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The influence of referentiality on relative clause processing in Brazilian Portuguese

A influência da referencialidade no processamento de orações relativas em português brasileiro

Gitanna Brito Bezerra
Universidade Federal da Paraíba, João Pessoa, Paraíba / Brasil
gitannabezerra@gmail.com

Márcio Martins Leitão
Universidade Federal da Paraíba, João Pessoa, Paraíba / Brasil
profleitao@gmail.com

Lorrane da Silva Neves Medeiros
Universidade Federal do Rio de Janeiro, Rio de Janeiro, Rio de Janeiro / Brasil
lorranesnm@hotmail.com

Abstract: In this paper we report two experiments that were conducted to investigate the influence of referentiality on the processing of relative clauses associated with complex noun phrases of substance reading (like "the bag of (the) leather"). The self-paced reading task showed an immediate preference for high-attachment, revealing a strong influence of N1 referentiality on relative clause processing. The eyetracking study, in turn, revealed an immediate effect of N2 referentiality: low attachment is favored when the N2 is referential and high attachment is preferred when the N2 is non-referential. Our data are in tune with the general proposal of the Construal Hypothesis (FRAZIER; CLIFTON, 1996).

Keywords: processing; relative clauses; referentiality.

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Resumo: Neste artigo apresentamos dois experimentos que foram conduzidos para investigar, no português brasileiro, o papel da referencialidade no processamento de orações relativas associadas a Sintagmas Nominais complexos (SNs complexos) do tipo substância (como "a bolsa de (do) couro"). O experimento de leitura automonitorada revelou uma preferência imediata pela aposição não local, evidenciando uma forte influência da referencialidade do N1 no processamento da oração relativa. O experimento de rastreamento ocular, por sua vez, revelou um efeito imediato da referencialidade do N2: uma aposição local é favorecida quando o N2 é referencial e uma aposição não local é preferida quando o N2 não é referencial. Nossos dados vão na direção do que é proposto pela Hipótese de *Construal* (FRAZIER; CLIFTON, 1996).

Palavras-chave: processamento; orações relativas; referencialidade.

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1 Introduction

In the field of Experimental Psycholinguistics, different sentence processing models seek to explain how subjects understand and produce language. Specifically regarding the linguistic comprehension process, such models differ, in general, as to the path proposed and undertaken to reach a sentence's interpretation. In this field, the Garden Path Theory (FRAZIER, 1979; FRAZIER; RAYNER, 1982) proposes that the interpretation of a sentence presupposes a syntactic structure: the meaning of a sentence is constructed compositionally as the parser, the sentence processor, assigns a syntactic structure to the linguistic input. This theory assumes, more specifically, that the parser, in its initial attribution of a syntactic representation to a linguistic input, has limited access to the syntactic information, and cannot, for instance, access discursive information immediately to decide if it attaches a noun phrase X to a location Y or a location Z. Decisions of this nature, originating from structural ambiguities, would, in fact, be made automatically according to a general principle: "Choose the first available analysis" (FRAZIER, 1987). An attachment is immediately determined by first considering the

analysis which requests the lower number of syntactic nodes (Minimal Attachment) and, in the case of two analyses of the same structural complexity, the analysis that implies an attachment to the phrase or clause currently being processed (Late CLosure).

This necessary initial analysis determination was rethought when the Garden Path Theory was reformulated, resulting in the Construal Hypothesis (FRAZIER; CLIFTON, 1996). One of the motivations for this reformulation was the emergence of experimental evidence that diverged in relation to the Late Closure principle predictions. In a sentence such as "*Alguém atirou no empregado da atriz que estava na varanda*" ("*Someone shot the servant of the actress who was on the balcony*"), such a principle predicts a systematic preference for the attachment of the relative clause to N2, "the actress", rather than to N1, "the servant". However, in a seminal work, Cuetos and Mitchell (1988) reported evidence that Spanish speakers in fact preferred the attachment to N1, while English speakers preferred the attachment to N2. Since then, this type of structure with a relative clause has become the focus of experimental studies in several languages, resulting in different hypotheses in the attempt to explain the absence of a systemic nature in preferences for analysis among the languages (CUETOS; MITCHELL, 1988; GIBSON; PEARLMUTTER; CANSECO-GONZALEZ; HICKOK, 1996; FODOR, 1998, 2002; HEMFORTH; KONIECZNY; SEELIG; WALTER, 2000; MAIA; FERNÁNDEZ; COSTA; LOURENÇO-GOMES, 2006; GRILLO; COSTA, 2014; HEMFORTH; FERNANDEZ; CLIFTON; FRAZIER; KONIECZNY; WALTER, 2015).

