The family of the victim supposed the worst when the jury took so long to reach a decision.
Did the jury make a quick decision?
- (6) The political correspondent reported the results after the polling places closed.
Did an election take place?

The results showed that, on average, the bilinguals with limited immersion experience took more time to read the English sentences (4284 ms, $SD = 313$) and were also slightly less accurate in their responses to the comprehension questions (85% correct responses, $SD = 9.8$) than the bilinguals with extensive exposure (reading time = 4124 ms, $SD = 345$; 88% correct responses, $SD = 5.1$). However, the differences between the two groups were not statistically significant (for reading times, $t(42) = -1.137$, $p > .20$; for percentage of correct responses, $t(42) = 1.615$, $p > .10$). This suggests that both groups were equally proficient in English, at least as indexed by the three measures used here.

Apparatus

In all the experiments reported in this study, we used eye tracking methodology to address the research question. It has been suggested that eye tracking is ecologically more valid than other methods of reading such as self-paced reading or word-by-word reading (but see Mitchell, 2004). Also, eye tracking has been argued to be more sensitive to

initial syntactic processing than are other timed-response measures (Rayner et al., 1989). The eye tracker employed for the present study was the SR Research Ltd. Eyelink system. The Eyelink consists of three miniature cameras mounted on a leather-padded headband, allowing for simultaneous tracking of both eyes and of head position for head-motion compensation. The system has a high spatial resolution (0.005°) and samples at a rate of 250 Hz (4 ms temporal resolution).

Stimuli were presented in lowercase letters, on a color 17-inch ViewSonic 17PS monitor. A nine-point calibration, followed by nine-point calibration accuracy test was performed for each participant at the start of the experimental session, after a short break, and when participants were approaching the end of the experiment. In addition, overall accuracy of the equipment was calculated for each participant every 20 items, by displaying an array of nine single digits across the display screen. Calibration was repeated if any point was in error by more than 1° , or if the average error for all points was greater than 0.5° . Before each trial, a black fixation target was displayed at the center of the screen. The subject fixated this target and the reported gaze position was used to correct any post-calibration drift errors. The participants were seated 60 cm from the monitor.

Materials and design

The sixteen experimental sentence pairs used in Carreiras and Clifton (1999) were employed in this experiment as well. Each sentence pair consisted of a complex noun phrase followed by a relative clause, and corresponded to two experimental conditions, exemplified in (7) and (8).

- (7) NP1 attachment: El policía arrestó a la hermana del criado que estaba enferma desde hacía tiempo.

[The police arrested the sister of the (male) servant who had been ill (fem) for a while.]

- (8) NP2 attachment: El policía arrestó al hermano de la niñera que estaba enferma desde hacía tiempo.

[The police arrested the brother of the (female) baby-sitter who had been ill (fem) for a while.]

In the NP1 attachment condition, the relative clause *que estaba enferma* contains an adjective (*enferma*) that is marked with female gender morphology. To satisfy the Spanish morpho-syntactic requirement that nouns and their modifiers agree in gender and number, the relative clause must attach to a feminine host. Given that the only suitable candidate is the NP1 *hermana* (a feminine noun), the sentence is said to be morphologically disambiguated toward high attachment. The NP2 (low attachment) condition was constructed by switching the gender of the nouns in the complex NP to disambiguate the relative clause toward the lower noun *niñera*.

The experimental stimuli used in this study were disambiguated by morphological (as well as conceptual) gender in the manner explained above and examined the same type of relation between the two noun phrases in the complex NP (i.e. kinship relations); therefore, the complex NP always contained two noun phrases with the feature [+human], separated by the preposition *de*. In addition, for all the experimental items, the complex NP was immediately followed by a subject relative clause. To avoid having the disambiguating region (i.e. the adjective in the relative clause) occupy the last position in the sentence, all sentences ended with some extra information (e.g. in (7) and (8), *desde hacía tiempo/for a while*). This ensured that any distortion on the fixation durations that could result from end-of-sentence effects would not fall on the region of interest.

