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Competing analyses and differential cost in the production of non-subject relative clauses

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The computational cost of restrictive non-subject relative clauses (RCs) in different processing conditions is discussed in relation to competing analyses of RCs. An elicited production experiment is reported in which adult speakers of Brazilian Portuguese (BP) were asked to continue a preamble in such a way that a right-branching restrictive RC would enable a particular referent to be identified. Two processing conditions were contrasted: fully planned (FPlan), in which the speaker could plan the RC as the sentence production started; and partially planned (PPlan), in which production started before it was clear that a restrictive RC was the only option to encode the reference unambiguously. It was anticipated that the number of standard RCs would be lower in the PPlan condition, with an increase in the non-standard alternatives. This prediction is verified, with chopping standing as a cost reducing strategy in the production of indirect object RCs. It is argued that, for the standard strategy, RCs as complements (as conceived of in most raising analyses) suit an online model of RC computation in the fully planned condition; however, the possibility of RCs as adjuncts, as proposed by most head external and matching analyses, is required for the incremental computation of a restrictive RC in the partially planned condition.

Keywords: relative clauses; complementation; adjunction; incrementality; computational cost; elicited production

1 Introduction

Relative Clauses (RCs) have been the subject of a considerable amount of linguistic and psycholinguistic research in recent decades. While linguistic analyses provide the possible combinatorial options for the speaker/hearer to compute these structures, psycholinguistic research identifies the factors that give rise to differential processing cost and provides models of the online syntactic computation carried out as sentences are produced and/or analyzed.

In descriptive terms, RCs present a head noun associated with an empty position or a gap (a resumptive pronoun, in some languages). The head noun (usually followed by a relative pronoun/complementizer) introduces the embedded clause with a particular syntactic position associated with it. In principle, any nominal constituent can be relativized. Typological studies suggest, however, that the more deeply embedded a constituent is, the less likely it is for relativization to be allowed, with subject (Subj) RCs (1) being the most common type of RC (Keenan & Comrie 1977). That is, the grammatical function of the relativized element in the relative clause plays a relevant role in the possibility of relativization across languages.

- (1) the student who/that called the teacher (Subj RC)

There have been different syntactic descriptions of RCs in the generative framework (Vergnaud 1974; Chomsky 1977; Kayne 1994; Sauerland 2003), most of which incorporate syntactic movement (internal Merge). This operation has been related to high computational cost (Chomsky 1995), even though such high cost may be restricted to some structures such as object relative clauses due to an intervention effect (Rizzi 2004; Grillo 2008; 2009) or specific processing conditions (Gordon et al. 2001).¹

The asymmetry between different types of RCs has been a major concern in psycholinguistic research. In particular, the differential demands of Subj and Direct Object (DO) RCs (2) have been widely attested in sentence comprehension for both children (Brown 1971; Tavakolian 1981; Corrêa 1995; Eisenberg 2002; Diessel & Tomasello 2000) and adults (Wanner & Maratsos 1978; Holmes & O'Regan 1981; Crain, Mckee & Emiliani 1990; Traxler, Morris & Seely 2002; Gibson et al. 2005).

- (2) the student who/that the teacher called (DO RC)

With regard to production, the processing of DO RCs is considerably impaired in SLI (Specific Language Impairment) (Stavrakaki 2001; van der Lely & Battell 2003; Friedmann & Novogrodsky 2004; Corrêa 2014), acquired aphasia (Grodzinsky 2000; Hadelich, Steinke & Schade 2001; Kljajevic 2012), and in other abnormal conditions (Geurts & Embrechts 2008). There is also evidence that Prepositional Phrase/Indirect Object (PP/IO) (3) and Genitive (GEN) RCs (4) impose even greater demands on children (de Villiers et al. 1979; Diessel & Tomasello 2000). Likewise, corpus analyses also show that GEN RCs are scarcely used (Gennari & MacDonald 2008).

- (3) the student to whom the teacher spoke (PP/IO RC)

- (4) the student whose teacher resigned (GEN RC)

The relative difficulty of non-subject RCs has been ascribed to factors such as the intervention of the subject of the RC, in a generalization or overextension of the relativized minimality principle (Grillo 2008; 2009; Friedmann, Belletti & Rizzi 2009).² From a psycholinguistic perspective, this difficulty has been ascribed to factors such as transient working memory load between the head noun and the gap (Wanner & Maratsos 1978), and the introduction of an additional referent (Gibson 1998; Gordon, Hendrick & Johnson 2001; Gibson et al. 2005).

Besides standard patterns, RCs may present non-standard forms. With regard to PP/IO, preposition stranding is a common non-standard strategy in languages such as English (5). In languages such as Portuguese (6) and Hebrew (7), for instance, a resumptive pronoun can be inserted in the position of the copy of the relativized element. As for GEN RCs, the insertion of a possessive pronoun is usually regarded as evidence of resumption (8) (McKee & MacDaniel 2001), as a last resort strategy in different languages (Hornstein 2001).

- (5) the girl who the teacher showed the book to

¹ In fact, in Chomsky's subsequent work, the idea of movement as an imperfection, giving rise to computational cost, has been revised (cf. Chomsky 2001).

² The intervention hypothesis relies on an extended version of the Relativized Minimality (RM) Principle, proposed by Rizzi (1990), which states that, in a configuration [X ... Z ... Y], "a local relation cannot hold between X and Y when Z is somehow a potential candidate for the local relation."

- (6) a menina que o professor mostrou o livro para ela
the girl that the professor showed the book to her
'the girl that the professor showed the book to'
- (7) *Hebrew* (Friedmann, Belletti & Rizzi 2009)
Tare li et ha-kof she-ha-yeled mexabek oto.
show to-me.ACC the-monkey that-the-boy hugs him
'Show me the monkey that the boy is hugging.'
- (8) the girl that her teacher arrived

Non-standard RC formation strategies (RCFSs) seem to shortcut the computational procedure of highly demanding sentences, mainly in informal speaking situations (Corrêa 1998). In languages such as Portuguese, in which preposition stranding is not generally allowed,³ chopping is used as an alternative in the production of PP/IO (12) and GEN RCs (15). Brazilian Portuguese (BP) allows for different types of non-standard RCs: resumptive and chopped. Chopped versions present the default relative pronoun/complementizer *que* 'that' and no preposition is present, whereas resumptive non-standard RCs allow for an overt pronoun to resume the relativized element in its base position. It has been observed that Brazilian Portuguese-speaking children rely on chopped RCs to the same extent that English-speaking children rely on resumptives (McKee & MacDaniel 2001; Grolla & Augusto 2016). An illustration of BP standard and non-standard RCs is provided below:

- (9) Standard DO RC
o aluno que o professor chamou
the student that the teacher call.PAST
'the student that the teacher called'
- (10) Non-standard resumptive DO RC
o aluno que o professor chamou ele
the student that the teacher call.PAST he.3SG.MASC
'the student that the teacher called him'
- (11) Standard PP/IO RC
o aluno de quem o professor falou
the student of whom the teacher talk.PAST
'the student about whom the teacher talked'
- (12) Non-standard chopped PP/IO RC
o aluno que o professor falou
the student that the teacher talk.PAST
'the student that the teacher talked about'