In this context, the Construal hypothesis emerged, acknowledging the relevance of the Late Closure principle and emphasizing that, before giving emphasis to the attachment differences observed among the languages, and before questioning the universality of such a principle, it would be necessary to observe the different existing analysis preferences in the same language, depending on what structure type had been focused upon. Therefore, the Construal hypothesis formalized a distinction between primary and secondary phrases. The first type refers to the subject and the main predicate in a finite clause, as well as to its mandatory constituents and complements. The second type refers to the phrases that cannot be analyzed, not even temporarily, as primary phrases. Secondary phrases "known as potentially primary" will have their "primary" status accessed first. To simplify, the first type of relation

refers to argument phrases and the second refers to adjunct phrases. The key to this distinction is the assumption that the parser employs different analysis mechanisms depending on the type of structure in question. Therefore, in face of an ambiguity involving the analysis of a primary phrase, the parser is subject to pressure to determine the lexical description of a given lexical head and proceeds to an immediate attachment, following structural principles – a given analysis is, thus, automatically constructed. However, such pressure is not present in an ambiguity involving an adjunct, given that this element is not involved in the specification of the properties of lexical heads, allowing for an initial underspecification in the syntactic phrase marker – the parser, in this case, proceeds to an association.

Having made this distinction, Frazier and Clifton (1996) proposed the hypothesis that the parsing of relative clauses, such as those previously mentioned, would not exhibit a systematic analysis preference among the languages, since it would be subject to the influence of both structural information and, crucially, non-structural information. Investigating the factors that could influence the processing of relative clauses, the authors proposed, for instance, the Referentiality Principle, according to which restrictive relative clauses are preferentially attached to referential heads. The present research focuses on this principle.

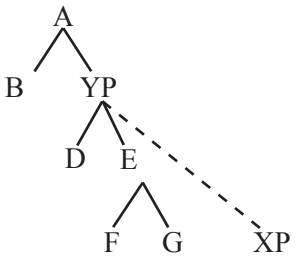
This paper reports on two experiments in Brazilian Portuguese (one self-paced reading and one eye tracking experiment) that were conducted to investigate the influence of this non-structural information of referentiality. Taking the obtained results into account, this work will discuss how much the subjects are led by non-structural information in online processing, and how sensitive and faithful they are to the gender information when used as disambiguating material. To support this discussion, the text will be organized as follows: in section 2, the Construal proposal will be addressed by presenting the notion of initial syntactic underspecification and the Referentiality principle; section 3 presents the two conducted experiments; and section 4 presents a general discussion of the results.

2 The Construal of relative clauses

The Construal Hypothesis (FRAZIER; CLIFTON, 1996, 1997) predicts the following for the processing of secondary phrases: a

secondary phrase must be attached to the thematic processing domain (the extended maximal projection of the last theta assigner) and must be interpreted by using structural and non-structural information. The association process, specifically, presupposes the possibility of a limited syntactic underspecification, briefly mentioned, which refers to the fact that, in constructing a syntactic representation, the parser can leave dominance and sisterhood syntactic relations not completely specified. In the following Figure, this syntactic underspecification is shown by the dotted line, which associates the secondary phrase XP to the structure by means of the YP, which, in this case, would be the maximal projection of the last theta assigner:

FIGURE 1 – Association of a secondary phrase



Source: Frazier; Clifton (1997, p. 280).

Although the authors contend that the parser may not determine a structural analysis immediately, the proposition of an initial association to a specific thematic domain ensures the secondary phrase receives a minimum structuring (thus not remaining without structuring, "loose", which, if appropriate, would affect its maintenance in the working memory) until, in the subsequent interpretation process, it receives a specific analysis. Considering Figure 1, in the interpretation process, the access to syntactic and non-syntactic information enables a given attachment location to be selected by the secondary phrase (XP): "*If XP associates to YP then XP must take YP, or some node dominated by YP, as its sister*" (FRAZIER; CLIFTON, 1997, p. 279). It is understood, therefore, that, after the initial underspecification, a syntactic compromise is eventually performed, reaching a structural representation with duly determined syntactic relations.

