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Early and late preferences in relative clause attachment in Portuguese and Spanish

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***Abstract:** This study presents new data about the cross-language application of the Late Closure principle (Frazier, 1978), whose universality was put in question by data from Spanish (Cuetos & Mitchell, 1988). Using sentences containing a restrictive relative clause unambiguously modifying the first or the second noun of a complex NP (os cúmplices do ladrão/o cúmplice dos ladrões que fugiram), this study compares the behavior of Brazilian and European Portuguese speakers participating in a self-paced reading task. The data confirm that, in early phases of processing, attachment preferences are driven by a locality principle such as Late Closure. Based on a review of studies on Portuguese, Spanish and other Romance languages, we argue that the high- versus low-attachment difference across languages emerges cleanly only in off-line tasks, such as questionnaire studies, thus limiting the types of explanations for the cross-linguistic differences. We also advance an explanation for the high attachment preferences found in unspeeded questionnaire studies based on the Implicit Prosody Hypothesis (Fodor, 1998a, 2002).*

1. Introduction

The present article reports the results of a new self-paced reading experiment and reviews studies which focus on the way Portuguese speaking adults process globally and temporarily ambiguous sentences containing a complex noun phrase (NP) followed by a relative clause (RC), as in the examples in English (1) and Spanish (2) provided below. In such sentences, the complex NP provides two potential attachment sites for the RC: the high (non-local) N1 and the low (local) N2. In a seminal study, Cuetos and Mitchell (1988) found a cross-linguistic difference in the RC attachment preferences of English and Spanish speakers: whereas English speakers prefer to attach low (1b), Spanish speakers prefer to attach high (2a):

- (1) Someone shot the maid of the actress who was on the balcony.
 - a. The actress was on the balcony.
 - b. The maid was on the balcony.

- (2) Alguien disparó contra la criada de la actriz que estaba en el balcón.
- a. La actriz estaba en el balcón.
 - b. La criada estaba en el balcón.

In addition to questionnaire data, Cuetos and Mitchell reported data from self paced reading experiments which arguably attested to an on-line high attachment preference for Spanish speakers. These results called into question aspects of the *Garden Path* model of sentence processing (Frazier and Fodor, 1978; Frazier, 1979) which proposed an innate—hence universal—mechanism for sentence processing based on principles of cognitive economy. Cuetos and Mitchell's discovery had significant implications, not only in the area of sentence processing, but also in the area of language acquisition. In order to acquire the grammar of a language, children have to parse sentences, since they cannot learn rules or set parameters on the basis of unstructured word strings (Fodor, 1998b). A similar problem is faced by the adult learner of a language, who must process input strings before these can serve as the intake that triggers the development of a second language grammar (VanPatten, 2002). A sentence processor with language-specific components would thus pose important challenges to models of language acquisition, since parameter setting depends largely on the structures the learner computes from input strings (for discussion of this problem, see Fodor, 1998a).

In the course of processing a sentence, the human sentence processor tries to attach each incoming item by building the simplest structure possible, pressed by working memory constraints. According to the *Garden Path* model, upon encountering local structural ambiguities, the parser does not entertain all structural configurations in parallel but commits itself to one of them on the basis of a set of decision principles or strategies which favor structures simpler in terms of their syntactic complexity (Minimal Attachment) and which prefer local attachments over non-local ones (Late Closure). A local association strategy had been

originally proposed by Kimball (1973) as the Right Association principle. In the framework of the garden path model, Kimball's Right Association was re-formulated as Late Closure, "when possible, attach incoming material into the clause or phrase currently being parsed" (Frazier 1979, p.76). By application of the Late Closure principle, the parser delays closing a current constituent in order to attach new material locally and inside it, since attaching new material inside the current constituent is more economical in terms of computational cost than attaching it non-locally, to a higher node. As this description implies, the phenomena that Late Closure is formulated to account for can also be seen as resulting from a "Recency Preference" in parsing (Gibson, Pearlmutter, Canseco-González and Hickock, 1996): incoming constituents are preferably attached to more recent, or local, hosts.

Having found a preference in Spanish for the non-local attachment of the RC, Cuetos and Mitchell (1988) suggested that Late Closure is not a universal principle of the parser and, indeed, most of the empirical work on this construction has focused on identifying the language-specific factor or factors that drive the cross-linguistic differences. Under one proposal (Mitchell and Cuetos, 1991), the parser's preference to attach relative clauses is modulated by the distribution of disambiguated attachments in the sentences the parser has been exposed to. We will outline this and other accounts of the cross-linguistic differences, as well as empirical evidence on how speakers of Romance languages process the construction of interest.

Attempts to identify the source for the cross-linguistic differences have involved research on the RC attachment ambiguity in a number of languages (see Fernández, 2003, for references), including Brazilian Portuguese (BP), which was at first classified as a low attachment language (Miyamoto, 1999). Other studies, however, have demonstrated that BP is in fact a high attachment language (Ribeiro, 2001; Maia and Maia, 2001/2005; Finger and Zimmer, 2002/2005; Lourenço-Gomes, 2003; Maia, Lourenço-Gomes and Moraes, 2004; Miyamoto

2005). Maia, Costa, Fernández and Lourenço-Gomes (2004) is the first study to examine relative clause attachment in European Portuguese (EP) and BP in parallel, observing high attachment preferences for both varieties of Portuguese, using an unspeeeded questionnaire procedure. We review these studies in the sections that follow, and present new data from a self paced reading experiment that compares the behavior of BP and EP speakers. This new study demonstrates that in hypothetically early phases of processing, attachment decisions are driven by a locality or recency principle such as Late Closure. This principle, derived from the general cognitive architecture, applies in all languages, even those for which the preferred attachment eventually turns out to be to the high site. We will argue that the high- versus low-attachment difference across languages emerges cleanly only in off-line tasks, such as questionnaire studies, thus limiting the types of explanations for the cross-linguistic differences. We will also advance an explanation for the high attachment preferences found in unspeeeded questionnaire studies based on the *Implicit Prosody Hypothesis* (Fodor, 1998a, 2002).