In addition to the 16 experimental items, 60 distracter sentences and 32 filler sentences were added. The distracter sentences were similar in length to the experimental stimuli, and included other types of ambiguities (e.g. *Mientras los invitados comían el flan que preparó Ana se enfriaba en el plato*; *While the guests were eating the flan that Ana prepared was cooling off on the plate*); the filler items were complex sentences containing a main and a subordinate clause (e.g. *El hermano de Susana dijo que su madre llegaría en unos pocos minutos*; *Susana's brother said that his/her mother would arrive in a few minutes*). Twelve practice items were added at the beginning of the experiment to familiarize participants with the requirements of the task and the type of stimuli. One third of the total number of items (experimental, distracters and fillers) in the experiment was followed by a comprehension question (e.g. *Arrestaron al criado/a la niñera?*; *Was the servant/the baby-sitter arrested?*). This was done to guarantee that participants were performing the reading task as expected. Half of the questions required

a “yes” answer and half a “no” answer. Questions were distributed evenly across experimental, distracter and filler sentences.

Two 120-item lists were created, each containing 16 experimental items (8 in each condition), 60 distracters, 32 fillers and the 12 practice sentences. Each list contained exactly one version of each experimental sentence (i.e. one version of a sentence within a sentence pair). The experimental sentences, the distracters and the fillers were pseudo-randomly interleaved; this resulted in the items being presented in a different order to each subject, yet the items in each stimulus type were evenly distributed throughout the duration of the experiment.

Procedure

When the participants arrived, they were seated in front of the computer screen and the headband was placed on their heads. Calibration of the equipment took approximately five minutes. Before the experiment began, participants were told that they were participating in a study on reading comprehension and were presented with an instruction screen, which explained the procedure. Participants were instructed to look at a fixation point that indicated the first character position of each sentence. When the participant was correctly looking at the fixation point, the experimenter pressed a button, causing a stimulus item to appear on the screen. Participants read each sentence at their own pace and then pressed a button that could either cause the presentation of a comprehension question or of another sentence. To answer the comprehension questions, participants pressed one of two hand-held buttons, one for a “yes” response and one for a “no” response. The instructions emphasized the importance of accuracy in responding to the questions presented during the experiment. Each experiment began with 12 practice sentences, followed by the 16 experimental items intermixed with the 92 other sentences that served as distracters to divert the participant from the structure of the experimental materials.

Results

The results obtained for the critical region are of theoretical interest to the present study. In this study, the critical region was defined as the adjective within the relative clause, given that it disambiguates the relative clause toward the higher or the lower noun. The fixation duration measures reported are first-pass and total reading times. First-pass is defined as the sum of all left-to-right eye-fixations on the critical region before leaving it the first time that it is read, and total times are the sum of all fixations on the critical region at any time, including re-reading (Rayner et al., 1989).

Overall accuracy on the comprehension questions was 96% for the Spanish monolinguals, 93% for the

