

RESEARCH PAPER

# When Grammar Meets Pragmatics: Subject Preference and Coherence Relations in Brazilian Portuguese Pronoun Interpretation

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Although pronominal reference is a common device in language, there is much debate about how we use contextual and structural cues to process pronouns. The main goal of the present study was to set a completion experiment following Rohde's (2008) work to test how pragmatic and grammatical cues interact during pronoun interpretation. Our motivation was to use Brazilian Portuguese as the target language, as its pronominal system is known to differ from English, which could give rise to cross-linguistic differences in pronoun interpretation. Forty-eight participants wrote continuations for incomplete passages to verify whether verbal aspect, verb semantics and coherence relations elicited the same pattern of pronoun interpretation as reported in Rohde (2008). Overall, our findings support an expectation-driven model, in which pronoun interpretation is the result of both structural and pragmatic cues. We conclude that cross-linguistic differences can be accounted by such model, and that structural cues have a more prominent role in causing these differences, while pragmatic-driven expectations would exert the same influence on pronoun interpretation across languages.

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**Keywords:** Pronoun interpretation; Ambiguous pronouns; Verbal aspect; Brazilian Portuguese; Psycholinguistics

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## 1. Introduction

Anaphoric expressions, such as pronouns, are very common linguistic devices used to connect sentences. These words play an important role in maintaining coherence between utterances and sentences, and yet there is large debate about when and how we use contextual and grammatical cues to interpret pronominal anaphora. Consider, for example, the sentence *John punished Bill*. If this sentence is to be followed by *He was very harsh in his punishment*, one would interpret the pronoun *he* as referring to John. However, if the following sentence is *He was mean and deserved it*, there is no doubt Bill is the subject of the sentence. In both cases, we can only be certain about who is being referred by the pronoun after finishing the sentence, but a topic commonly addressed in psycholinguistics is how listeners and readers interpret this ambiguous pronoun as soon it is encountered. Would our world knowledge lead us to expect that *he* would preferably refer back to Bill, as the following context may probably mention why he was being punished? Or would pronoun interpretation rely mostly on mapping the antecedent's grammatical roles, regardless of event representation? These questions have received much attention from previous studies in online pronoun processing (Stevenson, Crawley & Kleinman 1994;

Gernsbacher & Hargreaves 1988; Arnold 2001); as a consequence, pronoun interpretation models with conflicting premises have been proposed. A representative example of these theoretical differences are Centering Theory and coherence-driven models.

Focusing on information provided by linguistic structure, some instantiations of Centering Theory (Grosz, Joshi & Weinstein 1995) posit that the entities mentioned in the discourse constitute “centers” within a sentence that will guide pronoun interpretation. These centers are ranked considering their topicality, and pronoun comprehension is then characterized by an algorithm that sorts the most highly ranked element. Although Centering considers pronoun interpretation to be influenced by a variety of factors, ranks are commonly defined on the basis of grammatical information. The ordering would be such that subjects would rank over objects, and objects would rank over referents occupying other grammatical positions (Brennan, Friedman & Pollard 1987; Grosz, Joshi & Weinstein 1995). On the other hand, some coherence-driven theories do not consider pronoun interpretation to be an autonomous process mainly driven by grammatical information (Hobbs 1979). In these accounts, pronoun interpretation is the by-product of general inference processes that take place through the establishment of discourse coherence across sentences. As such, pronouns become bound to their referents by a process of sorting out which referent is likely to be mentioned in order to satisfy constraints imposed by coherence relations.

In all aspects, these two views could be regarded as irreconcilable and mutually exclusive, as both models neglect aspects that their competing theory considers to be of most importance. Centering does not take into account world-knowledge and inference, which are central to coherence-driven theories; on the other hand, coherence-driven approaches do not rank linguistic form and structure as some of the cues from which inferences are drawn. Despite these differences, Kehler & Rohde (2013) present results from experimental work on pronoun interpretation that cannot be explained by Centering or coherence-driven accounts alone. To explain these data, the authors propose a reconciliation of both views on pronoun interpretation, and claim that a thorough understanding of the phenomenon should consider the interplay between discourse and linguistic information.

This new reconciliatory account uses Bayes' Rule to explain pronoun interpretation as the result of a set of different biases. One of them would arise from a pronoun production bias highly influenced by grammatical factors. In this sense, pronoun interpretation would take into account how likely it is to produce a pronoun to refer to certain referents. The other bias acts on the probability of re-mentioning a referent in the ensuing context, and it is mainly driven by world-knowledge. In this paper, we test whether these biases can account for pronoun interpretation in Brazilian Portuguese. In doing so, we compare data from Brazilian Portuguese and English to test if the structural and the coherence-driven factors embodied in Kehler and Rohde's approach are equally affected by cross-linguistic differences.

The remaining of this paper is organized as follows. We detail Kehler and Rohde's model and discuss how their approach explain data from a completion task experiment whose results reflect biases associated with the use of pronouns in English. We then follow by presenting details about the use of overt and null pronouns in Brazilian Portuguese, and we predict that experimental data in this language would differ from English due to cross-linguistic differences in the pronominal systems of these two languages. We describe a completion task study in Brazilian Portuguese and follow with a discussion about the main differences in pronoun interpretation between both languages. In our final analyses, we present the case that Kehler and Rohde's model can explain cross-linguistic differences in pronoun interpretation, and we make the claim that these differences are mainly driven by grammatical factors, while the influence of world-knowledge and semantics on pronoun interpretation does not vary considerably across languages.

## 2. A Bayesian theory of pronoun interpretation: Kehler & Rohde (2013) model

Among the discourse processing models that aim at explaining the underlying mechanisms of pronoun interpretation, some have hypothesized that comprehenders create expectations about upcoming information that is likely to be mentioned next (Arnold 2001; Kehler et al. 2008; Rohde 2008). These so-called expectation-driven models fit a broader range of language processing accounts that emphasize the role expectations play in language comprehension. According to these accounts, language processing actively relies on the probabilities of encountering specific input, using this information to ease integration of the expected input or to anticipate its structural and conceptual information (cf. Kuperberg & Jaeger 2015 for a review). Such models have succeeded in explaining phenomena like syntax processing (Fine & Jaeger 2013), speech and word recognition (Astheimer & Sanders 2011; Dikker & Pylkkanen 2013; Salverda, Kleinschmidt & Tanenhaus 2014), and have also contributed to the understanding of discourse comprehension and production (Kehler et al. 2008; Rohde & Horton 2014).

Kehler & Rohde (2013) (henceforth, KR) posit a pronoun interpretation model that fits this broader range of work. Their account is best explained as a Bayesian approach that defines the probability of a pronoun being assigned as co-referent of a specific referent –  $p(\text{referent}|\text{pronoun})^1$  – in terms of the probability of producing a pronoun to refer to a given referent,  $p(\text{pronoun}|\text{referent})$ , and the probability of a referent being mentioned in the upcoming context,  $p(\text{referent})$ . The two terms that capture  $p(\text{referent}|\text{pronoun})$  reflect the two sets of factors that, according to KR, influence pronoun interpretation. On the one hand, there are structural factors constraining the use of certain referential forms (e.g., the use of a pronoun to refer preferably to the subject of a previous sentence); on the other hand, discourse coherence relations would define the probability of mentioning a referent in the ensuing context. To explain their model in detail, let's consider the work of Rohde (2008), which shows both the effects of  $p(\text{referent})$  and  $p(\text{referent}|\text{pronoun})$ .

Rohde (2008) had the explicit goal to test whether event representation, rather than thematic role preferences and syntactic cues, could explain pronoun resolution. The author hypothesized that if event representation was an important factor in resolving an ambiguous pronoun, there would be more goal-biased interpretations for pronouns in transfer-of-possession contexts similar to (1) than in contexts like (2). This would happen because the perfective aspect of the verb introduces a complete event, then focusing on its end-state and, consequently, on the referent occupying the thematic role of goal.

