



The actress was on the balcony, after all: Eye-tracking locality and PR-availability effects in Spanish

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ABSTRACT

The relationship between syntactic ambiguity and locality has been a reliable cornerstone in theories of language comprehension with one exception: non-local preferences in object-modifying relative clauses preceded by two potential hosts (DP1 of DP2 RC). We test the offline and online effects of the availability of an alternative structure, the pseudo-relative, on the parsing of relative clauses. It has been claimed that pseudo-relatives are preferred to relative clauses because of their simplicity at the structural, interpretive and pragmatic levels, and act as a confound in the attachment literature (Grillo, 2012; Grillo & Costa, 2014). Our results show that attachment preferences are modulated by the availability of pseudo-relatives in offline and online tests. However, when this factor is controlled, parsing of relative clauses in Spanish is initially ruled by principles of locality, which can eventually be overridden by other factors.

1. Introduction

Although it goes unnoticed by most of us, ambiguity is ubiquitous in natural language. The speech signal can be ambiguous at different linguistic levels, and so is the visual string of words when reading. There is ambiguity whenever the language comprehension system receives a linguistic input that is compatible with more than one interpretation at the semantic or syntactic level, which happens quite often if we take into account the incremental nature of language processing. From this point of view, parsing language consists of assigning a category label to new words and integrating these words into the ongoing syntactic representation quickly enough to guarantee efficient structure-building and enable the parser to make predictions about incoming material. In this process, ambiguity can arise when there is more than one option for the incoming word to be integrated into the phrase-structure representation. Take for instance the word *observed* in (1). *Observed* can be the main verb of the sentence as in (1a), the main verb yet with different meaning in (1b), or the embedded verb of a reduced relative clause (1c).

- (1) a. The girl observed something strange.
- b. The girl observed that it was cold in the room.
- c. The girl observed by the educational psychologist had problems at school.

Principles of optimal computation are responsible for the way comprehenders deal with underspecified or ambiguous input by imposing parsing principles of minimal effort. The study of parsing principles, which is mainly centred on how to deal with syntactic ambiguities, has regularly confirmed that processing economy constraints are a universal feature of the human parser. In this respect, relative clauses (RCs) have been very useful in psycholinguistics for testing parsing preferences. One example is the classic RC attachment ambiguity that emerges when a complex Determiner Phrase (DP) (DP1 of DP2) is followed by a RC, which has been critical for uncovering language properties relevant in parsing. The ambiguity in this structure relies on the possibility of attaching the RC to either the first DP (high attachment, HA) or to the second DP (low attachment, LA). Economy of structure building would favour the latter, provided that it minimises the processing load of the parser as the attachment is carried out locally. Locality is a principle that

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guides the parser preference to avoid long structural relations. In the literature on relative clause attachment, locality has been implemented as Late Closure (Frazier, 1978) and Recency (Gibson, 1991; Gibson, Pearlmutter, Canseco-Gonzalez, and Hickok, 1996), where both principles prompt local attachment or attachment to the most recent constituent in order to limit storage costs. Therefore, LA is the instantiation of locality in this literature. Nevertheless, contradictory evidence shows that preferences of attachment are not clear-cut across languages. Cuetos and Mitchell (1988) first reported that English speakers appear to prefer LA, or attachment to the second DP (the actress) in sentences like (2a), while Spanish speakers prefer HA, or attachment to the first DP (e.g. *el criado*, the servant in 2b).

(2) a. Someone shot [the servant₁ [of [the actress₂ [that was₂ on the balcony]]]]

b. Alguien disparó [[al criado₁ [de la actriz₂]] [que estaba₁ en el balcón]]

The preference for HA or LA was extended to other languages, leading to a classification of languages that prefer LA, e.g. English (Cuetos and Mitchell, 1988; Fernández, 2003; Frazier and Clifton, 1996; Mitchell and Cuetos, 1991), Arabic (Abdelghany and Fodor, 1999), Swedish (Ehrlich, 1999), Norwegian (Ehrlich, 1999), Romanian (Ehrlich, 1999), Basque (Gutierrez-Ziardegi, Carreiras, and Laka, 2004), and Chinese (Shen, 2006); and languages that prefer HA, e.g. Spanish (Carreiras, 1992; Carreiras, Salillas, and Barber, 2004; Cuetos and Mitchell, 1988; Fernández, 2003), Italian (De Vincenzi and Job, 1993, 1995), French (Mitchell, Cuetos, and Zagar, 1990), Galician (Fraga, García-Orza, and Acuña, 2005), Greek (Papadopoulou and Clahsen, 2003), Dutch (Brysbaert and Mitchell, 1996; Mitchell, Brysbaert, Grondelaers, and Swanepoel, 2000; Mitchell, Cuetos, and Zagar, 1990), Afrikaans (Mitchell, Brysbaert, Grondelaers, and Swanepoel, 2000), Serbo-croatian (Lovric, 2004), Russian (Fedorova, Yudina, and Yanovich, 2007; Sekerina, Fernández, and Petrova, 2003), German (Hemforth, Konieczny, and Scheepers, 1998; Konieczny and Hemforth, 2000) and Bulgarian (Sekerina and Fedorova, 2004) (see Grillo and Costa, 2014, for discussion).

The debate on the universality of Late Closure is one of the most researched topics in the psycholinguistics literature on sentence processing. Subsequent developments in this area have been fruitful in unveiling numerous factors, including syntactic, prosodic, semantic and pragmatic variables (some of which we revisit in section 1.1) whose effects influenced RC-attachment in similar ways across languages, though none of these factors is accountable for the observed cross-linguistic variation.

It is worth noting that research in this literature has focused mainly on a highly specific type of RC: right-branching RC, mostly with subject gap (subject RC), preceded by a complex DP with the preposition ‘of’ connecting the two DPs, and the complementizer ‘that’ heading the embedded clause.

In such restricted context, research in Spanish (the language under study in this paper) has almost systematically shown a preference for HA in numerous offline and online studies, including: forced-choice attachment questionnaires (Carreiras, 1992; Cuetos and Mitchell, 1988), self-paced reading studies (Carreiras, 1992; Carreiras, Betancort, and Meseguer, 2001; Carreiras and Clifton, 1993; Cuetos and Mitchell, 1988; Gilboy and Sopena, 1996), eye-tracking experiments (Carreiras and Clifton, 1999), and Event-related potentials (ERPs) studies (Carreiras, Salillas, and Barber, 2004). In other contexts, local attachment turns out to be the preferred resolution in Spanish.

For instance, when the RC is positioned in the centre-embedded position, the results contrast with the HA found in the right-branching position (Hemforth et al., 2015), as in example 3.

(3) a. Centre-embedded RC

El hijo del coronel que murió de apoplejía escribió cinco libros sobre enfermedades tropicales.

‘The son of the colonel who died of a stroke wrote five books on tropical diseases.’

b. RIGHT-BRANCHING RC

El doctor conoció al hijo del coronel que murió de apoplejía.

‘The doctor met the son of the colonel who died of a stroke.’

LA is also reported when the preposition ‘with’ mediates between the two DPs (Gilboy, Sopena, Clifton, and Frazier, 1995) (see example 4).

(4) Al millonario se le mostró una casa con una piscina que era tan grande como medio campo de fútbol.

‘The millionaire was shown a house with a pool that was as big as half a football field.’

It is also reported when the type of relative pronoun that introduces the embedded clause is not the complementizer *que*. Fernández (2003) reported LA in sentences such as 5, where the relative pronoun *el cual* is used instead of the complementizer *que*:

(5) Alguien disparó contra el criado_i del actor_j el cual_{i/j} estaba en el balcón.

‘Someone shot the servant of the actor who was on the balcony.’

Given the specificity of the problem, reducible to RCs in the specific context described earlier (i.e. right-branching RCs, preposition ‘of’ connecting the DPs, complementizer ‘that’ heading the embedded clause), it is difficult to state these differences as rooted at the fundamental level of parsing mechanisms. Such an assertion would not only imply different parsing principles for different languages but also different within-language mechanisms sensitive to syntactic and lexical information, which would apply selectively in fine-grained contexts. We will further analyse this question in section 1.2 presenting a proposal that could provide a valid framework for these results, the problem of specificity, and cross-linguistic variability.

Much research attempted to elucidate potential factors responsible for across- and within-language variation in terms of attachment preferences. Although some of these factors successfully predicted attachment variation, the prediction generalizes across languages in a similar manner. In the next section we will revise some of these factors, while paying particular attention to the literature in Spanish. We will then feature the PR-first Hypothesis, which suggests that a grammatical factor is responsible of the variation (Grillo and Costa, 2014). The research presented in this paper aims to test this hypothesis in Spanish.

1.1. Factors modulating attachment across languages

Prosody is known to play an essential role in syntactic parsing in helping to build the syntactic structure by segmenting the speech signal into intonational phrases. Prosodic effects are featured when the length of the RC is manipulated. There is a trend towards HA after long RCs that is explained by a tendency to place an intonational boundary before longer RCs. The boundary between the (complex) DP and the RC would create the projection of an independent intonational phrase containing the RC. The preference to attach new constituents to constituents of the same length (*Balanced Sister Hypothesis*, Fodor, 1998) would lead the long RC to attach high, since a complex DP would match the length of a long RC better than just a single DP. Prosodic effects of breaks after DP1 or DP2 (Fernández, 2017; Fromont, Soto-Faraco, and Biau, 2017; Teira and Igoa, 2007) and the length of the RC (Fernández, 2003; Hemforth et al., 2015) have been attested in Spanish.

Referentiality of the DPs that precede the RC has also been reported to determine attachment. In the classic experiment of Gilboy, Sopena, Clifton, and Frazier (1995), various types of DP relations were tested. Among other findings, these authors reported a shift in LA preference in Spanish from 17% to 83% depending on the type of relationship between the DPs, where the most referential DP is more likely to be modified by the RC (e.g. the first DP in *the glass of water*).

Lexical-semantic variables such as animacy, concreteness and emotional content (valence and arousal) of the DPs have also been shown to influence parsing by making one of the antecedents more likely to attract attachment. In particular, the property of being animate, concrete, frequent and highly arousing makes the DP more easily modified by the RC, as has been shown in numerous studies (Acuña-

Fariña, Fraga, García-Orza, and Piñero, 2009; Desmet, De Baecke, Drieghe, Brysbaert, and Vonk, 2006; Fraga, Piñero, Acuña-Fariña, Redondo, and García-Orza, 2012; MacDonald, Pearlmutter, and Seidenberg, 1994). When the vast literature on RC attachment in Spanish and other languages is navigated, it is clear that no single factor is responsible for determining RC attachment. The lack of across-studies coherence in terms of materials, experimental design or method, makes it difficult to compare between studies and languages. Moreover, new findings suggest earlier results may have been confounded by a grammatical factor (to which we turn in the next section). Some factors, such as those we have just mentioned, have been shown to affect RC attachment in similar ways across languages. Prosody, for instance, is an important factor that has partially explained cross-linguistic differences in some studies. Although the contribution of these factors is important, they could not explain the whole pattern of cross-linguistic differences. In the next section we feature a recent proposal that suggests cross-linguistic differences are rooted in an additional structural ambiguity that has been neglected in many earlier studies.