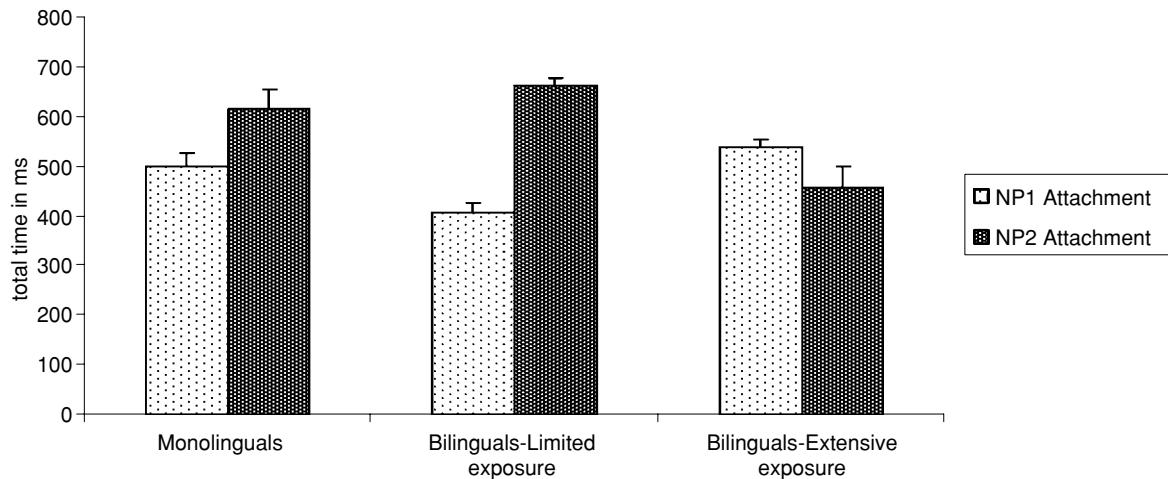


Figure 1. Total Reading Times at the Critical Region in the NP1 and NP2 Attachment Conditions. Spanish Monolingual speakers and Bilinguals with Extensive and Limited Exposure.

Spanish–English speakers with limited immersion experience and 91% for the Spanish–English bilinguals with extensive immersion experience. An ANOVA comparing fixation durations (first pass and total times) in the two attachment conditions (NP1 attachment and NP2 attachment) for the three groups of participants showed a lack of a significant interaction between group and attachment for first pass reading times, $F < 1$. However, a significant interaction effect emerged between group and attachment for total reading times [$F(2,85) = 21.17$, $p < 0.01$; $MSE = 14649.08$]. Follow-up *t*-tests comparing the performance of each group on the NP1 and NP2 attachment conditions indicated no difference between the two conditions for first-pass reading times [$t(43) = .18$, $p > .10$, for monolingual Spanish speakers; $t(23) = 1.36$, $p > .10$, for Spanish–English bilinguals with limited immersion experience; $t(19) = .12$, $p > .10$, for Spanish–English bilinguals with extensive immersion experience]. However, for Spanish monolingual speakers, total reading times were significantly longer for items that were disambiguated toward NP2 ($M = 613.87$ ms) compared to items disambiguated toward NP1 ($M = 497.96$ ms). Analyses were significant both by subjects [$t(43) = 4.33$, $p < .01$] and by items [$t(15) = 2.41$, $p < .05$]. These results corroborate the vast majority of the findings reported in the literature for attachment preferences in Spanish: monolingual Spanish speakers attach the relative clause to the first of the two potential host sites within the complex NP. The advantage obtained for the NP1 attachment condition over the NP2 attachment condition adds to this body of evidence (e.g. Cueto and Mitchell, 1988; Mitchell and Cueto, 1991; Carreiras and Clifton, 1993, 1999; Carreiras et al., 2004).

A similar finding emerged for the Spanish–English bilinguals with limited immersion experience. Sentences

disambiguated toward NP2 attachment were read slower ($M = 660.17$ ms) than those disambiguated toward NP1 attachment ($M = 406.54$ ms). The difference was significant by subjects [$t(23) = 6.12$, $p < .001$] and by items [$t(15) = 8.08$, $p < .001$]. This indicates that the Spanish–English bilinguals who are proficient speakers of English but who have lived in the L2 environment for a limited period of time resolve the ambiguous constructions in Spanish much like Spanish monolingual speakers. Finally, for the Spanish-dominant bilinguals with extensive immersion experience, analyses by subjects and items indicated that these participants were significantly faster when the sentence was disambiguated toward NP2 attachment ($M = 454.93$ ms) than when it was disambiguated toward NP1 attachment ($M = 537.86$ ms), [$t(19) = 3.68$, $p < .01$] and [$t(15) = 2.47$, $p < .05$] by subjects and items, respectively. The results show that these Spanish–English readers had difficulty at the disambiguation in sentences where NP1 attachment was favored, suggesting that NP2 attachment was the preferred strategy. Figure 1 presents total reading times for NP1 and NP2 attachment for all three groups.

