Parsing a first language like a second: The erosion of L1 parsing strategies in Spanish-English Bilinguals

Paola E. Dussias
The Pennsylvania State University

Abstract

Past research suggests that parsing processes in a bilingual's first language (L1) can undergo changes as a function of exposure to a second language (L2). Evidence for this claim comes from studies that have examined how Spanish-English bilinguals resolve temporarily ambiguous sentences containing a complex noun phrase followed by a relative clause, as is the case in "Peter fell in love with the daughter of the psychologist who studied in California." Previous studies indicate that whereas monolingual Spanish speakers attach the relative clause to the first noun in the complex noun phrase (non-local attachment), monolingual English speakers interpret the relative clause locally (i.e., attach the relative clause to the noun immediately preceding it). With respect to bilinguals, recent research with Spanish-English bilinguals and professional translators (e.g., Dussias 2001, 2003; Parede, 2004) have shown that bilinguals attach the relative clause to the second noun in the complex noun phrase, when reading in Spanish, their first language. The differences observed between monolingual and bilingual speakers have been attributed to experience in a second language immersion environment. For example, Dussias (2003) argues that extensive exposure to a preponderance of English constructions resolved in favor of local attachment can render this interpretation more available, resulting in the low attachment preference observed in Spanish-English bilinguals. Of interest in the present paper is to assess whether speakers with fewer years of immersion experience in the L2 environment than those reported in previous studies employ the correct strategy in each of their languages. To this end, eye-movement data was collected while proficient L1 Spanish/L2 English speakers read ambiguous sentences of the type described above, in their first language, and their performance was compared to a monolingual Spanish group. Analyses revealed that the L1 Spanish speakers of English favored local over non-local attachment when reading in their first languages. The results are most congruent with exposure-based or parallel interactive models of sentence parsing as postulated by Brysbaert & Mitchell (1996), Mitchell & Cuetos (1991) and Mitchell, Cuetos, Corley & Brysbaert (1995), given the assumption within these models that frequency-based exposure affects parsing decisions.

Key words

erosion

L1 L2

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Address for correspondence

Paola E. Dussias, Pennsylvania State University, Department of Spanish, Italian and Portuguese, 211 Burrowes Building, University Park, PA 16802, U.S.A.; telephone: (814) 865-1122; fax: (814) 863-7944; e-mail: <pdussias@psu.edu>.

1 Introduction

In the psycholinguistic study of bilingual[1] language comprehension, a considerable amount of research has been conducted in the domains of speech perception and word recognition (e.g., Altenberg & Cairns, 1983; De Groot & Nas, 1991; Grainger & Beauvillain, 1987; Grosjean, 1985, 1997; Grosjean & Soares, 1986; Kirsner, Smith, Lockhart, King, & Jain, 1984; Kroll, 1993; Kroll, Michael, Tokowicz, & Dufour, 2002; Kroll & Sholl, 1992; Kroll, Sumutka, & Schwartz, in press; Kroll & Sunderman, 2003) with considerably fewer studies investigating the structure and functioning of the mental mechanisms involved during syntactic processing and sentence parsing (some exceptions are, e.g., Fernández, 1995, 1999, 2003; Frenck-Mestre, 2002; Frenck-Mestre & Pynte, 1997; Hahne, 2001; Hahne & Friederici, 2001; Hernández, Bates, & Ávila, 1994; Hoover & Dwivedi, 1998; Juffs, 1998a and b; Juffs & Harrington, 1995). The reasons for this are manifold. For one, syntactic, semantic and pragmatic information needed to process language becomes available only after the lexicon has been accessed. Hence, it may seem logical to study word recognition in bilinguals before proceeding to investigate aspects that deal with higher level processing. Also, much has been written about the different tasks that are used to conduct lexical access studies and about the subsystems that these tasks tap into. From a methodological perspective, then, researchers in the bilingual domain may feel that they are better equipped to conduct investigations of specific aspects of word recognition in bilinguals than to study the processes that the parser follows to assign structure to the sentences it encounters. However, research on the architecture and mechanisms of bilingual sentence comprehension is important because we are dealing with a particular cognitive process, that of language, and as such, it is no different from trying to understand the architecture and mechanisms of other aspects of cognition, such as motor control. In other words, the study of bilingual sentence parsing is important because, just as monolingual sentence parsing, it relates to the rest of cognition. In addition, bilingual sentence parsing research can help us understand why language interactions among bilinguals work the way they do, why speakers in the process of becoming bilingual draw incorrect conclusions about the second language grammar and about its properties, why bilinguals sometimes comprehend written text differently from monolingual readers, and how language contact impacts bilingual sentence parsing.