1.2. Pseudo-relative availability: a confounding variable

A relatively recent development in the field suggested that a grammatical factor, i.e. the availability of pseudo-relatives (6) (Grillo, 2012; Grillo and Costa, 2014), has confounded previous literature.

- (6) Andrea vio [_{PR} al hombre que corría].
Andrea saw the man that ran.
'Andrea saw the man running.'

Pseudo-relatives (PRs) are pretty unknown in the psycholinguistics literature, though work on them in linguistics dates back to 1975 (Radford, 1975). Linguists have primarily focused on PRs in Romance languages (Brito, 1995; Burzio, 1986; Casalicchio, 2013; Cinque, 1992; Graffi, 1980; Grillo and Moulton, 2016; Guasti, 1988; Moulton and Grillo, 2015; Radford, 1975; Rafel, 1999; Rizzi, 1992), but the distribution of PRs is not constrained to any language family.

As described by the above authors, PRs are finite constructions that, like English eventive Small Clauses, are projected as complements of perceptual verbs.¹ In spite of their superficial similarity with RCs, PRs display clear differences at the structural, interpretive and prosodic levels.²

Grillo (2012) and Grillo and Costa (2014) pointed out that, given the apparent similarity between the two structures, the results of RC attachment preferences on the subset of languages that traditionally preferred HA may have been confounded by the availability of PRs in those languages. In fact, as Grillo (2012) and Grillo and Costa (2014) showed, the mapping of PR-availability and preference for HA is accurate except in the case of three languages (Russian, German and Bulgarian). Previous research has shown a preference for HA in Russian, German and Bulgarian despite the fact that none of them allows a PR reading. A common denominator in these three languages is that RCs are introduced by relative pronouns and not by complementizers. This grammatical particularity may be responsible for HA in these languages, in line with the proposal by Hemforth, Konieczny, and Scheepers (1998). Along these lines, attachment preferences are determined by

¹ Most research in psycholinguistics and linguistics to date have focused on perceptive constructions. Although PRs are also licensed in some languages (e.g. Italian) in constructions with other type of predicates, such as *stand*, *meet*, or *catch*, there is considerable variation as PRs are not a unitary phenomenon across languages.

² Preliminary results in Grillo and Turco (2016) report clear prosodic differences between PRs and restrictive RCs on the basis of temporal and melodic cues. Longer production duration and increased tonal movement are found in PRs in comparison to RCs, thus mirroring differences at the structural level.

anaphoric resolution processes.

Grillo (2012) and Grillo and Costa (2014) put forward the PR-first Hypothesis to determine how the PR/RC ambiguity is resolved by the parser and which reading is favoured. The PR-first Hypothesis (*When PRs are available, everything else being equal, they will be preferred over RCs*) suggests that PRs are favoured by the parser because those constructions are simpler than RCs at different levels. At the syntactic level, RCs (7a) are adjuncts whereas PRs (7b) are arguments. The advantage of argument relations over adjunct relations has been widely evidenced in psycholinguistics (Clifton Jr, Speer, and Abney, 1991; Liversedge, Pickering, Branigan, and van Gompel, 1998; Schütze and Gibson, 1999; Speer and Clifton, 1998). Moreover, the contribution of arguments to the main assertion of the clause is more relevant than that of RCs (*Relativized Relevance*, Frazier, 1990), which adds to the advantage of PRs.

- (7) a. Isabel vio [_{PR} [_{DP} al hombre] [_{CP} que estaba corriendo.]]
'Isabel saw the man running.'
b. Isabel vio [_{DP} al [_{DP} hombre [_{RC} que estaba corriendo.]]].
'Isabel saw the man that was running.'

From a discourse perspective, PRs are also simpler than RCs. The latter denotes properties of individuals aimed at identifying an individual from a contextually given set of alternatives. In the absence of such a context, this set must be presupposed. Since PRs denote direct perception of ongoing situations, they carry fewer unsupported presuppositions than RCs, which makes them more parsimonious and are therefore favoured by the parser (*Referential theory*, Altmann and Steedman, 1988; Crain and Steedman, 1985).

An immediate implication of PR-first is that the resolution of a PR/RC ambiguity should favour the PR parse, under which there is no attachment ambiguity since only the first DP is accessible as the subject of the PR (8). PRs are only licensed as complements of the verb and from that position, due to structural restrictions, only the first DP is accessible as a subject of the PR (i.e. only the first DP c-commands the subject gap in the CP) (Grillo and Costa, 2014). Therefore, in neutral contexts, high (non-local) attachment is predicted for PRs.

- (8) a. Vi al [_{PR} [_{DP} hijo₁ del médico₂] [_{CP} que EC_{1/*2} corría]]
'I saw the son₁ of the doctor₂ running₁.'

A growing number of studies are reporting a consistent effect of PR-availability in different PR languages: Italian (Grillo and Costa, 2014), Greek (Grillo and Spathas, 2014), Portuguese (Fernandes, 2012; Grillo and Costa, 2014; Tomaz, Lourenço Gomes, Santi, and Grillo, 2014), French (Pozniak, Hemforth, Haendler, Santi, and Grillo, 2019), and Spanish (Aguilar and Grillo, 2016, 2020). These studies have exploited one of several restrictions on PRs³ to modulate PR availability: PRs, being events, are only licensed in environments that license events (9a) (e.g. in perceptual reports) but not in environments that exclusively select entities (9b) (e.g. under stative/relational verbs such as *work with/be married to*).

- (9) a. Vi al hijo del maestro que jugaba al tenis.
'I saw the son of the teacher playing tennis/that played tennis.'
b. Trabajé con el hijo del maestro que jugaba al tenis.
'I worked with the son of the teacher that played tennis.'

The results of these studies, most of which were based on offline tasks, are compatible with the hypothesis that the PR parse is favoured. In languages where PRs are available HA is preferred under perceptual verbs, whereas the preference under non-perceptual verbs tends to be biased towards LA because only the RC reading is at play. Importantly, the results from Grillo, Costa, Fernandes, and Santi (2015) and Pozniak, Hemforth, Haendler, Santi, and Grillo (2019) make it highly implausible that PR-availability effects are explained by independent effects of

³ The licensing context of PRs is considerably more restricted than that of RCs, and includes restrictions on outer and inner aspect, tense, etc.

plausibility or predicate semantics. Although a minor role of semantic bias is expected with perceptual verbs even in languages where PRs cannot be a confound (e.g. English) (Grillo, Costa, Fernandes, and Santi, 2015), the effect does not reverse preferences found in exclusive RC contexts (i.e. LA is the overall preference). Moreover, when PR languages (e.g. French) are compared to non-PR languages (e.g. English), their behaviours differ significantly in PR-contexts (Pozniak, Hemforth, Haendler, Santi, and Grillo, 2019).

Now if we return to the specificity of the exception to Late Closure, PR-first predictions can explain LA preference in so-called HA languages when the factors indicated in the previous section are not met. For instance, in the case of centre-embedded RCs, local attachment preference is expected because PRs cannot be a potential confound in this context, at least in Spanish. In some languages, one of which is Spanish, PRs are not allowed in the subject position (10) (example adapted from Grillo and Moulton, 2016):

- (10) *Isabel que baila es todo un espectáculo.
'Isabel dancing is a must-see spectacle.'

PRs in the subject position are considered event-kind denoting PRs, i.e. PRs that contain habituais and represent multiple instances of an event. The intended meaning in 10 is that every instantiation or token of the event-kind of Isabel dancing, every time Isabel dances (plurality of events), is a must-see spectacle (see Grillo and Moulton, 2016). Kind-referring PRs are not allowed in Spanish, *inter alia*, and by extension, PRs are not allowed in the subject position, though they are allowed in the object position under the perceptual report of an episodic punctual reading of Isabel dancing as a single event (11).

- (11) Veo a Isabel que baila.
'I see Isabel dancing.'

Similarly, local attachments reported when the type of relative pronoun that introduces the embedded clause is not the complementizer *que* but the relative pronoun *el cual* (Fernández, 2003) can be easily explained by PR-first since relative pronouns are not compatible with PRs, at least in Spanish.

1.3. The present study

This study aims to fill a gap in the research on PR/RC ambiguity. Most of the research conducted on this topic is offline and there has been just one previous eye-tracking experiment (Pozniak, Hemforth, Haendler, Santi, and Grillo, 2019). Pozniak and colleagues explored PR/RC structural ambiguity resolution building on tense restrictions ascribed to PRs to create PR-compatible (tense match between matrix and embedded predicates) and PR-incompatible (tense mismatch) contexts. In their study, the PR-advantage in PR-compatible contexts could be established only in the first half of the experiment. A possible explanation for this is that adaptation effects cancelled out the main effect in the second part of the experiment due to a predictable combination of tense in their experimental design. Specifically, when the main tense was present, participants could predict tense mismatch with the embedded tense (which was always kept in the past tense) and so the effects of forced RC readings in initially PR-compatible sentences were neutralized. A similar experimental design was employed by Fernandes, Alexiadou, Chow, Santi, and Grillo (2018) in an acceptability judgement task. Also in that study, participants quickly learnt that a matrix verb in the present tense unequivocally led to tense mismatch and therefore to an unambiguous RC parse. Fernandes and colleagues attempted to reduce reliability on the cue by adding unambiguous PRs with proper name DPs preceding the CP, a solution that significantly reduced the effect.

The present study differs from that of Pozniak, Hemforth, Haendler, Santi, and Grillo (2019) in two important aspects. First, our study provides more information on how PR availability influences online attachment preferences in PR/RC ambiguous contexts and what are the attachment preferences in the absence of the PR-confound. In this study, therefore, we deal with two types of ambiguities, i.e. PR/RC structural

ambiguity in PR-compatible contexts and attachment ambiguity when a RC parse is at stake, whereas the study of Pozniak, Hemforth, Haendler, Santi, and Grillo (2019) focused only on structural PR/RC ambiguity. The second important difference is that the experimental design of the present study attempts to avoid reliable cues that could potentially lead to adaptation effects.

The main question this study tries to answer is how the process of PR/RC disambiguation takes place in real time. A second question is which are the online preferences of RC attachment when PR-availability is controlled for, i.e. when RC is the only possible parse. Both these questions are essential for testing the alleged cross-linguistic variation in RC-attachment preferences.

Following PR-first, a cost of integrating the disambiguating word should be observed when this forces LA in PR-compatible contexts, since PRs can only take the first DP as the subject of the embedded clause. Low-attached sentences are therefore expected to be harder to parse than high-attached sentences in the condition with perceptual verbs. In contrast, the pattern of results is expected to be the opposite in RC-only contexts. If locality principles apply in Spanish, a processing cost should be observed in high-attached sentences following non-perceptual verbs.

Before presenting the results of an eye-tracking experiment on PR/RC ambiguities, we first provide the results of an offline questionnaire aimed at testing the influence of PR-availability on ultimate attachment preferences in an offline questionnaire in Spanish. Previous offline studies in Spanish are contradictory. Whereas Alonso-Pascua (2020) reported an overall LA irrespective of matrix verb type, Aguilar and Grillo (2016) and Aguilar and Grillo (2020) found that PR-availability modulates attachment in ambiguous PR/RC contexts (HA preference), whereas the preference is to attach low in RC-exclusive contexts.