To test whether total reading time for NP1 and NP2 attachment preference is related to English proficiency and immersion exposure (measured in months), we performed a regression analysis on total reading times. The measures of English proficiency chosen were the reading times for the filler items used in the English verb bias experiment and the percentage of correct responses to the comprehension questions for the same filler items. Because the reading times for the filler items were only marginally significantly correlated with the percentage of correct responses ($r = -.232$, $n = 44$, $p = 0.065$), both variables were included in the regression model. The bilinguals' immersion exposure and the two objective measures of English proficiency were entered as the

predictor variables. The criterion variable was the effect of disambiguation. We calculate the effect of disambiguation (by participants) by subtracting the total reading times for items disambiguated toward NP1 attachment from the total reading times for items disambiguated toward NP2 attachment. Using the entered method, a significant model emerged [$F(3, 40) = 11.39, p < .001; MSE = 32015.29$], adjusted R square = .420. The regression analysis also indicated that immersion experience had a large impact on attachment preferences ($Beta = -.697, p < .001$), whereas proficiency was not a significant predictor ($Beta = -.055, p > .1$ and $Beta = .082, p > .1$, for reading times and percent correct for filler items, respectively). These results suggest that it is immersion exposure that accounts for the difference in the results obtained for the two groups of bilinguals.

To summarize, the results for the monolingual speakers replicate previous findings in the literature showing that Spanish speakers prefer attachment to the non-local noun when processing ambiguous constructions containing a complex noun phrase followed by a relative clause (e.g. Cuetos and Mitchell, 1988; Mitchell and Cuetos, 1991; Carreiras and Clifton, 1993; Carreiras and Clifton, 1999; Carreiras et al., 2004). The bilinguals with limited immersion experience in the L2 environment processed this construction in their L1 much the same way as Spanish monolinguals do. In contrast, the Spanish–English bilinguals with extensive exposure to English favored NP2 attachment when reading Spanish, their native language.

Discussion

From the early days of the study of bilingualism, a number of research projects have shown that there is an interaction of language knowledge between the bilingual's two linguistic systems. The obvious case is that of adult second language learners. We now know from off-line and on-line studies that late bilinguals (those who learned their second language after puberty) are influenced by lexical, syntactic and semantic information developed in their first language when processing the second language (see, for example, Hernández, Bates and Ávila, 1994; Frenck-Mestre and Pynte, 1997), even after having attained high degrees of proficiency in the second language. A considerable body of research has also shown that information specific to the second language produces linguistic modifications in the first language. Much of this research investigates the weakening or loss of the first language in prolonged (i.e. well over ten years) contact situations with a second language (e.g. see, for example, Seliger and Vago, 1991 and articles therein). In these studies, the transfer of linguistic knowledge from the second to the first language becomes evident because such transfer results in anomalous, marginally acceptable or pragmatically odd sentences in the first language, in

failure to retrieve words from the L1, or in the inability to pronounce the first language with native speaker pronunciation. However, very little work has attempted to examine the permeability of the first language system where the effects of language transfer are less apparent, as is the case when interference results in grammatically correct or semantically plausible sentences, and where the amount of language contact is not as extensive as past studies have reported. The present study is a first attempt to address this gap by examining whether parsing strategies typically associated with a bilingual's second language are employed while reading temporarily ambiguous constructions in the first language.

Several studies investigating the processing of syntactically ambiguous constructions involving a complex NP followed by a relative clause have shown that bilingual speakers sometimes resolve this type of ambiguity in a manner akin to the bilinguals' L1, and other times they use strategies derived from the L2. A factor driving the choice of one attachment resolution over the other is level of proficiency in the two languages. Another one is immersion experience in the second language environment. To date, the available evidence has considered the joint contribution of these two variables. For example, empirical evidence suggests that bilinguals who resolve the ambiguity in the L2 by adopting the same strategies employed by monolingual speakers are those who have been immersed in the second language environment for a greater period of time. Because they are also proficient in the L2, it is difficult to disentangle how these two variables each contributes to the bilinguals' parsing decisions. In a parallel fashion, studies in which bilinguals are shown to transfer strategies typically associated with the second language while processing input in the first (more dominant) language have been conducted while the bilinguals reside in the second language environment. Given this, comparing these results with those obtained from bilinguals who live in the L1 environment is particularly useful to address questions having to do with effects of exposure on bilingual parsing.

