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# On the impact of clause order on pronoun resolution: evidence from Spanish

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**Abstract:** In research on intra-sentential pronominal anaphora resolution in null subject languages, it has been argued that null pronouns tend to be biased towards subject antecedents, whereas overt pronouns tend to prefer object antecedents, as predicted by Carminati’s ‘Position of the Antecedent Hypothesis’. However, these studies have mainly focused on only one of the two possible clause orders (main-subordinate or subordinate-main), which have not been overtly contrasted. This paper investigates the effects of clause order on the interpretation of third-person subject pronouns in globally ambiguous intra-sentential contexts by 49 native speakers of Spanish. The results of an acceptability judgment task explicitly comparing both clause orders indicate that relative clause order is a key factor affecting the interpretation of pronouns: while a preference of overt pronouns for object antecedents holds across clause orders, null pronouns show a bias towards subject antecedents only in subordinate-main sequences. These findings refine the Position of the Antecedent Hypothesis predictions by restricting them to subordinate-main complex sentences.

**Keywords:** anaphora resolution; clause order; interpretive judgments; Spanish; subject pronouns

## 1 Introduction

Speakers employ referring expressions to communicate and create coherent discourses by choosing a specific form from an array of alternatives, a selection that is sensitive to a number of different factors. Its communicative effectiveness

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depends on the simultaneous and efficient coordination of different sources of information such as morphosyntax, discourse-pragmatic information and representation of other people's mental states, among others (Arnold 2010; Hendriks et al. 2014). Findings have shown that speakers, and comprehenders, employ different strategies for linking subject pronouns to antecedents to express topic maintenance and topic change.

Originating from the seminal work of Carminati (2002) for null-subject languages, it has been noticed that third-person null subject pronouns display a tendency to select subject antecedents, whereas overt subject pronouns prefer non-subject antecedents. This pattern is generally shared across different types of linkage between sentences, albeit not in an identical way. In the case of Spanish, a null-subject language, this general pattern has been roughly confirmed in a number of studies addressing the topic. However, mixed outcomes regarding both null and overt pronoun resolution have been found (e.g., Bel and García-Alcaraz 2015; Bel et al. 2016; Chamorro et al. 2016; Contemori and Di Domenico 2021; Filiaci et al. 2014; Jegerski et al. 2011; Keating et al. 2011, 2016; Lozano 2016, 2018).

One of the most commonly scrutinized contexts is that of temporal subordinate sentences. Previous findings have attested dissimilarities in referential subject pronoun resolution depending on the two relative clause orders that such sentences can display, i.e., main-subordinate or subordinate-main (Chamorro 2018 or Filiaci 2010, among others). The results, however, are far from conclusive since there is a lack of research and experimental designs focusing narrowly on the role of clause order for pronoun resolution and explicitly comparing the two contexts.

Integrating many of the previous findings concerning our specific topic, the goal of the current paper is to contrast the role of clause order on the interpretation of third person subject pronouns in Spanish by adult speakers of the Peninsular variety. To do so, we designed a preference test, shaped within a typical acceptability judgment task, in which we manipulate clause order within equivalent temporal sentences and maintain sentence ambiguity by controlling the implicit causality of the first predicate, among other aspects. Completely ambiguous contexts are the best ones, in our opinion, to observe the bare tendencies that subject pronouns inherently have. In this respect, our comparative design and expected results are innovative and might contribute to a better understanding of the broad and multi-faceted phenomenon of subject pronoun resolution.

## 2 Pronominal anaphora resolution in null subject languages

It has been proposed in theories based on discourse and pragmatic approaches that the choice and processing of referring expressions are affected by several cognitive and linguistic features that impact the accessibility or prominence of the potential antecedents (see von Heusinger and Schumacher 2019, for an overview). Traditional approaches have postulated a hierarchy of explicitness (Ariel 1990; Givón 1983; Gundel et al. 1993) according to which reduced referring forms (i.e., pronouns) refer to antecedents that are highly accessible in working memory, while semantically rich expressions (i.e., noun phrases) refer to less accessible antecedents. In pro-drop languages such as Spanish, phonologically null subject pronouns (*pro*) signal more accessible referents than overt subject pronouns (*él/ella*, ‘he/she’). In discourse terms, it can generally be said that null pronouns express topic continuity, while overt pronouns convey a change of topic (see Quesada 2014 for an overview).

To account for the alternation between subject pronouns from a structural and syntactic perspective, Carminati (2002) proposed her influential ‘Position of Antecedent Hypothesis’ (PAH), which predicts a division of labor between null and overt pronouns in intra-sentential contexts in Italian. According to this hypothesis, null pronouns have a strong preference to refer back to antecedents in prominent subject positions whereas overt pronouns show a clear bias for antecedents in less prominent object positions. These preferences clearly arise in globally ambiguous contexts. The examples from Carminati (2002: 220, 222) present a totally ambiguous main-subordinate sequence used in an offline task in (1), and a partially ambiguous subordinate-main sequence used in a self-paced reading task in (2). When ambiguity is at stake, *strictu sensu*, both the null (*pro*) and the overt (*lei*) subject pronouns can co-refer with the two potential antecedents introduced in the preceding clause. However, the results in both clause orders demonstrated complementary PAH biases of null and overt pronouns in that Italian speakers significantly preferred to interpret null pronouns as referring to subject antecedents and overt pronouns to object antecedents, as indicated by the subindex.