The information from the two studies we present here - the offline questionnaire and the eye-tracking experiment (which roughly use the same materials) - will be useful for determining the magnitude of the effect of PR-availability at different points of the processing event.

2. Experiment 1

2.1. Participants

Ninety European-Spanish native speakers (72 women, aged 18–39 ($M = 20.9$, $SD = 4.1$)) voluntarily participated in this questionnaire. All gave their informed consent before taking part in the study and were naive as to the goals of the experiment.

2.2. Materials & design

2.2.1. Norming study

A preliminary plausibility study with an initial pool of 61 target items was carried out to test the plausibility of the sentences and ensure that both interpretations (HA and LA) were equally plausible. Each item was presented in two versions. Version A contained sentences with a complex DP in the subject position. This was followed by the main verb, the adjective secondary predicate, and a prepositional phrase or direct object. There is no ambiguity of attachment here since only DP1, the subject of the sentence, can agree with the secondary predicate. Version B, on the other hand, contained a single DP subject followed by the main verb, the secondary predicate, and a prepositional phrase or direct object. There was therefore only one minimal difference between the two versions: version A contained the complex DP while version B contained only the DP that corresponds to DP2 in version A. Version A and version B corresponded to the interpretation obtained as a result of the RC disambiguation towards HA or LA, respectively (12). In other words, each version corresponded to one of the two interpretations corresponding to RC disambiguation that was eventually tested in the later experiments.

(12) Version A. El dermatólogo de la presentadora reía dichoso en la fiesta.

‘The dermatologist_{MASC} of the presenter_{FEM} laughed happily_{MASC} at the party.’

Version B. La presentadora reía dichosa en la fiesta.

‘The presenter_{FEM} laughed happily_{FEM} at the party.’

Seventy-seven European-Spanish native speakers (40 women, $M = 26.7$, $SD = 10$) who did not take part in experiments 1 and 2 evaluated the plausibility of each sentence in a Likert scale from 1 (“not plausible”) to 5 (“very plausible”). Each participant evaluated the plausibility of only one version of each item, and versions were counterbalanced in each participant group. Only pairs of sentences with scores greater than 3 in the two versions (i.e. rated as “fairly plausible”) were preselected. From this selection, all pairs of sentences that showed significant differences in plausibility between the two versions were discarded.

2.2.2. Final materials

The final set of critical items consisted of 32 fully ambiguous sentences with a complex DP of the form [DP1 of DP2] followed by a finite that-clause. The two DPs in the complex DP shared the same gender features, i.e. both DPs were feminine in half of the sentences and both were masculine in the other half,⁴ and were placed in the object position of either perceptual or non-perceptual verbs. PR-compatibility was therefore controlled at the matrix verb level by using event-taking predicates (i.e. perceptual verbs) compatible with a PR-interpretation, or entity-taking verbs (i.e. non-perceptual verbs), incompatible with PRs, as shown in example 13.

(13) a. Perceptual

Juan vio al entrenador_{MASC} del tenista_{MASC} que lloraba contentomasc por la victoria.

‘Juan saw the coach of the tennis player that cried happily for the victory.’

b. Non-Perceptual

Juan conoció al entrenador_{MASC} del tenista_{MASC} que lloraba contentomasc por la victoria.

‘Juan met the coach of the tennis player that cried happily for the victory.’

Target items were presented to participants in a standard Latin square design, the verb type factor was counterbalanced across items and the order of items was randomized individually for each participant.

Sixty-four filler sentences containing complex DPs were included to mask the objective of the task. Approximately one third of the fillers were passive sentences (e.g. *The policeman was criticized by the lady for smoking in the car*), another third were verb control sentences (e.g. *The teacher forced the student to get out of the classroom*), and the final third were implicit causality sentences (e.g. *The singer admired the guitar player because he was a talented young man*).

2.3. Procedure

The task was performed through the TestMaker platform, a free PHP-based application for generating linguistic tasks for online use (Haro, 2012). Participants were told to read each sentence silently and then fill in the gap in the sentence presented below the ambiguous sentence, with either DP1 or DP2, as illustrated in 14.

(14) Juan conoció al entrenador del tenista que lloraba contento por la victoria.

‘Juan met the coach of the tennis player that cried happily for the victory.’

El lloraba contento por la victoria.

⁴ All target items were presented in both the masculine and the feminine conditions, with counterbalancing across experiments, except for six target items that were presented only in the masculine condition and one target item that was presented only in the feminine condition because their conversion to the opposite gender rendered the frequency of the item very low (e.g. el interlocutor_{MASC} del rabino_{MASC}/the interlocutor of the rabbi)

‘The cried happily for the victory.’

Answers corresponding to DP1 (e.g. in the previous example either *the coach* or *the coach of the tennis player*) were computed as HA and answers corresponding to DP2 (e.g. *the tennis player*) were computed as LA.

2.4. Data analysis & results

A mixed-effects logistic regression using the glmer function in the lme4 package (Bates, Maechler, and Bolker, 2015) of R (version 3.6.1, R Core Team, 2018) was used to model the probability of participants’ responses, fitting Verb type as fixed effect and participant and item modelled as random effects with random slope. The binary dependent variable of attachment preference was coded as 1 (HA) and 0 (LA). The levels of the Verb type factor were coded as 1 (perceptual) and –1 (non-perceptual).

The results showed an overall preference for HA, with 84% of DP1 answers in the condition with perceptual verbs, and 73% of DP1 answers for non-perceptual verbs. Importantly, the analysis showed a significant main effect of the verb type factor ($\beta = 0.860$, $SE = 0.226$, $z = 3.790$, $p < 0.001$).

2.5. Intermediate discussion

The findings of this questionnaire show an overall preference for HA and, importantly, this preference is significantly higher in PR-compatible contexts than in PR-incompatible contexts.

The preference for attaching high under perceptual predicates is predicted by the PR-first Hypothesis, whereas other factors may be at play to explain HA preferences in RC contexts. The length of the RCs (which are considerably long in this study) may be a potential candidate. As was mentioned in the introduction, in the RC attachment literature length is widely reported to influence attachment (see, for example Hemforth et al., 2015, for Spanish). Moreover, the percentage of HA preference reported in the present study is comparatively higher than that observed in previous offline studies for the same language. Aguilar and Grillo (2020) reported 56.7% HA for perceptual verbs and 38.2% for non-perceptual verbs in shorter sentences, while Alonso-Pascua (2020) reported even lower percentages (40.70% HA for perceptual verbs and 25% for non-perceptual verbs) in sentences with clauses comprising just one word. The different materials and procedures employed in these studies, together with a potential interplay between length and PR-availability, may explain the variability in these results.

The experiment introduced in the following section is an eye-tracking study where effects of length may be minimized given the incremental nature of parsing. The aim is to explore how PR/RC ambiguity resolution takes place as it unfolds over time.

3. Experiment 2

3.1. Participants

Forty-two European-Spanish native speakers (mean age = 21.33, $SD = 5.38$, 36 women), recruited at Universitat Rovira i Virgili (Tarragona, Spain), participated in the experiment in exchange for course credit. Participants had normal or corrected-to-normal vision and reported no reading or other language-related disorders. All gave their informed consent before taking part in the study and were naive as to the goals of the experiment.

3.2. Materials & design

The materials for this experiment were adapted from the thirty-two target items used in the previous experiment. Temporary ambiguous sentences preceded by two potential antecedents were employed. The sentences were eventually disambiguated towards HA or LA by means of

gender morphology inflected in the adjectival secondary predicate following the verb. The adjectival secondary predicate only agreed with one of the antecedents, i.e. DP1 or DP2. The depictive secondary predicates were selected in accordance with semantic properties previously described in the literature. Specifically, the attribute described by the predicate had to be an intrinsic and transitory property, as noted by Rothstein (1983), and also by Hernanz (1988), who maintained that only adjectives that can be predicated with the Spanish verb *estar* 'to be' (e.g. *Javier está estresado*/'Javier is stressed out'), i.e. stage-level predicates, are accessible to secondary predication, in opposition to adjectives that cannot be predicated with the verb 'to be' when this verb denotes a permanent state (the verb *ser* in Spanish) (e.g. **Javier es estresado*/'Javier is stressed out'), i.e. individual-level predicates.

Gender disambiguation was chosen because it allowed us to have a focused point of disambiguation, keeping length of the region equal, with minimal changes across conditions (in Spanish, the gender morphemes for masculine and feminine differ in just one letter, with the morpheme 'o' used for masculine and the morpheme 'a' used for feminine). Both DPs were always animate and singular to avoid potential animacy and/or plural attraction effects. Although gender manipulation could also create attraction effects in comprehension, as previously reported in the literature (Acuña-Fariña, Meseguer, and Carreiras, 2014; Cunnings, González Alonso, Miller, and Rothman, 2017; Slioussar and Malko, 2016), to the best of our knowledge no cases have been reported so far in the literature of RC attachment. Nevertheless, this factor has been controlled in our experiment.

A quartet was constructed for each target item. Each quartet was composed of two sentences with perceptual matrix verbs and two sentences with non-perceptual matrix verbs, half of which were disambiguated towards DP1 (HA) and half towards DP2 (LA). Disambiguation was carried out using gender agreement between one of the antecedents and the adjective secondary predicate. The same applied to sentences with non-perceptual verbs, following a Latin square design as exemplified in 15.

The number of DP1_{MASC} and DP2_{FEM} configurations, was roughly the same as that for DP1_{FEM} and DP2_{MASC}. To counterbalance any potential effects of gender attraction, the same was true of the gender of the disambiguating word. Moreover, lexical/semantic/affective potential effects were controlled, since both antecedent DPs and disambiguating words were matched for length, frequency, concreteness, arousal and valence (see Appendix A for detailed description).

(15) a. **Perceptual, High Attachment**

Juan vio al entrenador_{MASC} de la tenista_{FEM} que lloraba amargado_{MASC} por la derrota.

'Juan saw the coach of the tennis player that wept bitterly for the defeat.'

b. **Perceptual, Low Attachment**

Juan vio al entrenador_{MASC} de la tenista_{FEM} que lloraba amargada_{FEM} por la derrota.

'Juan saw the coach of the tennis player that wept bitterly for the defeat.'

c. **Non-Perceptual, High Attachment**

Juan conoció al entrenador_{MASC} de la tenista_{FEM} que lloraba amargado_{MASC} por la derrota.

'Juan has met the coach of the tennis player that wept bitterly for the defeat.'

d. **Non-Perceptual, Low Attachment**

Juan conoció al entrenador_{MASC} de la tenista_{FEM} que lloraba amargada_{FEM} por la derrota.

'Juan has met the coach of the tennis player that wept bitterly for the defeat.'

Seventy-five fillers were intertwined with target items. Fillers contained 16 unambiguous PRs with proper nouns that cannot be modified by restrictive RCs (e.g. *El técnico de laboratorio observó a Rosa que estaba*

escribiendo las fórmulas en la pizarra/'The lab technician observed Rosa writing the formulas on the board'). Following the procedure by Fernandes, Alexiadou, Chow, Santi, and Grillo (2018) to avoid adaptation/repetition effects, these were included to balance the number of unambiguous RCs in the condition with non-perceptuals (i.e. there is no PR/RC structural ambiguity with non-perceptuals, just attachment ambiguity).