³ Preposition stranding is admitted in informal oral language in a small set of lexical prepositions such as *sobre* 'about' and *sem* 'without', as in:

- (i) o filme que a gente falou sobre
the movie that the people talk.PAST about
'the movie we talked about'
- (ii) aquele batom que não consigo viver sem
that lipstick that I can't live without
'the lipstick I can't live without'

- (13) Non-standard resumptive PP/IO RC
 o aluno que o professor falou dele
 the student that the teacher talk.PAST of him.3SG.MASC
 ‘the student that the teacher talked about him’
- (14) Standard GEN RC
 o livro cuja capa rasgou
 the book whose.SG.FEM cover tear up.PAST
 ‘the book whose cover is torn up’
- (15) Non-standard chopped GEN RC
 o livro que a capa rasgou
 the book that the cover tear up.PAST
 ‘the book that its cover is torn up’
- (16) Non-standard resumptive GEN RC⁴
 o livro que a capa dele rasgou
 the book that the cover of-it.3SG.MASC tear up.PAST
 ‘the book that its cover is torn up’

Apart from non-standard RCFs, the speaker can produce structurally simpler semantically equivalent alternatives. Passive subject RCs have been shown, for instance, to be a lower cost alternative strategy to DO RCs that adults and children (after 5 years old) rely upon (Friedmann, Belletti & Rizzi 2009) (17):

- (17) a menina que foi beijada pelo menino
 the girl that be.PAST.3SG kiss.PART.SG.FEM by-the boy
 ‘the girl who/that was kissed by the boy’

The association between processing cost and the speaker’s reliance on non-standard RCFs has not, however, been widely explored. With regard to BP in particular, speakers may resort to both standard and non-standard strategies, depending on the language register and their level of formal education. More formal contexts and written texts give rise to more standard forms, whereas oral speech and informal situations tend to result in non-standard options. Reliance on such strategies may also be due to the degree of incrementality in the production of RCs.

This paper focuses on the production of RCs by native adult speakers of BP in processing conditions that impose different degrees of incrementality. In BP, chopping appears to be a productive cost-reducing strategy. The working hypothesis is that the greater the degree of incrementality imposed by sentence production, the more likely it is for the speaker to rely on non-standard RCFs.

The aim of the present paper is twofold: (i) to verify whether or not the degree of incrementality imposed by different sentence planning conditions affects the production of standard non-subject RCs; and (ii) to provide a characterization of the online computation of RCs in those conditions, making reference to the standard analyses (complementation,

⁴ Resumptive RCs are low frequency structures in BP. The increase in the percentage of these structures from the XVIII to the XX century is small. By contrast, there is an increase in the percentage of chopped RCs paralleled by a decrease in the use of standard RCs (Tarallo 1983; Lessa-de-Oliveira 2009). It seems that resumptives are more often associated with IO/PP and GEN positions and it is not clear whether there are social factors determining their use (Tarallo 1983; Silva 2011). The quite stable and low frequency use of this structure may, in any case, suggest that it is a result of specific processing conditions in a sort of last resort procedure.

as in many raising analyses (e.g. Kayne 1994), and adjunction, as in many matching analyses (e.g. Sauerland 2003)) provided for RCs.

With regard to (i), an elicited production experiment is reported in which two sentence planning conditions – fully planned (FPlan) and partially planned (PPlan) – were created, as a function of the degree of incrementality they impose on the online processing. The participants were requested to complete a preamble with some information in order to unambiguously refer to a given character. The preamble consisted of a main clause with a transitive verb followed by an elicited complement that must include a restrictive RC. The experimental conditions were such that the participant would notice that he/she had to produce a restrictive RC either prior to reading the preamble (FPlan) or after having formulated the DP complement of the transitive verb (PPlan) (cf. (18) and Method in Section 3):

- (18) DP (subject) Transitive Verb Adjunct ... DP RC
(preamble) (elicited clause)

So, in the FPlan condition, the speaker knew in advance that a restrictive RC would be required as a noun modifier in order for the target referent to be identified. In PPlan, it was only when the critical DP started to be produced that it would become clear to the speaker that a restrictive RC was the only modifier enabling the target referent to be unambiguously identified. The information concerning the restrictive modifier was presented in such a way as to elicit the production of three types of non-subject RCs: DO, IO, and GEN. It was predicted that PPlan would give rise to a lower proportion of standard strategies. A higher number of responses stemming from alternative RCFs was expected under this condition. The extent to which sentence complexity affects the number or quality of these responses was also investigated.

With regard to (ii), the differential demands of each planning condition are assumed to give rise to different possible computational procedures. These are characterized in the light of two current competing linguistic analyses according to which RCs are presented: (i) as complements, as in many raising analyses (e.g. Kayne 1994), or (ii) as adjuncts, as in many matching analyses (e.g. Sauerland 2003). It is argued that, while complementation may fit for computation carried out in FPlan, adjunction provides a better account for the procedure implemented in PPlan. The possibility of non-standard RCs being derived from topic structures in BP (Kato & Nunes 2009) is also considered.

This paper is organized as follows: the next section briefly outlines the two major current competing analyses of RCs as well as an analysis for the derivation of RCs from topics proposed for BP non-standard RCs. In the following section, the elicited production experiment is reported. The breakdown of the participants' responses is provided and analyzed. In section 4, the online computation of RCs is characterized, in the light of the linguistic analyses provided, in order to differentiate the processing demands due to different degrees of incrementality. The concluding remarks recap the main findings and argue that bringing together current linguistic analyses and a psycholinguistic account of online computation is a promising line of research.

2 Relative clauses: Combinatorial possibilities

Even though languages can provide different strategies for the computation of RCs, most linguistic analyses refer to the standard form. In the classical generative framework, these analyses fall into two main categories, which conceive of the RC differently, either as a complement or as an adjunct. Complementation is typically associated with head raising analyses (see Alexiadou et al. 2000: 3), whereas adjunction is associated to most

head external (or matching) analyses. Head raising analyses share the idea that the head of the RC is derived by direct movement from within the RC (Brame 1968; Vergnaud 1974; Kayne 1994; Bianchi 1999), whereas head external analyses hold that the head is base-generated externally to the RC (Chomsky 1977). According to Salzmann (2006), the matching analyses (Chomsky 1965; Citko 2001; Sauerland 2003) can be seen as in between head external and head raising. Even though it is not logically necessary, recent instantiations of head raising analyses have all conceived of the RC as a complement (see Alexiadou et al. 2000: 3). Kayne's proposal is one of the most influential head raising analyses, which characterizes the RC as a complement of the Determiner:

(19) ${}_{DP}$ [the ${}_{CP}$ [${}_{DP}$ [book] ${}_i$ [${}_{D'}$ which t_i]] ${}_j$ John likes t_j]]

Under head external and matching analyses, the head of the RC is base-generated in the main clause and a *wh*-operator is moved to a peripheral position of the relative CP, bearing a predication relation to the head (or the internal head is deleted under identity with the paired external head).