To contribute to a better understanding of sentence processing in bilinguals, the present paper investigates first language erosion from the point of view of language processing (retrieval and integration) and of the cognitive mechanisms that speakers use to deploy linguistic knowledge in particular instances of language comprehension. The specific aim of the planned experiment reported here is to examine what Seliger (1985) has referred to as "erosion of linguistic performance," by investigating the impact that knowledge of and exposure to an L2 has on sentence parsing in the L1. The present paper, then, focuses on the various mental operations that the sentence processing mechanism of the bilingual speaker engages during L1 sentence comprehension, and asks whether

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[1]   Following Kroll & Dussias (2004), I use the term bilingual to refer to the housing of two languages in one single mind, and do not intend any reference to language proficiency and/or fluency.

the L1 comprehension system is permeable in the sense that parsing routines typically associated with an L2 affect sentence parsing in the bilingual's L1.

The construction used to examine processing routines in this study contains a complex noun phrase (NP) followed by a relative clause (RC), as illustrated in the sentence *Peter fell in love with the daughter of the psychologist who studied in California*. This syntactic structure is of interest to the present study because it can be parsed in more than one way. Specifically, the relative clause *who studied in California* can modify *the daughter*, the first noun in the complex NP (i.e., the daughter studied in California) or *the psychologist*, the second noun in the complex NP (i.e., the psychologist studied in California). Resolutions of the first kind are conventionally labeled *N1 attachment*, *early closure* or *high attachment*, on the assumption that the first site is located at a higher point than the second site in the syntactic tree. Correspondingly, the latter kind of interpretation is traditionally referred to as *N2 attachment*, *late closure* or *low attachment*.

The remainder of this paper is organized as follows. The first section presents an overview of the mainstream sentence parsing literature, involving constructions of the type that contain a complex NP followed by a relative clause, and briefly summarizes a range of relevant experimental findings concerning cross-linguistic parsing differences in monolingual speakers. The second section discusses relevant literature on relative clause ambiguity resolution in bilinguals. The third section presents the planned experiment, in which eye-tracking measures were collected to investigate how Spanish-dominant bilinguals who have been immersed in the second language environment for a limited period of time perform while parsing sentences that contain the structure at issue. The final section provides a tentative explanation for the results obtained.

2 Relative Clause Attachment Resolution: Evidence from the literature on monolingual speakers

Much of the discussion on sentence parsing in monolinguals centers around whether there exits a universal set of parsing strategies that is used to process different languages. Universal parsing strategies have been postulated to explain the tendency for readers and listeners to commit to one interpretation of an ambiguous sentence at points in the sentence where two or more alternative interpretations are possible. To take an example, the sentence *Donna put the books on the table in the car* has two interpretations. On one reading, the prepositional phrase (PP) *on the table* acts as a complement of the verb *put* (i.e., the books were put on the table). When this happens, the second PP remains without a syntactic node to attach to, resulting in a structurally anomalous sentence. On the second interpretation, *on the table* requires a relative clause reading (i.e., Donna put the books that were on the table in the car). Several studies (see, e.g., Frazier, 1987; Rayner, Carlson, & Frazier, 1983) have shown that the parser's initial preference is to attach the ambiguous region (i.e., the first PP) directly to the verb phrase (VP) rather than to the NP *the books*. Upon encountering the next prepositional phrase, the parser is forced to abandon the initial structure it has built in favor of one that can successfully integrate the new information.