Specifically regarding the association and interpretation processes of a relative clause, the referentiality of N1 and N2 is a non-structural information that, within the scope of the Construal, is treated as important in the analysis determination process. In general, the referential status of a given noun is related to its potential to refer or not to a discourse entity present in a discourse model, or to introduce a discourse entity in the discourse model under construction for a sentence. Based on this notion of what a referential noun would be, Gilboy, Sopena, Clifton, and Frazier (1995, p. 136) propose the Referentiality Principle:

> the heads of some maximal projections are referential in the sense that they introduce discourse entities (e.g., participants in events described in the discourse) into a discourse model (at least temporarily), or correspond to already existing discourse entities. Restrictive modifiers (e.g., restrictive relative clauses) preferentially seek hosts that are referential in this sense.

Specifically, the authors assume that a noun is referential when it is introduced by a determiner. According to the principle, if the current thematic domain includes a referential noun and a nonreferential noun, the relative clause will be attached to the referential noun, given that it, corresponding to a discourse entity, will be available for a restrictive modification, thus justifying the relative clause function. It should be noted that this principle would not have a specific prediction for cases involving noun phrases such as "*a filha do coronel*" (the colonel's daughter), as both nouns are in the same thematic domain and both are referential. The principle, according to the authors, could predict a specific preference for noun phrases such as "*a mesa de madeira*" (the wooden door) and "*a taça de vinho*" (the wine glass), the first being of the "substance" or "material" type, and the second being of the "quantity" (or "content" and "classification") type. In these types of phrases, it is more natural that N2 appears without a determiner, thus not being referential, with the entire complex NP seen as a single discourse entity. Consequently, in these cases, N1, which is referential, is seen as the preferred site for the attachment of the relative clause.

Gilboy et al. (1995) investigated, among other factors, this influence of the referential status in the processing of relative clauses by means of two questionnaires. Focusing on the "substance" NP, a

preference was identified, in questionnaires with English speakers and Spanish speakers, for the attachment of the relative clause to N1 in sentences such as "*Yesterday they gave me the sweater of cotton that was illegally imported*" (the Spanish version: "*Ayer me regalaron el jersey de algodón que importaban de contrabando*"), which contain only one referential noun: the N1. In a subsequent questionnaire, including only English speakers, the authors manipulated the referentiality of N2, making it referential as well: "*Yesterday they gave me the sweater of the cotton that was illegally imported*". The prediction was that the number of N2 answers would increase in this case, given that N2 is referential. In fact, the percentage of N2 answers increased from 26% for a nonreferential N2 in the previous questionnaire to 55% for a referential N2, thus corroborating the influence of the referentiality information in the analysis of relative clauses.

The Referentiality principle was first investigated in Brazilian Portuguese by Maia and Finger (2007). The authors conducted a questionnaire and investigated the influence of several types of complex noun phrases in relative clause processing. They also focused on the influence of prosodic factors in the attachment preferences. Regarding the noun phrase of substance type, the authors investigated the processing of sentences such as "*O técnico fez críticas à antena de metal que oxida*" (The technician criticized the metal antenna that oxidizes), in which only N1 is referential, and did not manipulate the referentiality of N2. The results followed the line of what is proposed by Gilboy et al. (1995): when presented with a referential N1 and a nonreferential N2, Brazilian Portuguese speakers opted for the relative clause attached to N1.

There is therefore evidence of the Referentiality principle, which basically refers to the off-line processing. A question that arises in this context is whether or not such information could influence the online comprehension of the relative clause, which leads to a broader reflection on the nature of the association and interpretation processes assumed by the Construal hypothesis. It should be noted that this hypothesis does not propose a specific analysis mechanism for the processing of adjunct phrases, as it does not clearly postulate how the interpretation process occurs and how persistent is the syntactic underspecification in the course of processing. It is therefore an open question for the Construal hypothesis to determine how fast the interpretation responsible for attributing a specific analysis to the underspecified material would

be, which results from the fact that it is unclear just how the parser has access to non-structural information that is responsible for determining an analysis. In processing primary phrases, specifically in the reanalysis process, the access to non-structural information by the parser is enabled by the thematic processor (RAYNER; CARLSON; FRAZIER, 1983; FRAZIER, 1990), which, for instance, translates information concerning the discourse and plausibility into readable vocabulary for the parser. It would also be necessary to clarify how the parser sees nonsyntactic information that is responsible for guiding it in determining the analysis of a secondary phrase (association > attachment).