(1) John<sub>source</sub> handed a book to Bob<sub>goal</sub>. He \_\_\_\_\_

(2) John<sub>source</sub> was handing a book to Bob<sub>goal</sub>. He \_\_\_\_\_

In fact, a completion task showed that the interpretation of pronouns in (1) had a 50/50 distribution between source and goal, mirroring the findings of a previous study (Stevenson, Crawley & Kleinman 1994), while there was a clear source bias in contexts like (2). When aspects were compared, there were significantly more source interpretations for imperfective contexts than for perfective sentences. These results show that event representation does play a role in pronoun reference, especially if we consider that the source bias was greater for verbs that evoked an event that does not require the participants to be co-located in the same place (e.g., *to wire money*, *to fax a resume*), and, therefore, places less focus on the referent occupying the thematic role of goal. However, the 50/50

<sup>1</sup> In conditional probability,  $p(A|B)$  stands for the probability of A given B – in this case, the probability of assigning a specific referent given a pronoun.

distribution for perfective sentences also shows that verb aspect may interact with a subject-preference associated with the use of pronominal anaphora in English.

The fact that pronouns tend to refer to the subject of a previous sentence is predicted by models such as Centering Theory (Brennan, Friedman & Pollard 1987) and it has influenced early works on pronoun resolution (Crawley, Stevenson & Kleinman 1990; Frederiksen 1981). More recent studies found that although subject-preference may not be the only factor involved in pronoun interpretation, it still plays an important role during language processing (Järvikivi et al. 2005). Considering there is a cognitive salience associated with first-mentioned referents (Gernsbacher & Hargreaves 1988), a position usually occupied by the syntactic subject of a clause, these findings are in line with corpus-based studies that find less informative referential forms (such as pronouns) to be commonly used to refer to highly accessible referents (Gundel, Hedberg & Zacharski 1993). As for Rohde's results, a possible explanation would be that while perfective aspect would increase the chances of a goal interpretation, the subject preference associated with pronouns would privilege a subject (and hence source) interpretation, and the combination of these antagonistic cues would result in a scenario with no bias for sources or goals. This explanation presupposes that, in the absence of a pronoun-prompt that would trigger a subject preference, a goal bias would emerge. In fact, recent studies have shown that when this sentence completion task follows a full-stop prompt scenario (e.g., *John handed a book to Bob. \_\_\_\_\_*), participants are more likely to mention the goal referent of the previous sentence as the subject of their continuation; moreover, this bias is stronger in perfective contexts (Ferretti et al. 2009; Gruter, Rohde & Schafer 2017).

KR take this difference in production and interpretation as evidence of two different biases guiding pronoun processing. In the full-stop condition, with no pronoun-prompt, continuations are guided by  $p(\text{referent})$ , i.e., the probability of a referent being mentioned next. In transfer-of-possession contexts,  $p(\text{goal})$  is greater than a hypothetical mean of 0.5, especially in perfective contexts. However, when there is a pronoun-prompt like in (1–2),  $p(\text{referent})$  is not the only term defining how the sentence may continue. In this scenario,  $p(\text{referent})$  is considered along with  $p(\text{pronoun}|\text{referent})$ , i.e., the likelihood of using a pronoun to refer to a given referent. As shown in various experimental and corpus-based studies (Brennan, Friedman & Pollard 1987; Gundel, Hedberg & Zacharski 1993; Järvikivi et al. 2005), pronoun use is biased towards the grammatical subject, which would render  $p(\text{pronoun}|\text{goal})$  to be lower than  $p(\text{pronoun}|\text{source})$  for the sentences in Rohde's work. The equation in (3), from KR's work, shows the relationship between pronoun production and interpretation in Bayesian terms:<sup>2</sup>

$$(3) \quad p(\text{referent} | \text{pronoun}) = \frac{p(\text{pronoun}|\text{referent})p(\text{referent})}{p(\text{pronoun})}$$

In sum, even if  $p(\text{goal})$  is above 0.5, signaling a great probability of a goal mention in the ensuing sentence, the final coefficient would be lower, due to its interaction with  $p(\text{goal}|\text{pronoun})$ .

Until now, we have not addressed what defines  $p(\text{referent})$ , i.e., what type of information increases or decreases the probability of mentioning a particular referent. The theoretical approach outlined in KR states that the expectations that influence pronoun resolution are driven by the process of building coherence relations across sentences. According to this coherence-driven model, pronoun resolution is a result of both (i) the probability of occurrence of a specific coherence relation in the ensuing context and (ii) the estimate of

<sup>2</sup> Bayes' Rule is written  $p(A|B) = \frac{p(B|A)p(A)}{p(B)}$ . In (3),  $p(\text{pronoun})$  refers to the probability of using a pronoun, and it plays a role in normalizing the probabilities.

how likely a referent is to be mentioned next (which, in turn, is also conditioned by the predicted coherence relation). In order to explain these claims, let's consider once again Rohde's results.

The 50/50 distribution in goals/sources for perfective sentences and the source bias found in imperfective contexts were explained on the basis of an interaction between event representation constraints and a subject-bias triggered by the use of a pronoun. However, following earlier work on how coherence relations may impact language processing (Hobbs 1979; Kehler 2002), Rohde predicted that pronoun interpretation biases would emerge from the coherence relation established between context sentences and the continuation sentences provided by the participants. According to this hypothesis, coherence relations such as Occasion, which focuses on what happens after the main event (e.g., *Bill gave the book to John. He read it.*), and Result, which focuses on the results or consequences of the main event (e.g., *Bill gave a book to John. He said thanks.*), would lead to more goal-bias interpretations for pronouns due to the fact that these coherence relations focus on the end-state of the previous event. Conversely, Elaboration, which provides information about how the event happened (e.g., *Bill gave a book to John. He handed it very carefully.*), and Explanation, which explains why the event happened (e.g., *Bill gave a book to John. He wanted his friend to read that book.*), would lead to pronouns being preferably associated to the source of the previous sentence, as these coherence relations are more focused on the event itself. When the results from Rohde's experiment were broken down by coherence relations, two interesting patterns emerged.

First, data on pronoun interpretation confirmed Rohde's hypothesis: there was a source bias in pronoun interpretation for sentences that held an explicative or an elaborative relation with the previous context, and a goal bias when these coherence relations focused on the following events or on the main event's consequences. These results remained the same regardless of verbal aspect. Secondly, although there was no effect of aspect on interpretation bias when data were controlled by coherence relations, aspect exerted influence on how likely a particular coherence relation was to be used in that context. Occasion relations were more common following perfective sentences, while imperfective contexts yielded more Elaborations. This shift in coherence relations would explain the results for pronoun interpretation: it is not the case that perfective aspect alone yields more goal-biased continuations compared to imperfective, but perfective contexts give rise to more coherence relations like Occasion, which, in turn, leads to more goal interpretations. In other words, event representation (guided by cues such as verbal aspect) conditions how the discourse is likely to continue, and how the discourse is likely to be continued (in terms of coherence relations) then conditions pronoun interpretation. Thus, in defining the likelihood of mentioning a referent we have both the probability of a particular coherence relation to occur,  $p(\text{CR})$ , and the probability of mentioning the referent given that coherence relation,  $p(\text{referent}|\text{CR})$ .

In sum, KR's model defines the interpretation of pronouns as a probabilistic incremental process that relies on two biases. The first bias is in line with theories like Centering, and predicts a bottom-up process in which information structural or grammatical factors such as subjecthood will condition  $p(\text{pronoun}|\text{referent})$ . On the other hand, pronoun interpretation also takes into account top-down coherence-driven expectations about which referent will be mentioned next, and these expectations condition  $p(\text{referent})$ .