The remaining fillers consisted of sentences in the active and passive voice without structural ambiguity. The total number of items were 107, approximately a third of which ($n = 33$) were followed by a comprehension question. Questions in the target items covered the content of the embedded clause or the matrix clause but never ambiguity resolution (e.g. Did Juan meet the coach of the tennis player?).

3.3. Procedure

The participants were tested individually using an EyeLink 1000 (SR Research) eye tracker to record eye movements while reading. Stimuli were presented at a constant distance of 60 cm from a 19-inch computer screen set at a resolution of 1,024 × 768 pixels. Viewing was binocular but only the movements of the right eye were continuously recorded at a sampling rate of 1000 Hz. The sentences were presented in random order in a left-aligned single line in the centre of the screen and in black lowercase (Arial, 24). Before the experiment began, the participants read the instructions and completed a short practice of six sentences to become familiar with the procedure.

Before each recording session, a calibration procedure using a standard 9-point calibration routine was performed. Recalibration took place after a break and whenever necessary throughout the experiment. Before each trial, the participants were asked to fix their gaze on a fixation point on the left-hand side of the screen to ensure proper gaze measurement and attention. The fixation point marked the beginning of the sentence, coinciding with the first letter, and the sentence would only be displayed when the participant's gaze was successfully detected on the fixation point. The stimuli were presented using SR-Research Experiment-Builder software.

3.4. Data analysis & results

Accuracy rates for the answer to the comprehension question were above 75% for all participants. The error rate, which ranged from 0 to 24.24, averaged 8.33 (SD = 5,0.19). No differences in accuracy rates were found across conditions (all $p > 0.05$). Prior to data analysis, trials with blinks, track loss or data collection errors were deleted. In addition, eye fixations of less than 80 ms in duration were merged into longer fixations within a visual angle distance of 0.5. Remaining fixations below 80 ms or above 1000 ms were deleted.

Analyses of target items were carried out on two regions as shown in example 16 separated by a vertical pipe (|).

(16) Juan vio al entrenador de la tenista que lloraba | contenta | por la victoria.

'Juan saw the coach of the tennis player that cried | happily | for the victory.'

The first region comprises the region of interest (RoI), which contained the disambiguating word: the adjective inflected with morphological gender information which agreed with just one of the antecedents (DP1 or DP2). That word was 'contenta' in the previous example. The second region contained the spillover region. This region contained two or three words, which in most cases formed a Prepositional Phrase (PP) (e.g. *por la victoria* in example 16).

Analyses were computed for four eye-movement measures, two of which are considered early measures (First Fixation duration and Gaze Duration) and two are considered late measures (Regression Path Duration and Total Time). First Fixation duration is the duration of the first fixation in a region - from the time the region is first entered from the left until a subsequent fixation is made. Gaze Duration (also called

first-pass reading time) is the sum of all fixations in a region from when the region is first entered until the region is exited (to the right or left), given that the region was fixated at least once. Regression Path Duration is the sum of fixation durations from the time the region is first entered from the left until it is exited to the right (including any fixations made to the left of the region). Total Time Duration is the total duration of all fixations in the region, including re-readings. These measures were log-transformed and when the measure returned no data, i.e. there were no fixations on the region, the trial was treated as a missing value in the analysis.

The first fixation measure was not computed in the spillover region due to its length (between two and three words).

Data were analysed with R (R Core Team, 2018) fitting linear mixed-effects model (Baayen, Davidson, and Bates, 2008) to the reading times data, implemented using the *lme4* package (Bates, Mächler, Bolker, and Walker, 2015) for each dependent measure in each region of interest. The model included *Verb type* (Perceptual vs Non-Perceptual) and *Attachment* (High vs Low) as fixed effects, with the interaction term in the model, and participants and items as random effects. Maximal random effect structure was attempted in all analyses. If the model failed to converge, we first removed correlation parameters between random intercepts and random slopes, then interactions between random slopes, and finally the random slopes themselves until convergence was achieved.

The data set and R code for all analyses reported here are available under this link (<https://osf.io/y6td4>).

The results for each region are discussed below in the order in which the regions appear in the sentence.

3.5. Results in the critical region (RoI)

The results for this region are summarized in Table 1 for descriptive statistics and Table 2 for inferential statistics.

Analyses of First fixation duration showed a significant interaction between Verb type and Attachment (see Fig. 1). This interaction is explained by a selective effect of Attachment in the condition with non-perceptual verbs ($\beta = -0.101$, $SE = 0.027$, $t = -3.689$, $p < 0.001$), where low-attached sentences were read faster than high-attached ones. No effect was found on perceptual verbs ($\beta = 0.020$, $SE = 0.027$, $t = 0.748$, $p < 0.453$).

Gaze Duration delivered similar results, as shown in Fig. 2. There is an interaction between Verb type and Attachment that reflects a

Table 1
Summary of mean reading times (with standard deviations in parentheses) in the disambiguating region.

Measure	Mean (sd)
<i>First Fixation duration</i>	
Perceptual + HA	265.3 (46)
Perceptual + LA	278.5 (68)
Non-Perceptual + HA	287.9 (59)
Non-Perceptual + LA	257.1 (44)
<i>Gaze duration</i>	
Perceptual + HA	404.8 (120)
Perceptual + LA	416.2 (47)
Non-Perceptual + HA	430.1 (119)
Non-Perceptual + LA	383.2 (94)
<i>Regression Path duration</i>	
Perceptual + HA	647.8 (513)
Perceptual + LA	602.1 (13)
Non-Perceptual + HA	684.6 (531)
Non-Perceptual + LA	638.4 (422)
<i>Total times</i>	
Perceptual + HA	638.8 (207)
Perceptual + LA	737.2 (248)
Non-Perceptual + HA	702.1 (225)
Non-Perceptual + LA	713.4 (306)

Table 2
Summary of LME analyses of log first fixation, gaze duration, regression-path duration and total time at the disambiguating region.

Measure and condition	β	SE	t-value	p-value
<i>First fixation duration</i>				
Effect of Verb type	0.043	0.039	1.086	0.277
Effect of Attachment	-0.027	0.039	-0.696	0.486
Effect of Item order	0.0002	0.001	0.224	0.822
Verb type*Attachment	-0.160	0.079	-2.013	0.044*
Verb type*Item order	-0.001	0.002	-0.671	0.502
Attachment*Item order	-0.0008	0.002	-0.395	0.692
Verb type*Attachment*Item order	0.002	0.004	0.571	0.567
<i>Gaze duration</i>				
Effect of Verb type	-0.058	0.051	-1.138	0.254
Effect of Attachment	-0.044	0.050	-0.870	0.384
Effect of Item order	-0.001	0.001	-1.155	0.247
Verb type*Attachment	0.251	0.102	2.460	0.013*
Verb type*Item order	0.002	0.002	0.943	0.345
Attachment*Item order	-8.514e-05	0.002	-0.031	0.974
Verb type*Attachment*Item order	-0.008	0.005	-1.587	0.112
<i>Regression path duration</i>				
Effect of Verb type	0.183	0.069	2.653	0.007**
Effect of Attachment	-0.082	0.064	-1.281	0.200
Effect of Item order	-0.0007	0.001	-0.405	0.684
Verb type*Attachment	-0.018	0.0129	-0.140	0.888
Verb type*Item order	-0.008	0.003	-2.454	0.014*
Attachment*Item order	0.001	0.003	0.407	0.683
Verb type*Attachment*Item order	-0.001	0.006	-0.151	0.879
<i>Total Time</i>				
Effect of Verb type	-0.061	0.060	-1.022	0.306
Effect of Attachment	0.057	0.057	1.004	0.315
Effect of Item order	-0.008	0.001	-5.423	<0.001***
Verb type*Attachment	0.378	0.115	3.288	0.001**
Verb type*Item order	0.003	0.003	1.036	0.299
Attachment*Item order	-0.001	0.003	-0.524	0.599
Verb type*Attachment*Item order	-0.016	0.006	-2.601	0.009**

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

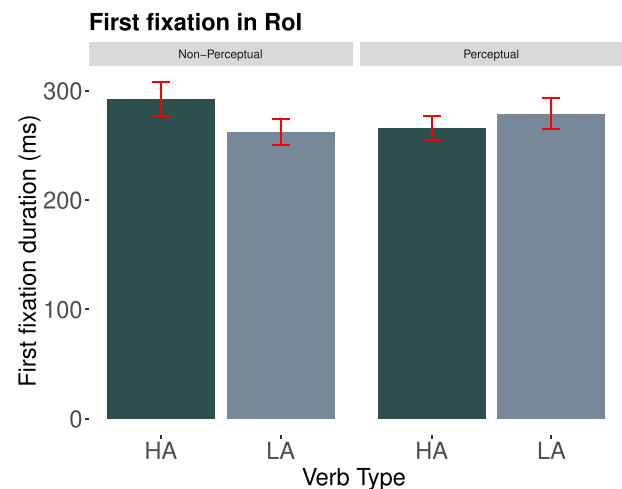


Fig. 1. First fixation duration in the disambiguating word (error bars represent SE).

selective effect of Attachment in the subset with non-perceptuals ($\beta = -0.099$, $SE = 0.035$, $t = -2.848$, $p < 0.004$) but a null effect with perceptuals ($\beta = 0.008$, $SE = 0.036$, $t = 0.224$, $p < 0.822$).

Regression Path Duration times were longer for sentences with non-perceptual verbs, as is shown by the main effect of Verb type. There was

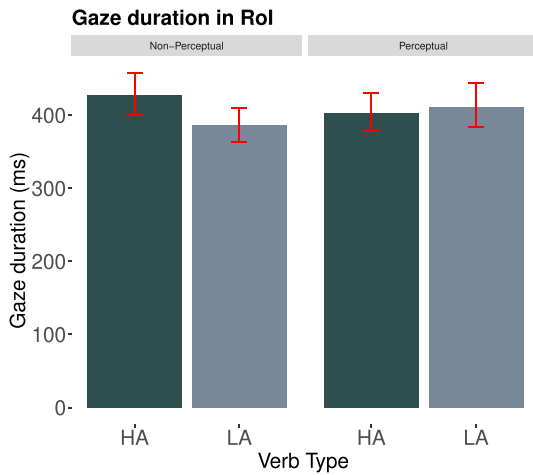


Fig. 2. Gaze duration in the disambiguating word (error bars represent SE).

also significant interaction between Verb type and Item order, which indicated that the advantage of perceptual verbs observed in the first half ($\beta = 0.106, SE = 0.044, t = 2.402, p = 0.016$), later disappeared ($\beta = -0.018, SE = 0.046, t = -0.390, p = 0.696$).

Analysis of Total reading times showed an effect of Item order, which indicates a faster reading pace as the experiment goes by. There is also an interaction between Verb type and Attachment, and a three-way interaction between Verb type, Attachment and Item order. The two-way interaction reflects a selective effect of Attachment only in the subset with perceptuals ($\beta = 0.89.204, SE = 30.266, t = 2.947, p = 0.003$) but a null effect in the subset with non-perceptuals ($\beta = 3.186, SE = 32.494, t = 0.098, p = 0.921$) (see Fig. 3).