- (1) *Marta<sub>i</sub> scriveva frequentement a Piera<sub>j</sub> quando*  
 Marta write.IPFV.3SG frequently to Piera when  
*pro<sub>i</sub>/lei<sub>j</sub> era negli Stati Uniti.*  
*pro/she be.IPFV.3SG in+the United States*  
 ‘Marta wrote frequently to Piera when *pro*/she was in the United States.

- (2) *Dopo che Giovanni<sub>i</sub> ha criticato Franco<sub>j</sub>*  
 after that Giovanni have.AUX.3SG criticize.PST.PTCP Franco  
*così ingiustamente, pro<sub>i</sub>/lui<sub>j</sub> gli ha chiesto*  
 so unjustly pro/he CL.DAT.3SG have.AUX.3SG ask.PST.PTC  
*scusa / si è sentito umiliato.*  
 pardon CL.REFL be.AUX.3SG feel.PST.PTCP humiliated  
 ‘After Giovanni criticized Franco so unjustly, *pro*/he apologized/felt humiliated.’

## 2.1 Anaphora resolution in Spanish and the Position of Antecedent Hypothesis

The validity of the PAH in Spanish has been tested by several online and offline studies to further explore the existence of micro-variation among pro-drop languages. Filiaci (2010) and Filiaci et al. (2014) used a self-paced reading task to compare the antecedent preferences of ambiguous pronouns that were semantically disambiguated at the end of the sentence, as in (3) from Filiaci et al. (2014: 27). These studies found that in subordinate-main intra-sentential contexts, as in Italian, Spanish null subject pronouns exhibited a strong and obvious processing bias towards subject antecedents but, different from Italian, Spanish overt pronouns solved their referential dependencies in a more flexible way with either the preceding subject or object antecedent. Similar co-reference patterns were attested in globally ambiguous sentences by Jegerski et al. (2011) through a forced-choice task in main-subordinate clause order, and by Bel and García-Alcaraz (2015, 2018) through an acceptability judgment task in subordinate-main clause order.

- (3) *Después de que Bernardo<sub>i</sub> criticó a*  
 after PREP that Bernardo criticize.PFV.3SG PREP  
*Carlos<sub>j</sub> tan injustamente, pro<sub>i</sub>/él<sub>i</sub>/<sub>j</sub> le pidió*  
 Carlos so unjustly pro/he CL.DAT.3SG ask.PFV.3SG  
*disculpas/ se sintió ofendido.*  
 apologies CL.REFL feel.PFV.3SG offended  
 ‘After Bernardo had criticized Carlos so unjustly, *pro*/he apologized to him/felt offended.’

The aforementioned flexible bias of Spanish overt pronouns towards both subject and object antecedents, however, has not been attested in other recent studies. Keating et al. (2016), in a self-paced reading task, found a complementary

distribution of subject pronoun biases in subordinate-main orders in Spanish, in line with the predictions of the PAH: a steady well-attested preference bias of null pronouns towards subject antecedents and a significant preference of overt pronouns towards object antecedents. Similar findings were also attested by studies using offline forced-choice tasks in main-subordinate orders (Bel et al. 2016; Contemori and Di Domenico 2021; de la Fuente 2015; García-Alcaraz 2015), as well as in subordinate-main orders (García-Alcaraz 2015).

In other recent studies, by contrast, both online (self-paced reading and eye-tracking while reading) and offline (acceptability judgment and forced-choice tasks) evidence from main-subordinate globally ambiguous anaphora gives rise to another different picture (Bel and García-Alcaraz 2015, 2018; Chamorro 2018; Chamorro et al. 2016; Filiaci 2010): the consistent bias that null pronouns have in subordinate-main contexts, the opposite clause order, seems to fade, not showing any clear-cut tendency whereas overt pronouns significantly prefer object antecedents. The comparison of this set of findings supports the idea that anaphora resolution may be also sensitive to discourse and coherence properties related to the assembly of information dependent on clause order. As mentioned above, variations in the organization of information affect the prominence, and thus the accessibility, of a potential antecedent.

Maybe one reason for the attested divergences among overt subject pronouns can be attributed to the nature of the experimental items employed: sometimes the PAH was tested in globally ambiguous contexts; sometimes the implicit causality of the first-clause verb was controlled to avoid any semantic biases towards one of the two potential antecedents of the pronoun (Bel et al. 2016; García-Alcaraz 2015). These variations show how sensitive to discourse properties (overt) subject pronouns are and how manipulating some traits that mediate in discourse coherence may well reveal a very broad range of possible interpretations. In any case, leaving reference selection as open and free as possible can result in subtle differences.

To sum up, the results on the validity of the PAH in Spanish are not unanimous and, as will be shown and further developed here, the chronology of the intervening clauses appears to play a relevant role: while some studies have only attested a PAH partial observance with a clear bias of null pronouns towards subject antecedents and a flexible indeterminate behavior of overt pronouns (Jegerski et al. (2011), Keating et al. (2011), for main-subordinate clause order; Bel and García-Alcaraz (2015, 2018), Filiaci (2010), Filiaci et al. (2014), for subordinate-main clause order), other studies have claimed that the PAH's predictions completely hold for Spanish in globally ambiguous anaphora, both in main-subordinate (Bel et al. 2016; Contemori and Di Domenico 2021; de la Fuente 2015; García-Alcaraz 2015) and subordinate-main contexts

(García-Alcaraz 2015; Keating et al. 2016). Finally, some recent studies have found no bias of null pronouns in main-subordinate anaphora resolution (Bel and García-Alcaraz, 2015, 2018; Chamorro 2018; Chamorro et al. 2016; Filiaci 2010). Even though Carminati (2002) suggested that the PAH mainly affects subordinate-main sequences, not many studies have examined these contexts. In addition, only a few research papers have explored both clause orders in subordinate contexts all together and within the same individuals. In order to achieve a more precise picture of pronominal resolution, it is necessary to undertake a comprehensive exploration of both orders and explicitly compare main-subordinate versus subordinate-main contexts. The next section reviews to what extent modifications in clause order affect coherence organization in discourse, particularly those discourses containing pronominal anaphora.