Most of the data that confirm these assumptions come from experiments in English, but recently more evidence from other languages and from L2 processing have also corroborated these claims (Gruter, Rohde & Schafer 2016; Kim, Gruter & Schafer 2013; Mayol 2017; Ueno & Kehler 2016). Kaiser (2013) has stressed the importance of testing KR's predictions in other languages, especially considering cross-linguistic differences on



pronoun distribution and usage that could shift  $p(\text{pronoun}|\text{referent})$ . In fact, for theories of language and/or language processing to make general claims, it is essential to consider typological differences, as they are a productive way to discern language-specific traits from underlying principles that guide comprehension in a more homogeneous way across different languages.

Because the pronominal system in Brazilian Portuguese differs from English as it includes overt and null pronouns, this language is a good candidate to test the effects of coherence relations on pronoun interpretation when the subject preference associated with overt pronouns is altered. Next, we describe the characteristics of Brazilian Portuguese regarding the use of overt and null pronouns and make the case for why this language may show slightly different results in a completion task similar to Rohde's.

### 3. Null and Overt pronouns in Brazilian Portuguese and the subject preference

Different from English, the inventory of referential forms in some Romance languages such as Spanish, Italian and European Portuguese (henceforth, EP) includes both null and overt pronouns, and it has been argued that both forms would have different distributions and uses. Because null pronouns are the least informative expression in these languages, they, rather than overt pronouns, are believed to be used preferably to refer to the most salient entity in discourse (like a syntactic subject), while overt pronouns would be used more often to refer to referents in other syntactic positions (Carminati 2002). However, it is not clear whether the use and interpretation of overt pronouns in Brazilian Portuguese (henceforth, BP) would follow these constraints.

In contrast to other Romance languages such as Spanish, Italian, and EP, Brazilian Portuguese has undergone linguistic changes that have led to an increase in the use of overt pronouns over the last century (Duarte 1993, 1995). One of the causes for this may be the change in referring expressions used as second and third-person pronouns. Historically, *tu* ('you') and *nós* ('we') were used as second-person singular and first-person plural pronouns, respectively. Both forms require the agreeing verb to bear a person-specific morphological inflection (*corre-s* – you run<sub>2nd-singular</sub>; *corre-mos* – we run<sub>1st-plural</sub>), and this leads to higher rates of null pronouns as verbal morphology alone can identify to the verb's syntactic subject.

However, since the beginning of the 20<sup>th</sup> century, there has been a wider acceptance and use of two new second-person singular and first-person plural pronouns: *você* ('you') and *gente* ('we' – literally, 'the people', including the speaker). Both pronouns, widely used in modern BP, require the agreeing verb to be inflected using a third-person morphological marker, thus making it impossible to distinguish second-person singular, third-person singular, and first-person plural by means of verbal inflection alone (*você corre* – 'you run'; *ela/e corre* – 's/he runs'; *a gente corre* – 'we run'). This process of morphological impoverishment may have motivated the increase of overt pronouns and decrease of null pronouns as documented by previous research (Duarte 1995), and this change in distribution may have affected how BP speakers use and interpret overt pronouns.

Mostly because of these changes, several linguists have argued that BP is now so different from other Romance Languages that it cannot be classified as a full Null Subject Language (NS), like Spanish or EP; instead, this language should receive the status of partial Null Subject Language (pNS) (Barbosa 2001; Barbosa, Duarte & Kato 2005). Besides the high rates of overt pronouns, another characteristic of BP that supports this decision is the difference among EP and BP speakers on how they interpret pronouns in sentences (4) and (5).

- (4) Antônio disse que foi ao cinema.  
Antonio said that  $\emptyset$  went<sub>(3rd. singular)</sub> to the movies.
- (5) Antônio disse que ele foi ao cinema.  
Antônio said that he went<sub>(3rd. singular)</sub> to the movies.

Barbosa (2011) argues that in EP, an NS language, sentences with null pronouns like in (4) are mandatory if the embedded sentence takes *Antônio* as the antecedent to its subject. At the same time, *ele* in sentence (5) preferably signals a topic shift, and would be interpreted as referring to a referent other than the main clause subject, *Antônio*. Similar patterns have been documented by corpora and psycholinguistics studies that investigated the interpretation and production of null and overt pronouns in EP. These studies found that overt pronouns are mostly interpreted/used to refer to the object of the previous clause, while null pronouns usually refer to the syntactic subject (Costa, Faria & Matos 1998; Fernandes et al. 2018). Furthermore, while this trend seems more robust in intra-sentential contexts (cf. Morgado 2011), it has also been documented in inter-sentential non-adjacent contexts (Barbosa, Duarte & Kato 2005).

However, BP speakers show a different judgment regarding the interpretation of third-person pronoun *ele* in (5): for them, this pronoun can also refer to someone other than Antônio, but it could also refer to him. This difference between EP and BP has been taken as evidence that BP is better described as a pNS Language (Barbosa 2011), and it signals that the use of an overt pronoun in this language is less influenced by structural constraints than in EP. In fact, this question has been addressed by studies that describe the use/interpretation of third-person singular pronouns in BP and point some similarities and differences between these languages.

Similar to EP, in BP the use of third-person null pronouns signals a co-reference with the syntactic subject of the previous clause. Experimental research has showed that, when a null pronoun is used in BP, it is preferably interpreted as referring to the antecedent in the subject position (Fonseca & Guerreiro 2012; Teixeira, Fonseca & Soares 2014), and that BP speakers rate null pronouns as more acceptable when referring to the subject rather than the object of the previous sentence (Almor et al. 2017). However, as argued by Fernandes et al. (2018), the object-bias instantiated by third-person overt pronouns in BP is not as strong as the subject-bias associated with null pronouns. Fonseca & Guerrero (2012) have reported an object-bias associated to the interpretation of overt pronouns in BP, similar to the one found in EP. However, Barbosa, Duarte & Kato (2005) show that overt pronouns can be used to refer to a syntactic subject in a rate closer to or greater than 50% in some contexts. Similarly, Teixeira, Fonseca & Soares (2014) have reported that overt pronouns in intra-sentential contexts show no object or subject bias, contradicting the division of labor between null and overt pronouns documented in NS languages.

Taken together, the aforementioned studies indicate that using a third-person null pronoun in BP gives the reader/listener a cue about the syntactic category of its antecedent. However, this is not the case for overt pronouns, as there is no clear object or subject bias associated with the use of this referential expression. Using KR's notation, we would say that, in BP,  $p(\text{overt pronoun}|\text{subject})$  and  $p(\text{overt pronoun}|\text{object})$  – the probability of using an overt pronoun given a subject and the probability of using an overt pronoun given an object, respectively – are similar. This is a depart from both EP and English, languages that have clear biases associated with the use of overt pronouns that would respectively predict that  $p(\text{overt pronoun}|\text{subject}) < p(\text{overt pronoun}|\text{object})$  and  $p(\text{overt pronoun}|\text{subject}) > p(\text{overt pronoun}|\text{object})$ .

For pronoun processing models like the one proposed by KR, which predicts that  $p(\text{pronoun}|\text{referent})$  is one of the factors that defines pronoun interpretation, these cross-linguistic differences may give rise to different patterns of pronoun interpretation. It may be the case that the use of an overt pronoun in the BP version of the sentence *John handed a book to Bob. He...* may not increase the probability of a subject reference as strongly as it would in English.<sup>3</sup> This would have a direct impact on pronoun interpretation as a whole, giving rise to more situations in which goal continuations would be preferred, such as coherence relations like Occasion, or even altering biases within coherence relations for transfer-of-possession sentences (e.g., pronoun interpretation under Elaboration relations would still show a source-bias in BP, but this probability would be lower in BP than in English due to a lower  $p(\text{overt pronoun}|\text{subject})$ ). These considerations lead us to question to what extent both biases described by KR –  $p(\text{pronoun}|\text{referent})$  and  $p(\text{referent})$  – would be subjected to cross-linguistic differences.