2. Managing the Late Closure crisis

As we have already noted, one way to account for the cross-linguistic differences in processing the RC attachment ambiguity involves proposing that the parser itself is the source of the cross-linguistically different behavior. The parser might “tune” itself such that its preference to attach RCs matches the type of attachment more frequently experienced in the environment. The *Tuning Hypothesis* (Mitchell and Cuetos, 1991) proposes just that, and thus predicts that the input to learners contains more frequent unambiguous high attachments than unambiguous low attachments, for a language whose speakers exhibit a high attachment preference when interpreting ambiguous sentences. Some work comparing corpus data and behavioral data has found such a correlation; for example, Igoa (1996) offers evidence confirming this prediction for

Spanish. The Tuning Hypothesis has faced complications in light of corpus data, reported by Mitchell and Brysbaert (1998), demonstrating that, in a set of Dutch corpora, unambiguous attachments are predominantly to the low site, a finding at odds with the observed preference by Dutch readers to attach RCs high. Desmet, De Baecke, Drieghe, Brysbaert and Vonk (2006) attempt to reconcile the mismatch between Dutch corpus and behavioral data (as reported by Brysbaert and Mitchell, 1998) by claiming that the parser makes structural decisions guided by information stored in the lexicon. Desmet et al. report Dutch corpus data which, as predicted by the Tuning Hypothesis, correspond with the attachment preferences of Dutch readers, when the animacy and concreteness of the host nouns (two lexically specified properties) are taken into account as variables in the analyses. High attachment is most frequent, both in the corpora examined and in the interpretation preferences observed, when the high noun is animate, an effect that engages in complex interactions with the concreteness of the high and low nouns in the complex NP.

In contrast to the Tuning Hypothesis, the source for the cross-linguistic differences might be posited to be linked to the parser's use, after an initial analysis, of extra-syntactic information. The *Construal Hypothesis* (Frazier and Clifton, 1996) proposes that RCs are not incorporated into an on-going parse following the routines used for attaching primary phrases. Rather, RCs (and other non-primary phrases) are loosely associated to structural representation within the current thematic domain and their ultimate interpretation is driven by pragmatic considerations. Under the Construal framework, the difference between English and Spanish is linked to the language-specific consequences of the application of universal pragmatic principles. In Spanish, for example, an RC is preferably attached high because the higher site is more salient in the current discourse than the lower site, by a discourse principle because of which relative clauses are preferably interpreted as referring to more salient elements. In contrast, in English, an

ambiguous RC is preferably attached low because, although the high site is more salient, this consideration is overridden by a discourse factor that weighs the informativeness of the high attachment interpretation of the ambiguity. In English, there exists an unambiguous way to express the high attachment meaning of (1): in *the actress' maid who was on the balcony*, the RC can only be attached to *maid* (attachment to *actress* is ungrammatical).

The Construal Hypothesis is not implausible as an account for the general preference for the high site observed in many languages. However, Construal's specific claims about the cross-linguistic differences in RC attachment fail the empirical test: Dutch and Croatian are languages whose grammars provide unambiguous structural alternatives to the high attachment interpretation of the ambiguity (similar to the genitive construction in English), yet speakers of both of these languages exhibit a preference to attach high (for Dutch, Brysbaert and Mitchell, 1996; for Croatian, Lovrić, 2003).

The *Implicit Prosody Hypothesis* (Fodor, 1998a, 2002) resembles Construal in its assumption of a parser that operates under universal principles which apply no matter what language is being processed. But unlike Construal, it hypothesizes that speakers of different languages exhibit different attachment preferences because of differences in their internalized phonologies. The prosodic structure (intonation and phrasing) projected when reading out loud can influence ambiguity resolution. According to the Implicit Prosody Hypothesis, a prosodic structure generated implicitly during silent reading can also influence ambiguity resolution. Under this account, a language like Spanish has a phonology such that prosodic structures supporting high attachment interpretations are projected by default, in contrast to a language like English, whose default phonology generates prosodic structures that support low attachment interpretations. In the end of section 4 below, we review prosody studies in EP and BP and

offer some evidence that supports the role of implicit prosody in the resolution of the Portuguese RC attachment ambiguity.

Under a comprehensive account about how RC attachments are resolved, one might propose that multiple variables can affect the ultimate resolution of the ambiguity—including lexically specified features, the status of relevant constituents in the information structure of the sentence, and the prosody projected implicitly for the string during silent reading or explicitly when listening or reading aloud. But do such factors override an initial preference to attach low, driven by locality principles such as Late Closure? Let us consider three alternative positions. The lexically driven parser proposed by Desmet et al. (2006) would be affected by lexically specified information as early as possible, and particular combinations of animacy and concreteness features in the host nouns should drive attachment preferences quite early in the time-course of processing: with animate N1s, we would expect early high attachment preferences. The parsing mechanism of Construal (Frazier and Clifton, 1996) would have no early attachment preference for non-primary relations like RC attachments, since early on an RC is only associated within the thematic domain. Finally, the influence of implicit prosody would take place only when a prosodic contour has been projected over the whole structure formed by the complex NP and the RC and the boundaries of the intonational phrases have been marked: Fodor (2002) notes that "syntactic analysis and prosody assignment can be interleaved, with prosodic processing following along in the wake of low-level syntactic processing, and feeding later syntactic decisions." (p. 83).

3. RC Attachment preferences in Romance

The RC attachment preferences of speakers of Romance languages have been investigated in a number of studies, and provide a useful reference point in any discussion of RC

attachment in Portuguese. Questionnaire data probing the preferences of speakers of French (Zagar, Pynte and Rativeau, 1997), Galician (García-Orza, Fraga, Tejido and Acuña, 2000), Italian (De Vincenzi and Job, 1993) and Spanish (among others, Cuetos and Mitchell, 1988; Fernández, 2003) all confirm a robust preference for high attachment in these languages. The only member of the Romance family that to date fails to fall into the category of high attaching languages is Romanian, which apparently resembles English in its preference for low attachment (Ehrlich, Fernández, Fodor, Stenshoel and Vinereanu, 1999). The data from Romance (Romanian to the side) are therefore clear when the measure of attachment is untimed, or "off-line", as in questionnaire-based experiments which present ambiguous sentences to participants who are then asked to indicate their interpretation of the RC: the eventual preference for speakers of these languages is to attach high. However, when the measure of attachment is timed, or "on-line", we have contradictory findings.