Specifically considering what could lead or encourage the parser to progress from a phrase's association to its attachment, Swets, Desmet, Clifton, and Ferreira (2008) emphasize the role played by the experimental task demand, proposing a dialog between the Construal Hypothesis and the Good-Enough Theory (FERREIRA; BAYLEY; FERRARO, 2002; FERREIRA, 2003; FERREIRA; PATSON, 2007; KARIMI; FERREIRA, 2015). This theory's foundation is the following: language processing does not necessarily involve the construction of accurate, detailed, and complete linguistic representations, and this would result from the fact that, in an actual communication situation, the purpose of the comprehension system would not be to produce optimal representations based on thorough syntactic computing, but rather to deliver an interpretation that is only good enough to enable the production system to generate an appropriate response, contributing to the interaction's success. According to this line of thinking, the depth of linguistic material processing (in terms of syntactic compromise) would be related to the purpose of the task in which the subjects are engaged. The "good-enough" in actual communication situation may no longer be good enough in an experimental task situation, for instance.

Swets et al.'s (2008) proposal is that, subsequently to the initial association of the secondary phrase, the search for information that aids in the resolution of ambiguity may be gradual, and may or may not extend to the determination of an analysis according to the reader's purposes. In this sense, in the absence of a disambiguating material and of pressure, in experimental terms, for a specific attachment, the consultation to several information sources may only be superficial. According to the authors, the pressure to perform an attachment could result from the type of comprehension question present in an experimental task: given an

ambiguity as to the attachment of a relative clause, such as in "Alguém atirou no empregado da atriz que estava na varanda" ("Someone shot the servant of the actress who was on the balcony"), the subjects in a task including a comprehension question that focuses on the relative clause tend to perform a more immediate attachment, which does not occur in the case of task including a superficial comprehension question, that is, a question that does not lead to the interpretation of the relative clause, in which the subjects tend, in fact, to leave a underspecified analysis.

However, Frazier's (2008) criticism to the Good-Enough Theory must be taken into account. According to the author, it is clear that the purpose of language comprehension is not to compute a syntactic representation, but this computation would be a necessary means to reach the speaker's intended message. Syntax, therefore, would not be simply an issue of "niceties of high style", but rather a way to individualize and access entities and events, without which the interpretation could be "a salad of word meanings". As to the subordination of the linguistic processing to the experimental task demand, the author questions the idea of a strategic control of syntactic computation and argues that it could even be inappropriate to talk about the "purpose" of the syntactic processor, as this would be an automatic inference system. The author speculates, however, that the most interpretive phase of processing is possibly more open to the effects of processing depth, depending on the experimental task.

The debate is ongoing and the present study is part of this general theoretical discussion, as it proposes to investigate aspects such as initial syntactic underspecification and analysis determination by means of nonstructural information in processing relative clauses in Brazilian Portuguese.

3 Experiments

The experiments conducted by Gilboy et al. (1995) were off-line measurements, emphasizing the role played by referentiality in the process of interpreting relative clauses. However, to determine the extent to which this information could influence the online processing of relative clauses, being more directly inserted in the discussion about the degree of underspecification in the syntactic processing underlying the notion of association proposed by the Construal hypothesis, this study chose

to investigate not only the most reflexive moment of comprehension, but rather, and above all, the moment that involves more automatic and unconscious processes. In this sense, two online experiments were conducted to understand the nature of the phenomenon in question, which will be presented below.

3.1 Self-paced reading

In this experiment, the N2 referentiality and the relative clause participle gender were manipulated, resulting in the following experimental conditions:

a) Nonreferential N2 / Attachment to N1 (N2NR/N1)

O policial apreendeu/ a bolsa de couro/ que foi irregularmente importada/ pela empresa. (The police officer apprehended/ the bag of leather / that had been irregularly imported (feminine participle)/ by the company.

b) Nonreferential N2 / Attachment to N2 (N2NR/N2)

O policial apreendeu/ a bolsa de couro/ que foi irregularmente importado/ pela empresa. (The police officer apprehended/ the bag of leather / that had been irregularly imported (masculine participle)/ by the company.

c) Referential N2 / Attachmentto N1(N2R/N1)

O policial apreendeu/ a bolsa do couro/ que foi irregularmente importada/ pela empresa. (The police officer apprehended/ the bag of the leather / that had been irregularly imported (feminine participle)/ by the company.

d) Referential N2 / Attachmentto N2(N2R/N2)

O policial apreendeu/ a bolsa do couro/ que foi irregularmente importado/ pela empresa. (The police officer apprehended/ the bag of the leather/ that had been irregularly imported (masculine participle)/ by the company.