Until now, we have argued that the probability of using an overt pronoun to refer to the subject of a previous sentence is a factor of great variability across languages due to cross-linguistic differences in pronominal systems. However, pronoun interpretation, according to KR, is also driven by expectations that arise from more general cognitive processes that we believe to be more homogeneous across languages, partly because they are not constrained by grammatical information. These processes concern the building of coherence relations, and depend mainly on event representation. Of course, event representation is built from linguistic cues (e.g., a perfective aspect may reinforce the completeness of an event), but what we mean here is that, although the probability of using an overt pronoun may impact pronoun interpretation in different ways across different languages, the influence of coherence relations will be more homogeneous cross-linguistically, as this process is driven mainly by world knowledge.

In what follows, we describe an exploratory study that aims at testing how the two biases defined by KR –  $p(\text{pronoun}|\text{referent})$  and  $p(\text{referent})$  – differ cross-linguistically, and we do so by predicting that any cross-linguistic difference between English and BP may be explained by differences in  $p(\text{pronoun}|\text{referent})$  alone, while  $p(\text{referent})$  will remain constant in both languages. The two main questions we address are: a) does BP differ from English in relation to how an overt pronoun prompt influences story continuations? and b) is the influence of coherence relations and event representation on pronoun interpretation similar in both languages, despite differences regarding overt pronouns and subject preference? By answering these two questions, we will also assess if the model proposed by KR can be generalized to other languages.

#### 4. Experiment

We ran a story continuation experiment to test if BP speakers would show the same biases as English speakers when interpreting an ambiguous pronoun following a transfer-of-possession (henceforth, TOP) event. Following the same experimental design set in Rohde (2008), we asked participants to write continuations for incomplete passages and we tested whether verbal aspect, sentential semantics and coherence relation elicited in BP the same pattern of pronoun interpretation reported in English.

If, as we have argued,  $p(\text{overt pronoun}|\text{subject})$  is not as strong a bias in BP as it is in English, we believe our data will show a clear goal-bias following perfective sentences, differing from the 50/50 distribution found in English. However, because we believe that

<sup>3</sup> It may be worth noting that this explanation does not imply that overt pronouns in BP do not show a subject preference when compared to other referential expressions such as definite descriptions. It only states that, compared to English, this effect may be weaker.



the effects from event representation will have the same impact in BP, we expect to observe the same biases documented in English for verbal aspect and sentential semantics. Thus, imperfective sentences are expected to show fewer goal continuations when compared to perfective contexts, and more goal continuations are expected following sentences denoting an event in which both participants need to be co-located (*to hand the book, to pass a sandwich*) than following sentences whose event representation does not require the participants to be co-located (e.g., *to wire money, to ship the package*). Most importantly, because verbal aspect influences pronoun interpretation only indirectly by shifting the distribution of coherence relations, we also expect to see a similar effect in BP.

Finally, according to KR's model, any increase in the proportion of goal continuations following perfective sentences may emerge from changes regarding coherence relations. This means that, for KR approach to be correct, any differences observed between perfective and imperfective contexts have to be explained by coherence relations alone, not by verbal aspect.

#### 4.1. Participants

Forty-eight native speakers of BP (29 female, 17 male, 2 other; mean age = 24.06, standard-deviation = 3.66) participated in the experiment voluntarily. All of them had an undergraduate degree or were enrolled in an undergraduate program at the time of their participation. They gave formal consent before taking part in the experiment.

#### 4.2. Materials and procedures

To test our hypothesis, we created experimental stimuli following Rohde's 2 (verbal aspect) × 3 (verb type) design. Verbal aspect was either perfective or imperfective, and there were 3 types of TOP verbs that varied in how much the goal referent would be perceived as salient.

The stimuli presented to the participants consisted of eighteen experimental items and twenty-nine filler passages. Experimental items consisted of a context sentence and a target incomplete sentence. Context sentences depicted a TOP event in which verb aspect (perfective or imperfective) was manipulated. Participants saw either the perfective or the imperfective form of a single sentence. None of the verbs was presented more than once to the same participant. The source and goal referents were both proper names with the same gender, rendering an ambiguous pronoun as the prompt of the following target sentence. Pronoun gender in target sentences was balanced: half of the sentences contained the female pronoun *ela* ('she') and the other half displayed the male pronoun *ele* ('he') as the ambiguous prompt. In order to avoid that ambiguous pronouns could refer to the theme of the previous sentence (*coffee*, in the example below), the inanimate objects chosen for this position had a different grammatical gender from the source/goal referents.

In BP, the indefinite article *um* is homophone and homograph to the numeral one, so we chose to present the theme with definite articles *o/a* ('the') to avoid ambiguous readings.

- (6) a. Juliana<sub>SOURCE</sub> levou o café para Marina<sub>GOAL</sub>. Ela \_\_\_\_\_  
 (Juliana took the coffee to Marina. She \_\_\_\_\_)
- b. Juliana<sub>SOURCE</sub> estava levando o café para Marina<sub>GOAL</sub>. She \_\_\_\_\_  
 (Juliana was taking the coffee to Marina. She \_\_\_\_\_)

Because we wanted to assess how event representation would impact pronoun interpretation, we followed Rohde's verb-type classification. The eighteen experimental stimuli were classified on the basis of the co-location of event participants (co-located or not co-located) and the guarantee of successful transfer (guaranteed transfer and no guaranteed transfer), as presented in **Table 1**.

**Table 1:** Verb classes for experimental stimuli.

<b>Verb Class 1: participants co-located; guaranteed transfer</b> servir ('serve'), trazer ('bring'), levar ('take'), dar ('give'), passar ('pass'), entregar ('hand')
<b>Verb Class 2: participants co-located; no guaranteed transfer</b> jogar ('throw'), arremessar ('throw'), chutar ('kick'), lançar ('toss'), atirar ('throw'), rolar ('roll')
<b>Verb Class 3: participants not co-located; no guaranteed transfer</b> enviar carta ('mail'), encaminhar ('forward'), despachar ('ship'), transferir ('wire'), mandar ('send'), repassar ('forward')

The experimental items were presented along with 29 filler passages. These passages were adapted from the filler sentences used by Rohde. They consisted of context sentences with non-transfer of possession verbs followed by an incomplete target sentence. Context sentences contained intransitive and transitive verbs, and transitives were presented in passive or active voice. Target sentences were prompts just as the ones in experimental stimuli, but for filler items these prompts were adverbs, proper names and unambiguous pronouns.

We created a list with all the fillers, nine experimental items with perfective verbs and nine experimental items with imperfective verbs. This list had three sentences with perfective and three sentences with imperfective verbs for each one of the verb classes presented in **Table 1**. A second list was created rotating verbal aspect in experimental items. The experimental and filler items were pseudorandomized to create four versions of each list.

### 4.3. Task

Participants were instructed to write, for each one of the 48 stimuli, the first continuation that came to their minds avoiding humor. *Googleforms* was used as a platform to present the stimuli. After giving explicit consent and filling out an identification form with their age, location, native language and educational background, participants completed three passages as a training phase to get used to the task. All participants completed the task within less than one hour.

### 4.4. Analyses

Two trained judges analyzed the responses independently and annotated (a) whether the pronoun interpretation referred to the goal or source of the context sentence; (b) the coherence relation established between the context and the target sentence. We used the guidelines provided by Rohde (cf. Rohde 2008: 199) to classify coherence relations in six categories. Four of them, Occasion, Result, Elaboration and Explanation, were described previously in section 3. The other two are Violated-Expectation, which describes an unexpected result of the event described in the first sentence, and Parallel, which posits a similarity between the events described in both sentences. **Table 2** shows examples of this annotation.