On-line procedures differ in important respects from questionnaire procedures. In the latter, participants are asked to read globally ambiguous sentences, and their attachment preference is measured by examining the distribution of responses to direct questions about the interpretation of the RC. For a sentence like (1), participants might be asked to answer *Who was on the balcony?* In contrast, a timed, or "on-line", procedure compares reading time measures or eye gaze time measures for regions inside sentences where attachment is disambiguated one way or the other, or left ambiguous. The preferred interpretation is assessed indirectly: we can infer that a disambiguation site is preferred if we observe shorter reading or eye gaze times for it, compared either to the disambiguation that is more difficult or to the ambiguous version of the sentence (but see Traxler, Pickering and Clifton, 1998, for an empirical demonstration, and discussion of the theoretical implications, that the fastest reading times are obtained, for English at least, when attachment remains ambiguous).

According to some studies, the on-line preference for languages in the Romance family is for materials disambiguated to attach high (e.g., Cuetos and Mitchell, 1988; Mitchell and Cuetos, 1991; Carreiras and Clifton, 1993, 1999; Mitchell, Cuetos and Zagar, 1990). But other studies report precisely the opposite preference, namely, low attachment on-line, even when the final preference is for high attachment (Baccino, De Vincenzi and Job, 2000; De Vincenzi and Job, 1993, 1995; Fernández, 2003), and contemplate explanations for their findings that involve different stages in the processing of this construction (see also Pynte, 1998). Plausibly, speakers of all languages prefer local attachments on a first parse, but can be guided (by both lexical and other non-structural factors, including pragmatics and/or prosody) toward an ultimate high-attachment interpretation of the construction. It is perhaps not insignificant that no language studied to date has exhibited an early preference for high attachment that reverses "off-line" to a late preference for low attachment.

How to reconcile the discrepancies between the experiments just cited is unclear, since any of the design and implementation differences between them could be to blame. These studies use sentence materials that are segmented in different (and therefore non-comparable) ways. The details of the procedure often differ between these studies—for instance, not all use comprehension questions after every trial. The disambiguation in the materials is sometimes achieved using pragmatics, in other cases it relies on number agreement features, and in yet other cases it employs gender agreement features.

In addition to off-line questionnaire data and on-line reading data, some studies examining the resolution of the RC attachment ambiguity have reported data for questions posed to readers after reading target sentences on-line. Appearing after the final segment for the target sentence is read, these comprehension questions probe the resolution of the attachment in a *yes/no* format (e.g., *Was the maid on the balcony? yes, no*, Fernández, 2003) or in a binary

forced-choice format (e.g., *Who was on the balcony? the maid, the actress*, De Vincenzi and Job, 1993). Responses to such questions have consistently been reported as more accurate when attachment in the target is disambiguated to the high site, not just in (high attaching) Romance languages like Spanish (Fernández, 2003) and Italian (De Vincenzi and Job, 1993), but also in low attaching languages like English (Fernández, 2003). Accuracy in responding to reading comprehension questions like these is possibly not linked to the ultimately preferred resolution of the attachment of the RC. Instead, perhaps responses to such questions reflect how information is retained during discourse processing, assuming that sentence reading plus comprehension question answering involves the processing of mini-discourses. Elements more central to the main arguments of the target sentence (less embedded elements; Matthews and Chodorow, 1988) should be easier to recall during the question-answering part of the task. Thus, correctly answering *yes* to *Was the maid on the balcony?* should be easier than correctly answering *yes* to *Was the actress on the balcony?* since *the maid* is a more central element in the target sentence than *the actress*. Of course, correctly answering such questions will also hinge on accurately noticing the form of disambiguation in the target sentence, and thus accuracy in answering such sentences could be linked to how efficiently the means for disambiguation is processed.

4. Previous studies of RC attachment in Portuguese

Two studies were carried out in the late nineties investigating the processing of the RC attachment ambiguity in Brazilian Portuguese. These studies were developed independently at about the same time and reached contradictory conclusions about the preferences of RC attachment in the language. On the one hand, Edson Miyamoto's (1999) PhD dissertation, *Relative clause attachment in Brazilian Portuguese*, claimed that BP speakers preferred to attach

RCs low; on the other hand, Antonio Ribeiro's (1998) unpublished paper, "Um caso de não aplicação de Late Closure no Português do Brasil," argued that BP RCs preferably receive a high attachment interpretation.

Miyamoto (1999) asked native speakers of BP living in the United States to read sentences with full (3) and reduced (4) RCs. The attachment of the RC was disambiguated by number agreement, as illustrated in the examples.

- (3) a. O ator tentou ignorar a manchete das revistas que **foi mencionada** no rádio.
"The actor tried to ignore the headline[sg] of the magazines[pl] that was mentioned[sg] on the radio."
b. O ator tentou ignorar as manchetes da revista que **foi mencionada** no rádio.
"The actor tried to ignore the headlines[pl] of the magazine[sg] that was mentioned[sg] on the radio."
- (4) a. O ator tentou ignorar a manchete das revistas **mencionada** no rádio.
"The actor tried to ignore the headline[sg] of the magazines[pl] mentioned[sg] on the radio."
b. O ator tentou ignorar as manchetes da revista **mencionada** no rádio.
"The actor tried to ignore the headlines[pl] of the magazine[sg] mentioned[sg] on the radio."

The gender of the two nouns in the complex NP was systematically matched, so that the only disambiguating feature would be morphological number. Miyamoto analyzed reading times for fragments of the target sentences, which had been displayed using a word-by-word moving-window non-cumulative self-paced reading procedure. For the critical region, the RC verb (in boldface in the examples above), the effect of attachment site was significant for singular verbs with full-RC materials and only marginally significant with reduced-RC materials. The RC verb was read faster when the materials forced the attachment of the RC to the low site, as in (3b) and (4b), suggesting that low attachment of the RC is preferred in BP. Answers to comprehension questions presented after every sentence were answered significantly more accurately for low attachment materials with reduced RCs, but there was no difference in accuracy for high or low attachment materials with full RCs.