(20) ${}_{DP}$ [the ${}_{NP}$ [book] ${}_i$] [${}_{CP}$ [Op/which book] ${}_i$] John likes t_j]

Structural arguments favoring each of the competing analyses have been put forward (see also Cinque (2015) and references therein),⁵ which suggest that both analyses are necessary to account for the variety of linguistic facts involved in the generation of RCs:

“The ambiguity concerns the position in which the head NP of the relative clause is interpreted. In some cases, the head must be interpreted in a position internal to the relative clause. In others, it appears that the head must be interpreted external to the relative clause. These two kinds of facts have been used to show that we need both an analysis in which the relative clause is purely internally headed and also one in which the relative clause is externally headed.” (Hulsey & Sauerland 2006: 111)

The specific demands of the actual use of RCs may also contribute, nevertheless, to the view that competing analyses can be maintained since each of them may be more suited to some specific production condition. In fact, it is argued here that these analyses provide combinatorial possibilities allowed by the language, which can be instantiated in particular processing conditions.

As far as BP is concerned, a null object language, it is possible that non-standard RCs are derived from a topic position – a left-dislocated phrase. Left-dislocated elements are generated to the left of the sentence and are resumed by either overt or null pronouns. In the case of RCs formed from left-dislocated structures, it is the left-dislocated element

⁵ The following examples from Kayne (1994) provide evidence for raising analyses, that is, that the relativized element is interpreted internally to the RC. Example (i) rests upon the fact that some types of DPs are only licensed if followed by a RC; example (ii) illustrates the case of idioms, which shows that the external head has to be interpreted inside the RC; example (iii) shows that Condition A of the Binding Theory, which requires that anaphors be c-commanded by the antecedent (variable binding), is satisfied:

- (i) *The Paris was beautiful./The Paris that I knew was beautiful.
- (ii) The headway that Mary made
- (iii) A photo of himself ${}_i$ that every boy ${}_i$ liked

By its turn, example (iv) is evidence for a matching analysis, that is, the relativized element is externally interpreted. Condition C of the Binding theory requires that an R-expression is free, so it should not be c-commanded by the pronoun inside the RC:

- (iv) The picture of John ${}_i$ which he ${}_i$ saw

(a DP) that is being relativized, which explains why, in non-standard RCs in BP, there is always a default relative pronoun/complementizer. The head noun will also be resumed by an overt pronoun (giving rise to resumptive RCs) or by a null pronoun (giving rise to chopped RCs; cf. (21a); Kato & Nunes 2009).⁶ This strategy would minimize the computational cost since, unlike the standard strategy, the relativized element is resumed as the topic of the embedded clause. Hence, the subject of the RC does not count as an intervening element as it does in the standard non-subject RCs (Grillo 2008). It can be argued then that this kind of RC is cost equivalent to subject RCs.

This RCFS can be unequivocally attested in PP/IO and GEN RCs, as seen in the examples provided below. Prepositions only appear in their base position (but never adjacent to the relative pronoun) if followed by a resumptive pronoun, otherwise they are deleted and a null pronoun is used (21b). The special genitive pronoun (*cujo*, ‘whose’) is absent (21c).⁷

- (21) a. [_{DP} A [_{CP} [_{DP_k} menina_i [_{DP} que t_i] [_{CP} [_{LD} DP_k [_{TP} a tia falou _{-k}/dela)_k]]]]]
- b. A menina que a professora falou <null>/dela
the girl that the teacher talk.PAST <null>/of-her.3SG.FEM
‘the girl that the teacher talked about her’
- c. O menino que a caneta <null>/dele desapareceu
the boy that the pen <null>/of-he.SG.MASC disappear.PAST
‘the boy that his pen disappeared’

With regard to DO, both chopping and standard strategies would provide a similar outcome, given that null objects are allowed in this language. Stress shift in particular contexts may, in any case, distinguish the RCFS adopted (null pronouns would block stress shift, but traces/copies of moved elements would not) (see Nunes & Santos 2009). Given the context of elicited production in the present study, this possible distinction was not explored here.

This investigation focused, then, on the production of RCS in different conditions regarding planning, addressing particularly the types of RCFSs speakers would resort to, as described in the experiment reported below.

3 Experiment: Elicited production of RCs in fully and partially planned situations

The experiment reported here was intended to elicit the production of non-subject restrictive RCs. The participants were introduced to two images of similar characters (one of which is the referent of the object of the clause about to be or being produced) and asked to read aloud and continue a preamble (see appendix) in such a way that the intended referent is distinguished by means of a noun modifier. In this experiment, only RCs would be suitable for distinguishing one of the two characters presented.

The independent variables were as follows: **Sentence Planning** (between-subjects factor), with two processing conditions (fully planned (FPlan) and partially planned (PPlan)); and **Type of RC** (within-subjects factor) with three levels of structural complexity (DO, IO, and GEN). The dependent variable was the number of standard RCs produced.

⁶ Movement proceeds from the topic position (LD in (21a)) to a higher position, being resumed by an overt/null pronoun (Kato & Nunes 2009).

⁷ Relative pronouns in BP: *que* ‘that/who/which’ (the same form can be a complementizer or a relative pronoun); *o qual, a qual, os quais, as quais* ‘which/who’ (composed of an article, expressing gender and number and the pronoun, expressing number); *cujo, cuja, cujos, cujas* ‘whose’ (expressing gender and number); all of these may be preceded by a preposition. Notice that the possessive relation in BP may be codified in a PP, which makes its form similar to IO structures.

The rationale of this experiment was the following: an FPlan condition portrays a speaker who intends to distinguish a particular referent of a certain kind in a given context, making use of a DP containing an RC. The speaker knows that the RC is indispensable in order to unequivocally distinguish this referent. The computation of RCs in such a condition would be compatible with analyses in which the RC is taken as a complement, as most raising analyses, and the speaker knows the grammatical function of the DP inside the RC in advance. Consequently, the need for this constituent to be moved to the head noun position can be anticipated (from inside [John likes] to the CP domain and from there to the complement of D) (cf. (22)).

(22) ${}_{DP}$ [the ${}_{CP}$ [${}_{DP}$ [book] ${}_i$ [${}_D$ which t_i]] ${}_j$ John likes t_j]

A PPlan condition, by its turn, portrays a speaker who notices that a non-modified DP is insufficient for the identification of the intended referent, while syntactically encoding this referential expression. In this case, a noun modifier must be encoded in a highly incremental fashion. Noun modifiers include adjectives, PPs, and RCs, with the latter being the most demanding one. If an adjective or a PP cannot express the distinguishing property of the referent at stake, a RC must be adjoined to the DP. This online solution is compatible with the combinatorial possibilities described by head external/matching analyses, in so far as the head noun is generated outside the RC.

(23) ${}_{DP}$ [the ${}_{NP}$ [book] ${}_i$] [${}_{CP}$ [Op/which book] ${}_j$] John likes t_j]

In the light of these analyses, it can be assumed that no specific type of RC needs to be planned in advance when this structure is computed in real time. In fact, a non-modified DP can actually be produced (articulated) before an RC is computed, when the grammatical function of the relativized element cannot be anticipated. The key distinction for accommodating highly incremental production of RCs is therefore their characterization as an adjunct.

Since incrementality places a burden on processing, not only does an adjunction configuration of non-planned RCs seem more suitable, but simpler structural configurations would be expected to emerge as well. It is thus predicted that, in a processing condition where a restrictive RC cannot be planned in advance, it is very likely that the speaker will rely on non-standard RCFs.