The fact that readers make incorrect parsing decisions of the type described above suggests that there is a universal *first-pass strategy* that the parser uses to build

syntactic trees. One of the earliest models to support the view that the parser is guided by a number of universal principals was proposed by Frazier (1978). The model, better known as the *Garden Path Model*, postulates that early decisions in parsing are deter-mined by a small set of fixed strategies whose function is to increase the speed and efficiency with which the syntactic representation of sentences are built during real-time processing. The two most important principles in the model are *Minimal Attachment* and *Late Closure*. Minimal Attachment ensures that the parser constructs an analysis using the fewest permissible number of syntactic nodes. In our example above, the parser's initial preference is to attach *on the table* directly to the VP because, being this analysis the one requiring the smallest number of nodes, it avoids the additional work involved in constructing more complex structures. Late Closure directs the parser to integrate new constituents into "… the phrase postulated most recently" (Frazier, 1987, p. 562). The prototypical sentence used to illustrate how Late Closure works is given in (1) below:

(1)   Someone shot the daughter of the actor who went to a private clinic.

Structurally, the relative clause *who went to a private clinic* is ambiguous in that there are two potential host sites for its attachment. Attachment to the higher noun phrase in the complex NP *daughter of the actor* will result in an interpretation whereby *the daughter* went to the clinic. Conversely, if the relative clause attaches to the lower noun phrase, *the actor* will be understood as having gone to the clinic.

The basic observation about on-line processing of phrases of this kind is that in English, the parser's initial choice is to attach the adjunct phrase (i.e., the relative clause) to the lower noun in the complex NP (see, e.g., Cuetos & Mitchell, 1988 and Mitchell & Cuetos, 1991, using questionnaire and self-paced reading data, and more recently Henstra, 1996, and Carreiras & Clifton, 1999, using eyetracking data). In conventional terms, these speakers are said to *favor*, *to show a bias*, or *to display a preference* for low attachment. The primary evidence for the preference reported in English comes from measures of the difficulty observed when English speakers process sentences containing a temporary ambiguity which is eventually resolved in favor of the presumably dispre-ferred NP1 reading. This is illustrated in (2):

(2)   Someone shot the daughter of the actor who went to a private clinic to give birth to her first-born child.

A parser that systematically attaches the relative clause low into the complex NP will be forced to reanalyze when it reaches the fragment containing the disambigua-ting information (i.e., give birth). Since giving birth to humans is a property unique to females, the reanalysis must involve attachment of the relative clause from *the actor* to *the daughter*, or from the preferred NP2 attachment to the dispreferred NP1 attachment. Because reanalysis is presumed to require additional processing, (2) should take longer to read than a comparable sentence containing an ambiguity resolved in favor of low attachment (e.g., Someone shot the son of the actress who went to a private clinic to give birth to her first-born child).

Although late closure explains a number of phenomena that had previously been accounted for in an ad hoc manner, well over a decade ago Cuetos and Mitchell (1988)

published a well-known study that challenged its universality, by 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 monolingual English speakers reading sentences like (2) displayed a general preference to attach the relative clause to the structurally closer noun, but crucially monolingual Spanish speakers interpreted the relative clause as referring the syntactically higher (i.e., more distant) noun in the complex NP. Since then, this particular structure has been studied in various languages (e.g., French, Dutch, German, and Greek) and a preference for high attachment has been established. The cross-linguistic differences in relative-clause (i.e., modifier) attachment have been the impetus for a number of subsequent proposals that explain why relative-clause attachment preferences vary across languages. We give a brief overview of some of these accounts below (for a detailed overview, we refer the reader to Cuetos, Mitchell, & Corley, 1996; a prosodic explanation for relative-clause ambiguity resolution is found in Fodor, 1998; a recent account of relative-clause ambiguity resolution that appeals to the notion of anaphor resolution is discussed in Hemforth, Konieczny, & Scheepers, 2000).

2.1
Linguistic tuning

To explain their results, Mitchell and Cuetos (1991) raised the possibility that the only universal principle is that early parsing preferences are resolved by the experience the individual reader or listener has with the environment (and not in a fixed manner, as suggested by late closure). *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 (see also Cuetos, Mitchell, & Corley, 1996).