To further analyse the three-way interaction, the factor Item order was dichotomised into the first and second half of the experiment, and analyses were run in the subsets of PRs and RCs in both parts of the experiment. The analyses showed again the selective effect of Attachment with perceptuals ($\beta = 89.204, SE = 30.266, t = 2.947, p = 0.003$) but not with non-perceptuals ($\beta = 3.186, SE = 32.494, t = 0.098, p = 0.921$). The effect was significant in the first half ($\beta = 129.496, SE = 42.460, t = 3.049, p = 0.002$) but not in the second half ($\beta = 36.955, SE = 43.767, t = 0.844, p = 0.398$) of the experiment (see Fig. 4).

In the subset with non-perceptuals, only the effect of Item order was significant ($\beta = -8.133, SE = 1.747, t = -4.657, p < 0.001$).

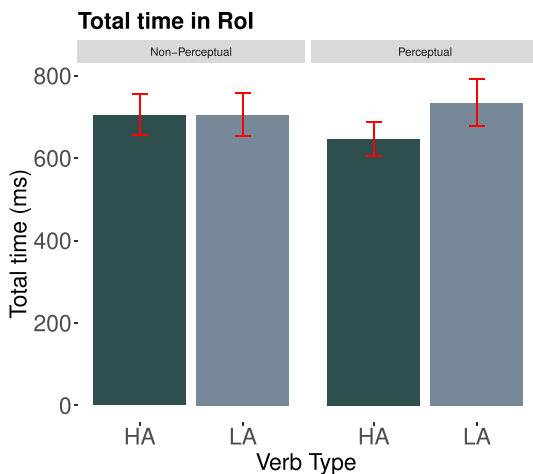


Fig. 3. Total Reading times in the disambiguating word (error bars represent SE).

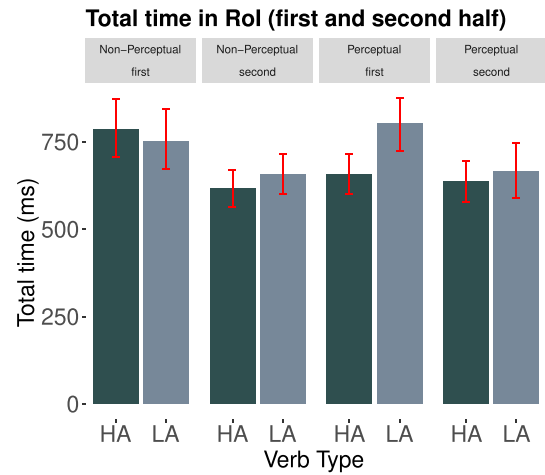


Fig. 4. Total Reading times in the disambiguating word (error bars represent SE).

3.6. Results in the spillover region

Results for this region are summarized in Table 3 for descriptive statistics and in Table 4 for inferential statistics.

Analyses of Gaze duration showed an effect of Item order, which is explained by an increasingly faster reading pace over the experiment as participants got used to the task. The same was observed in Regression Path Duration. For this reading measure there was also a marginal effect of Attachment, which shows that there was a general penalisation for LA, an interaction between Verb type and Attachment, and a three-way interaction between Verb type, Attachment and Item order. Further analyses revealed a selective effect of Attachment in perceptuals ($\beta = 0.166, SE = 0.057, t = 2.920, p < 0.003$), with faster reading times when the sentences were high-attached. This effect was significant in the first half of the experiment ($\beta = 0.286, SE = 0.076, t = 3.743, p < .001$) but not in the second half ($\beta = 0.042, SE = 0.075, t = 0.560, p = 0.575$). Analyses in the subset with non-perceptual verbs did not reveal any effect (all $ps > 0.05$).

The results in Total times showed the same effect of Item order as was observed earlier.

4. Discussion

We conducted an eye-tracking experiment to investigate whether PR-availability effects and locality principles apply to the online processing

Table 3

Summary of mean reading times (with standard deviations in parentheses) in the spillover region.

Measures	mean (sd)
<i>Gaze duration</i>	
Perceptual + HA	586.3 (314)
Perceptual + LA	593.5 (259)
Non-Perceptual + HA	561.9 (245)
Non-Perceptual + LA	563.3 (262)
<i>Regression-Path duration</i>	
Perceptual + HA	2278.7 (1551)
Perceptual + LA	2816 (1980)
Non-Perceptual + HA	2654.7 (1727)
Non-Perceptual + LA	2960.7 (2539)
<i>Total times</i>	
Perceptual + HA	798.9 (358)
Perceptual + LA	895.5 (362)
Non-Perceptual + HA	833.1 (410)
Non-Perceptual + LA	877.1 (472)

Table 4

Summary of LME analyses of log gaze duration, regression-path duration and total time in the spillover region.

Measure and condition	β	SE	t-value	p-value
<i>Gaze duration</i>				
Verb type	-31.259	40.028	-0.780	0.434
Attachment	29.750	39.859	0.746	0.455
Item order	-3.626	1.087181	-3.335	<0.001***
Verb type*Attachment	29.992	79.972	0.375	0.707
Verb type*Item order	-0.027	2.162	-0.012	0.990
Attachment*Item order	0.173	2.153	0.080	0.935
Verb type*Attachment*Item order	-2.584	4.325	-0.597	0.550
<i>Regression path duration</i>				
Verb type	0.008	0.081	0.104	0.916
Attachment	0.149	0.081	1.828	0.067
Item order	-0.016	0.002	-7.23	<0.001***
Verb type*Attachment	-0.448	0.163	-2.737	0.006**
Verb type*Item order	0.002	0.004	0.482	0.629
Attachment*Item order	-0.002	0.004	-0.601	0.547
Verb type*Attachment*Item order	0.019	0.008	2.217	0.026*
<i>Total time</i>				
Verb type	0.008	0.060	0.144	0.885
Attachment	0.069	0.059	1.160	0.245
Item order	-0.010	0.001	-6.476	<0.001***
Verb type*Attachment	-0.160	0.119	-1.340	0.180
Verb type*Item order	-0.001	0.003	-0.480	0.630
Attachment*Item order	0.001	0.003	0.313	0.753
Verb type*Attachment*Item order	0.002	0.006	0.364	0.715

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

of PR/RC ambiguities in Spanish. Our results provide new evidence from Spanish in support of the universality of the principles of locality: the online effects of locality apply early on when PR-availability is controlled. Our data also showed that the effect of PR-availability surfaces later on.

In PR-incompatible contexts, there was a steady processing cost when the RC was disambiguated non-locally. This arose immediately when an adjective disagreeing in gender with DP2 was encountered and quickly recovered by the time the eyes moved on to the next region. This is the first evidence of early local preference in Spanish in the RC attachment ambiguity literature using gender disambiguation. Our results therefore contrast with previous findings that so far shown a bias to HA preference has been observed in online experiments in Spanish. Eye-tracking studies (Carreiras and Clifton, 1999) reported a late preference (in total reading times) for HA. Experiments with ERPs observed enhanced amplitudes of the P600 waveform which indicated syntactic reanalysis when RC was forced to attach low (Carreiras, Salillas, and Barber, 2004). However, it is important to stress that neither of these online studies controlled for PR availability. This could crucially account for the difference between the results of our study and previous ones. The results of the eye-tracking study showed that, apart from an early preference for LA in RC-exclusive contexts, there was an eventual across-the-board penalisation for low-attached sentences at the spillover region. The results in this region match well those reported in the questionnaire, i.e. a general preference for HA. It seems that the online results reflect syntactic preferences of attachment (i.e. locality), while the offline results encompass other effects which, given the incremental nature of parsing, are more likely to be captured by offline measures.

The offline/online mismatch is not new in the literature. Although most research on RC attachment is based on offline tasks, some online studies also exist. Some of these studies show a match between offline and online tasks (Carreiras and Clifton, 1993, 1999; Carreiras, Salillas, and Barber, 2004) while others report an asymmetry. When De Vincenzi and Job (1993) tested offline and online RC attachment preferences in Italian, they reported an early cost to parse RCs disambiguated towards

HA and a later preference for high-attached sentences.

The same asymmetry (offline HA preference/online LA preference) is found in other studies, such as that by Pynte, Portes, Holcomb, and Di Cristo (2003) for French, or across studies within the same language (e.g. see Maia, Fernández, Costa, and Lourenco-Gomes, 2007). There is some consensus in the literature to explain the offline/online misalignment on the basis of the multi-factorial nature of RC attachment preferences and the fact that syntactic effects can be measured online, but the influence of other factors such as pragmatics or length is more likely to be measurable in offline tasks.

On the other hand, the results of the eye-tracking study in PR-compatible contexts match those found in the questionnaire. The online parsing of ambiguous PR/RC sentences showed a penalisation for low-attached sentences, though this effect only surfaced in total reading time. The significant difference between perceptual and non-perceptuals in both studies signifies that, although attachment in PR contexts may interact with other factors, the effect reported here is due to the preference for a PR-parse in perceptual contexts, thus giving support to the PR-first Hypothesis.

If we compare the present study with previous research on PR/RC disambiguation, the results found here match those found in offline questionnaires in Spanish (Aguilar and Grillo, 2020). Analyses of eye movements in Pozniak et al. in French showed effects of PR preference in Regression Path Duration at the disambiguating region. However, as we mentioned earlier, their study did not involve attachment ambiguities since their goal was not to test the influence of PR-availability on attachment but to directly test the fundamentals of PR-first building on PR restrictions on tense match. The need to check for tense match between embedded and matrix verbs might explain regressions from the embedded verb to previous regions of the sentence in order to check for PR requirements of simultaneity. Independent properties of the processing of tense and the specifics of the experimental design in the study by Pozniak et al. (as well as the fact that that study was in French) make it difficult to compare the two experiments and may be responsible for the differences observed between the two studies.

We should also add that, despite our efforts to avoid learning effects over the experiment, some effects were cancelled out in the second part of the experiment. Specifically, the penalization for LA found in perceptuals at the critical region and in perceptuals at Regression Path duration at the spillover region was not found in the second part of the experiment. Although there were no reliable cues in our experiment, RCs outnumbered PRs (even after unambiguous PRs were added to the fillers), which may explain why the effect was only observed in the condition with perceptuals.

4.1. Conclusion

The results presented here provide important information about two questions raised in the introduction. The answer to the question regarding which preferences Spanish speakers have in RC attachment ambiguity (once the PR-availability is controlled for) is straightforward: the parser prefers to initially build local relations between the RC and nearest DP very early on, which supports locality principles. This finding makes an important contribution to the literature. Spanish, the first language for which a non-local attachment preference has been found in the literature, aligns with languages such as English in RC attachment preferences. Offline, however, the preference is to attach high, as other factors such as length may have a greater influence on offline processing.

The second question asked how the PR/RC ambiguity resolution takes place in time. Our results showed a clear effect of PR-availability in Spanish that surfaces in total time duration. The results from the online study mirror those reported in the offline questionnaire: agreement between the embedded verb and DP1 is questioned in PR-compatible contexts, arguably because the PR-parse is preferred over the RC one, thus supporting to the PR-first Hypothesis. We conclude that although the resolution process may involve the interaction of different factors,

PR-availability plays a crucial role and can (at least partly) explain previous cross-linguistic variation. This evidence highlights the importance of controlling the availability of PRs in future research.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Credit author statement

Miriam Aguilar: Conceptualization, Methodology, Writing- Original

Appendix A. Appendix

Lexical-semantic variables were controlled in this experiment to prevent any potential confound. The two antecedent DPs (DP1 and DP2) and the disambiguating words were matched for length, frequency, concreteness, arousal and valence. The values for length and frequency were obtained from the EsPal database (Duchon, Perea, Sebastián-Gallés, Martí, and Carreiras, 2013). The other values (concreteness, arousal and valence), which are not available in the database, were obtained from a series of questionnaires designed for this purpose.