Ribeiro (1998) administered an unspeeeded questionnaire to native speakers of BP living in Rio de Janeiro. Ribeiro based his materials on the set used by Cuetos and Mitchell (1988), excluding 8 sentences in which one of the potential antecedents was inanimate (e.g., *the book of the girl*). Ribeiro reported that the preference to attach high, as estimated by the percent of N1 choices in questions posed about ambiguous sentences, was 72%. As a follow-up of this study, Ribeiro (2001) carried out a non-cumulative self paced reading experiment replicating one of Cuetos and Mitchell's (1988) speeded reading experiments and observed significantly faster reading times in the critical last segment in simple NP RC control sentences as in (4b) than in complex NP RC sentences as (4a).

- (5) a. Alguém atirou no empregado da atriz / que estava na varanda / **com seu marido**.
“Someone shot the servant [masc] of the actress / who was on the balcony / with her husband.”
- b. Alguém atirou na atriz / que estava na varanda / **com seu marido**.
“Someone shot the the actress / who was on the balcony / with her husband.”

(The slashes indicate the boundaries used to segment the sentences in the self-paced reading task.)

The significant differences in reading times between critical segments in experimental and control conditions were taken to indicate that BP readers do not adopt a Late Closure strategy but instead immediately attach the RC high, causing the final segment to appear anomalous.

Even though both Miyamoto's and Ribeiro's studies were carried out at about the same time, only the former—a dissertation from the Massachusetts Institute of Technology, and written in English—became known and cited in the relevant psycholinguistics literature. Ribeiro's studies—originally presented in conferences in Brazil and making up part of Ribeiro's

doctoral dissertation research—have only recently appeared in a publication in Portuguese (Ribeiro, 2005).

Two other unspeeded questionnaire studies on RC attachment in BP were also carried out shortly after Miyamoto (1999) and Ribeiro (1998), both confirming a high attachment preference for BP (Maia and Maia, 2001/2005, and Finger and Zimmer, 2002/2005). Maia and Maia investigated the comprehension of BP and English ambiguous sentences containing the RC attachment construction by native speakers and L2 learners of both English and BP. Using an off-line questionnaire task based on Cuetos and Mitchell (1988), the study investigated the comprehension preferences of four groups of subjects: Portuguese native monolingual speakers, English native monolingual speakers, BP L1 / English L2 bilinguals, and English L1 / BP L2 bilinguals. The preference for high attachment, clear in the case of monolingual BP speakers, was not observed in the group of BP L2 bilinguals, who did not display a significant preference to attach high, but rather showed preferences probably influenced by the factor that influences English monolinguals to attach low. Likewise, the study captured an effect on English of the Portuguese non-application of Late Closure: L1 speakers of BP had low attachment rates significantly smaller than those displayed by the English monolinguals. Maia and Maia also found statistically robust differences between the Portuguese of monolingual natives and the L1 Portuguese of bilinguals, and between the English of monolingual natives and the L1 English of bilinguals, but attributed these effects to experiment immediacy effects: bilingual subjects answered L1 questionnaires right after L2 questionnaires, and were possibly not in the most monolingual mode possible when completing questionnaires in L1. Results like these suggest an interpretation of the low attachment preference observed by Miyamoto (1999) as being linked to the influence of English—after all, the native speakers of BP recruited for that study were all living in the US at the time of testing, and all had some degree of proficiency in English. Not

enough information is available to confirm or disconfirm such an interpretation with certainty (Miyamoto reports that the participants all learned English as adults, and had a length of residence in the US ranged from one week to 15 years). More importantly, we lack space here for a thorough exploration of that idea, which would require a review of studies of processing in second language learners.

Other studies have considered the influence of prosody in the processing of RC in Portuguese. Finger and Zimmer (2002/2005) carried out a questionnaire study manipulating RC length in BP, designed to explore some of the predictions of Fodor's (1998a, 2002) Implicit Prosody Hypothesis. The prosody projected for sentences might differ based on their prosodic weight. In a sentence like *Someone shot the maid of the actress who sings*, the RC is very unlikely to be phrased separately from the material before it. However, if the RC lengthened by adding lexical content, e.g., *who sings in the choir at church*, the likelihood of the RC being phrased as an independent prosodic constituent increases. According to the Implicit Prosody Hypothesis, separate prosodic phrasing of the RC increases high attachment rates. In accord with this prediction, Finger and Zimmer (2005) found that the overall off-line preference in BP for high attachment is modulated by RC length: long RCs exhibited a greater likelihood to attach high (69%) than short RCs (58%).

Another investigation systematically manipulating RC length in BP was carried out by Lourenço-Gomes (2003) and further developed by Maia, Lourenço-Gomes and Moraes (2004). This investigation reports BP prosodic patterns in oral production and shows that these patterns can predict attachment preferences in the parsing of sentences in silent reading. Furthermore, the investigation demonstrates that constituent length affects the prosodic contours projected by speakers in an elicited production task, and the interpretations of the ambiguity in a silent reading comprehension task. The same materials were used in both tasks, and are illustrated in (6).

- (6) Um homem reconheceu / o cúmplice / do ladrão / que fugiu (depois do assalto ao banco).
“A man recognized / the accomplice / of the thief / who fled (after the bank robbery)”
- (a) O cúmplice fugiu. (b) O ladrão fugiu.
“The accomplice fled.” “The thief fled.”

In the elicited production study (Lourenço-Gomes, 2003), attachment was forced high or low by number agreement morphology on the verb of the RC (e.g., *os cúmplices do ladrão que fugiu/fugiram*, "the accomplices of the thief who fled[sg]/[pl]). Materials containing short (up to 5 syllables making up only 1 prosodic word) and long (10-12 syllables and multiple prosodic words) RCs were read aloud by 7 native speakers of BP. Acoustic analyses of the recorded utterances indicated reliably longer durations for the tonic syllable of the noun immediately preceding a long RC, compared to that preceding a short RC. This durational difference signaled a greater probability of a prosodic break between the complex NP and a long RC, a finding compatible with proposals that the distribution of prosodic breaks is influenced by constituent length as well as by syntactic structure (Selkirk, 2000; see also Shaked, to appear).