## 2.2 The role of clause order in the PAH compliance

Beyond the grammatical function of the referents, the process of establishing co-reference is also influenced by the plausibility of the semantic and pragmatic context, discourse status, the linkage between clauses and coherence relations. In addition, non-linguistic processing constraints impact the choice and interpretation of referential forms (e.g., Arnold 2010). The feature that has received the most attention is the implicit causality of verbs, which crucially affects referential biases (Caramazza et al. 1977; Koornneef and Van Berkum 2006; Long and De Ley 2000). Also, following the line of reasoning of Arnold (2010), relational links (i.e., coherence) between clauses can trigger or suppress pronoun interpretation preferences (Kehler and Rohde 2019; Kehler et al. 2008). In a lower layer, clause ordering within sentences also intervenes in the establishment of coherent relations and, as such, it can modulate pronominal interpretation. As the seminal work from Carminati (2002) has already shown, different coherent links at the intra-sentential level – for instance, she compared temporal and conditional complex sentences – may result in differences in accessibility for overt or null subject pronouns to refer back to antecedents as a consequence of different syntactic configurations. However, the phenomenon of how relative clause order impacts our understanding of subject pronoun resolution has received very little attention or has not been overtly and experimentally compared in previous studies (Romano 2019).

Carminati (2002) tested the PAH in complex sentences displaying mostly subordinate-main clause order and attested a clear division of labor between null and overt pronouns. Although she did not contrast both reverse orders, she also tested main-subordinate sequences and argued that stronger pronoun biases are

found within the subordinate-main order. According to her account, based on Bever and Townsend (1979) and Garnham et al. (1998), information of the initial clause in which the antecedents are introduced is more accessible if this initial clause is a subordinate clause. In this case, the structural and surface representation of the initial subordinate clause has to be kept in short-term memory until the processing of the upcoming main clause, given that the information contained in the subordinate clause needs to be related to the subsequent main clause to be interpreted. On the other hand, if the main clause appears in the initial position, it can be interpreted independently from the potential following clauses so that it is likely that short-term memory is freed up before a potential incoming subordinate clause is processed. Thus, material in the first clause seems to be more available at the working memory in subordinate-main sequences than in the opposite clause order.

Additional evidence comes from Rummer et al.'s (2003) study, who attested faster reading times for subordinate-main causal sentences compared to main-subordinate sentences. These authors used a clause-by-clause self-paced reading task in which participants had to read two-clause sequences displaying different syntactic structures (coordinated, main-subordinate and subordinate-main) and recall them orally. Comparing the two subordinate sequences, no differences were attested regarding recall performance, but when the first clause anticipated the subordinate structure (i.e., in subordinate-main), a reading time advantage was observed. After these findings, they claim that if a main clause is presented first, it is stored separately in memory, whereas if the subordinate clause precedes the main clause, the two clauses are represented as a chunk.

Carminati further hypothesized that adverbial temporal sentences in the main-subordinate order may be attached to the VP so that the object antecedent and the subject pronoun occur within the same domain. Main-subordinate contexts would thus favor the retrieving of the object, which may weaken the typical subject bias that emerges in subordinate-main contexts for null pronouns, while the bias of overt pronouns would remain unaffected. Therefore, according to Carminati (2002), a stronger subject preference for null pronouns within the subordinate-main order is expected.

Only two studies have contrasted main-subordinate versus subordinate-main orders. Filiaci (2010), using a self-paced reading design with semantically disambiguated anaphora, revealed a clear bias in linking null pronouns to prominent subject antecedents in subordinate-main order, weakened in main-subordinate order, but a flexible behavior in linking overt pronouns to subject and object antecedents in both clause orders. In line with Filiaci's online findings, Bel and García-Alcaraz (2015, 2018) found that the predictions of the PAH emerge in Spanish chiefly in subordinate-main contexts in an offline

acceptability judgment task. Their results show that null pronouns significantly refer back to antecedents in subject position, but overt pronouns reach only a non-significant tendency towards object antecedents, thus showing a flexible pattern of antecedent assignment in Spanish. In main-subordinate contexts, on the other hand, null pronouns did not show any preference towards subject or object antecedents, while overt pronouns did show a significant bias towards object antecedents. Thus, these studies did not find a bias of null pronouns, as expected by the PAH, with main-subordinate sentences, showing a weakening of the null-subject bias.

However, using a different offline task (forced choice), García-Alcaraz (2015) attested a complementary distribution of referential preferences of null and overt pronouns in Spanish consistent with the PAH predictions in both clause orders. This finding introduces an interesting observation with regard to what extent the nature of the task can introduce variation in the results making clause-order effects change or, even, disappear. Although the scheme conceptualization of the sentence stimuli (i.e., globally ambiguous resolution sentences with non-biased verbs regarding implicit causality) was the same in both offline experiments (an acceptability judgment task in Bel and García-Alcaraz (2015), and a forced-choice task in García-Alcaraz (2015)), it seems that when comprehenders are forced to choose an antecedent for a (null or overt) pronoun, they are not able to modulate their selection and offer fine distinctions introduced by changes in clause chronology.