Given these considerations, it can be predicted that, if **Sentence Planning** affects the participants' reliance on the standard RCFs, then more of these responses are expected in the FPlan condition. Regarding **Type of RC**, it is possible to verify the extent to which the structural complexity of the RC affects and interacts with the specific processing conditions created.

3.1 Method

Participants: Forty adult native speakers of BP (11 male) (age range: 18–48 years) took part in the study. All participants were undergraduate/graduate students who either volunteered to take part or obtained an extra-curricular activity credit for their participation. They were distributed in two groups, with a similar number of male and female participants in each.

Material: The material consisted of three sets of slides: 3 for training, 18 for test sentences (6 per experimental condition), and 55 for fillers. The slides presented a written preamble in the form **Subject Transitive Verb Adv...**, with an image of two characters and a full sentence stating some information directed to one of them by an arrow (cf. **Figures 1** and **2**). The participants were asked to complete the preamble sentence in order to identify one of the characters. In the training and in the filler sets, the characters

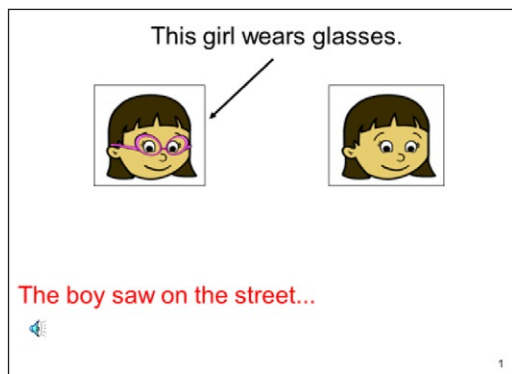


Figure 1: Training/filler slide.

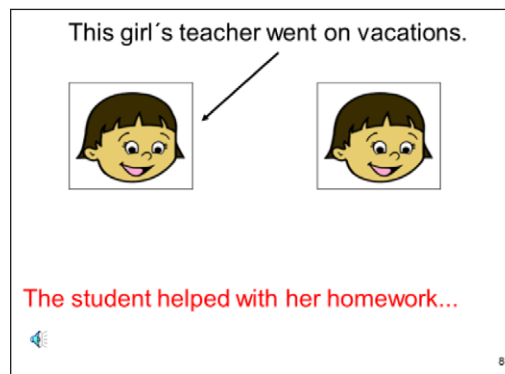


Figure 2: Test slide.

were visually distinguished in such a way that different sorts of noun modifiers could be produced (adjective, a PP, or a Subject RC). In the test set, the characters were visually indistinguishable. Only restrictive DO, IO, or GEN RCs were expected. Action and psychological verbs were counterbalanced.⁸ For each group defined by *Sentence Planning*, the distinguishing information introduced with an arrow was presented at different moments. For the FPlan group, it was presented as soon as the images appeared in the slide. In the PPlan group, however, this critical information was presented 5 seconds after the presentation of the preamble and the image (roughly as the DO of the main clause in the preamble started to be produced).

Apparatus: A Toshiba laptop, with the programming platform *LabVIEW*, was used for the stimulus presentation.

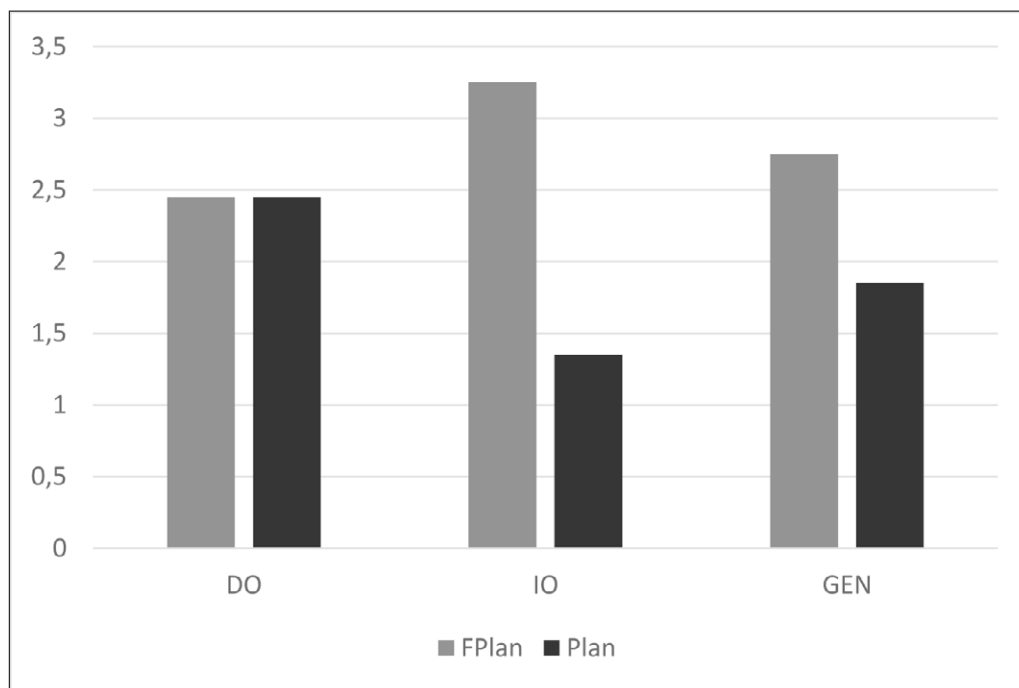
Procedure: The participants were told that the study was about how speakers of BP identify a character when reporting an event. The overall description of the procedure was initially explained orally by the researcher. He/she was then transferred to a sound-proof cabin/silent room equipped with the computer. Written instructions were presented on the screen and a training session was conducted in the presence of the researcher. The participants were instructed to read aloud the preamble and to continue completing the preamble sentence orally, in a natural way, in order to identify one of the characters to a possible hearer. The experimenter left the cabin after being assured that the procedure had been understood. The whole session took approximately 20–25 minutes. The data were recorded using the computer to be transcribed later.

3.2 Results

Standard RCFSs (target responses) were scored 1 for the statistical analysis (Max score: 6 per condition) and non-target responses were scored zero. The latter were categorized in the breakdown of responses (cf. section 3.3).

Graph 1 presents the mean standard responses obtained in each condition. These data were submitted to non-parametric statistical tests since the distribution for each variable did not meet normality standards. The homogeneity of variances was, nevertheless, preserved, and the skewness values were all positive, indicating symmetrical distributions, and close to zero. A Mann-Whitney test indicated that the number of standard responses was greater for the FPlan condition (Mdn = 24.38) than for the PPlan condition (Mdn = 16.63), $U = 122.5$ $p = .035$. The Friedman test for differences across repeated measures (for *Type of RC*) was conducted and rendered a Chi-square value of 0.105, which was not significant. The direction of the means for each type of RC was,

⁸ Type of verb was initially considered as a possible independent variable in light of the data in Gennari & MacDonald (2008). This factor did not, however, have a significant effect during a pilot study.