Lourenço-Gomes and Moraes (2005) demonstrate, in a perception study, that the duration of the tonic syllable was the parameter that correlated most reliably with the examined boundary in the study by Lourenço-Gomes (2003). The lengthening of the tonic syllable in the noun immediately preceding a long RC could by itself be a relevant parameter to the perception of a prosodic boundary. A sentence as that in (6) was read aloud by a trained phonetician to have the most neutral prosody possible. This sentence was synthesized, using the *CSL-ASL* speech synthesis software and served as the source for the acoustic stimuli that were presented to listeners participating in a boundary detection task. The durations of the tonic and post-tonic vowels of the word that preceded the RC (pre-boundary word) were, in isolation and in combination, progressively lengthened and shortened proportionally to each other, in 10%

intervals, maintaining the original F0 contours and amplitude variations intact. Two different versions of the experiment with random distribution of stimuli were presented to two different groups of subjects (40 in all). In a forced choice task, subjects were asked to indicate the presence or absence of a boundary between the RC and the immediately preceding word. The lengthening of the tonic vowel was, in isolation, perceived by listeners as a sign of an upcoming prosodic boundary. In contrast, the lengthening of the post-tonic vowel in the same word had a less relevant role in the boundary perception, even though it was the phrase-final syllable.

In order to assess whether pre-RC breaks favor high attachment in silent reading, two speeded compatibility judgment experiments were carried out. In each experiment, native speakers silently read sentences containing ambiguous short or long RCs, and judged the compatibility of a follow-up statement corresponding to the high or low attachment interpretation, as in (6a) and (6b), as an adequate description of the previous sentence. In the first experiment, the sentences were presented in one frame and remained on the screen for 4000 ms, after which the follow-up statement appeared and participants were prompted for a compatibility judgment. In the second experiment the sentences were presented in four non-cumulative consecutive frames, indicated by the slash marks in (6), each of which remained on the screen for 1000 ms (second and third frames) or 1250 ms (first and fourth frames), and were followed by a prompt for a compatibility judgment of the following statement.

For the long RCs, which are most comparable to those tested by Miyamoto (1999), Lourenço-Gomes and colleagues observed an overall high attachment preference (76%), in conformity with Maia and Maia (2005), Miyamoto and Finger (2002), and Ribeiro (2005), though contrasting with Miyamoto (1999). As predicted by the Implicit Prosody Hypothesis, both RC length and presence/absence of segmentation affected acceptance rates for the follow-up statements. When the sentences were not segmented, acceptance rates were higher for high-

attachment follow-up statements (6a) when the RC was long, but higher for low-attachment follow-up statements (6b) when the RC was short. This effectively replicates the RC length effect observed in questionnaire studies: high attachment interpretations are more likely when the RC is long. When the sentences were segmented, though, the difference between short and long RCs disappeared, with both RC lengths generating higher acceptance rates for high-attachment follow-up statements. In contrast with Gilboy and Sopena (1996), who proposed that with “small segmentation there is no cue for prosodic boundaries” (p. 203), the data from this investigation by Lourenço-Gomes and colleagues suggest that small segmentation provides an *excess* of cues for prosodic boundaries: the results are exactly as predicted if we assume that readers treat every segmentation boundary as signaling a prosodic boundary. Thus, the authors conclude, the Implicit Prosody Hypothesis offers an elegant explanation of the findings.

Let us briefly come back to the discrepancy between the initial Miyamoto (1999) and Ribeiro (1998) studies on RC attachment in BP. Reviewing his original study, Miyamoto (2005) has reinterpreted his findings as resulting from an artifact caused by the use of number agreement to disambiguate the materials in his self-paced reading experiment. Citing work that has demonstrated that plural features intervening between a singular noun and the verb with which it agrees can disrupt sentence comprehension (e.g., Nicol, Forster and Veres, 1997), Miyamoto (2005) claims that the preference for forced low attachments is due to the interference of plural features in half of his materials forced to attach high. In such sentences (e.g., (7)), the plural feature in N2 interferes with the high attachment interpretation.

- (7) ... o supervisor dos engenheiros que foi...
“... the supervisor of the engineers who was...”

According to Miyamoto (2005), a reanalysis of the reading times obtained in his self-paced reading study shows that the shorter times with materials forced to attach low are only observed

in the conditions in which the verb is singular. Miyamoto argues that with a high attachment in which N2 is plural and the verb is singular, as (7), processing costs should be attributed to the agreement interference configuration and not to a difficulty in establishing a non-local association.

However, the BP puzzle is not solved yet. On the one hand, Miyamoto does not consider differences in unspeeded and speeded methodologies and methods of disambiguation, which have been argued to be relevant in understanding the evidence from Spanish (for discussion, see Fernández, 2003; Fernández and Sainz, 2004). On the other hand, no study so far has tried to determine whether an early preference for RC attachment could be established on the basis of a speeded methodology using a number agreement disambiguation method but explicitly avoiding the agreement interference configuration.

5. European Portuguese enters the picture

Maia, Costa, Fernández and Lourenço-Gomes (2004) started a joint research program in order to systematically investigate RC attachment preferences in both Brazilian and European Portuguese. In this section we review their off-line study. We also present the results of two new self paced reading experiments carried out simultaneously in Brazil and in Portugal.

The two Portuguese varieties present different linguistic properties that could be relevant for the study of RC sentence processing. First, there are well-known differences in the verbal and the nominal agreement systems in both languages. EP is clearly a null subject language, with a strong inflection system that preserves the verbal agreement paradigm with three grammatical persons, in both singular and plural (in the standard variety, the plural second person is no longer used, but it is strongly represented in regional varieties and in the written language). In contrast, BP's verbal morphology is in the process of weakening and consequently

exhibits a reduction from three to two grammatical persons (loss of the second person, in both singular and plural). In some BP varieties, there is even a more radical reduction of morphological features, affecting, for example, the agreement relations inside the NP (Galves, 1993; Kato, 1999; Barbosa, Duarte and Kato, 2000).

Even though there are few studies systematically comparing BP and EP at the level of prosody, there are some indications that EP and BP may also differ at this level of analysis. In terms of their rhythmic properties, EP is more stress-based and BP more syllable-based. EP has stress- and syllable-timing characteristics, whereas BP presents syllable- and mora-timing properties (Frota, Vigário and Martins, 2002). However, these differences are unlikely to affect the prosodic phrasing which, for our purposes is the crucial variable in the mapping between syntax and phonology.