Central to the linguistic tuning account is the claim that the architecture of the language processing system consists of information that is revised over time, as the parser is exposed to language. This stands in marked contrast with the Garden Path model, where it is assumes that the module that builds syntactic structure has access to only fixed parsing-specific principles. This being the case, the tuning account predicts that in cases of ambiguity, there should be a close correspondence between corpus data and behavioral data. As a test of the linguistic tuning account, Mitchell, Cuetos, & Corley (1992, cited in Cuetos, Mitchell, & Corley, 1996) conducted a corpus analysis of relative clause attachment in ambiguous sentences of the type NP1-of-NP2 RC to determine attachment preferences in discourse. Their findings revealed that in English most tokens of the ambiguity are resolved in favor of low attachment. Contrary to this, and in support of the exposure-based account of parsing, in Spanish the ambiguity is most often resolved in favor of high attachment. However, there are some notable exceptions to the correspondence between corpus statistics and on-line parsing data that is not expected if the tuning hypothesis is correct. For example, for three-site relative clause attachment (e.g., … las lámparas cerca de las pinturas de la casa que fue dañada

en la inundación/the lamps near the paintings of the house that was damaged in the flood), Gibson, Pearlmutter, Canseco-Gonzalez, & Hickok (1996) showed that corpus frequencies and parsing preferences stand in marked contrast. In addition, Mitchell, & Brysbaert (1998) discuss evidence from Dutch that low attachment of relative clauses is more frequent in corpora, whereas high attachment prevails in on-line data.

2.2
Construal

To reconcile the findings reported for English and Spanish, as well as for other languages, Frazier and Clifton (1996) proposed a radical revision of the Garden Path model that has come to be known as the *Construal Hypothesis*. The fundamental argument of the Construal hypothesis is that the principles of Minimal Attachment and Late Closure maintain their universal status, but are only operable when the parser encounters phrases that are dependent on the main predicate of the sentence. These phrases are termed *primary phases* (roughly, arguments) and stand in contrast with nonprimary phrases (roughly, modifiers and adjuncts), which presumably are *construed* or associated with some constituent(s) within a sentence through a number of discourse and semantic operations, Gricean principles, and focus effects. According to this account, the attachment of modifiers (such as relative clauses) follows a complex set of pragmatic, thematic and syntactic constraints.

The construal hypothesis provides an account for the differences in parsing preferences observed in Spanish and English. Frazier and Clifton (1996, pp. 71 – 80) argue that initially the relative clause in constructions similar to (2) will be associated to the entire complex NP phrase, making either NP within the phrase a suitable candidate to host the relative clause. Later, discourse principles, the most important of which is *Relativized Relevance* (Frazier, 1990), will introduce a general bias for high attachment. Relativized Relevance directs the parser to "… preferentially construe a phrase as being relevant to the main assertion of the current sentence" (Frazier, 1990, p. 321). In (2) above, this would mean associating the relative clause to *the daughter*. Since the principle of Relativized Relevance is assumed to be universal, English is predicted to show the same preference bias as, for example, Spanish. The fact that it doesn't is explained by the workings of an additional factor. In English, a relative clause unambiguously modifies the first noun in a complex NP if the Saxon genitive (i.e., the actor's daughter) is used. The ambiguity arises only when the Norman genitive is employed. Frazier and Clifton (1996, p. 80) suggest that, following Grice's maxim of manner ("avoid obscurity and avoid ambiguity"), a speaker intending association of the relative clause to *the daughter* would have chosen the Saxon genitive over the Norman genitive. The fact that the Norman genitive was used instead signals to the listener/reader that the intended interpretation is one where the relative clause modifies *the actor*.

Although this account provides a workable explanation for the prevalent finding of high attachment preferences observed in many languages as well as the idiosyncratic pattern of English, several issues remain unresolved. Most notably, Brysbaert and Mitchell (1996; see also Mitchell & Brysbaert, 1998) discuss evidence from Dutch that suggests that the construal hypothesis may need revision. These authors explain that Dutch is similar to English in that the Norman genitive coexists 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 low attachment bias found in English, Dutch readers should interpret a speaker's 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 high attachment.