For our analysis, we discarded 8.9% of the observations. These included sentences in which both judges considered that the pronoun interpretation was ambiguous (7.6%) or in which both judges did not agree on the pronoun interpretation (0.23%). 0.5% of data was lost because responses were nonsensical or because subjects had not interpreted the preposition *para* as depicting a TOP event.<sup>4</sup> Finally, 2 continuations (0.5%) were discarded because the coherence relation established between sentences was considered ambiguous by at least one of the judges. The remaining dataset (n = 713) was used in the present analyses.

<sup>4</sup> In BP, *para* can convey the meaning of *to* (*Roger sent the package to Samuel*) as well as *for* (*Roger sent the package for Samuel*).

**Table 2:** Example of annotated data.

<b>Translation of experimental sentences [Answers provided by participants]</b>	<b>Coherence relation</b>	<b>Pronoun interpretation</b>
Rodrigo was serving cake to Caio. He [cut a large slice.]	elaboration	goal
Monica was wiring money to Leticia. She [needed to pay her.]	explanation	source
Carol was sending an email to Claudia. She [wound up sending it to Cláudio.]	violated-expectation (v-e)	source
Juliana took the coffee to Marina. She [drank it.]	occasion	goal
Lucia gave a gift to Marcia. She [thanked her.]	result	goal
Rodrigo was serving cake to Caio. He [served one for himself too.]	parallel	source
Rodrigo served a cake to Caio. He [asked for one extra slice.]	ambiguous (occasion or explanation)	goal
Raul was handing a pen to Julio. He [dropped it.]	[not analyzed because of ambiguous pronoun]	ambiguous

## 5. Results

To test for main effects for verb class, verbal aspect, and coherence relations on pronoun interpretation, we used mixed-effects logistic regression models with the lme4 package (Bates et al. 2015) in R (R Development Core Team 2008). These models were used to allow for the inclusion of participant and item variability as random effects within a single model (Baayen, Davidson & Bates 2008). The significance of each term in the models was assessed by comparing nested models, and p-values were adjusted using the False Discovery Rate (Benjamini & Hochberg 1995).

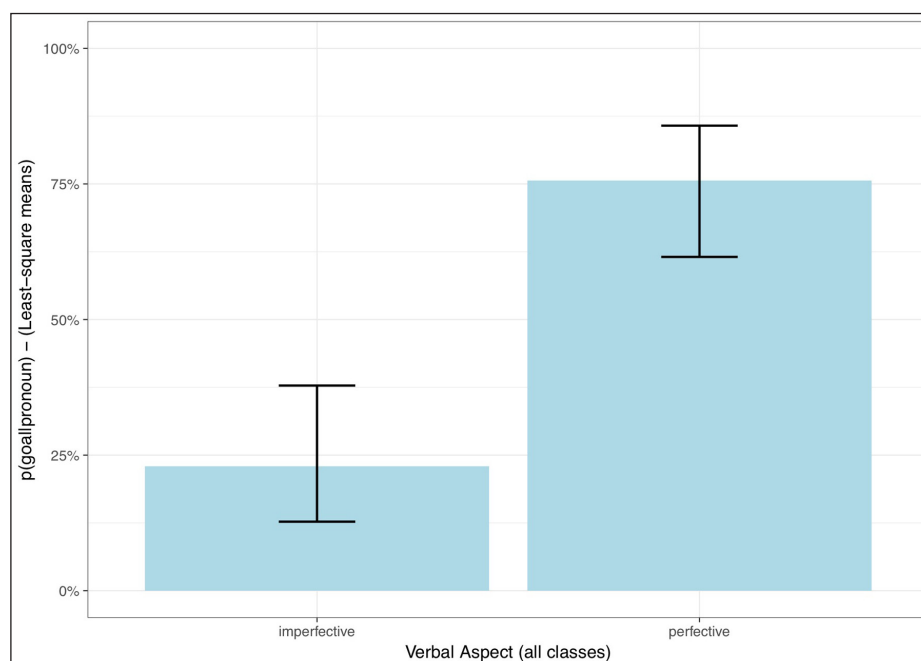
### 5.1. Verbal aspect and verb classes

Our first analysis aimed at assessing the role of verbal aspect and verb class in the rates of goal interpretation, the reference level for our dependent variable. Aspect, a two-level variable (perfective/imperfective), was centered using deviation coding (0.5, -0.5) to allow for the test of main effects (Barr 2013). Because verb classes are ordered in relation to how much the end-state of an event is focused (more focused for verbs in class 1 and less focused for verbs in class 3), the verb class variable was coded using orthogonal contrasts to compare class 1 to class 2 in the first contrast (0.5, -0.5, 0), and the combination of class 1 and class 2 to class 3 in the second contrast (0.33, 0.33, -0.66). In addition to random intercepts for participants and items, the model also included random slopes for class and aspect. This full model was the best fitting model, and the following analysis is based on its results with perfective as the reference level for aspect. **Table 2** shows coefficients ( $\beta$ ), standard errors (SE), z-values and p-values for the intercept (the grand mean of pronoun interpretation; Barr 2013), the effect of aspect, the two contrasts set for verb class and their interaction with aspect.

In general, our dataset was not particularly biased towards source or goal interpretations. There was a main effect of aspect, with goal-biased interpretations being significantly more common for perfective rather than imperfective sentences. There was no effect of verb class when class 1 and class 2 verbs were compared, but these two verb classes combined yielded more goal continuations than verbs in class 3. The analysis showed an

**Table 3:** Effects of verbal aspect and verb class on pronoun interpretation.

	$\beta$	SE	Z	p-value
(Intercept)	-0.039	0.319	-0.123	0.9214
aspect	2.343	0.294	7.965	<b>&lt;0.0001</b>
class 1 vs class 2	-0.139	0.520	0.268	0.8896
class 1 + 2 vs class 3	1.881	0.466	4.030	<b>&lt;0.001</b>
aspect:class 1 vs class 2	-1.973	0.656	-3.008	<b>0.0062</b>
aspect:class 1 + 2 vs class 3	-0.150	0.580	-0.258	0.8896

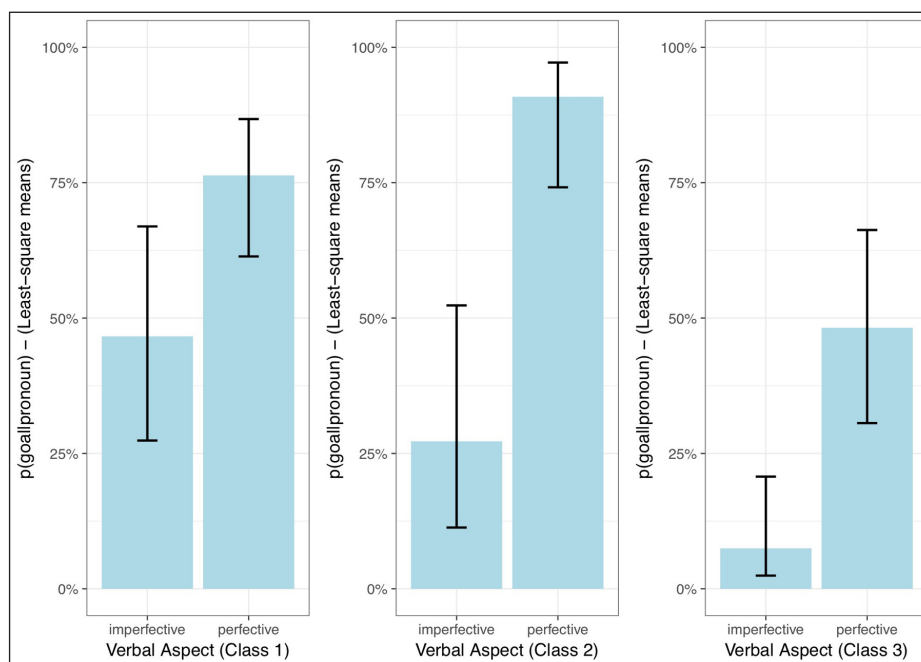
**Figure 1:** Effects of verbal aspect on pronoun interpretation; bars show 95% confidence interval.

interaction between aspect and verb class when class 1 and class 2 verbs were compared, with a stronger aspect effect for verbs in class 2. However, this interaction was not significant when the subset that comprises verbs in class 1 and class 2 was contrasted with verbs in class 3 (cf. **Table 3**). **Figures 1** and **2** show the frequency distribution of goal interpretations as predicted by our mixed-effect model along with their 95% confidence intervals. Note that the overlap of confidence intervals does not mean a lack of significance in hypothesis testing (Krzywinski & Altman 2013).