In terms of prosodic phrasing, concerning the structures with relative clauses in EP, there is evidence that long materials increase the tendency for major intonational phrase (IP) breaks, while parentheticals and other similar materials form their own IP (Frota 2000). Vigário (2003) verifies that explicative (non-restrictive) relative clauses form their own IP, while restrictive relative clauses are grouped in the same IP as the one containing the antecedent. However, comparable studies have not been carried out in BP so far. The future development of such studies will be relevant in order to unequivocally establish how prosodic phrasing relates to parsing in on-line processing.

Maia et al. (2004) present the results of a questionnaire study carried out in parallel in Brazil and Portugal, examining the comprehension of globally ambiguous sentences containing the construction of interest: a complex NP followed by either a short or a long RC. Materials were adapted from those used in earlier studies of BP, carefully written to avoid semantic or pragmatic bias for the RC to attach to either N1 or N2. The participants were 60 undergraduate

students tested in Rio de Janeiro or Lisbon. The findings were identical for both Portuguese varieties: high attachment was more likely for long than short RCs, as predicted by the Implicit Prosody Hypothesis (Fodor, 1998a; 2002).

We conducted a self-paced reading experiment, run in parallel in Brazil and Portugal, using identical materials and procedure, but samples of speakers of the two different regional variants of the language. This experiment permits a more detailed look at the source for the ultimate preference for high attachment exhibited by speakers of BP and EP as documented by Maia et al.(2004). At the same time we put to the test Miyamoto's (2005) claims about his earlier findings with BP as being an artifact of the agreement interference configuration.

The participants were 40 native speakers of BP and 40 native speakers of EP, all graduate students in comparable institutions in Rio de Janeiro and Lisbon, respectively. The participants were assigned pseudo-randomly to one of four versions of the experiment. No participants were rejected based on criteria pertaining to language history or performance in the task.

The target materials consisted of 24 target items in four versions, obtained by crossing the variables of RC Attachment (forced high or low) and RC Length (short or long). Attachment was forced by the configuration of number agreement features in the complex NP and the RC verb. The RC verb always appeared with third person plural morphology, and the two nouns in the complex NP were mismatched in number. Thus, high attachments never occurred in materials with an "intervening" plural N2, avoiding the "agreement interference" configuration discussed earlier. All target sentences contained animate and concrete nouns in the complex NP. The materials, based on those used by Maia et al. (2004), did not require any adaptation for use with both varieties of Portuguese, since they were originally written to exclude BP- or EP-specific lexical material.

. A sample item is provided below, in (8), with lexical material added to RCs in the long versions of the sentences, as shown in parentheses. The target sentences were counterbalanced across four lists, such that no participant would see the same item in more than one of its versions.

- (8) a. A vítima reconheceu / os cúmplices do ladrão que fugiram (depois do assalto ao banco).
b. A vítima reconheceu / o cúmplice dos ladrões que fugiram (depois do assalto ao banco).

"The victim recognized the accomplice(s) of the thief (thieves) who ran away[3rdPI] (after the bank robbery)."

The target materials were presented in two frames. Frame 1 included the subject and verb of the matrix sentence. Frame 2 contained the target construction in its entirety. This permitted the projection of a natural prosodic contour, but did not force it, as would be the case if the materials segmented the RC separately from the complex NP. Frame 3 contained a question that queried the attachment of the RC (always of the form *Who V[3rd Sg]*, e.g., *Quem fugiu?* "Who ran away?"), followed by two possible answers, corresponding to the two NPs in the complex NP. Participants used keyboard button presses to advance from frame to frame and to answer the question. Serving as distractors, 48 filler items were also included in the experiment, all consisting of two frames followed by a third frame containing a reading comprehension question. Participants were not given feedback on their responses to the comprehension questions.

The critical data are the reading times for the target construction presented in Frame 2, where attachment is disambiguated. Also informative, though not directly linked to the on-line resolution of the ambiguity, are the error data for the comprehension question presented in Frame 3. We will also briefly outline the outcomes of other analyses performed on reading times for Frames 1 and 3. Reading time values that were 2 standard deviations above or below the mean for a given participant were excluded, and reading time values above or below pre-set upper and

lower cut-offs were replaced with those extreme values; this procedure affected less than 5.5% of the data¹. Participant- and item-based summary reading time values for the first, second and third frames, and error rates for the third frame were calculated and used in the analyses reported, in a design that included the variables of Variety of Portuguese (BP, EP), RC Attachment (high, low) and RC Length (short, long). An additional variable (participant groups in the participant-based analysis, item sets in the item-based analyses) was included to extract irrelevant variance, but will not be reported here. Table 1 provides the reading times for the three frames and error rates for the third frame.

Table 1.
Mean reading times (RTs) at Frames 1, 2 and 3 and error rates (Errors) at Frame 3, for BP and EP participants, as a function of RC length (short, long) and attachment (high, low).

		Frame 1 RTs (ms)		Frame 2 RTs (ms)		Frame 3 RTs (ms)		Frame 3 Errors (%)	
		BP	EP	BP	EP	BP	EP	BP	EP
Short RC	High	1899	2010	4062	4223	1797	1535	20.5	8.3
	Low	1952	2035	3689	3887	1935	1555	29.0	11.2
Long RC	High	1936	1899	5853	5900	1959	1586	10.7	6.4
	Low	1925	2006	5509	5828	1872	1662	28.4	20.2

Analyses of the reading times for Frame 1 reveal no reliable main effects or interactions (all p's > .10). This finding is important as it serves as a baseline for comparing the performance

¹ The standard deviation cutoffs affected 5.2%, 4.0% and 5.8% of the data in Frames 1, 2 and 3, respectively. The absolute lower cutoffs were set at 400 ms for all three frames; the absolute upper cutoffs were set at 8000 ms for Frames 1 and 3, and at 14000 ms for Frame 2. Absolute cutoffs affected 0.1%, 0.6% and 0.3% of the data in Frames 1, 2 and 3, respectively.

of the BP and EP groups: participants in the two groups display no appreciable differences in basic reading times, as measured in a frame unrelated to the target construction.