Sixty-three Spanish native speakers (mean = 19.44, SD = 3.13, 60 women) voluntarily participated in the questionnaire survey. Participants had to rate the concreteness of the words on a scale ranging from 1 to 7, and arousal and valence in a scale ranging from 1 to 9. Analyses were performed to compare these values in DP1 versus DP2, in masculine versus feminine disambiguating words, and in high-attaching versus low-attaching disambiguating words. The results did not show any statistical difference (all $p > .05$). The final values for each variable are shown in Table 5 for DP1 and DP2, and in Table 6 for critical word disambiguating towards DP1 (High) and critical word disambiguating towards DP2 (Low).

Table 5
Mean (sd) values for words in DP1 and DP2.

	DP1	DP2
Length	8.63 (2.09)	8.88 (2.49)
Frequency	3.38 (0.78)	3.32 (0.73)
Concreteness	5.62 (0.65)	5.84 (0.43)
Arousal	4.11 (0.55)	4.03 (0.50)
Valence	5.04 (0.53)	4.96 (0.50)

Table 6
Mean (sd) values for the disambiguating word in HA and LA conditions.

	HA	LA
Length	8.90 (1.84)	8.90 (1.84)
Frequency	3.48 (0.81)	3.43 (0.79)
Concreteness	3.41 (0.88)	3.47 (0.92)
Arousal	5.44 (1.60)	5.40 (1.67)
Valence	4.50 (2.34)	4.44 (2.32)

Table 7
Mean (sd) values for masculine and feminine disambiguating word.

	Masc	Fem
Length	8.91 (1.84)	8.91 (1.84)
Frequency	3.59 (0.80)	3.33 (0.79)
Concreteness	3.43 (0.94)	3.45 (0.86)
Arousal	5.35 (1.62)	5.50 (1.64)
Valence	4.35 (2.30)	4.60 (2.35)

draft, Formal analysis, Resources, Investigation, Visualization.

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Appendix B. Appendix

Target items across conditions employed in the eye-tracking study (condition a = perceptual + high attachment; condition b = perceptual + low attachment; condition c = non-perceptual + high attachment; condition d = non-perceptual + low attachment).

1. a. Ángel vio al monaguillo de la sacerdotisa que rezaba arrodillado en el banco.
- b. Ángel vio al monaguillo de la sacerdotisa que rezaba arrodillada en el banco.
- c. Ángel conocía al monaguillo de la sacerdotisa que rezaba arrodillado en el banco.
- d. Ángel conocía al monaguillo de la sacerdotisa que rezaba arrodillada en el banco.
2. a. Jesús oyó al fontanero de la arrendataria que dialogaba entretenido con los vecinos.
- b. Jesús oyó al fontanero de la arrendataria que dialogaba entretenida con los vecinos.
- c. Jesús trabajó con el fontanero de la arrendataria que dialogaba entretenido con los vecinos.
- d. Jesús trabajó con el fontanero de la arrendataria que dialogaba entretenida con los vecinos.
3. a. Marina miró a la interlocutora del rabino que pactaba inquieto el nuevo horario.
- b. Marina miró a la interlocutora del rabino que pactaba inquieta el nuevo horario.
- c. Marina colaboró con la interlocutora del rabino que pactaba inquieto el nuevo horario.
- d. Marina colaboró con la interlocutora del rabino que pactaba inquieta el nuevo horario.
4. a. Teresa escuchó al adjunto de la funcionaria que telefoneaba preocupado al centro deportivo.
- b. Teresa escuchó al adjunto de la funcionaria que telefoneaba preocupada al centro deportivo.
- c. Teresa se casó con el adjunto de la funcionaria que telefoneaba preocupado al centro deportivo.
- d. Teresa se casó con el adjunto de la funcionaria que telefoneaba preocupada al centro deportivo.
5. a. Marisa oyó al técnico de la subdirectora que respondía dudoso a las preguntas.
- b. Marisa oyó al técnico de la subdirectora que respondía dudosa a las preguntas.
- c. Marisa conocía al técnico de la subdirectora que respondía dudoso a las preguntas.
- d. Marisa conocía al técnico de la subdirectora que respondía dudosa a las preguntas.
6. a. Montse observó al confesor de la monja que paseaba taciturno por los pasillos.
- b. Montse observó al confesor de la monja que paseaba taciturna por los pasillos.
- c. Montse escribió al confesor de la monja que paseaba taciturno por los pasillos.
- d. Montse escribió al confesor de la monja que paseaba taciturna por los pasillos.
7. a. Marga vio a la analista del diplomático que bromeaba animado en la celebración.
- b. Marga vio a la analista del diplomático que bromeaba animada en la celebración.
- c. Marga colaboró con la analista del diplomático que bromeaba animado en la celebración.
- d. Marga colaboró con la analista del diplomático que bromeaba animada en la celebración.
8. a. Judith miró a la descendiente del cónsul que caminaba armado con una pistola.
- b. Judith miró a la descendiente del cónsul que caminaba armada con una pistola.
- c. Judith trabajó con la descendiente del cónsul que caminaba armado con una pistola.
- d. Judith trabajó con la descendiente del cónsul que caminaba armada con una pistola.
9. a. David escuchó a la asistente del congresista que charlaba tranquilo en la reunión.
- b. David escuchó a la asistente del congresista que charlaba tranquila en la reunión.
- c. David se casó con la asistente del congresista que charlaba tranquilo en la reunión.
- d. David se casó con la asistente del congresista que charlaba tranquila en la reunión.
10. a. Isabel observó al preparador de la golfista que gesticulaba agitado en el campo.
- b. Isabel observó al preparador de la golfista que gesticulaba agitada en el campo.
- c. Isabel escribió al preparador de la golfista que gesticulaba agitado en el campo.
- d. Isabel escribió al preparador de la golfista que gesticulaba agitada en el campo.
11. a. Juan observó al monitor de la submarinista que fotografiaba entusiasmado estrellas de mar.
- b. Juan observó al monitor de la submarinista que fotografiaba entusiasmada estrellas de mar.
- c. Juan trabajó con el monitor de la submarinista que fotografiaba entusiasmado estrellas de mar.
- d. Juan trabajó con el monitor de la submarinista que fotografiaba entusiasmada estrellas de mar.
12. a. Arturo oyó a la asesora del fabricante que charlaba tumbado en la butaca.
- b. Arturo oyó a la asesora del fabricante que charlaba tumbada en la butaca.
- c. Arturo colaboró con la asesora del fabricante que charlaba tumbado en la butaca.
- d. Arturo colaboró con la asesora del fabricante que charlaba tumbada en la butaca.
13. a. Paco vio a la limpiadora del duque que revisaba obsesionado la previsión del tiempo.
- b. Paco vio a la limpiadora del duque que revisaba obsesionada la previsión del tiempo.
- c. Paco se casó con la limpiadora del duque que revisaba obsesionado la previsión del tiempo.
- d. Paco se casó con la limpiadora del duque que revisaba obsesionada la previsión del tiempo.
14. a. Laura vio a la nutricionista del conde que corría fatigado en la maratón.
- b. Laura vio a la nutricionista del conde que corría fatigada en la maratón.
- c. Laura conocía a la nutricionista del conde que corría fatigado en la maratón.
- d. Laura conocía a la nutricionista del conde que corría fatigada en la maratón.
15. a. Leticia miró a la becaria del funcionario que fumaba pensativo en el pasillo.
- b. Leticia miró a la becaria del funcionario que fumaba pensativa en el pasillo.
- c. Leticia escribió a la becaria del funcionario que fumaba pensativo en el pasillo.
- d. Leticia escribió a la becaria del funcionario que fumaba pensativa en el pasillo.
16. a. Pablo escuchó al hijastro de la camionera que canturreaba despreocupado en el bar.
- b. Pablo escuchó al hijastro de la camionera que canturreaba despreocupada en el bar.

- c. Pablo trabajó con el hijastro de la camionera que canturreaba despreocupado en el bar.
d. Pablo trabajó con el hijastro de la camionera que canturreaba despreocupada en el bar.
17. a. Laura oyó a la inquilina del casero que cantaba afónico en la verbena.
b. Laura oyó a la inquilina del casero que cantaba afónica en la verbena.
c. Laura colaboró con la inquilina del casero que cantaba afónico en la verbena.
d. Laura colaboró con la inquilina del casero que cantaba afónica en la verbena.
18. a. Ana observó al gestor de la empresaria que conducía estresado por la ciudad.
b. Ana observó al gestor de la empresaria que conducía estresada por la ciudad.
c. Ana se casó con el gestor de la empresaria que conducía estresado por la ciudad.
d. Ana se casó con el gestor de la empresaria que conducía estresada por la ciudad.
19. a. Elena miró al alumno de la mecánica que reposaba cansado en el taller.
b. Elena miró al alumno de la mecánica que reposaba cansada en el taller.
c. Elena conocía al alumno de la mecánica que reposaba cansado en el taller.
d. Elena conocía al alumno de la mecánica que reposaba cansada en el taller.
20. a. Ángela vio a la asistente del farmacéutico que ordenaba concentrado el nuevo pedido.
b. Ángela vio a la asistente del farmacéutico que ordenaba concentrada el nuevo pedido.
c. Ángela trabajó con la asistente del farmacéutico que ordenaba concentrado el nuevo pedido.
d. Ángela trabajó con la asistente del farmacéutico que ordenaba concentrada el nuevo pedido.
21. a. Araceli escuchó al mensajero de la emperatriz que leía apenado la nueva noticia.
b. Araceli escuchó al mensajero de la emperatriz que leía apenada la nueva noticia.
c. Araceli escribió al mensajero de la emperatriz que leía apenado la nueva noticia.
d. Araceli escribió al mensajero de la emperatriz que leía apenada la nueva noticia.
22. a. Mario oyó a la administrativa del vicepresidente que carraspeaba nervioso por la situación.
b. Mario oyó a la administrativa del vicepresidente que carraspeaba nerviosa por la situación.
c. Mario colaboró con la administrativa del vicepresidente que carraspeaba nervioso por la situación.
d. Mario colaboró con la administrativa del vicepresidente que carraspeaba nerviosa por la situación.
23. a. Paloma miró al redactor de la senadora que sonreía satisfecho en el homenaje.
b. Paloma miró al redactor de la senadora que sonreía satisfecha en el homenaje.
c. Paloma se casó con el redactor de la senadora que sonreía satisfecho en el homenaje.
d. Paloma se casó con el redactor de la senadora que sonreía satisfecha en el homenaje.
24. a. Jorge observó al sastre de la marquesa que lloraba afectado por la pérdida.
b. Jorge observó al sastre de la marquesa que lloraba afectada por la pérdida.
c. Jorge conocía al sastre de la marquesa que lloraba afectado por la pérdida.
d. Jorge conocía al sastre de la marquesa que lloraba afectada por la pérdida.
25. a. Sergio vio a la sirvienta del archiduque que reñía indignado al personal nuevo.
b. Sergio vio a la sirvienta del archiduque que reñía indignada al personal nuevo.
c. Sergio se casó con la sirvienta del archiduque que reñía indignado al personal nuevo.
d. Sergio se casó con la sirvienta del archiduque que reñía indignada al personal nuevo.
26. a. Susana miró al chófer de la duquesa que conversaba contento en el café.
b. Susana miró al chófer de la duquesa que conversaba contenta en el café.
c. Susana trabajó con el chófer de la duquesa que conversaba contento en el café.
d. Susana trabajó con el chófer de la duquesa que conversaba contenta en el café.
27. a. Iván vio a la paciente del podólogo que comía desganado en el restaurante.
b. Iván vio a la paciente del podólogo que comía desganada en el restaurante.
c. Iván colaboró con la paciente del podólogo que comía desganado en el restaurante.
d. Iván colaboró con la paciente del podólogo que comía desganada en el restaurante.
28. a. José escuchó al ayudante de la arqueóloga que comunicaba orgulloso el hallazgo realizado.
b. José escuchó al ayudante de la arqueóloga que comunicaba orgullosa el hallazgo realizado.
c. José escribió al ayudante de la arqueóloga que comunicaba orgulloso el hallazgo realizado.
d. José escribió al ayudante de la arqueóloga que comunicaba orgullosa el hallazgo realizado.
29. a. Carlos vio a la abogada del concejal que asistía angustiado al encuentro.
b. Carlos vio a la abogada del concejal que asistía angustiada al encuentro.
c. Carlos conocía a la abogada del concejal que asistía angustiado al encuentro.
d. Carlos conocía a la abogada del concejal que asistía angustiada al encuentro.
30. a. Mireia oyó al entrenador de la tenista que lamentaba decepcionado la derrota.
b. Mireia oyó al entrenador de la tenista que lamentaba decepcionada la derrota.
c. Mireia trabajó con el entrenador de la tenista que lamentaba decepcionado la derrota.
d. Mireia trabajó con el entrenador de la tenista que lamentaba decepcionada la derrota.
31. a. Silvia escuchó a la psicóloga del actor que hablaba apasionado de su trabajo.
b. Silvia escuchó a la psicóloga del actor que hablaba apasionada de su trabajo.
c. Silvia escribió a la psicóloga del actor que hablaba apasionado de su trabajo.
d. Silvia escribió a la psicóloga del actor que hablaba apasionada de su trabajo.
32. a. Antonio miró al manager de la pianista que reía dichoso en la fiesta.
b. Antonio miró al manager de la pianista que reía dichosa en la fiesta.
c. Antonio conocía al manager de la pianista que reía dichoso en la fiesta.
d. Antonio conocía al manager de la pianista que reía dichosa en la fiesta.