In an attempt to put the results of previous findings on more secure footing, we compared the performance of monolingual Spanish speakers with that of Spanish–English bilinguals who had limited or extensive immersion experiences in the L2 environment. Participants read temporarily ambiguous constructions in Spanish, their dominant language, which consisted of a complex NP followed by a relative clause. Our findings show that the Spanish monolingual speakers reliably attached the relative clause to the first noun; this pattern of results was evident only in total reading times. Although the controversy remains unresolved about which reading time measure is more diagnostic of the initial processes followed by the parser, what

seems clear is that our findings for the monolingual Spanish reflect aspects linked with the normal processing of the construction in Spanish. The Spanish–English speakers with limited immersion experience in the L2 environment resolved the ambiguity in favor of NP1 attachment; conversely, the Spanish–English bilingual with extensive exposure attached the relative clause to the second noun. Importantly, the results were apparent after proficiency between the two groups of bilinguals was matched.

These findings present a rather unique type of linguistic permeability – that at the level of parsing routines. The present study demonstrates a substantial difference for the interpretation of ambiguous relative clause constructions between monolingual Spanish speakers and Spanish–English bilinguals residing in a Spanish–dominant environment on the one hand vs. Spanish–English bilinguals residing in an English-dominant environment, on the other hand.

The sociolinguistic context of the bilingual speakers living in the English setting was such that primary language maintenance was considered of high utilitarian and social value among the participants. Many were pursuing graduate doctoral work in Spanish, for which a high command of the language was necessary, or all used their knowledge of Spanish for economic gain. In addition, the speakers kept close ties with nuclear and extended family in their home country, and therefore regarded Spanish as vital for maintaining their social and emotional ties with their native lands. This is, perhaps, a context in which primary language erosion has the least opportunity to come about, and yet we found in the L1 system of these speakers signs of permeability. This permeability manifested itself as the convergence of parsing routines: NP1 attachment, the parsing operation associated with the processing of the temporarily ambiguous Spanish construction investigated here, was replaced by NP2 attachment, the process that characterizes the final attachment outcome when monolingual English speakers are confronted with the same type of ambiguity.

The present demonstration of a difference in the parsing routines between the Spanish–English bilinguals with limited exposure to the L2 environment and the Spanish–English bilinguals immersed in English indicates that parsing preferences in bilinguals can undergo shifts in directionality. Assuming that the Spanish speakers embarked on the task of L2 language acquisition with a set of processing strategies from their L1 (i.e. a preference for NP1 attachment), these results can be explained under the premise that daily exposure to English has shifted the attachment preferences. This strongly suggests that the observed permeability of the L1 system is a consequence of exposure to the second language in the natural environment.

A notable feature of our findings is that the processing routines that speakers engage in when assigning a syntactically licit structure to an incoming string of words appear to be susceptible to change even in cases when bilinguals maintain close ties with their first language. This is a significant finding given that the L1 literature on languages in contact has shown that if “erosion” in the primary language occurs at all, it does so when two variables interact: pervasive influence of the second language and limited contact with and use of the first language. For example, de Bot, Gommans and Rossing (1991) demonstrated that the L1 proficiency of their Dutch–French bilinguals, as measured by an oral test of overall proficiency, did not change over time if the bilinguals were in close contact with Dutch.