Further analyses showed that, for the whole dataset, pronouns following a perfective sentence were mainly interpreted as referring to the goal referent ( $\beta = 0.9090$ ,  $SE = 0.3114$ ,  $z$ -value = 2.92,  $p = 0.008$ ), but there was a source bias following imperfective sentences ( $\beta = -1.0629$ ,  $SE = 0.3813$ ,  $z$ -value = -2.788,  $p = 0.01$ ). The result for perfective verbs is different from the results reported for English (Rohde 2008), which showed no bias for goals or sources in perfective contexts prompted by an overt pronoun.

## 5.2. Discussion of verbal aspect and verb class results

The main difference between our results and those described in Rohde comes from the analysis of the perfective sentences. As predicted, BP showed a preference for goal continuations in this context, in contrast with the 50/50 distribution described for English.



**Figure 2:** Effect of verbal aspect and verb class on pronoun interpretation.

This difference is in line with the prediction that BP would have more goal continuations because, according to several studies (Almor et al. 2017; Barbosa, Duarte & Kato 2005; Fonseca & Guerreiro 2012; Teixeira, Fonseca & Soares 2014), overt pronouns in this language are not preferably used to refer to the subject of a previous sentence. Furthermore, the difference between both languages can be easily explained by assuming that pronoun interpretation is subject to the probability of using a pronoun to refer to specific referents, and that this probability is conditioned mainly by grammatical constraints that vary across languages. In other words, we claim that the pattern observed in perfective contexts in BP can be accounted by  $p(\text{pronoun}|\text{referent})$ , which represents a pronoun production bias highly influenced by grammatical factors. Thus, the difference between BP and English may arise from the fact that the probability of using a pronoun to refer to a subject referent in BP –  $p(\text{pronoun}|\text{subject})_{\text{BP}}$  – is lower than in English due to typological differences between these languages.

Despite this difference, our results resemble those reported by Rohde (2008) in showing that event structure influences pronoun resolution. This can be seen by comparing the rates of goal interpretations across verbal aspect, which are greater following perfective contexts in both languages. Another evidence for the influence of event structure in pronoun interpretation comes from the effects reported for verb class. As in English, verbs in class 3 yielded fewer goal interpretations when compared to verbs in class 1 and class 2, although no difference was found between class 1 and class 2 verbs. These similarities may be an indication that event representation had the same effect on both languages, despite differences motivated by structural factors.

Finally, we note that the expectation-driven proposal outlined in KR states that verbal aspect does not influence pronoun interpretation directly, but it does so by giving rise to different distributions in coherence relations. To test if this finding also holds for BP, we analyzed data from coherence relations elicited in our story continuation task.

### 5.3. Coherence relations and pronoun interpretation

Because we wanted to test if coherence relations would influence pronoun interpretation in BP the same way they do in English, we ran additional analyses considering the coherence relations produced by participants in our experiment. These new analyses were set to test



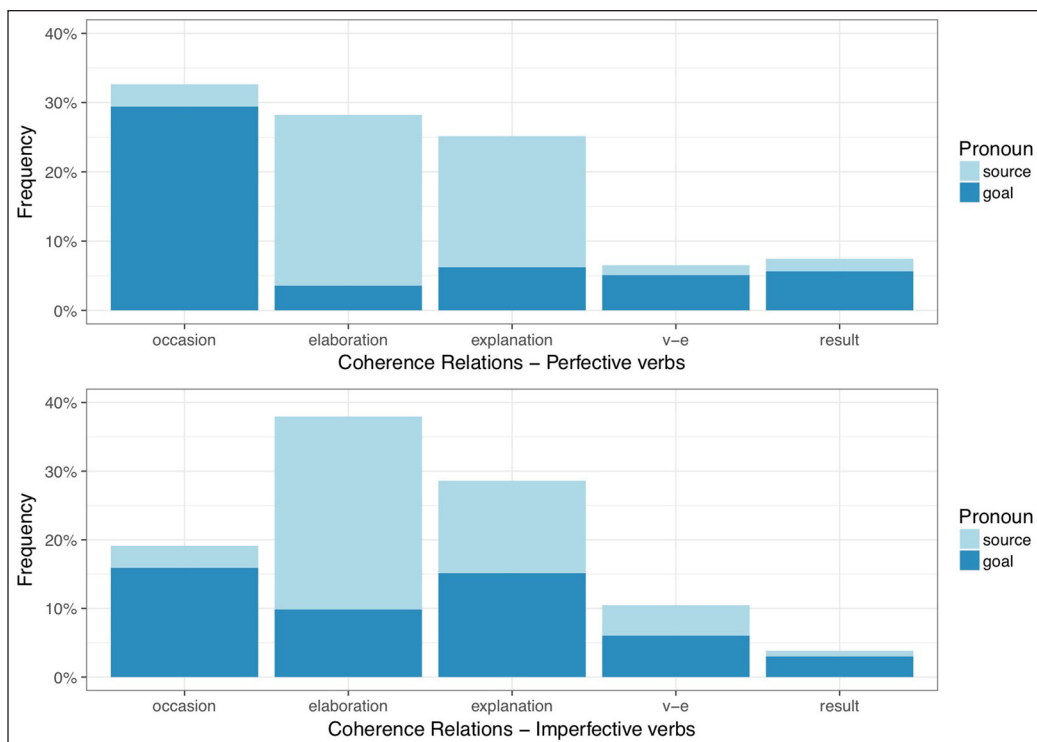
(a) whether coherence relations have an effect on pronoun interpretation biases, (b) and whether the distribution of coherence relations would differ depending on verbal aspect. **Figure 3** shows the raw means of each coherence relation per aspect and their pronoun interpretations biases. This figure and the analyses described below exclude the only occurrence of a parallel relation found in our data.

The small number of Result (perfective:  $n = 35$ ; imperfective:  $n = 12$ ) and Violated-expectation continuations (perfective:  $n = 31$ ; imperfective:  $n = 38$ ) did not allow for a proper logistic regression analysis regarding their variation across verbal aspect. For this reason, the following analyses describe tendencies associated with the three most common coherence relations found in previous studies: Occasion, Elaboration and Explanation. To assess pronoun interpretation preferences for each coherence relation, data from perfective and imperfective contexts were considered separately. A model was fit for each coherence relation with random intercepts for items and participants.

Data from Occasion relations showed a goal bias above a hypothetical mean of 0.5 for both perfective ( $\beta = 3.271, SE = 1.003, z = 3.26, p = 0.003$ ) and imperfective contexts ( $\beta = 11.640, SE = 5.019, z = 2.319, p = 0.03$ ). In sentences with Elaboration relations, pronouns were preferably interpreted as referring to sources following perfective and imperfective contexts (perfective:  $\beta = -1.399, SE = 0.388, z = -3.60, p = 0.001$ ; imperfective:  $\beta = -2.1790, SE = 0.4674, z = -4.662, p < 0.0001$ ). For Explanation relations, although there was a source preference in pronoun interpretation, it did not reach significance in both verbal contexts (perfective:  $\beta = -0.8186, SE = 0.4969, z = -1.647, p = 0.1$ ; imperfective:  $\beta = -1.1057, SE = 0.5906, z = -1.872, p = 0.09$ ).