Graph 1: Mean standard responses as a function of **Sentence Planning** and **Type of RC**.

nevertheless, different in each **Sentence planning** condition (see **Graph 1**). The means for DO RCs were identical in the two planning conditions. In the case of IO and GEN, however, while the number of IO and GEN standard responses was greater than the number of DO standard responses in the FPlan condition, the opposite was observed in PPlan. The standard responses for IO and GEN were submitted to a Mann-Whitney test, and the result was significant: there were a greater number of standard responses for the FPlan (Mdn = 25.2) than for the PPlan condition (Mdn = 15.8), $U = 106$ $p. = .01$. This effect was particularly due to IO sentences. When IO and GEN responses are analyzed separately, the result is significant for IO (Mdn = 25.55 for the PPlan condition, Mdn = 15.45 for the PPlan condition), $U = 99$ $p. = .01$, and approaches significance for GEN sentences (Mdn = 22.98 for the FPlan and 18,03 for the PPlan), $U = 150.05$ $p. = .08$ (one-tailed).

The effect of **Sentence Planning** was in the predicted direction, suggesting that the pressure of highly incremental processing affects the online computation of RCs by means of the standard strategy. It was, nevertheless, the elicitation of IO and GEN sentences that was affected by this variable. The absence of a significant effect of **Type of RC** is mainly due to the small number of DO standard responses, which were expected to be less demanding than IO and GEN, and to the relatively high number of GEN responses, in comparison with IO. The following breakdown of the responses seeks to clarify this point.

3.3 Breakdown of responses

Non-target responses (alternative responses) were categorized as follows: passive subject RCs; non-standard chopped and resumptive RCs; and others. **Table 1** illustrates the conditions in which each alternative response is applicable.

Table 2 provides some examples for each category of response present in the data.

Tables 3 and **4** provide percentage responses to DO and IO-GEN, respectively.

Table 3 shows that not only is the number of standard DO responses similar in the two planning conditions, but also the number of passive subject RCs does not vary between groups. Adults, like children (cf. Friedmann, Belletti & Rizzi 2009), seem to avoid the cost of DO by relying on the lower cost subject RC, suggesting that the relative cost of

Table 1: Categorization of non-target responses per sentence type.

Non-target responses	DO	IO	GEN
Passive subject RC	✓	N/A	N/A
Resumptive RC	✓*	✓	✓
Chopped RC	??	✓	✓
Others	✓	✓	✓

* Not present in the data.

Table 2: Examples of non-target responses.

NON-TARGET RESPONSES	EXAMPLES
Passive subject RCs	o menino que foi assustado pelo palhaço the boy that be.PAST.3SG scare.PART.SG.MASC by-the clown 'the boy who was scared by the clown'
Non-standard chopped PP/IO RCs	a menina que o turista falou the girl that the tourist speak.PAST 'the girl that the tourist spoke to'
Non-standard resumptive PP/IO RCs	o menino que o advogado concordou com ele the boy that the lawyer agree.PAST with he.3SG.MASC 'the boy that the lawyer agreed with him'
Non-standard chopped GEN RCs	a menina que o professor saiu de férias the girl that the teacher go.PAST on vacation 'the girl that the teacher went on vacation'
Non-standard resumptive GEN RCs	o menino que o técnico dele perdeu a hora the boy that the coach of-he.3SG.MASC lose.PAST time 'the boy that his couch got late'
Other response: Inappropriate genitive relative pronoun for a different structure	a menina cujo campeão treinou the girl whose champion train.PAST 'the girl whose champion trained'
Other response: Subject RCs with reversed thematic relations	a menina que havia ajudado um estudante the girl that had help.PART a student 'the girl that had helped the student'
Other response: Simpler semantically equivalent structures with different verbs	o menino que levou um susto do palhaço the boy that take.PAST a fright from the clown 'the boy that took a fright from the clown'
Other response: Disrupted outcomes	a menina loira sorridente, não, não dá, não sei... the girl blonde smily, no, no, no know.PRES 'the blond smiling girl, no, no, I don't know...'

passive sentences is lower than the cost of an object RC. The availability of this cost reduction strategy can explain why DO sentences presented the smallest number of standard responses in the FPlan condition, and why sentence planning did not have an impact in the production of this type of RC. It cannot be ruled out, however, that the standard responses may in fact be instances of the chopping strategy in general or in the most demanding tasks. Further investigation in which stress shift can be contrasted may clarify this point (Nunes & Santos 2009). Resumptive pronouns were not a productive alternative to this type of RC, which is compatible with findings in both diachronic and synchronic studies (Tarallo 1983; Lessa de Oliveira 2009; Silva 2011).

Table 4 shows that the number of chopped and resumptive RCs to IO and GEN is greater in the PPlan condition. These responses were submitted to a Mann-Whitney test.

Table 3: Distribution of responses (%) to DO RC (Total = 120).

Type of response	Sentence Planning	
	Fully planned	Partially planned
Standard	40.8	40.8
Passive	39.2	32.5
Resumptive pron	00.0	00.0
Others	20.0	26.7
Total	100.0	100.0

Table 4: Distribution of responses (%) to IO and GEN RCs (Total = 120).

Type of response	Sentence Planning			
	Fully planned		Partially planned	
	IO	GEN	IO	GEN
Standard	54.2	45.8	22.5	30,8
Chopped	15.8	17.5	30.8	19.2
Resumptive pron	0.8	00.0	5.0	1.7
Others	29.2	36.7	41.7	48.3
Total	100.0	100.0	100.0	100.0

The number of these non-target responses was greater in the PPlan (Mdn = 23.5) than in the FPlan condition (Mdn = 17.5), $U = 140$, $p = .046$ (one-tailed). It can also be noted that, for both IO and GEN RCs, there is a relatively high number of *other* responses. These included inappropriate use of a relative pronoun (genitive case marked pronoun *cujo/a* [whose]) in DO and IO RCs, and *o qual* [which/that] in GEN sentences (see **Table 2**). The misuse of the genitive case marked relative pronoun in DO and IO RCs suggests a disruption in the post-syntactic retrieval of the morphophonological form of the relative pronoun. The educated participants of this study may have tried to be as close as possible to the standard RC form in the test situation. The post-syntactic retrieval of this pronoun may explain at least some of the standard responses for GEN RCs. They may result from a chopped strategy followed by the post-syntactic retrieval of the genitive case marked relative pronoun. The production of RCs with reversed thematic relations, simpler semantically equivalent structures with different verbs, and disrupted outcomes were also categorized as *other responses* (see **Table 2** for examples). All of these suggest an effect of the demands of the highly incremental processing of the PPlan condition.

In sum, relying on alternative RCFSs may be associated with high processing demands. The possibility of passive subject RCs as an alternative to DO enables these demands to be circumvented. The effect of high incrementality is particularly noticeable in chopped RCs, in resumptive RCs, and in a variety of responses that seem to be last resort solutions to prevent the total disruption of the syntactic computation. The possibility of a post syntactic retrieval of a genitive case marked relative pronoun makes standard GEN RCs less informative as a measure of processing demands. The IO RCs emerge as the most informative structure for the effect of the degree of incrementality on the relative clause formation strategies upon which the speaker can rely.