2.3
Constraint-Satisfaction Models

The last type of theoretical account discussed here is one that, like the Linguistic Tuning Hypothesis, also assigns an important role to adjustments made by the parser as it is exposed to language. Constraint-based theorists (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994a; Trueswell, Tanenhaus, & Garnsey, 1994) assume that there are no architectural restrictions — as those underlying the Garden-Path model or the Construal Hypothesis — on the use of particular sources of information during sentence parsing. They argue that readers or listeners use multiple sources of information interactively (e.g., syntactic category information, plausibility information, verb-bias, information, frequency information, etc.) throughout processing. With regards to relative-clause ambiguity resolution, the claim made by these models is that ambiguity and ambiguity resolution are guided by lexical information. For example, MacDonald, Pearlmutter, and Seidenberg (1994b) suggest that cross-linguistic variation in relative-clause attachment preferences may be explained in terms of the modifiability of the nouns in the complex NP. The preference for low attachment in English could be accounted for by assuming that the noun *actor* appears in English accompanied by a postnominal modifier more often than the noun *son* does. This information influences attachment decisions, and hence *actor* in (2) ends up being modified by the relative clause. In Spanish, the situation is assumed to be the reverse, resulting in a high attachment preference.

The past decade has seen a growing interest in the investigation of on-line parsing performance in bilingual sentence processing from the point of view of language acquisition (e.g., Dussias, 2003; Fernández, 1995, 1999; Juffs, 1998a and b; Juffs & Harrington, 1995; White & Juffs, 1998). Motivated in part by the view that certain structural principles of language are innate, much of this work assumes a competence-based theory of human natural language processing, where the core of syntactic parsing consists of the local application of a number of grammatical principles. Central in these studies is the question of whether bilingual speakers process target language input in the same manner as their monolingual counterparts, or whether the performance of bilingual speakers is different in certain respects from monolinguals. Variables such as language proficiency, language exposure and working memory capacity are investigated to arrive at an understanding of the precise nature of bilingual sentence processing, and to contribute to the understanding of the fundamental properties of the human sentence processing mechanism. We now overview the research that examines relative clause ambiguity resolution in bilinguals, as it is relevant to the planned experiment presented in this study.

3 Bilingual relative clause ambiguity resolution

Although several studies exist that have examined the way bilingual speakers process temporarily ambiguous relative clauses in real time, the results obtained are difficult to reconcile. In a self-paced reading study, Papadopoulou and Clahsen (2003) examined how Spanish, German and Russian L2 speakers of Greek resolved relative clause ambiguities when reading Greek equivalents of sentences such as *A man called the student (masc) of the teacher (fem) who was disappointed (masc) by the new educational system*. Papadopoulou and Clahsen report that whereas the Greek native speakers showed a preference for NP1 attachment, none of the L2 learners showed any consistent preference for either NP1 or NP2 attachment. The results suggest that even highly proficient L2 learners parse sentences differently from native speakers (see also Felser, Roberts, Gross, & Marinis, 2002, for similar results with German and Greek learners of English; for additional literature on differences between L1 and L2 syntactic processing, see Hanhe 2001; Hahne & Friederici, 2001; Hernández, Bates, & Avila, 1994; Weber-Fox & Neville, 1996; Wulfeck, Juárez, Bates, & Kilborn, 1986). Similar findings are reported in Fernández (2003), who used an unspeeded (i.e., questionnaire) task and a self-paced reading task to investigate the attachment preferences of Spanish-English and English-Spanish bilinguals in their two languages. Results for the on-line task (Experiment 4) indicated that the Spanish — and English-dominant bilinguals exhibited no sensitivity to one attachment site over another in both of their two languages.

Recently, Dussias and Sagarra (submitted) collected eye-movement records with Spanish-English bilinguals and monolingual Spanish speakers to investigate the effect that intense contact with English had on attachment preferences in Spanish, their first language. Functionally monolingual Spanish speakers and Spanish-dominant bilinguals who had lived in an L2 environment for an extended period of time participated in the experiment. The structure under investigation contained a complex noun phrase followed by a relative clause. (e.g., 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). They found that the Spanish monolingual participants showed the conventional bias for high attachment reported in the literature. Conversely, the Spanish-English speakers showed a consistent preference for low attachment when reading sentences in their first, suggesting that the parsing routines used to process the second language had an impact on the processing of the first language as well (see also Dussias, 2003, for similar results using a self-paced reading task). This indicates that parsing routines in bilinguals are permeable. This permeability manifested itself as the convergence[2] of parsing routines: high attachment, the parsing operation associated with the processing of the temporarily ambiguous Spanish construction was replaced by low attachment, the process that characterizes the final attachment outcome when monolingual English speakers are confronted with the same type of ambiguity. To explain the findings reported for the Spanish-English bilinguals, the authors suggested that the amount of exposure to the second language by these speakers could have played