#### 5.4. Verbal aspect and coherence relations

To test whether verbal aspect could predict the distribution of coherence relations in BP, coherence relations were coded as binary outcomes (occasion/no-occasion, elaboration/no-elaboration, explanation/no-explanation), and mixed-effects logistic



**Figure 3:** Effects of aspect on coherence relation distributions and pronoun interpretation.

regression models were fit for each coherence relation separately. The response variable was the rate of the coherence relation; aspect was the only fixed effect, and it was contrasted using treatment coding to allow for a direct comparison between perfective and imperfective contexts. The model included random intercepts for participants and items, and random slopes for aspect. Compared to imperfective contexts, perfective sentences yielded more Occasion relations ( $\beta = 1.9320$ ,  $SE = 0.3176$ ,  $z = 6.084$ ,  $p < 0.0001$ ) and fewer Elaborations ( $\beta = -1.1532$ ,  $SE = 0.2024$ ,  $z = -5.697$ ,  $p < 0.0001$ ), but there was no difference in the rate of Explanations ( $\beta = -0.1102$ ,  $SE = 0.3180$ ,  $z = -0.347$ ,  $p = 0.8$ ).

Finally, we assessed if verbal aspect also influenced pronoun interpretation bias within the set of each coherence relation. If so, then verbal aspect would not only have an effect on the choice of a coherence relation, but also on the pronoun interpretation itself. For each coherence relation a model was fit with pronoun interpretation as the response variable, aspect as the fixed effect, random intercepts for participants and items and random slopes for aspect. There was no effect of aspect for Occasion ( $\beta = 0.7697419$ ,  $SE = 7.299629$ ,  $z = 0.105$ ,  $p = 0.9$ ), Elaboration ( $\beta = -0.6372298$ ,  $SE = 0.5741058$ ,  $z = -1.11$ ,  $p = 0.350$ ) and Explanation ( $\beta = -0.6935491$ ,  $SE = 0.526627$ ,  $z = -1.317$ ,  $p = 0.26$ ), indicating that pronoun interpretation preferences associated with coherence relations are independent from verbal aspect.

### **5.5. Discussion of coherence relations**

By proposing an expectation-driven model to account for pronoun interpretation, KR place the establishment of coherence relations as the primary factor in generating expectations about which referent is more likely to be mentioned next. This emphasis on the role of coherence relations on pronoun processing builds on previous work (Hobbs 1979) and relies on two of Rohde's findings. First, the author reports that pronoun interpretation for some coherence relations is biased towards the goal (Occasion and Result), while for others (Elaboration, Explanation, Violated-Expectation) pronouns tend to be interpreted as referring to the source. More importantly, verbal aspect does not seem to influence biases within each coherence relation, but it leads to different coherence distribution patterns: more Occasion in perfective sentences, and more Elaboration and Explanation following imperfective sentences. Although there are some differences we must address later, similar conclusions can be drawn from our data.

In our experiment, Occasion also elicited more goal-oriented readings, and Elaboration biased pronoun interpretation towards the source. Furthermore, our analyses indicate that verbal aspect did not influence pronoun interpretation within each coherence relation, but it had a significant effect on shifting coherence relation distribution from more goal-oriented relations in perfective sentences to more source-oriented ones following imperfective contexts. Therefore, we can assume that although perfective sentences elicit more goal interpretations, this is not done by direct influence of verbal aspect. Instead, it is the coherence relation that defines whether pronouns are more likely to refer to sources or goals, and verbal aspect interacts with pronoun interpretations only by changing the probability of occurrence of specific coherence relations. As Rohde puts it, “[t]he factor responsible for pronoun interpretation differences between perfective and imperfective conditions is thus the differing distributions of coherence relations” (Rohde 2008: 48).

Although our results support KR's claims in showing that coherence relations are the main mediating factor on pronoun interpretation, they also point to an incongruence that needs to be addressed in future research. Here, we mention the finding that Explanation did not elicit any bias in BP, despite the fact that English shows a clear source-bias for this coherence

relation in TOP contexts (Rhode 2008). To account for this cross-linguistic difference, we refer once again to the equation KR provide to explain pronoun interpretation:

$$(3) \quad p(\textit{referent} | \textit{pronoun}) = \frac{p(\textit{pronoun}|\textit{referent})p(\textit{referent})}{p(\textit{pronoun})}$$

In (3), it is stated that the probability of the occurrence of a referent (source or goal) given a pronoun is defined by the probability of this particular referent being referred back by a pronoun and the likelihood of this referent being mentioned in the upcoming context. For a moment, let's consider the term  $p(\textit{referent})$ , which stands for the probability of occurrence of a particular referent in a given context. As stated before, the likelihood of a referent in a given context is conditioned by both (i) how likely the discourse is to continue in terms of coherence relations that may follow and (ii) how likely a referent is to be mentioned given a particular coherence relation, i.e.,  $p(\textit{referent}|\textit{CR})$ . For the English language, we have seen that  $p(\textit{source}|\textit{pronoun})$  is greater than 0.5 when the established coherence relation is Explanation, but this does not follow necessarily from the assumption that  $p(\textit{source}|\textit{Explanation})$  is also greater than 0.5. Actually, considering responses using Explanation relations alone,  $p(\textit{source}|\textit{pronoun})$  would be the result from (5), which considers both  $p(\textit{source})$  and  $p(\textit{pronoun}|\textit{source})$ .

$$(5) \quad p(\textit{source} | \textit{pronoun}) = \frac{p(\textit{pronoun}|\textit{source})p(\textit{source})}{p(\textit{pronoun})}$$

In these terms, when  $p(\textit{pronoun}|\textit{source})$  decreases, then we will also see a decrease in  $p(\textit{source}|\textit{pronoun})$  even if  $p(\textit{source})$  remains constant. As discussed previously, it is reasonable to believe that subject-preference (which is the same as  $p(\textit{pronoun}|\textit{source})$  in the TOP contexts we are evaluating here) is not as strong in BP as it is in English, and this difference can decrease the general probability of a pronoun referring back to the source in BP. This would be true regardless of the coherence relation held between sentences; thus, it may be the case that the likelihood of a source reference given Explanation – i.e.,  $p(\textit{source}|\textit{Explanation})$  – is not much greater than 0.5, and then the coefficient for  $p(\textit{pronoun}|\textit{source})$  will be crucial to define interpretation biases within this coherence relation. Because probabilities associated with subject-preference in pronoun interpretation are greater in English, pronouns in explicative relations show a source bias in this language; because the same probability is lower in BP, we see no bias associated with pronoun interpretation following explicative sentences. Therefore, we explain the difference between BP and English by assuming that biases within each coherence relation do not differ cross-linguistically, but pronoun interpretation may vary due to variance in the probabilities of a subject bias conditioned by the choice of an overt pronoun as the referential expression.

If this assumption is correct, then we can make predictions about interpretation biases in Explanation and the distribution of this coherence relation that are also borne out by data in English. As we put it, pronoun interpretation for Explanation in English is biased towards the source partly due to the strong influence of subject preference instantiated by an overt pronoun. Thus, any change that decreases this subject preference while maintaining an explicative relation between sentences could lower the source bias detected in Rhode (2008) for Explanation. A possible way to halt subject preference would be presenting the TOP sentences without a pronoun prompt, a situation that is known to increase goal interpretations significantly (Ferretti et al. 2009). Without a pronoun, then it would be expected that the source bias found for Explanation in English would be attenuated, resulting in a probability closer to that observed in BP.

Gruter, Rohde & Schafer (2016) describe a dataset that comprises pronoun interpretation in TOP contexts after pronoun prompts and full-stops, i.e., sentences with no prompts. Because half of the data came from full-stop sentences, this dataset shows less subject-preference than data obtained only with pronoun-prompt sentences. Authors do not provide a complete descriptive analysis of their data for coherence relations, but in this less source-biased context, Explanation did not seem to entail any preferences towards the source or goal for either perfective or imperfective sentences. At the same time, Occasion and Elaboration showed the same biases reported by Rohde and described in this paper. We see this as an indication that the Explanation bias for the source is close to 0.5, and the source preference documented for English emerges from the interaction of this probability with a strong subject preference associated with the use of an overt pronoun.