Recently, Chamorro (2018) has also centered the attention on clause order as one of the key factors affecting pronominal resolution in order to explain the lack of bias of null pronouns in her results for main-subordinate contexts. She resorted to an offline three-alternative multiple-choice task (allowing dual or even triple responses) with globally ambiguous sentences, but only intuitively ‘semantically neutral’ verbs were selected. Importantly, the sentence stimuli only included main-subordinate temporal anaphora so that clause-order contrast could only be built on an inferential basis and against previous data reported in the literature. The author attributed the divergences between main-subordinate sentences in her results and subordinate-main sequences previously studied in the literature Filiaci (2010), and Filiaci et al. (2014) mainly to clause-order effects and not to the different design used (online vs. offline), albeit the author does mention this aspect. In fact, offline results in Chamorro (2018) replicate the findings in Chamorro et al. (2016), in which an online eye-tracking-while-reading task was used, and the findings referring to main-subordinate order in Filiaci (2010) through self-paced reading. Beyond the significance of the intrinsic findings, the lack of direct comparison is the main limitation of Chamorro’s study.



To summarize, on the one hand, only two studies have overtly contrasted both clause orders, and their findings are not conclusive, with some results showing a modulating effect of clause order and others revealing no clear impact. In addition, studies focusing specifically on the role of clause order do not actually compare both clause orders; they do so only tangentially, and, consequently, within-subjects comparisons cannot be determined. On the other hand, the online-offline distinction is not the dimension where the results diverged in prior work on the topic; rather, they diverged in the more or less open character of the task. Thus, allowing for a range of possible responses, as happens in acceptability judgment tasks, could be a good strategy in order to observe nuances such as those derived from clause order in intra-sentential anaphora resolution. Further research is therefore needed, especially regarding semantically ambiguous contexts in which resolution preferences can freely arise. In fact, the presence of disambiguating information may well be necessary in some online experiments in order to coerce one interpretation over the other persuading participants to solve non-predictable readings to obtain expected processing penalties; however, in offline tasks, solving subject pronouns in permanently ambiguous sentences may make it possible for the comprehenders to ponder all the possible interpretations and to freely resolve the pronouns because there is no disambiguating information that might force them to a given reading.

Ultimately, anaphora resolution is a non-categorical phenomenon and it is very sensitive to different aspects and nuances that arise in the surrounding changing discourse environment. Therefore, it is necessary to explore how relative clause order, which changes and promotes units of information differently in the linear discourse, influences pronominal interpretation. For these reasons, the present study focuses on the role of relative clause order and fills a gap that allows checking whether clause order modulates and shapes the interpretation of null and overt subject pronoun resolution within the confines of intra-sentential anaphora.

### 2.3 Research questions and predictions

Going beyond previous research, the current study aims to find out whether the predictions of the Position of the Antecedent Hypothesis (PAH; Carminati 2002) hold for intra-sentential pronominal anaphora interpretation in Peninsular Spanish in both main-subordinate and subordinate-main clause orders. More specifically, we want to address the following research questions:

- 1) Is the PAH applicable to the grammar of backward intra-sentential subject pronoun resolution in Spanish?

- 2) Are Spanish speakers sensitive to relative clause order as a factor that modulates the interpretation of null and overt pronominal subjects?
- 3) Does clause order affect null subject pronouns and overt subject pronouns differently?

We made two major predictions. The first prediction was that our results will support the PAH effectiveness in Spanish since it derives from the interpretive patterns found in previous offline research on intra-sentential subject anaphora resolution. However, based on Filiaci (2010) and Bel and García-Alcaraz (2015, 2018), we expect pronoun biases to be stronger in the subordinate-main clause order. Following Garnham et al. (1998) and Carminati (2002)'s hypothesis, we speculate that the signal that another clause will follow when the subordinate clause appears first, will keep both subject and object antecedents equally active in short-term memory when the subject pronoun of the subsequent main clause is encountered. This context is therefore expected to give rise to clearer PAH-like interpretations of null and overt pronouns, relying mainly on syntactic cues (i.e., the grammatical function of the antecedent). In main-subordinate clause order, the information in the main clause may not be as activated, favoring the accessibility of the object antecedent. Secondly, we expected differences between the co-reference patterns of null and overt pronouns with null subject pronouns being more sensitive to order alterations between clauses. This prediction follows from existing evidence from intra-sentential backward subject pronoun resolution that signaled the weakening of the null-subject bias; in contrast we did not expect to find a comparable effect of clause order differences in overt pronouns. If main-subordinate sequences favor the retrieval of object antecedents, the predicted object-bias of overt pronouns may be preserved or even reinforced, but null pronouns are hypothesized to be more sensitive to the changes derived from clause-order manipulation.

## 3 Methods

### 3.1 Participants

49 monolingually raised Spanish speakers voluntarily participated in this study. In addition to the experimental task, they completed a language background questionnaire to assess linguistic and sociolinguistic information. All the participants were university students born and raised in a central monolingual region of Spain (age range: 18–32; mean age = 22.16; SD = 2.49). They also came from monolingual families and none of them reported having acquired any other languages from birth.