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[2] I follow Silva-Corvalan (1994) in defining the term *convergence* to describe the achievement of greater structural similarity in a given aspect of two languages, which was assumed to be different at the onset of contact.

a role. The Spanish-English participants had lived in the second language environment for approximately seven years, and had been under close contact with English. It could have been that exposure to a large number of English complex NPs + relative-clause constructions resolved in favor of low attachment may have rendered this interpretation more available, ultimately resulting in the preference for low attachment observed in the results (see also, Paredes, 2004, for a similar argument).

Although exposure to the second language may have played a role in the parsing preferences used by the Spanish-English bilinguals, a competing explanation focuses, instead, on the cognitive demands placed on the bilingual language processor. The assumption is that N2 attachment (i.e., local attachment) is a parsing principle favored by the processing system on the grounds that it allows listeners and readers to immediately integrate new material with prior material, and by way of local attachment minimizes the chances of exceeding the memory limits of the sentence processing mechanism (see, e.g., Fodor, 1998; Frazier, 1978; Frazier & Clifton, 1996). The suggestion is that the bilingual processor favors low attachment to minimize delays in processing time that come about from housing two languages. These processing delays arise because the processor is required to manage two linguistic systems, as bilinguals do not completely deactivate one of the two languages, even in a monolingual language mode (Grosjean, 1985, Grosjean, 1997).

The bilingual populations that participated in the studies reviewed above have their own circumstantial traits. 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 have lived for a limited period of time in an environment where English is the dominant language to monolingual speakers should be especially useful to investigate whether convergent parsing strategies are indeed the result of language exposure, or whether they are a consequence of bilingualism per se. This was the goal of the present experiment.

4 The present study

The critical question in the experiment reported here is to further examine whether convergence in parsing strategies is modulated by amount of exposure to the second language. To this end, the present study examines parsing preferences in Spanish-English bilinguals with limited immersion experience in the second language environment, and compares the results to previously gathered data from Spanish monolinguals.

5 Method

5.1
Participants

Twenty L1 Spanish-L2 English bilinguals participated in this experiment for payment. At the time of data collection, the bilinguals were residing in the second language environment. Language proficiency in the L1 and the L2 was assessed via a self-rated language background questionnaire. The questionnaire revealed that the Spanish-English bilinguals in this study shared a number of characteristics with the Spanish-English bilinguals

that participated in Dussias and Sagarra (submitted). That is, both groups reported using Spanish and English in their daily lives and in a variety of contexts, formal and informal. For example, they used both languages for academic purposes (i.e., in the pursute of graduate degrees) or at the work environment, as well as with colleagues, family and friends. Both groups also indicated that English was the language most frequently read, and that the texts read were more diversified in English (magazines, textbooks, research articles, literary works, newspapers) than in Spanish (magazines or newspapers). In addition, all bilinguals reported feeling integrated and acculturated in the L2 environment and valued the attainment of high proficiency in English. The one distinguishing feature that sets these two groups of bilinguals apart is that the participants in the present experiment had been immersed in the second language context for an average of 3.7 years. A group of monolingual Spanish speakers (N = 36) was also recruited.

5.2
Materials

The materials were identical to those employed in Dussias and Sagarra (submitted).

Sixteen item sets[3] were used in this experiment. An item set consisted of a pair of sentences in each of two versions, corresponding to two experimental conditions, exemplified below:

Condition 1: 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].

Condition 2: 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].

In Condition 1, the relative clause *que estaba enferma* contains an adjective (i.e., *enferma*) that is marked with female gender morphology. To satisfy the Spanish morphosyntactic 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 N2 *niñera* (a feminine noun), the sentence is said to be *morphologically disambiguated* in favor of low attachment. Condition 2 was constructed by switching the gender of the nouns in the complex NP to force attachment of the relative clause to the higher noun.