Appendix C. Appendix

Extended tables with further information about estimates of the variance and SD of each random effect, number of datapoints for subjects and items, and total number of observations.

Table 8
Summary of LME analyses of log first fixation ($\log(\text{FFD}) \sim \text{Verb} * \text{Attachment} * \text{Item_order} + (1 | \text{Subject}) + (1 | \text{item})$).

Measure and condition	β	SE	t-value	p-value
<i>First fixation duration</i>				
Effect of Verb type	0.043	0.039	1.086	0.277
Effect of Attachment	-0.027	0.039	-0.696	0.486
Effect of Item order	0.0002	0.001	0.224	0.822
Verb type*Attachment	-0.160	0.079	-2.013	0.044*
Verb type*Item order	-0.001	0.002	-0.671	0.502
Attachment*Item order	-0.0008	0.002	-0.395	0.692
Verb type*Attachment*Item order	0.002	0.004	0.571	0.567
Random effects	Variance	SD		
Subject	0.017	0.134		
Item	0.002	0.054		
Residual	0.116	0.341		

N_{subj} = 44.

N_{item} = 32.

Observations = 1210.

* p<0.05 ** p<0.01 *** p<0.001

Table 9
Summary of LME analyses of log gaze duration ($\log(\text{GD}) \sim \text{Verb} * \text{Attachment} * \text{Item_order} + (1 | \text{Subject}) + (1 | \text{item})$).

Measure and condition	β	SE	t-value	p-value
<i>Gaze duration</i>				
Effect of Verb type	-0.058	0.051	-1.138	0.254
Effect of Attachment	-0.044	0.050	-0.870	0.384
Effect of Item order	-0.001	0.001	-1.155	0.247
Verb type*Attachment	0.251	0.102	2.460	0.013*
Verb type*Item order	0.002	0.002	0.943	0.345
Attachment*Item order	-8.514e-05	0.002	-0.031	0.974
Verb type*Attachment*Item order	-0.008	0.005	-1.587	0.112
Random effects	Variance	SD		
Subject	0.034	0.185		
Item	0.030	0.174		
Residual	0.190	0.436		

N_{subj} = 44.

N_{item} = 32.

Observations = 1210.

* p<0.05 ** p<0.01 *** p<0.001.

Table 10
Summary of LME analyses of log Regression Path Duration ($\log(\text{RPD}) \sim \text{Verb} * \text{Attachment} * \text{item_order} + (1 + \text{Verb} | \text{Subject}) + (1 + \text{Verb} | \text{item})$).

Measure and condition	β	SE	t-value	p-value
<i>Regression path duration</i>				
Effect of Verb type	0.183	0.069	2.653	0.007**
Effect of Attachment	-0.082	0.064	-1.281	0.200
Effect of Item order	-0.0007	0.001	-0.405	0.684
Verb type*Attachment	-0.018	0.129	-0.140	0.888
Verb type*Item order	-0.008	0.003	-2.454	0.014*
Attachment*Item order	0.001	0.003	0.407	0.683
Verb type*Attachment*item order	-0.001	0.006	-0.151	0.879
Subject	0.006	0.081		
Item	0.013	0.115		
Residual	0.303	0.551		

N_{subj} = 44.

N_{item} = 32.

Observations = 1210.

* p<0.05 ** p<0.01 *** p<0.001

Table 11
Summary of LME analyses of log total time (log(TOTAL) ~ Verb*Attachment*item_order + (1 + Verb| Subject) + (1 + Verb| item)).

Measure and condition	β	SE	t-value	p-value
<i>Total Time</i>				
Effect of Verb type	-0.059	0.057	-1.031	0.300
Effect of Attachment	0.059	0.057	1.034	0.300
Effect of Item order	-0.008	0.001	-5.426	<0.001***
Verb type*Attachment	0.377	0.115	3.264	0.001**
Verb type*Item order	0.003	0.003	1.001	0.316
Attachment*Item order	-0.001	0.003	-0.567	0.570
Verb type*Attachment*Item order	-0.016	0.006	-2.575	0.010*
Random effects	Variance	SD		
Subject	0.068	0.262		
Item	0.048	0.220		
Residual	0.250	0.500		

N_{subj} = 44.

N_{item} = 32.

Observations = 1231.

* p<0.05 ** p<0.01 *** p<0.001.