### 3.2 Materials and procedure

An offline and untimed acceptability judgment task (AJT) with totally ambiguous intra-sentential contexts was designed. Three variables were manipulated: clause order (main-subordinate or subordinate-main), type of pronoun (null or overt) and syntactic position of the antecedent (subject or object). The task included a total of 64 experimental items (8 per condition level) and 80 fillers, which were counter-balanced and randomized across two versions; half of the participants completed the version with potential subject antecedents and the other half, the version with object antecedents.<sup>1</sup>

The experimental sentences were similar to those used in Bel and García-Alcaraz (2015) and consisted of two clauses: in the first clause two characters of the same gender were introduced as potential antecedents in subject and object position, and in the second clause either a null or an overt ambiguous pronoun appeared in subject position. Each sentence was followed by a continuation sentence providing an interpretation for the ambiguous pronoun (i.e., referring to the subject or the object antecedent in the first clause). In the task, participants had to read the sentences and judge the acceptability of the pronoun's interpretation in the continuation sentence using a four-value Likert scale (1 = totally unacceptable, 4 = perfectly acceptable). Two examples of experimental items, one for main-subordinate clause order and one for subordinate-main clause order, respectively, are shown in (4) and (5) below, together with the continuation sentences participants had to assess:

- (4) *Ana esperó a Olga cuando pro/ella llegó de viaje.*  
 Ana wait.PFV.3SG PREP Olga when pro/she arrive.PFV.3SG from trip  
 'Ana waited for Olga when pro/she came back from a trip.'
- a. *Ana llegó de viaje.* (Subject interpretation)  
 Ana arrive.PFV.3SG from trip  
 'Ana came back from a trip.'
- b. *Olga llegó de viaje.* (Object interpretation)  
 Olga arrive.PFV.3SG from trip  
 'Olga came back from a trip.'

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<sup>1</sup> As an anonymous reviewer suggested, it is worth acknowledging that presenting participants only with potential subject or potential object interpretations of the pronouns could change their interpretive preferences based on the input provided in the task, determining adaptation (Contemori 2019; Fernandes et al. 2018). However, if adaptation occurs, it should be evened out across the two sub-groups of participants.

- (5) *Cuando Tomás vio a Alberto, pro/él estaba nervioso.*  
 when Tomás see. PFV.3SG PREP Alberto pro/he be.IPFV.3SG nervous  
 ‘When Tomás saw Alberto, *pro*/he was nervous.’
- a. *Tomás estaba nervioso.* (Subject interpretation)  
 Tomás be.IPFV.3SG nervous  
 ‘Tomás was nervous.’
- b. *Alberto estaba nervioso.* (Object interpretation)  
 Alberto be.IPFV.3SG nervous  
 ‘Alberto was nervous.’

In order to ensure that the sentences were totally ambiguous, the implicit causality of the verbs in the first clause was as neutral as possible (based on Goikoetxea et al. 2008) so that there were no semantic cues that guided the interpretation of the pronoun in the second clause. Subordinate clauses were temporal adjunct clauses introduced by *cuando* (‘when’) or *mientras* (‘while’) and the biological gender of the characters was controlled across conditions. Recent work has attested differences in the interpretation of null pronouns in Spanish depending on the temporal subordinating conjunction, *mientras* favoring subject interpretations for null pronouns compared to sentences with *cuando* (Martín-Villena et al. (2021), in a picture verification task). As will be reported in the results section, however, when pronominal resolution preferences in sentences with *cuando* and *mientras* were compared in our data, no differences emerged.

### 3.3 Data analyses

The ratings of the sentences were analyzed in a cumulative link mixed-effects model in R (v. 4.1.0; R Core Team 2021) using the ‘clmm’ function of the ‘ordinal’ package (Christensen 2019). Cumulative link models allow for the analyses of ordinal data as categorical data but take into account its ordered nature (Christensen 2018). As fixed effects, the model included Clause order (main-subordinate, subordinate-main), Pronoun (null, overt) and Antecedent (subject, object), and the interactions between these factors. The random effects included varying intercepts for participants and items, with by-participant varying slopes for Pronoun and Clause order. More complex random effects structures led to estimation problems within the models. The summary of the full model is reported in Appendix. The categorical effects were dummy coded, with main-subordinate clause order, null pronoun and object antecedent being modeled with the intercept. Likelihood ratio tests were also used to obtain p-values by comparing the full model against reduced models without the factor or the interaction we were

interested in Winter (2019). Differences between conditions of experimental manipulations in the presence of interactions were computed using the ‘emmeans’ package (Lenth 2021).

## 4 Results

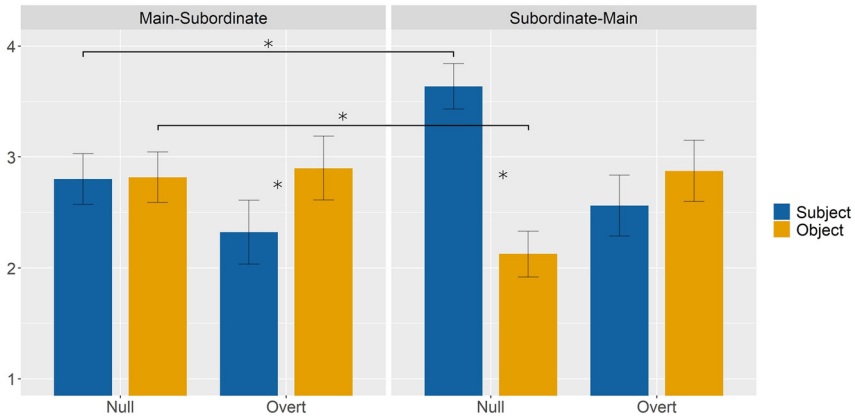
In the offline acceptability judgment task, the participants rated each anaphoric two-clause sentence on a four-point scale depending on their perceived naturalness of interpretation. Table 1 shows participants’ score means and standard deviation for each condition; results are displayed respectively for each clause-order sentence sequence.