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 include 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 prepare was cooling off on the plate); the filler items were complex

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3   The experimental sentences are from Carreiras & Clifton (1999).

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. Finally, one third of the total number of items (experimental, distracters and fillers) in the experiment was followed by a comprehension question (e.g., ¿Arrestaron a la niñera?/ Was 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 the sentences within an item set). The experimental sentences, the distracters and the fillers were pseudorandomly 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.

5.3
Procedure

Stimuli were presented on a color monitor using an Eyelink eye-tracker, interfaced with an IBM-compatible PC. The system consists of three miniature cameras mounted on a leather-padded headband. Two of the cameras allow for binocular eye tracking, while the third camera records the stimuli displayed on the computer screen. Recording of eye-fixations is done at a sampling rate of 250 Hz. The eye-tracker was calibrated and validated for each participant at the start of the experimental session, after a short break, and when participants were approaching the conclusion of the experiment.

Each sentence appeared in its entirety across one line on the computer screen. Participants were instructed to read the each sentence at their own pace, and to answer the comprehension question, by pressing one of two hand-held buttons. Before the experiment began, subjects were told that they were participating in a study on reading comprehension and were presented with an instruction screen, which explained the procedure and emphasized the importance of accuracy in responding the questions presented during the experiment.

5.4
Results

The disambiguation region (e.g., *enferma* in Conditions 1 and 2 above) is the area of theoretical interest to the present study. 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 is read, and total times are the sum of all fixation on the critical region at any time, including rereading (Rayner, Sereno, Morris, Schmauder, & Clifton, 1989). To contextualize the findings reported in this study, we first present the mean fixation durations for first pass and total reading times for the monolingual speakers. These are presented in Table 1.

Table 1

Means for first-pass and total reading times in millisecond for the critical region in the N1 and N2 attachment conditions. Spanish monolingual data

	N2 attachment condition	N1 attachment condition
First pass	302	295
Total time	613	525

As can be seen, there is a numerical cost associated with the condition forcing low attachment over the condition favoring high attachment. Pairwise comparisons indicated that although first-pass times were numerically faster in the critical region when the construction was disambiguated toward high attachment than when it was disambiguated toward low attachment, the difference did not approach significance ($p > .1$). However, the analyses on the total reading times indicated that the participants read the critical region faster in the N1 attachment condition than in the N2 attachment condition. The difference between the means for two conditions was significant, $F(1, 34) = 25.1, p < .05$.

The results obtained in for the Spanish monolingual speakers corroborate the vast majority of 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. In this experiment, the advantage for the condition favoring N1 attachment over N2 attachment adds to this body of evidence (e.g., Cuetos & Mitchell, 1988; Mitchell & Cuetos, 1991). The effect manifested itself rather rapidly, in terms of a small difference in fixation durations for first-pass reading times; however, this difference was strong enough to be statistically significant only in total reading time measures.

We now turn to the data of central interest here, the fixation durations for the Spanish-English bilinguals with limited exposure to the second language environment. Means for first pass fixations and total time are presented in Table 2.

Table 2

Means for first-pass and total reading times in millisecond for the critical region in the N1 and N2 attachment conditions. Spanish-English bilinguals with limited exposure

	N2 attachment condition	N1 attachment condition
First pass	268	334
Total time	404	548

More time was spent on the disambiguating region in the N1 attachment condition than in the N2 attachment condition. Pairwise comparisons showed that the low attachment sentences caused less disruption than the high attachment one. This reading advantage was significant for first pass fixations, $F(1, 18) = 6.25, p < .05$, and for total reading times, $F(1, 18) = 11.47, p < .05$. Thus, readers had difficulty at the disambiguation in sentences where high attachment was favored. This indicates that N2 attachment was the preferred strategy for this group of bilinguals.

The results indicate that bilinguals with limited immersion experience in the L2 prefer to attach the relative clause low, to the second N, rather than high, to the first N, when reading in Spanish, their native language. In this respect, their behavior is distinct from that of monolingual Spanish speakers, given that for the Spanish monolinguals the preference was tilted rather consistently towards N1 attachment.