The results reported here that the L1 language-processing system is open to influence from the L2 system are consonant with those reported in other areas of bilingual language processing research. For example, Schwartz, Kroll and Diaz (under review) asked native English speakers who learned Spanish during adulthood to name cognates and non-cognates in English and Spanish. Their findings showed that the time it took bilinguals to name words in their L2 was affected by the correspondence between the lexical codes in the two languages. That is, when the orthography between the two words was very similar, it took longer to name the words in the L2 if the phonology between them was more distinct. Remarkably, a similar pattern of results was observed for word naming in the L1. A follow-up experiment with monolingual English participants revealed no significant differences. This suggests that the lexicon is a permeable system, with influences not only from the dominant L1 to the weaker L2, but also from the L2 to the L1.

Our findings are also congruent with the results in the French-Mestre and Pynte (2000b), which demonstrate that parsing preferences can be affected by the linguistic environment surrounding the participants. These authors provide evidence that the observed NP1 preference reported for monolingual French speakers when parsing structures of the type NP1–*of*–NP2 RC deteriorated if, during the experimental session, participants first read a block of sentences containing structures that favored NP2 attachment resolution (i.e. complex NPs with prepositions that assign thematic roles). Put simply, the prior reading of sentences for which attachment of the relative clause to the second NP was the suitable parsing decision impacted the subjects’ subsequent performance when reading structures for which NP1 is the generally preferred attachment site.

Given these findings, it seems clear that a comprehensive account of human sentence processing must include an explanation of what causes readers to change parsing preferences in the so-called stable L1 linguistic system. Of the models that have been proposed

in the monolingual literature to account for parsing decisions concerning modifier ambiguity resolution, the one that most readily provides an explanation for the findings reported in the present study is a frequency-based model of the sort proposed in the Tuning hypothesis. As previously stated, at the time of data collection the bilinguals with extensive exposure to English were living in a predominantly English-speaking environment, whereas the bilinguals with limited immersion experience in English were living in an entirely Spanish-speaking environment. It may be that exposure to a preponderance of N1-*of*-N2-RC English constructions resolved in favor of NP2 attachment may have rendered this interpretation more available, ultimately resulting in the preference for NP2 attachment when bilinguals read in the first language. Hence, a model such as Linguistic Tuning, which incorporates statistical frequency as an important variable within the cognitive architecture, can directly account for the phenomena reported here. It can also account for a number of findings stemming from the bilingual literature on sentence parsing that have shown clear effects of exposure on the development of parsing strategies (e.g. Frenck-Mestre, 2005).

The results of the present study add to the growing body of evidence suggesting that the Construal account, as it is currently formulated, needs revision (e.g. Mitchell et al., 2000). Strictly speaking, the absence of a Saxon genitive in Spanish should indicate to our Spanish participants that attachment of the relative clause to the first noun in the complex NP (i.e. high attachment) is the intended meaning. Although this was the preferred attachment option for the monolingual Spanish speakers and the Spanish-English bilinguals with limited exposure to the L2, the Spanish-English bilinguals who had extensive immersion experience in the natural L2 environment opted for attachment of the relative clause to the most recent noun, despite the fact that Spanish only has one syntactic construction available to express genitive relationships.

Future research needs to examine whether more closely tied relations than the ones that exist between arguments and their modifiers (such as those between verbs and their core arguments) are equally likely to be permeable. One may be tempted to speculate, for example, that sources of information accessed to parse certain types of constituent are more susceptible to external influence than others, so that, for example, we may find the information directing parsing decisions of verbal arguments may not be as vulnerable to intrusion as the factors that affect the parsing of, say, adjunct phrases. If this turns out to be the case, it would lend some support to models of sentence processing that postulate distinct parsing processes for different types of constructions.

In concluding, the demonstration that sources of information guiding L2 parsing decisions seep into the L1 comprehension system carries the implication that

there is activation of L2 knowledge in memory during the process of L1 sentence parsing. Therefore, current models of human sentence processing need to be able, in principle, to deal with resolution effects that are obtained during bilingual sentence parsing when providing an account of the underlying mental processes that guide the human sentence parsing mechanism.

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Received May 3, 2004

Revisions received December 20, 2005; March 6, 2006

Accepted April 4, 2006

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