The results revealed a significant three-way interaction Clause order  $\times$  Pronoun  $\times$  Antecedent ( $\chi^2(1) = 13.508, p < .001$ ), showing a strong effect of clause order with more PAH-like behaviors in subordinate-main order. Figure 1 visually displays different configuration patterns revealed by this interaction for null and overt pronouns, which will be detailed in the following paragraphs. Clause order is found to affect mainly null pronouns, displaying a subject bias only in subordinate-main contexts, given that object antecedents co-referring to null pronouns become more accepted in main-subordinate contexts compared to the opposite order. By contrast, overt pronouns exhibit a steadier pattern across clause orders.

Pairwise contrasts for the three-way interaction from the perspective of Clause order revealed the interpretation of null pronouns to be modulated by sentence relation: co-reference with subject antecedents was rated significantly higher in subordinate-main than in main-subordinate contexts ( $\beta = -2.463, SE = 0.489, z = -5.040, p < .001$ ) and, conversely, co-reference with object antecedents was rated higher in main-subordinate than in subordinate-main contexts ( $\beta = 1.482, SE = 0.453, z = 3.273, p = .001$ ). Object antecedents seem thus to be more accessible to null pronouns in main-subordinate clause order. On the other hand, overt pronouns’ higher preference for object antecedents and lower preference for

**Table 1:** Descriptive results for the offline acceptability judgment task.

Clause order	Main-subordinate				Subordinate-main			
	Null		Overt		Null		Overt	
Pronoun								
Antecedent	Subject	Object	Subject	Object	Subject	Object	Subject	Object
Mean	2.80	2.80	2.32	2.96	3.64	2.18	2.56	2.91
SD	1.08	1.05	1.08	1.06	0.69	0.95	1.06	1.09



**Figure 1:** Mean preferences of null and overt pronouns towards subject and object antecedents in main-subordinate and subordinate-main contexts.

subject antecedents remained stable across clause orders since no significant differences emerged when comparing the two intra-sentential contexts (for subject interpretations:  $\beta = -0.611$ ,  $SE = 0.446$ ,  $z = -1.369$ ,  $p = .171$ ; for object interpretations:  $\beta = 0.046$ ,  $SE = 0.447$ ,  $z = 0.103$ ,  $p = .918$ ). Thus, clause-order effects seem to be form-specific and to have a stronger impact on null pronouns, which showed more free interpretations in main-subordinate contexts.

Concerning contrasts from the perspective of the Antecedent, focusing first on main-subordinate sequences, null pronouns displayed no biases ( $\beta = 0.061$ ,  $SE = 0.489$ ,  $z = 0.124$ ,  $p = .901$ ) whereas overt pronouns exhibited a significant difference in antecedent choice, preferring object antecedents ( $\beta = 1.343$ ,  $SE = 0.570$ ,  $z = 2.357$ ,  $p = .018$ ). In spite of the significant three-way interaction, the PAH strategy hardly emerged in main-subordinate clause order, as suggested in previous research (e.g., Chamorro 2018). With reference to subordinate-main sequences, a significant preference of null pronouns towards antecedents in subject position was attested ( $\beta = -3.844$ ,  $SE = 0.557$ ,  $z = -6.976$ ,  $p < .001$ ); however, overt pronouns exhibited no bias but only a non-significant tendency ( $\beta = 0.686$ ,  $SE = 0.584$ ,  $z = 1.175$ ,  $p = .240$ ). Hence in this order, different from what is observed in the main-subordinate order, the tendency of overt pronouns to co-refer with objects appears rather attenuated in the subordinate-main analysis. Previous findings also report this flexibility shown by overt pronouns in Spanish (e.g., Bel and García Alcaraz 2018; Filiaci et al. 2014).

Finally, comparisons from the perspective of the Pronoun corroborate that null and overt pronouns in Spanish display complementary biases in subordinate-main

contexts: whereas subject antecedents are preferentially picked up by null pronouns ( $\beta = 2.934$ ,  $SE = 0.555$ ,  $z = 5.286$ ,  $p < .001$ ), the interpretation of object antecedents tends to show higher acceptance rates when they are picked up by overt pronouns ( $\beta = -1.636$ ,  $SE = 0.522$ ,  $z = -3.135$ ,  $p = .002$ ). In main-subordinate contexts, however, as expected after reporting the previous contrasts, subject interpretations are also preferred for null pronouns over overt pronouns ( $\beta = 1.082$ ,  $SE = 0.489$ ,  $z = 2.212$ ,  $p = .027$ ), but no differences were attested for object interpretations regarding the behavior of null and overt subject pronouns ( $\beta = -0.200$ ,  $SE = 0.487$ ,  $z = -0.411$ ,  $p = .681$ ). In this way, object antecedents in main-subordinate clause order seem to be more prominent for both (null and overt) subject pronouns.

To discard the possibility that having two different connectors introducing the subordinate clauses in the experimental sentences influenced our results, the same model adding Connector (*cuando*, *mientras*) as a fixed factor was also computed. The four-way interaction Connector  $\times$  Clause order  $\times$  Pronoun  $\times$  Antecedent was not significant ( $\chi^2(13) = 10.076$ ,  $p = .688$ ). Moreover, looking at pair-wise contrasts derived from the four-way interaction we did not find any qualitative differences. In sum, including Connector in the analyses did not improve the model or change the interpretation of the answers to our research questions.