6 Discussion

The aim of this study was to investigate first language erosion at the level of sentence processing. To examine this question, we investigated preferred attachments when complex NPs are followed by modifiers (in this case, relative clauses). The basic finding reported here is that monolingual Spanish speakers favor high attachment. In contrast, Spanish-English bilinguals show a uniform bias in favor of low attachment, the same bias reported in the monolingual literature for English speakers.

The evidence presented here suggests that parsing preferences in bilinguals can undergo shifts in directionality. The L1 Spanish-L2 English speakers showed a significant bias for low attachment over high attachment when reading Spanish, their first language. Assuming that our Spanish speakers embarked on the task of L2 language acquisition with a set of processing strategies from their L1 (i.e., a preference for high attachment), these results can be explained under the premise that daily exposure to English has shifted the attachment preferences for this group of subjects. A notable feature of our findings is that the processing routines that speakers engage when assigning a syntactically licit structure to an incoming string of words appear to be susceptible to change even when speakers are exposed to a second language environment for a relatively short period of time (an average of 3.7 years in our case). This is surprising given that the L1 literature on language loss has shown that if erosion in the primary language occurs at all, it does so only under pervasive influence of the second language; numerous studies show, for example, that after 10 years of immersion in an L2 environment, many linguistic aspects of the L1 remain largely unaffected (e.g., de Bot, 1996; de Bot, Gommans & Rossing, 1991; but see, Bouba, Filiaci, Heycock, Sorace, & Tsimpli, 2002).

In discussing the occurrence of erosion of the L1 system, it is important to know whether there has been a change in the participants' L1 knowledge (the tacit linguistic information, be it syntactic, semantic, pragmatic, etc. that resides in the speaker's mind) or whether there has been a change in the participant's control of that knowledge (the on-line access mechanisms that the speaker draws upon to deploy that knowledge during real-time processing) (Sharwood Smith & Van Buren, 1991). Until we have a refined theory of syntactic parsing that can satisfactorily account for the cross-linguistic findings reported in the literature for relative clause ambiguity resolution, we will not be able to provide an unequivocal answer this question. As a first approximation, we may propose that difficulty at the level of retrieval and integration of information (i.e., control) for the data reported here would manifest itself in terms of dysfluent reading (i.e., with eye-movement records, significantly longer fixation durations than those observed for monolingual readers). The fact that first pass and total time fixations for the monolingual Spanish speakers and for the Spanish-English bilinguals are very similar does not seem to suggest a loss of fluent access on the part of the latter group of participants.

Rather, it seems to be the case that for these bilinguals, the erosion has occurred at the source of knowledge that guides monolingual Spanish speakers to choose the higher of the two NP hosts for attachment of the relative clause.

Although there is disagreement in the mainstream parsing literature as to what sources of knowledge guide relative clause ambiguity resolution, most recent proposals explaining the processing of nonprimary phrases have put forward accounts that draw upon discourse-pragmatic factors to explain the attachment resolution of temporarily ambiguous relative clauses. As explained earlier, Frazier, & Clifton (1996) propose that different processes are engaged for the processing of primary and nonprimary phrases. Whereas primary phrases are parsed according to the application of universal parsing principles such as Late Closure and Minimal Attachment, phrases whose syntactic function is that of acting as modifiers (as are relative clauses) are attached following a complex set of pragmatic and discourse constraints (e.g., discourse principles such as Grice's principle of Clarity, together with the application of pragmatic principles such as Relativized Relevance, both discussed in Section 2). In the same vein, Hemforth, Konieczny, & Scheepers (2000) also appeal to the application of pragmatic principles to explain why relative pronouns prefer to be bound to the higher of two antecedents. If these accounts are correct, the results reported in this study suggest that the pragmatic knowledge that directs parsing decisions is permeable to intrusion from other linguistic systems. This hypothesis finds support in the literature on languages in contact, where there is ample evidence of the permeability of linguistic systems at the discourse-pragmatic level (e.g., Prince, 1992). To conclude, one may be tempted to speculate that certain sources of information are more susceptible to external influence than others, so that, for example, we may find syntactic sources of information directing parsing decisions to be not as vulnerable to intrusion as pragmatic sources. This possibility is left for future research.

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