The dependent variable used was the reading time for segment three, which contains the disambiguating material, and the general

hypothesis considered was that of an online influence of N2 referentiality and gender information, thus assuming a general preference for the high attachment of the relative clause when N2 is nonreferential, but an attenuation of this preference when N2 is referential, with the participle gender signaling these preferences. Along these lines, the following predictions are listed:

1) longer reading times for (b) than for (a);

2) shorter reading times for (d) than for (c), since in (d) both variables converge towards low attachment;

3) shorter reading times for (d) than for (b), since in (b) the nonreferential N2 does not favor the low attachment forced by gender;

4) finally, longer reading times in (c) than in (a), since (c) contains a referential N2, which potentially favors low attachment, but gender guides the parser to high attachment.

3.1.1 Method

a) Participants

The participants were thirty-two undergraduates from state and private universities in the city of Campina Grande, PB Brasil (majoring in Law, Nursing, and Chemical Engineering), all of which were native speakers of Brazilian Portuguese, with an average age of 21.

b Materials

The material included four experimental sets, each one with sixteen experimental sentences and thirty-two fillers: in compliance with the 2x2 design, four experimental conditions (explained above) were generated, and, in each experimental set, four experimental sentences by condition and twice as many filler sentences were inserted. The distribution of the experimental items in four sets responded to the Latin square design logic and to the intra-subject design, in such a way that all participants were in contact with all experimental conditions, but not with more than one version of the same experimental item.

The experimental sentence structure and segmentation mode displayed the following structuring: NP + V / complex NP (N1 of N2) / relative clause / Agent of the passive. Segment 2 structure was modified between the conditions: under the N2NR, N2 was not preceded by a Determiner, differently from what was observed under the N2R conditions. Still regarding the complex NP, N1 and N2 were always different in gender: when N1 corresponded to the feminine gender, N2 corresponded to the masculine gender, and vice-versa. The structure of segment 3, which is the critical segment, was also altered between the conditions: under N1 conditions, the participle gender agreed with N1, leading to a high attachment of the relative clause, while under N2 conditions, the participle gender agreed with N2, leading to a low attachment of the relative clause. Segment 4 corresponded to both the post-critical segment and the final segment of the sentence. After this segment, a comprehension question was shown in all experimental items, which focused the relative clause attachment to N1, such as "A bolsa foi importada?" ("Was the bag imported?"), for the previously shown sentences. Since the question focused on N1, under the conditions (a) and (c), the correct response was YES, whereas under the conditions (b) and (d), the correct response was NO.

c) Procedures

The experiment was conducted using an online self-paced reading technique, in the non-cumulative modality. The participants read sentences shown in a segmented manner on the computer screen, and pressed the L key to move between segments, answering YES or NO to the comprehension question shown after each sentence. The experimental apparatus included a *Macbook Apple*, whose operational system supports the *Psyscope* program, which was used to program and run the present experiment.

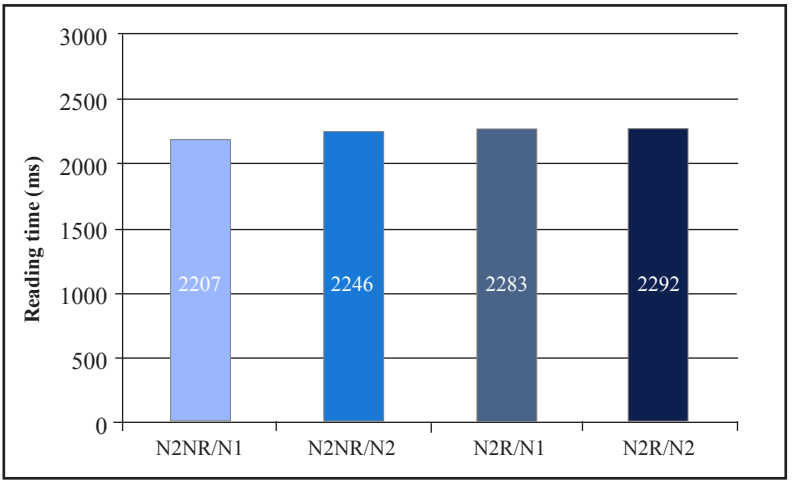
In the experimental sessions, participants were tested individually, in an isolated room, and, prior to performing the task, received instructions from the experimenter regarding the general task mechanism. In addition to this instruction, the subjects participated in a previous practical stage, in which they were exposed to eight sentences whose structures were different from those of experimental sentences. Each experimental session

lasted approximately 20 minutes, and the subjects reported no difficulties in performing the task.