## 5 Discussion and conclusion

Starting with our first research question, i.e., the applicability of the PAH to subject pronoun resolution in permanent ambiguous intra-sentential contexts, the predictions of Carminati's (2002) PAH are not completely borne out at the interpretive preference level in Spanish. Null subject pronouns do not always resolve anaphoric dependencies with antecedents in the previous subject clause position, given the modulating effect relative clause order has, while overt subject pronouns tend to be object-biased across clause orders. These findings are consistent with previous results in Peninsular Spanish. In main-subordinate anaphora, null pronouns show no preference of subject over object antecedents, whereas overt pronouns display a robust bias towards object antecedents (Bel and García-Alcaraz 2015, 2018; Chamorro 2018; Chamorro et al. 2016). In subordinate-main anaphora, null pronouns show a clear-cut bias towards subject antecedents whereas overt pronouns show a non-statistically significant tendency to co-refer to object antecedents (Bel and García-Alcaraz 2015, 2018; Filiaci 2010; Filiaci et al. 2014). Similar findings to those of main-subordinate contexts have been attested in extensive texts collected with corpus non-experimental data, where null pronouns

have been found to be used to convey topic shift as well as topic maintenance, even at the inter-sentential level (García-Alcaraz and Bel 2019; Lozano 2016; Martín-Villena and Lozano 2020).

With regard to our second research question, we also set out to investigate whether relative clause order is a key factor affecting pronoun resolution when interpreting indistinct and competing antecedents. Indeed, our results showed effects of clause order on the referential choices of pronominal anaphora confirming our expectations: main-subordinate clause order is less PAH-constrained, particularly where null pronouns are concerned, than subordinate-main clause order, where (null and overt) subject pronouns follow a PAH-sanctioned route. The different effects of clause order on pronoun resolution patterns can be explained by taking into account how the different flux of information that the two opposite strings convey, is processed, as stated earlier in Section 2.2. On the one hand, in the subordinate-first clause option, more memory resources are consumed waiting for a second clause whose existence is revealed by the (temporal) conjunction that initiates the preceding subordinate clause and that acts as a cue for the syntactic parser (Garnham et al. 1998; see also Townsend and Bever 1978). As a result, both potential antecedents are uniformly (in)active and accessible in memory, and when the subject pronoun is encountered in the following matrix clause, its reference is recovered resorting to the strategy put forth by the PAH. In other words, subordinate-main clause order is the perfect scenario for the PAH to apply since it makes subject antecedents more accessible (Carminati 2002). This scenario is even more definitive in our sentence stimuli, given our effort to hold all informative elements as ambiguous as possible. This effect was also observed in previous studies (Carminati (2002) for Italian; Bel and García-Alcaraz (2015, 2018) for Spanish). On the other hand, in the main-first clause alternative, the lack of a cue signaling that a second clause will follow opens up a free interpretation for the subsequent subject pronoun, and the effects of the PAH disappear giving rise to other strategies. These ideas will be further developed in the next paragraphs.

It is important to underline that similar effects in main-subordinate clause order in Spanish were attested in Filiaci (2010), Filiaci et al. (2014) and Chamorro et al. (2016): in both online and offline comprehension data, the antecedent preferences of null pronouns disappeared; however, their experimental sentences were not completely ambiguous. In the former case, the second clause semantically disambiguated the interpretation, whereas in the latter, the disambiguation relied on number cues. In contrast, in the current research, our sentence stimuli were carefully controlled for ambiguity at all levels (including



the implicit causality of the first verb) to ensure that the subject pronoun's interpretation was ranked in a completely ambiguous environment. Under these circumstances, subject pronouns' interpretation relies only on the intrinsic interpretative properties that such pronouns may have.

Chamorro's (2018) study aims focused on the role of clause order in anaphora resolution in Spanish. However, as has been described in the introduction, her design did not contain stimuli in both clause orders. She compared her results with main-subordinate sentences to those from the literature with subordinate-main sequences (Filiaci 2010; Filiaci et al. 2014) and she attributed the alleged divergences between the two tested contexts to clause-order effects. Although her findings regarding main-subordinate clause order are in harmony with ours, the lack of contrast between clause orders is a limitation of Chamorro's study that our research overcomes.

Our third research question is closely linked to the previous one. Indeed, different clause orders impact to a different extent the two types of subject pronouns scrutinized, and dissociation between the preferred associations of null and overt pronouns in the two sentential sequences in contrast emerges: whereas overt pronouns appear rather stable across clause orders (though the preference seems to be stronger in main-subordinate order), null pronouns are susceptible to clausal ordering. Immediately, a question arises: why are null pronouns more affected than overt pronouns in main-subordinate temporal contexts, losing their prototypical preference for subject over object antecedents and showing interpretive optionality? The answer could be explained from two complementary angles. First, syntactically, the attested free behavior of the null pronoun is consistent with Carminati's (2002) proposal that temporal subordinate clauses are attached to the VP (and, different from conditional clauses, not attached to the IP) so that the object of the matrix clause is more accessible and more easily recovered as an antecedent for the subsequent null subject pronoun. This advantage for object antecedents may also play a part in reinforcing the interpretive biases of overt pronouns. Even if no differences were attested between clause orders regarding overt pronouns, which makes their biases more consistent across intra-sentential contexts than those of null pronouns, the preference to co-refer to object antecedents was only significant when the main clause preceded the subordinate clause. Secondly, it can also be related to differing discourse expectations regarding topic continuity and topic change entailed by null and overt pronouns, on the one hand, and main-subordinate relative clause order, on the other. Unlike the subordinate-main order, the main-first clause context does not indicate that more discourse text is coming, and thus, without

any clue, the interpretation of the pronoun is more likely due to chance, given that neither the preceding subject nor the object is more accessible (i.e., more activated). To put these ideas in other words, the matrix clause is informatively 'flat'; consequently, since there is no discursively prominent argument, there is no room for the PAH to apply. Presumably, in this case, the sentence processor selects a potential antecedent relying sometimes on parsing principles such as recency, and sometimes on the configurational and pragmatic properties that shape the understanding of anaphor resolution (e.g., givenness and accessibility, as in Ariel's (1990) Accessibility Theory). This suggestion aligns with Carminati's proposal in structural terms, which explains that the syntactic configuration of main-subordinate adverbial temporal sentences favors the retrieval of the object as antecedent over the subject, thus weakening the null subject bias, as mentioned in Section 2.1 above, and possibly slightly strengthening the overt subject biases.