3.4 General discussion

The present results support the view that the degree of incrementality in sentence production can determine the sort of RCFS that is relied upon in the grammatical encoding of the sentence. The PPlan condition did result in considerable processing demands. Reliance on

non-standard RCFSs as a function of these demands can be clearly attested in the most demanding RCs – IO and GEN, particularly in IO RCs.

IO RCs are structurally more complex than DO RCs, and do not allow for semantically equivalent subject RCs to be produced, nor for a chopped strategy to result in an apparent standard response. Additionally, unlike GEN, standard responses cannot result from the post-syntactic insertion of a case marked pronoun. In these sentences, the omission of the preposition is unequivocal evidence of speakers' reliance on a non-standard procedure. How is syntactic computation carried out when it is hard for the standard strategy to be pursued? Would different forms of conceiving the structural relations between the relative and the main clauses provide some clue to an online model?

4 The on-line computation of RCs in different planning conditions

In this section, the online computation of RCs in FPlan and PPlan conditions is characterized in the light of the analyses adopting the RC as a complement or an adjunct, as well as in relation to the non-standard combinatorial possibilities. It must be emphasized that the characterization of online computation (in production/comprehension) cannot be equated with the derivation of sentences in a formal model of grammar for a number of reasons. In particular, the bottom-up direction of current grammatical derivations cannot capture incremental procedures (Phillips 1996; Corrêa 2008; Corrêa & Augusto 2011). In the following online characterization, computation is assumed to be carried out bi-directionally in parallel derivational spaces. The formal features of functional elements are assumed to be directly related to what can be conceived of as intentional systems, since they are essential for the definition of the illocutionary force, for situating the event presented by a sentence in time, and for the reference to entities in the world. Elements of the lexical categories, in turn, are mainly composed of semantic features for the encoding of conceptual information, which is compatible with the view that these elements are directly related with conceptual systems. Given these considerations, functional items are assumed to give rise to top-down generated functional skeletons (CPs and DPs derived in parallel spaces). NPs (or max N) and VPs (or max V) are in turn constructed in a bottom-up fashion (given the categorial and semantic requirements of these lexical elements) (Corrêa 2005). They occupy minimal and maximal syntactic positions in the top-down generated phrase markers under construction, being attached as complements of the functional nodes (TP, DP) when the structures generated in parallel spaces are assembled (Corrêa 2005; Corrêa & Augusto 2007; 2011).

Such bi-directionality enables distinguishing the conditions that result in RCs being computed as complements or adjuncts, as well as the conditions in which non-standard RCFSs are adopted.

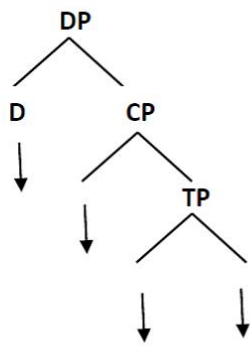
It has been argued here that the computation of RCs as complements of D is particularly suitable in the FPlan condition, since the grammatical function of the relativized element in the RC can be anticipated. The diagrams in (25) and (26) below illustrate how this possibility can be implemented online, for a RC as (24), given the standard RCFS.

(24) O professor viu a menina sobre a qual o diretor falou.
the teacher saw the girl about the.SG.FEM whom the dean talk.PAST

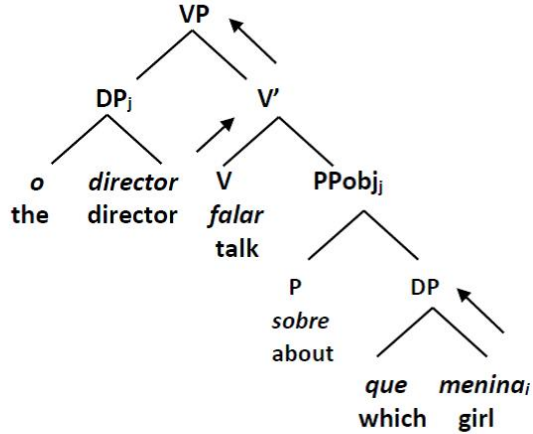
In (25), a functional skeleton based on DP (min/max), CP (min/max), and TP (min/max) is generated. The CP is assumed to be a complement of D. In a parallel space, a VP is generated in a bottom-up fashion.⁹

⁹ Tree diagrams are simplified (for example, a vP domain is not represented).

(25)



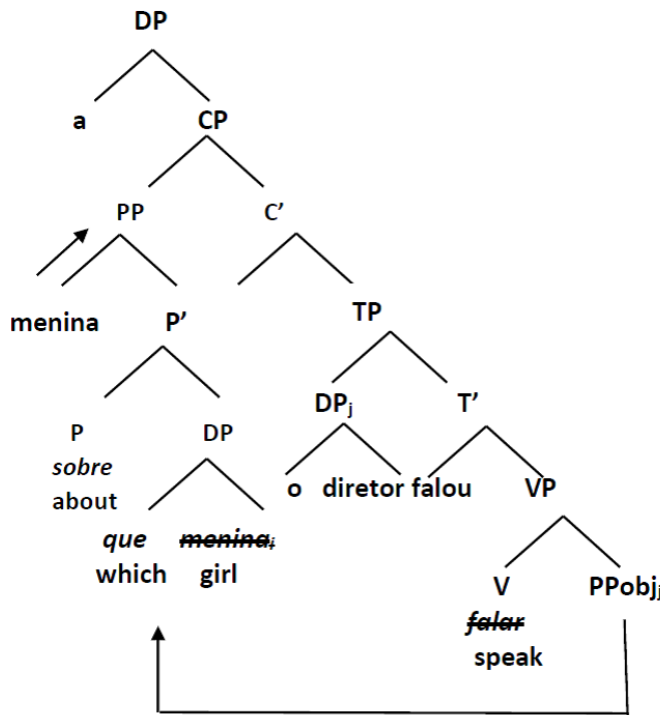
Assembling of a DP with a CP/TP skeleton as complement



Assembling of the VP structure to be attached to the CP skeleton as a complement of T

The phrase markers are combined so that the VP occupies its position as the complement of T, while the whole PP is moved to Spec, CP (see (26)).¹⁰ It is clear that by the time the first left-to-right chunk is transferred to phonological encoding, the syntactic relation that grammatically encodes the identification of a particular referent has already been computed.