In the reading times for Frame 2, we observe a simple pattern consisting of two unmodified main effects. First, and uninterestingly, we find a highly reliable main effect of RC Length: it took participants 1807 ms longer on average to read materials with long RCs ($F(1,72) = 217.19, p < .001$; $F(1,20) = 391.53, p < .001$). Second, and crucial for our purposes, we find a reliable main effect of RC Attachment: participants took 281 ms longer on average to read materials forced to attach high ($F(1,72) = 13.64, p < .001$; $F(1,20) = 4.71, p < .05$). Importantly, the preference for materials forced to attach low is the same for materials of either length (Attachment \times Length interaction: $F(1, F2 < 1)$), and for speakers of either variant of Portuguese (Attachment \times Variant interaction: $F(1, F2 < 1)$); the three-way interaction is also not significant ($F(1, F2 < 1)$). In Frame 2, the reading times for BP participants are 181 ms faster on average than for EP participants, but this difference is not reliable ($F(1 < 1$; $F(1,20) = 4.20, p > .05$; the trend in the item-based analysis is traceable to a handful of slower readers in the EP group).

To summarize the findings so far: the early preference for speakers of Portuguese is for materials forced to attach low. We can infer that this preference is driven by the application of a locality principle, such as Late Closure, during the first-pass parse. The preference for low attachment emerges even though the materials contained nouns in the complex NP that, according to Desmet, De Baecke, Drieghe, Brysbaert and Vonk (2006), would promote high attachment interpretations because of the animacy features specified for the noun in the high site. Our findings are thus difficult to account for based on a parser whose attachment

preferences are driven by lexical properties (animacy, concreteness) of the attachment sites, as proposed by Desmet et al. (2006).

We can reconcile this effect of an early low attachment preference with accounts that see the eventual preference for high attachment observed in some languages as originating outside of the parser, and note that the preference for low attachment is present in our data not only with short RCs, but also with long RCs. This is not explained by either prosodic or information structure considerations. Compared to short RCs, long RCs are more likely to be phrased as separate prosodic constituents and would therefore promote more high attachment interpretations (Fodor, 1998a; Vigário, 2003). Also, long RCs would be more likely to be taken as more informative and therefore would be more likely to be interpreted as modifying constituents in the sentence that are more central to the discourse. The materials expressly avoid the agreement interference configuration claimed by Miyamoto (2005) to be causing what he describes as an artifactual finding. And the materials were based on those used in the questionnaire reported by Maia et al (2004), a study confirming an eventual preference in BP and EP for high attachment, so our finding of an early low attachment preference cannot be attributed to unintentional intrinsic bias in the materials.

Let us now examine the data for Frame 3, where participants answered questions about the resolution of the ambiguity. Responses to this frame are most plausibly understood as not driven at all by principles applied during the on-line processing of the target construction. Instead, and as argued earlier in section 3, it is possible that responding to these questions is easiest when the correct answer is about an element more central to the information structure of the target sentence. By this reasoning, questions about target sentences with forced high attachments should be easier, because the correct answer involves the direct object of the target sentence, N1.

As revealed by the data reported in Table 1, this is precisely the behavior we observed. In Frame 3 error rates, participants made 11% less errors overall with materials forced to attach high than with materials forced to attach low ($F(1,72) = 21.22, p < .001$; $F(1,20) = 10.11, p < .005$). This effect is present in both BP and EP (Variant \times Attachment interaction: $F(1,72) < 1$; $F(1,20) = 3.61, p > .05$; Variant \times Attachment \times Length: $F(1,72) < 1, F(1,20) < 1$).

The question-answering data for Frame 3, though, reveal an intriguing and unexpected difference between BP and EP. In their reading times, BP participants were 306 ms slower than EP participants in responding to these questions, a robust difference ($F(1,72) = 5.56, p < .025$; $F(1,20) = 37.89, p < .001$). No other main effects or interactions emerge in the analyses of Frame 3 reading times (all p 's $> .15$). This reading time disadvantage demonstrated by the BP participants is echoed in their error rates for Frame 3: BP participants made on average 10.6% more errors than their EP counterparts, also a robust difference ($F(1,72) = 14.69, p < .001$; $F(1,20) = 74.69, p < .001$).

We can attribute this difference between the two Portuguese varieties to a growing difference in the representation of number agreement. As we have already noted, in BP the verbal inflection system is weakening, a process accompanied by an increase in the preference for (overt) lexical and/or pronominal subjects. In EP, in contrast, the verbal inflection system remains strong as does the preference for null subjects. EP maintains differences between three grammatical persons (first, second and third), whereas BP has reduced the paradigm to two, having lost unique morphology for second person (Galves, 1993; Kato, 1999; Barbosa, Duarte and Kato, 2000). In non-standard varieties of BP, there is also a weakening of NP number inflections (Costa and Silva, 2003).

Why should the representation of morphological features, like person and number inflections—in effect, part of the internalized grammar—affect the timing and accuracy of responses by the BP participants? Answering these comprehension questions accurately depends on having processed accurately the disambiguation of the RC in the preceding target sentence, which requires an integration of the number morphology in the complex NP and the person and number morphology in the RC verb. If these features are not as available to BP speakers as they are to EP speakers, because they are more weakly represented in the BP grammar, we have a plausible explanation for this intriguing behavioral difference between the two regional variants.

Of course, this explanation at the same time predicts that BP and EP speakers should be just as accurate in responding to such questions if disambiguation depends on a morphosyntactic feature that is equally strongly represented in the grammars of the two variants, e.g., gender agreement, or if disambiguation is achieved using semantics or pragmatics. This prediction awaits empirical confirmation.

In the Frame 3 error data, we also observe a significant interaction of Variant and RC Length ($F(1,72) = 6.13, p < .025$; $F(1,20) = 14.30, p < .001$) and a significant interaction of RC Length and Attachment ($F(1,72) = 8.25, p < .01$; $F(1,20) = 8.80, p < .01$). To facilitate the following remarks, Figure 1 plots the relevant question-answering error data reported in the rightmost two columns of Table 1.