The findings regarding main-subordinate clause order are in line with other studies (Kehler et al. 2008), which suggest that pronominal solving preferences may arise as a result of more general discourse-based coherence relations in which other properties related to discourse status of referents are at play. In a review paper, Arnold (2010) mentions coherence features such as givenness (in general, subjects are known information), syntactic and thematic prominence, as well as recency (objects are information more recently mentioned in a clause), in an effort to calculate and model accessibility. Albeit her proposal is made from the production perspective, some of these features might come up in pronominal solving decisions in the context of the type of sentences we are discussing. In addition, recent work on anaphora resolution has shown that it is also sensitive to the influence of connectives in coherence relations (Rohde and Kehler 2014) as well as inter-clausal relations so that the key features that appear to participate in the antecedent accessibility in one clause type might well not apply to another type, as the seminal work from Carminati (2002) regarding conditional clauses already demonstrated. This is a multifaceted complex issue that still remains open for further investigation. Hence, it would be relevant to go beyond temporal sequences addressing the influence of different connectives on pronoun resolution.

The different type of task is an issue that deserves further attention. On the one hand, the results of previous studies are not fully comparable due to the different type of task (offline vs. online); on the other, even within offline tasks, methodological factors might be influencing the results. To give an example, more evidence regarding the role of clause order for Spanish subject pronoun

resolution comes from García-Alcaraz (2015). Using a two-option forced-choice preference task including similar temporal experimental sentences to the current research, it was shown that the order of presentation of clauses did not influence pronominal antecedent choices since both null and overt subject pronouns displayed the same behavior regardless of clause order. Consistent with Carminati's PAH, null pronouns significantly established co-reference with previous subject elements, while overt pronouns did with elements in the preceding object position. The findings are clearly different from the ones obtained here as well as in other studies with regard to main-subordinate sequences.

Given this divergence, a note on the nature of the task should be made. A forced-choice task, which has been used in the majority of offline experiments reported in the literature, offers less detailed answers than an acceptability judgment task, in which judging all options by means of a numerical scale can capture more fine-grained interpretive idiosyncrasies and help uncover subtle distinctions: in an acceptability judgment task the participants can ponder interpretations that are discarded in a forced-choice task. Thus, the interpretive optionality reflected in our null pronoun results in the main-subordinate order may somewhat depend on the task.

Our experimental proposal adds significant value to previous findings in Spanish: in addition to the type of the task, our effort to hold all factors as ambiguous as possible (including, and neutralizing, the implicit causality of the first verb as well as maintaining referents homogeneous for gender) makes the two reverse clausal orders in temporal sentences, which lie at the heart of our interest, overtly comparable. It provides reliable evidence showing that pronominal anaphora resolution cannot be explained solely from the PAH strategy and that it is sensitive to other factors such as the structural organization of linguistic information. The existence of the PAH as a bias that operates depending on clause order should be further explored since it may well apply differently to other subordinate contexts or, even, in inter-sentential short discourses. In addition, our data come from interpretive judgments, and there are reasons to think that comprehension and production are somewhat dissociated with regard to subject pronoun choices.

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# Appendix

Summary of the reported model (main-subordinate clause order, null pronoun and object antecedent were modeled with the intercept):

<b>Cumulative Link Mixed Model fitted with the Laplace approximation</b>									
formula: values ~ clauseorder * pronoun * antecedent + (1   item) + (1 + clauseorder * pronoun   ID)									
data: data									
link	Threshold	nobs	logLik	AIC	niter	max.grad	cond.H		
logit	Flexible	1,565	-1839.61	3,721.22	2,379(13,891)	2.79E-03	8.20E+02		
<b>Random effects:</b>									
Groups	Name	Variance	Std. Dev.	Corr					
item	(Intercept)	0.4442	0.6665						
ID	(Intercept)	1.0871	1.0427						
	clauseorderSubMain	1.3782	1.174	-0.392					
	pronounOvert	2.1163	1.4548	-0.366	0.078				
	clauseorderSubMain:pronounOvert	1.3547	1.1639	0.091	-0.579				
Number of groups: item 64, ID 49									
<b>Coefficients:</b>									
clauseorderSubMain	Estimate	Std. Error	z value	Pr(> z )					
pronounOvert	-1.48196	0.45275	-3.273	0.001063					
antecedentSubject	0.20032	0.48687	0.411	0.680752					
clauseorderSubMain:pronounOvert	-0.06072	0.48892	-0.124	0.901167					
clauseorderSubMain:antecedentSubject	1.43595	0.5985	2.399	0.016429					
pronounOvert:antecedentSubject	3.94467	0.67054	5.883	4.03E-09					
clauseorderSubMain:pronounOvert:antecedentSubject	-1.28259	0.69044	-1.858	0.06322					
Signif. codes: 0 '***' 0.01 '**' 0.05 '*' 0.1 '.' 1	-3.28751	0.86594	-3.796	0.000147					

(continued)

**Threshold coefficients:**

	Estimate	Std. Error	z value
1 2	-2.3327	0.3531	-6.606
2 3	-0.7376	0.3471	-2.125
3 4	0.9151	0.3471	2.636

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