References

- Abdelghany, H., & Fodor, J. D. (1999). Low attachment of relative clauses in Arabic. In *Vol. 99. Poster presented at AMLAP (Architectures and Mechanisms of Language Processing)* (pp. 23–25).
- Acuña-Fariña, J. C., Fraga, I., García-Orza, J., & Piñeiro, A. (2009). Animacy in the adjunction of Spanish RCs to complex NPs. *European Journal of Cognitive Psychology*, 21(8), 1137–1165.
- Acuña-Fariña, J. C., Meseguer, E., & Carreiras, M. (2014). Gender and number agreement in comprehension in Spanish. *Lingua*, 143, 108–128.
- Aguilar, M., & Grillo, N. (2016). Testing the effect of Pseudo relatives on relative clause attachment in Spanish. In *Amlap (Architectures and Mechanisms for Language Processing)*. Spain: Bilbao.
- Aguilar, M., & Grillo, N. (2020). *Spanish is not different: On the universality of minimal structure and locality principles* (Manuscript submitted for publication.).
- Alonso-Pascua, B. (2020). New evidence on the pseudorelative-first hypothesis: Spanish attachment preferences revisited. *Topics in Linguistics*, 21(1), 15–44.
- Altmann, G., & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, 30(3), 191–238.
- Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, 59(4), 390–412.
- Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1), 1–48.
- Bates, D., Maechler, M., & Bolker, B. (2015). Walker, s. fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1), 1–48.
- Brito, A. M. B. d. (1995). Sobre algumas construções pseudorelativas em português. *Revista da Faculdade de Letras LINGUAS E LITERATURAS*, 12, 25–54.
- Brysbaert, M., & Mitchell, D. C. (1996). Modifier attachment in sentence parsing: Evidence from Dutch. *The Quarterly Journal of Experimental Psychology Section A*, 49(3), 664–695.
- Burzio, L. (1986). *Italian syntax: A government-binding approach (Vol. 1)*. Springer Science & Business Media.
- Carreiras, M. (1992). Estrategias de análisis sintáctico en el procesamiento de frases: cierre temprano versus cierre tardío. *Cognitiva*, 4(1), 3–27.
- Carreiras, M., Betancort, M., & Meseguer, E. (2001). Relative clause attachment in Spanish: Do readers use different strategies when disambiguating by gender and number. In *In Poster presented at the 14th Annual CUNY Conference on Human Sentence Processing*. Philadelphia, PA: University of Pennsylvania.
- Carreiras, M., & Clifton, C. (1993). Relative clause interpretation preferences in Spanish and English. *Language and Speech*, 36(4), 353–372.
- Carreiras, M., & Clifton, C. (1999). Another word on parsing relative clauses: Eyetracking evidence from Spanish and English. *Memory and Cognition*, 27(5), 826–833.
- Carreiras, M., Salillas, E., & Barber, H. (2004). Event-related potentials elicited during parsing of ambiguous relative clauses in Spanish. *Cognitive Brain Research*, 20(1), 98–105.
- Casalicchio, J. (2013). *Pseudorelative, gerundi e infiniti nelle varietà, romanze: affinità (solo superficiali e corrispondenze strutturali) (PhD dissertation)*. Università degli Studi di Padova.
- Cinque, G. (1992). The pseudo-relative and ACC-ing constructions after verbs of perception. *Working Papers in Linguistics*, 2(1992), 1–31.
- Clifton, C., Jr., Speer, S., & Abney, S. P. (1991). Parsing arguments: Phrase structure and argument structure as determinants of initial parsing decisions. *Journal of Memory and Language*, 30(2), 251–271.
- Crain, S., & Steedman, M. (1985). On not being led up the garden path: The use of context by the psychological parser. In D. Dowty, L. Karttunen, & A. Zwicky (Eds.), *Natural language processing: Psychological, computational, and theoretical perspectives*. Cambridge University Press.
- Cuetos, F., & Mitchell, D. C. (1988). Cross-linguistic differences in parsing: Restrictions on the use of the late closure strategy in Spanish. *Cognition*, 30(1), 73–105.
- Cunnings, I., González Alonso, J., Miller, D., & Rothman, J. (2017). Gender attraction in Spanish comprehension. In *Proceedings of the 30th annual CUNY conference on human sentence comprehension*.
- De Vincenzi, M., & Job, R. (1993). Some observations on the universality of the late-closure strategy. *Journal of Psycholinguistic Research*, 22(2), 189–206.
- De Vincenzi, M., & Job, R. (1995). An investigation of late closure: The role of syntax, thematic structure, and pragmatics in initial interpretation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21(5), 1303.
- Desmet, T., De Baecke, C., Drieghe, D., Brysbaert, M., & Vonk, W. (2006). Relative clause attachment in Dutch: On-line comprehension corresponds to corpus frequencies when lexical variables are taken into account. *Language & Cognitive Processes*, 21(4), 453–485.
- Duchon, A., Perea, M., Sebastián-Gallés, N., Martí, A., & Carreiras, M. (2013). EsPal: One-stop shopping for Spanish word properties. *Behavior Research Methods*, 45(4), 1246–1258.
- Ehrlich, K. F. (1999). Low attachment of relative clauses: New data from Swedish, Norwegian and Romanian. In *Poster presented at the 12th annual CUNY Conference on Human Sentence Processing*, New York, NY (pp. 18–20). March.
- Fedorova, O. V., Yudina, M., & Yanovich, I. S. (2007). Relative clause attachment in Russian: The role of conceptual and grammatical gender. Linguistic investigations into formal description of Slavic languages. *Frankfurt am Main: Peter Lang*, 91–100.
- Fernandes, B. (2012). *Attachment Preferences in Prepositional Infinitive Constructions (unpublished master's thesis)*. Centro de Linguística da Universidade Nova de Lisboa.
- Fernandes, B., Alexiadou, A., Chow, W.-Y., Santi, A., & Grillo, N. (2018). Adaptation to complex cues in sentence comprehension. In *31st CUNY Conference on Human Sentence Processing* (pp. 441–442).
- Fernández, E. M. (2003). *Bilingual sentence processing: Relative clause attachment in English and Spanish (Vol. 29)*. John Benjamins publishing.
- Fernández, E. M. (2017). The prosody produced by Spanish-English bilinguals: A preliminary investigation and implications for sentence processing. *Revista da ABRALIN*, 4(1/2).
- Fodor, J. D. (1998). Learning to parse? *Journal of Psycholinguistic Research*, 27(2), 285–319.
- Fraga, I., García-Orza, J., & Acuña, J. C. (2005). La desambiguación de oraciones de relativo en gallego: Nueva evidencia de adjunción alta en lenguas romances. *Psicológica*, 26(2), 243–260.
- Fraga, I., Piñeiro, A., Acuña-Fariña, J. C., Redondo, J., & García-Orza, J. (2012). Emotional nouns affect attachment decisions in sentence completion tasks. *The Quarterly Journal of Experimental Psychology*, 65(9), 1740–1759.
- Frazier, L. (1978). *On comprehending sentences: Syntactic parsing strategies (unpublished doctoral dissertation)*. University of Connecticut.
- Frazier, L. (1990). Parsing modifiers. Special purpose routines in the human sentence processing mechanism? In D. Balota, & G. F. d'Arcais (Eds.), *Comprehension processes in reading* (pp. 303–330). Hillsdale, N.J.: Lawrence Erlbaum.
- Frazier, L., & Clifton, C. (1996). *Construal*. MIT Press.
- Fromont, L. A., Soto-Faraco, S., & Biau, E. (2017). Searching high and low: Prosodic breaks disambiguate relative clauses. *Frontiers in Psychology*, 8, 96.
- Gibson, E. (1991). *A computational theory of human linguistic processing: Memory limitations and processing breakdown (unpublished doctoral dissertation)*. Carnegie Mellon University.
- Gibson, E., Pearlmutter, N., Canseco-Gonzalez, E., & Hickok, G. (1996). Recency preference in the human sentence processing mechanism. *Cognition*, 59(1), 23–59.
- Gilboy, E., & Sopena, J. (1996). Segmentation effects in the processing of complex NPs with relative clauses. *Language processing in Spanish*, 191–206.
- Gilboy, E., Sopena, J. M., Clifton, C., & Frazier, L. (1995). Argument structure and association preferences in Spanish and English complex NPs. *Cognition*, 54(2), 131–167.
- Graffi, G. (1980). Su alcune costruzioni "pseudorelative". *Rivista di Grammatica Generativa*, vol., 5(1980), 115–139.

- Grillo, N. (2012). Local and universal. In V. Bianchi, & C. Chesi (Eds.), *Enjoy linguistics! Papers offered to Luigi Rizzi on the occasion of his 60th birthday* (pp. 234–245). Siena, Italy: CISCL Press.
- Grillo, N., & Costa, J. (2014). A novel argument for the universality of parsing principles. *Cognition*, 133(1), 156–187.
- Grillo, N., Costa, J., Fernandes, B., & Santi, A. (2015). Highs and lows in English attachment. *Cognition*, 144, 116–122.
- Grillo, N., & Moulton, K. (2016). *Sorting out Pseudo relatives: Clausal determiners and mediated AGREE* (Under revision for Natural Language and Linguistic Theory).
- Grillo, N., & Spathas, G. (2014). *Tense and Aspect modulate RC attachment: Testing the PR hypothesis in Greek*. DGfS 2016–36 Jahrestagung der Deutschen Gesellschaft für Sprachwissenschaft.
- Grillo, N., & Turco, G. (2016). Prosodic disambiguation and attachment height. *Speech Prosody*, 2016, 1176–1180.
- Guasti, M. T. (1988). La pseudorelativa e les phénomènes d'accord. *Rivista di Grammatica Generativa*, vol., 13(1988), 35–57.
- Gutierrez-Ziardegi, E., Carreiras, M., & Laka, I. (2004). Bilingual sentence processing: Relative clause attachment in Basque and Spanish. In *CUNY Conference on Human Sentence Processing*. University of Maryland.
- Haro, J. (2012). Testmaker: Aplicación para crear cuestionarios online Computer software and manual Triangulated Surface Library. <http://jharo.net/dokuwiki/testmaker>.
- Hemforth, B., Fernandez, S., Clifton, C., Frazier, L., Konieczny, L., & Walter, M. (2015). Relative clause attachment in German, English, Spanish and French: Effects of position and length. *Lingua*, 166, 43–64.
- Hemforth, B., Konieczny, L., & Scheepers, C. (1998). Syntactic attachment and anaphor resolution: The two sides of relative clause attachment. In M. W. Crocker, M. Pickering, & C. Clifton (Eds.), *Architectures and Mechanisms for Language Processing* (p. 259–281). Cambridge University Press.
- Hernanz, L. (1988). En torno a la sintaxis y la semántica de los complementos predicativos en español. *Estudi General*, 8, 7–29.
- Konieczny, L., & Hemforth, B. (2000). Modifier attachment in German: Relative clauses and prepositional phrases. In A. Kennedy, R. Radach, D. Heller, & J. Pynte (Eds.), *Reading as a perceptual process* (pp. 517–527). Oxford: North-Holland.
- Liversedge, S. P., Pickering, M. J., Branigan, H. P., & van Gompel, R. P. (1998). Processing arguments and adjuncts in isolation and context: The case of by-phrase ambiguities in passives. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, 24(2), 461.
- Lovric, N. (2004). *Implicit prosody in silent reading: Relative clause attachment in Croatian*. (PhD thesis). City University of New York.
- MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review*, 101(4), 676.
- Maia, M., Fernández, E. M., Costa, A., & Lourenco-Gomes, M. D. C. (2007). Early and late preferences in relative clause attachment in Spanish and Portuguese. *Journal of Portuguese Linguistics*, 5, 203–226.
- Mitchell, D. C., Brysbaert, M., Grondelaers, S., & Swanepoel, P. (2000). Modifier attachment in Dutch: Testing aspects of construal theory. In *Reading as a perceptual process* (p. 493–516). Elsevier.
- Mitchell, D. C., & Cuetos, F. (1991). The origins of parsing strategies. *Current issues in natural language processing*, 1–12.
- Mitchell, D. C., Cuetos, F., & Zagar, D. (1990). Reading in different languages: Is there a universal mechanism for parsing sentences?. In *Comprehension processes in reading* (p. 285–302). Inc: Lawrence Erlbaum Associates.
- Moulton, K., & Grillo, N. (2015). Pseudo relatives: Big but transparent. In T. Bui, & D. Ozyildiz (Eds.), *NELS 45: Proceedings of the forty-fifth annual meeting of the north east linguistic society* (pp. 193–202). MA: MIT Cambridge.
- Papadopoulou, D., & Clahsen, H. (2003). Parsing strategies in L1 and L2 sentence processing: A study of relative clause attachment in Greek. *Studies in Second Language Acquisition*, 25(4), 501–528.
- Pozniak, C., Hemforth, B., Haendler, Y., Santi, A., & Grillo, N. (2019). Seeing events vs. entities: The processing advantage of pseudo relatives over relative clauses. *Journal of Memory and Language*, 107, 128–151.
- Pynte, J., Portes, C., Holcomb, P., & Di Cristo, A. (2003). Relative clause attachment in french: An ERP study. *AMLaP-2003*, 47, 44.
- R Core Team. (2018). *R: A language and environment for statistical computing [Computer software manual]*. Vienna, Austria. Retrieved from <https://www.R-project.org/>.
- Radford, A. (1975). Pseudo-relatives and the unity of subject raising. *Archivum linguisticum*, 6(32–64).
- Rafel, J. (1999). *Complex Small Clauses (unpublished doctoral dissertation)*. Universitat Autònoma de Barcelona.
- Rizzi, L. (1992). Direct perception, government and thematic sharing. *Geneva Generative Papers*, 1, 39–52.
- Rothstein, S. (1983). *Predication (unpublished doctoral dissertation)*. MIT, Cambridge: Doctoral dissertation.
- Schütze, C. T., & Gibson, E. (1999). Argumenthood and English prepositional phrase attachment. *Journal of Memory and Language*, 40(3), 409–431.
- Sekerina, I., & Fedorova, O. (2004). *Questionnaire studies of relative clause attachment ambiguity in russian*. The City University of New York: Unpublished manuscript.
- Sekerina, I., Fernández, E. M., & Petrova, K. A. (2003). Relative clause attachment in Bulgarian. In *The proceedings of the 12th annual workshop on formal approaches to Slavic linguistics. the Ottawa meeting* (pp. 375–394).
- Shen, X. (2006). *Late assignment of syntax theory: Evidence from Chinese and English (PhD dissertation)*. University of Exeter.
- Slioussar, N., & Malko, A. (2016). Gender agreement attraction in Russian: Production and comprehension evidence. *Frontiers in Psychology*, 7, 1651.
- Speer, S. R., & Clifton, C. (1998). Plausibility and argument structure in sentence comprehension. *Memory and Cognition*, 26(5), 965–978.
- Teira, C., & Igoa, J. M. (2007). The prosody-syntax relationship in sentence processing. *Anuario de Psicología/The UB Journal of Psychology*, 38(1), 45–69.
- Tomaz, M., Lourenço Gomes, M., Santi, A., & Grillo, N. (2014). *A concordância de número em construções relativas e pseudorelativas em Português europeu* (In Textos Seleccionados do XXIX Encontro Nacional da Associação Portuguesa de Linguística).