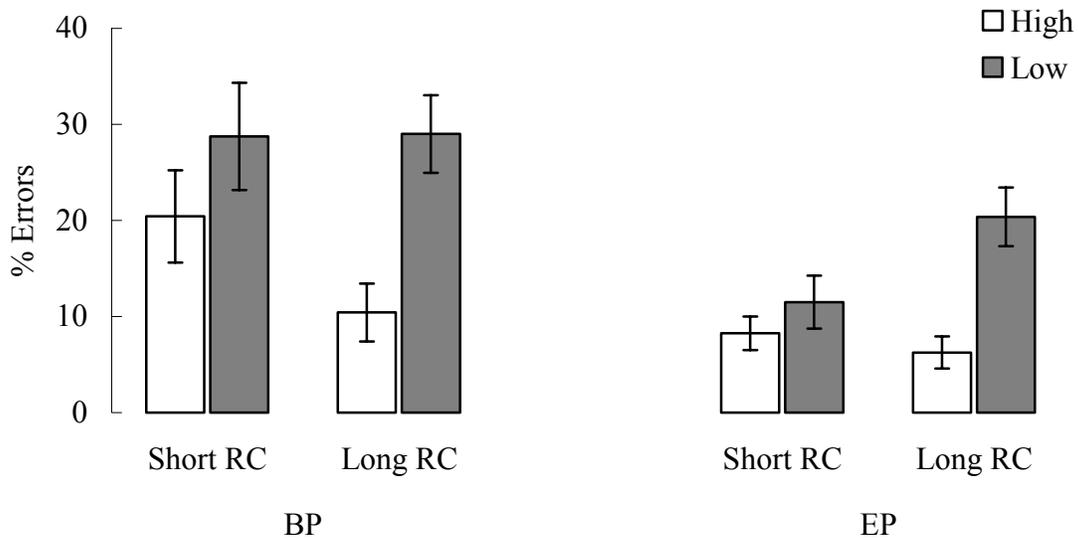


Figure 1.
Mean percent errors in Frame 3 for BP and EP participants responding to comprehension questions about materials forced to attach high or low, with short or long RCs.

Figure 1 offers a clear visual representation of the interaction of RC Length and Attachment. When the RC is short, the difference in error rates with materials forced to attach low or high is marginal at best ($F(1,72) = 3.94, p = .051$; $F(1,20) = 2.48, p > .10$). In contrast, when the RC is long, error rates are reliably greater with forced-low materials ($F(1,72) = 27.32, p < .001$; $F(1,20) = 16.09, p < .001$). In the subanalyses, the interaction of Variant and Attachment fails to reach significance (all $ps > .15$), but the main effect of Variant remains robust (short materials only: $F(1,72) = 21.80, p < .001$; $F(1,20) = 51.71, p < .001$; long materials only: $F(1,72) = 3.76, p = .056$; $F(1,20) = 29.66, p < .001$).

That question-answering error rates are not sensitive to the RC attachment manipulation when the RC is short is perhaps not surprising, if we view error rates in this part of the task as reflecting discourse processing difficulties. A short RC provides a minimal amount of information for the reader to recall the agreement relationship between it and the noun it

modifies. In contrast, a long RC provides more information for the reader to link between the RC and the host noun in the complex NP. As we have argued, it is easier to make such recall links when the RC is attached to a more central element in the discourse, which in this construction happens to be the more distant noun, the direct object of the main verb of the sentence.

6. Summary and conclusions

We have reviewed studies examining relative clause attachment in Brazilian and European Portuguese as well as in several other Romance languages. These studies have reported uniformly that the eventual off-line preference for Romance languages (except Romanian) is for high attachment, as demonstrated with questionnaire instruments. In contrast, the early preference for these languages is reported to be high attachment by some studies, low attachment for others. Discrepancies in the empirical base present important problems in developing explanatorily accurate explanations for the parsing phenomena that presumably account for interpretation preferences.

We have also reported a self-paced reading study which was conducted in order to test a claim by Miyamoto (2005) that a finding of low attachment in BP (Miyamoto, 1999) could be due to number agreement interference effects. Our experiment revealed an initial advantage for low attachment: on-line reading times for the critical frame were significantly longer when sentences were forced toward high attachment, regardless of RC length and language variety. However, this pattern was reversed in off-line error rates for answering the comprehension questions that followed the trials. Participants made overall more errors in answering reading comprehension questions when the materials were forced to attach low than when they were forced to attach high. This effect interacted with RC length (it was only reliable with long RC

materials). Another interesting finding of the self-paced reading study was that BP participants were significantly slower and made more errors in the comprehension questions than EP participants.

Further experimental research would be useful to expand on this investigation of RC attachment preferences in BP and EP in early and later phases of processing, but our present results along with the available evidence lead us to the following conclusions:

(a) The time-course for processing RC attachment in BP and EP is similar to that reported for other Romance languages: unspeeded questionnaire tasks tap behavior that favors high attachment, whereas speeded methodologies tapping earlier phases of processing, such as self-paced reading, indicate an initial preference for low attachment. We take this finding as evidence of a universal preference to attach incoming constituents locally, to more recent hosts (Fernández, 2003; see also Frazier, 1978; Gibson, Pearlmutter, Canseco-González and Hickock, 1996). This claim requires further empirical work to clarify apparent counterevidence, e.g., to demonstrate that experiments that have found an "on-line" preference to attach high in languages like Portuguese (Ribeiro, 2005) or Spanish (Carreiras and Clifton, 1993, 1999) were not tapping the earliest phases of processing.

(b) RC length affects attachment preferences only in later phases of processing, possibly after syntactic (first-pass) parsing principles have applied. Existing data suggest that implicit prosody influences late attachment decisions, and should, therefore, be thought of as a post-syntactic factor in sentence processing. Initial parsing decisions are made on the basis of structural strategies, such as Late Closure, and later revised due to prosodic factors such as constituent length.

(c) The early low attachment preference in BP and EP should not to be taken as an artifact related to interference of agreement features, as claimed by Miyamoto (2005). The critical

configuration containing a plural local noun and a singular verb (e.g., *o cúmplice dos ladrões que fugiu*) was not used in our experiment but this did not eliminate the preference for low attachment in the relevant reading time data.

(d) The difference in error rates in the comprehension questions found between the two varieties of Portuguese is in line with previous observations (Galves, 1993; Kato, 1999; Barbosa et al., 2000) that the representation of agreement is in the process of weakening in BP and, therefore, reflects a difference in the internalized grammars of speakers of BP and EP.

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