Another indication of this assumption comes from the distribution of coherence relations in perfective and imperfective contexts. In our experiment, we found that the distribution of Occasion and Elaboration changes depending on verbal aspect; however, no change was found for Explanation. Because verbal aspect would influence pronoun interpretation by increasing or decreasing the probability of specific coherence relations that are biased towards the end-state of an event, we can assume that the constant number of explicative sentences in perfective and imperfective contexts reflects the fact that this coherence relation does not have a previous bias. As a consequence, Explanation is not favored by contexts that focus either on the event's end-state or on the ongoing event itself. In fact, our experiment was not the only one to report this finding. Results from Gruter, Rohde & Schafer (2016) show influence of verbal aspect on the number of Occasion and Elaboration occurrences, but not on the number of Explanation occurrences. Even in Rohde's work that inspired the present study and that reports a source bias for Explanation, verbal aspect did not shift the distribution of this coherence relation. This is difficult to explain if we assume that the number of source-biased coherence relations are increased by imperfective sentences and that Explanation is a source-biased coherence relation. However, this pattern is perfectly in line with the assumption that Explanation *per se* is not biased toward any particular direction, and, therefore, its distribution should not be affected by verbal aspect.

## 6. General discussion

Our first goal in setting a completion experiment following Rohde's work was to test whether the lack of subject-preference associated with the use of an overt pronoun in BP would influence pronoun interpretation in TOP contexts, resulting in an outcome with less source-biased interpretations compared to English. While data from this experiment mirrored previous findings about the effect of verbal aspect and verb semantics on the proportion of source/goal interpretations, BP showed a clear preference for goals in perfective contexts. We claimed this marks an important depart from English, for which it has been argued that a subject-preference associated with the production of overt pronouns would restrain this language from showing a goal-bias following perfective sentences. Thus, it is possible that the results of this experiment demonstrates that subject bias associated with an overt pronoun is not much different from its object bias, in line with previous research (Teixeira et al. 2014). Future work must address this hypothesis in more detail, investigating whether the use of overt pronouns in BP imposes a subject preference on comprehension, even if the effect is not as strong as the one observed in other languages. For a clear picture of this effect, it is also necessary to assess speaker's preferences on producing null and/or overt pronouns to refer to sources and goals in TOP contexts. These issues are the subject of ongoing work, but the results presented here are enough to signal that any model of

pronoun processing must consider how probabilities evoked by superficial cues may interact with more general inferencing processes. As such, we endorse KR's claims that an approach that focuses on coherence-driven processes alone (e.g., Hobbs 1979) cannot fully account for pronoun interpretation, and we add that this may be particularly true once differences from cross-linguistic studies are taken into account.

Although semantic and pragmatic information alone cannot explain pronoun interpretation, our results support the claim that coherence-driven expectations also play a role in this process by defining the probability of a referent being mentioned in the ensuing context. Our results have shown that coherence relations are the main factor in generating these expectations, as there was no influence of aspect on pronoun interpretation when continuations were broken down by coherence relations. Moreover, results from BP confirm the claim made by KR that the influence of event representation on pronoun interpretation can be reduced to the influence of coherence relations. Other types of pragmatic information that seem to have an impact in pronoun interpretation – such as verbal aspect or verb semantics – would do so by changing the probability of continuing a sentence using a particular coherence relation.

Furthermore, we found that Occasion and Elaboration have in BP the same biases reported by previous studies about TOP events in other languages (Kim, Gruter & Schafer 2016; Rohde 2008; Ueno & Kehler 2016). This was not the case for Explanation, that was previously reported to have a source preference in other languages, but showed no bias in BP. We explain this difference by stating that Explanation does not have a source-bias; rather, the preference for source continuations found in English for Explanation may be the result of the interaction between a non-biased coherence relation and the high probability of a source reference given an overt pronoun in this language. This would also explain why Explanation distributions are not influenced by verbal aspect as much as the distribution of Occasion and Elaboration, and why this is the case both in BP and in English.

This interpretation is a depart from KR assumptions and, as such, it needs further research to be thoroughly tested. One question that may arise is why  $p(\text{pronoun}|\text{referent})$  would be able to change the interpretation bias when there is an explicative relation, but not when these relations are Occasion and Elaboration. It may be that some coherence relations embody biases more prototypically associated with the beginning or with the end-state of an event, and that Occasion and Elaboration are such coherence relations. In fact, studies that investigate how specific cues change the distribution of coherence relations that evoke diametrically opposed biases tend to compare the rates of Occasion and Elaboration (Mayol 2017; Rohde 2008 (experiment VIII)).

As for Explanation, there is no clear reason why this particular relation would be biased towards the source or the goal of a previous sentence. Although Explanation does not build upon the end-state of an event, describing its consequences or subsequent states, it is not true that its focus may rely preferably on the referent that initiated the described event. The cause of a TOP event – which is the inference retrieved by an explanation – may emerge from the source's as well as from the goal's behavior and intentions. This interpretation builds on previous work on implicit causality that presents evidence for the bias of an explicative sentence to result from verb semantics (e.g., Caramazza et al. 1977; Koornneef & Van Berkum 2006), but it remains to be tested.

Finally, we stress that these analyses are exploratory in nature. The fact that we used 18 experimental items for a  $2 \times 3$  design, which results 3 items per condition per participant, may rise some questions about the robustness of the results reported here. Research on Transfer-of-Possession contexts may find it difficult to tackle this issue, as the number of verbs that can be used as experimental items is limited: the experiment described in Rohde (2008), for instance, used 21 verbs. However, there are other contexts that are fitted for



the study of the interplay between  $p(\text{referent})$  and  $p(\text{pronoun}|\text{referent})$ , such as implicit causality verbs, sentences in passive voice and relative clauses that are particularly biased to a specific referent (Rohde & Kehler 2013; Kehler & Rohde In press). Results of English pronoun interpretation in these contexts have endorsed KR's Bayesian model of pronoun interpretation, but cross-linguistic comparisons may test whether pronoun interpretation would vary as a function of changes in  $p(\text{pronoun}|\text{referent})$ .

## 7. Conclusion

Overall, our findings support a model in which pronoun interpretation is the result from both structural and pragmatic cues. Along with KR, we assume that grammatical factors have great impact in conditioning the probability of a pronoun being used to mention a specific referent, while expectations about coherence relations are the main factor in conditioning the probability of mentioning that same referent. Supported by our results, we make the additional claim that these two biases are not equally affected by cross-linguistic differences. Factors particularly influenced by structural constraints are expected to show greater variation across languages, as is the case for the subject preference associated with the use of overt pronouns. Meanwhile, expectations derived from world-knowledge may play a more homogeneous role in conditioning expectations cross-linguistically. Differences in pronoun interpretation across languages should then be explained by addressing the interaction between these two complementary factors.

## Acknowledgements

We are grateful to Hannah Rohde for providing us with details about her stimuli and data annotation, and for giving useful insight during our attempt to replicate her work. Any errors are our own.

## Competing Interests

The authors have no competing interests to declare.

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**How to cite this article:** Godoy, M. C., Weissheimer, J., & Mafra, M. A. (2018). When Grammar Meets Pragmatics: Subject Preference and Coherence Relations in Brazilian Portuguese Pronoun Interpretation. *Journal of Portuguese Linguistics*, 17: 6, pp. 1–22. DOI: <https://doi.org/10.5334/jpl.197>

**Submitted:** 07 February 2018

**Accepted:** 17 July 2018

**Published:** 26 November 2018

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