(26)

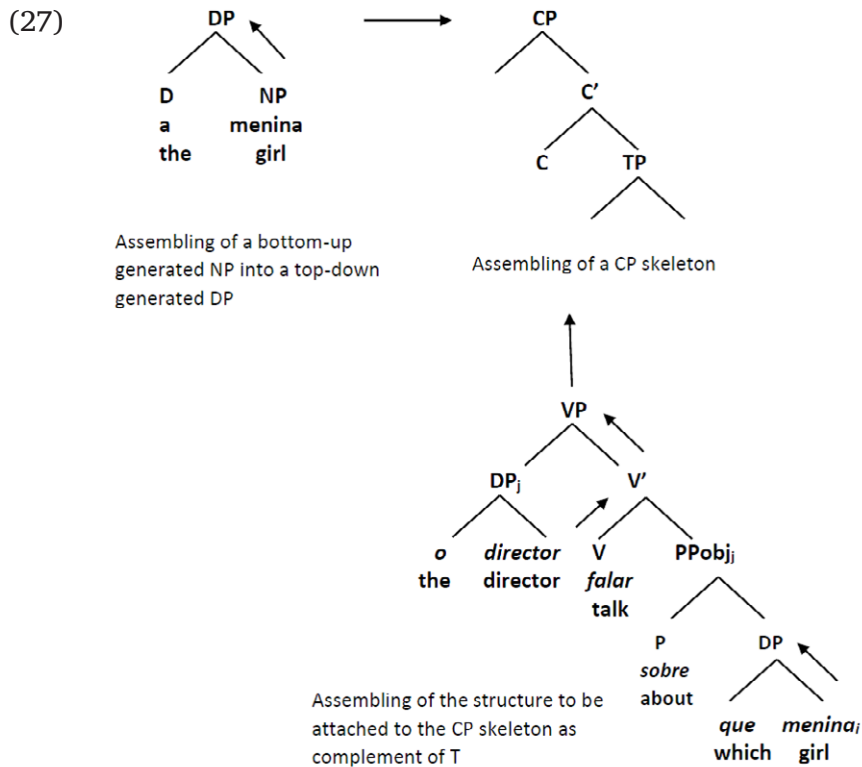


Attachment of the parallel generated phrase markers and movement of the PP to the CP domain

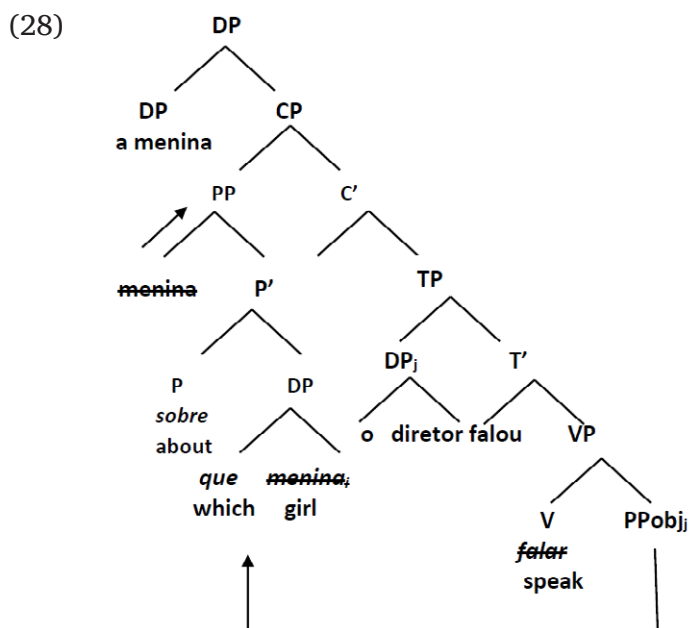
Regarding the PPlan condition, a top-down DP functional skeleton is generated, without a CP as complement (27). It is only when the DP has been transferred to phonological encoding and starts to be articulated that the speaker takes into account the need to specify its

¹⁰ There is also an internal movement of *menina/girl* to Spec PP.

referent (the idea of DPs as phases is assumed (Augusto, Corrêa & Forster 2012; Forster & Corrêa 2017). At this point, the speaker has no choice but to generate an independent CP to be adjoined to the DP. Notice that this sort of computation requires, in the online model proposed, that three phrase markers are dealt with simultaneously, which is made possible by the parallel derivational spaces assumed (see also Nunes & Uriagereka 2000).

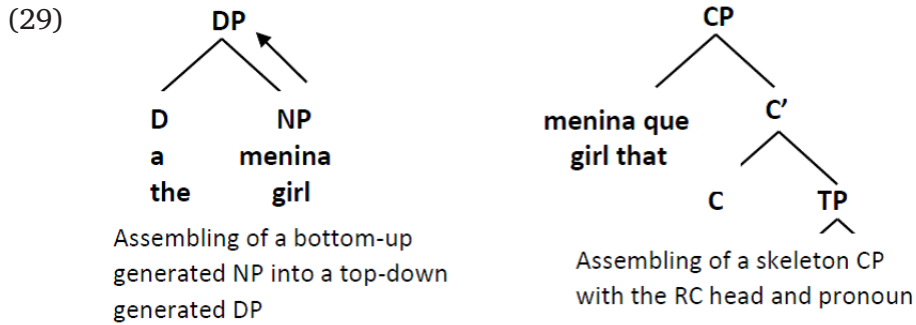


Moreover, in the PPlan condition, the additional computation cost stems from the need to assemble a structure in which the grammatical function of the relativized element has not been anticipated and is still being computed. It would thus be quite demanding, particularly when the relativized element is inside a PP, as in (28).

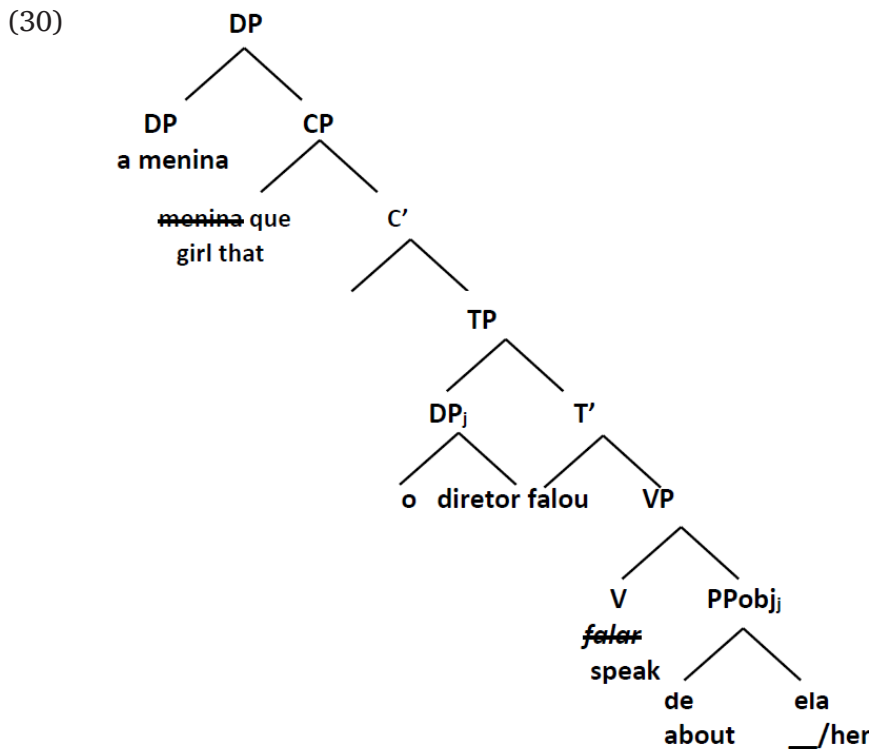


The view of computational cost expressed in this online model can provide an explanation for the differential demands that the two planning conditions compared here impose on the production of standard RCs.

The online computation of non-standard IO RCs, likely to occur in the PPlan condition, is characterized below. When an IO restrictive RC cannot be anticipated, a default relative pronoun may be generated alongside the head noun in the CP functional skeleton (29).

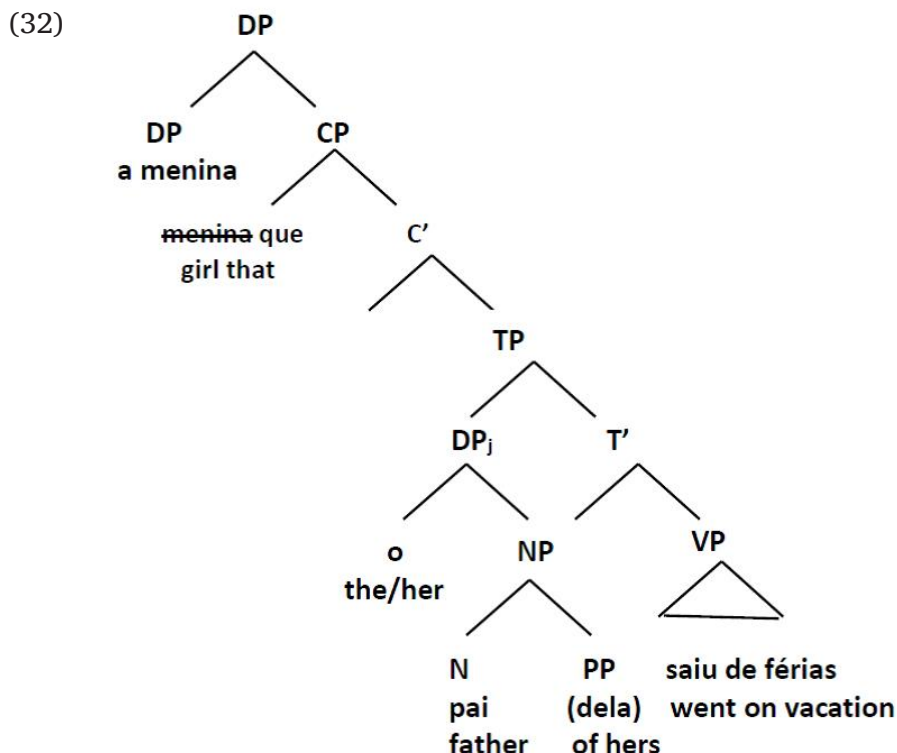


In this sense, when the actual PP RC is computed, there is no choice but to adhere to either preposition stranding (in languages like English) or a resumptive pronoun (overt or null, as in BP) (30).



As for GEN RCs, if a default relative pronoun is assumed in the CP domain, the possessor relation of a (non-anticipated) GEN RC must be expressed by a resumptive pronoun (31) (see (32)), as it is attested in current language use and children’s production (McKee & MacDaniel 2001; Gennari & MacDonald 2008):

- (31) A menina que o pai (dela) saiu de férias.
 the girl that the father (of-she.3SG.FEM) leave.PAST on vacation
 ‘The girl that her father went on vacation.’



The discussion of the actual computation of RCs in the context of a model of sentence production shows that the speaker's reliance on the possibility of RCs being derived as a complement of D can be favored when the need for a restrictive RC is anticipated from the start of the sentence planning (although the computation of the RC as an adjunct cannot be ruled out).¹¹ With regard to the PPlan condition, however, the derivation of RCs as complements is most unlikely, since it is only when a DP is about to be closed as a unit that the speaker can realize the need for adjoining a noun modifier.¹²

In sum, both complement and adjunct analyses of RCs are computational options provided by the grammar, upon which the speaker can rely. There are independent arguments in the literature for both types of analyses. In this paper, this discussion was conducted from the point of view of the actual production of RCs in different conditions. The online computation of RCs in the light of these analyses not only accounts for the differential demands of the production of standard RCs in different planning conditions, but also captures the dynamics of the non-standard procedures that either minimize computational cost or are used as a sort of last resort strategy.

5 Final remarks

This paper has provided empirical evidence for the differential demands of the production of restrictive RCs as a function of the degree of incrementality of the task. A fully planned processing condition facilitates the speaker's reliance on the standard (more demanding) RC formation strategy whereas a partly planned condition favors the non-standard ones, as became particularly clear in the production of IO RCs. Current colloquial language use is likely to promote the sort of incremental planning captured in the partially planned condition created here. It may explain the speakers' reliance

¹¹ As one reviewer has pointed out, RCs as adjuncts could also fit the FPlan condition, given the extra time speakers would have for planning the structure.

¹² It should be recalled that, in BP, the online computation of RCs can also be conceived of as derived from the left-dislocated position (cf. (21a)), giving rise to a potentially low-cost procedure.

on non-standard strategies in informal situations, even though these strategies are not allowed in written language and some of them can be stigmatized in formal language use by educated speakers.

Each of the two types of current competing analyses of RCs considered here seem to better account for the sort of grammatical relations established in each of the processing conditions compared. On the one hand, the online computation of RCs as complements of D suits the early planning of a restrictive RC very well. On the other hand, only RCs as adjuncts would be able to account for the late planning of a restrictive RC. Even though RCs as adjuncts could be generalized to both conditions, it is our contention that both possibilities can be available in the grammar. Formal analyses of RCs can be viewed as possibilities for the online computations that the speaker can carry out on different processing conditions. This relation between formal analyses and online computation has enabled the cost of producing RCs to be associated with the amount and nature of the processing operations carried out in real time. It has also provided an explanation for the presumption that non-standard strategies reduce costs.

It appears that linguistic analyses carried out in the current generative framework, in which grammatical principles incorporate constraints imposed by the cognitive apparatus involved in language processing,¹³ facilitates a closer relationship to be resumed between formal linguistics and psycholinguistic research – as long as a clear distinction between computation in a formal model of language and online computation is maintained. The sort of online modeling provided here illustrates the possibility of integrated work between linguistic and psycholinguistic research.

Abbreviations

ACC = accusative, BP = Brazilian Portuguese, CP = complementizer phrase, DO = Direct Object, DP = determiner phrase, FEM = feminine, FPlan = full planned, GEN = Genitive, LD = left-dislocated, MASC = masculine, Mdn = median; NP = noun phrase, Op = operator, p = probability; PART = participle form, PAST = past tense, PL = plural, PP/IO = Prepositional Phrase/Indirect Object, PPlan = partly planned, PRES = present tense, RC = relative clause, RCFs = Relative Clause Formation Strategies, SG = singular, SLI = Specific Language Impairment, Subj = Subject, TP = tense phrase, U = The Mann-Whitney test statistic; vP = little verbal phrase, VP = verbal phrase, 3 = third person.

Additional File

The additional file for this article can be found as follows:

- **Appendix.** Linguistic material for eliciting the production of relative clauses by Portuguese-speaking adults. DOI: <https://doi.org/10.5334/gjgl.401.s1>

Ethics and Consent

The study was approved by the Ethics committee of the Pontifical Catholic University of Rio de Janeiro following the standards of the Resolution 466, from Conselho Nacional da Saúde (Health National Council), according to Helsinki Declaration (1964).

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¹³ The Principle of Full Interpretation and the satisfaction of economy conditions (Chomsky 1995 and thereafter) are assumed here to be the means whereby a formal model of language can guarantee the processability of the structures generated, i.e. the possibility of linguistic utterances being perceived/articulated, semantically interpreted, and mapped onto referents and events.

Competing Interests

The authors have no competing interests to declare.

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