3.1.2 Results

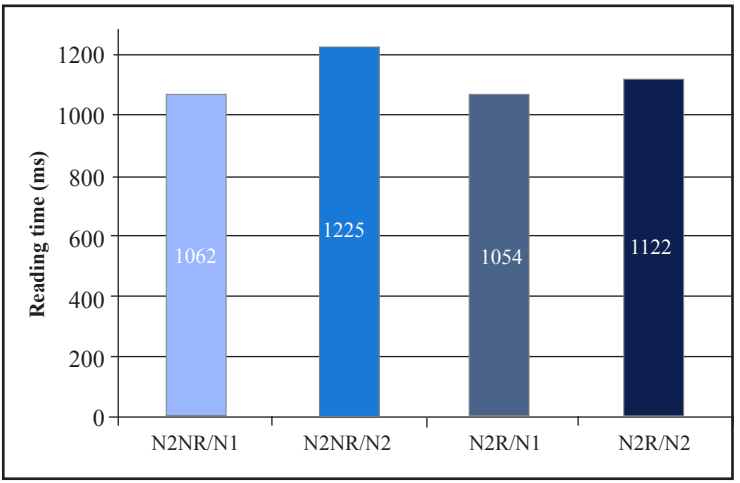
The results obtained in the statistical analysis of the critical segment were not compatible with the predictions: the analysis of variance (ANOVA) did not reveal a main effect of N2 referentiality ($F(1.31)=0.459$; $p< 0.5$) nor a main effect of gender ($F(1.31)=0.076$; $p<0.7$), nor did it reveal an interaction effect ($F(1.31)=0.019$; $p<0.8$). The mean reading times can be seen in Graph 1:

GRAPH 1 – Mean reading times for the critical segment



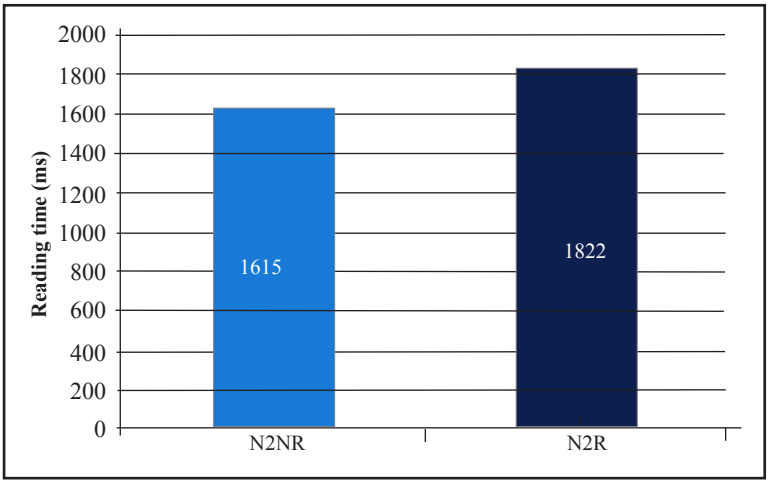
In search of a spillover effect, the post-critical segment reading times were analyzed. The ANOVA revealed a main effect of gender ($F(1.31)=8.34$; $p<0.007$), showing longer reading times for the N2 conditions (gender forcing N2 attachment), but did not reveal a main effect of N2 referentiality ($F(1.31)=1.29$; $p<0.2$) or an interaction effect ($F(1.31)=1.51$; $p<0.2$). Considering the gender effect, the analyses conduted with the T Test revealed a significant difference only in the comparison N2NR/N1 vs. N2NR/N2 ($t(31)=2.79$; $p<0.008$), but not in the comparison N2R/N1 vs. N2R/N2 ($t(31)=1.28$; $p<0.21$). The mean reading times can be seen in Graph 2:

GRAPH 2 – Mean reading times for the post-critical/final segment



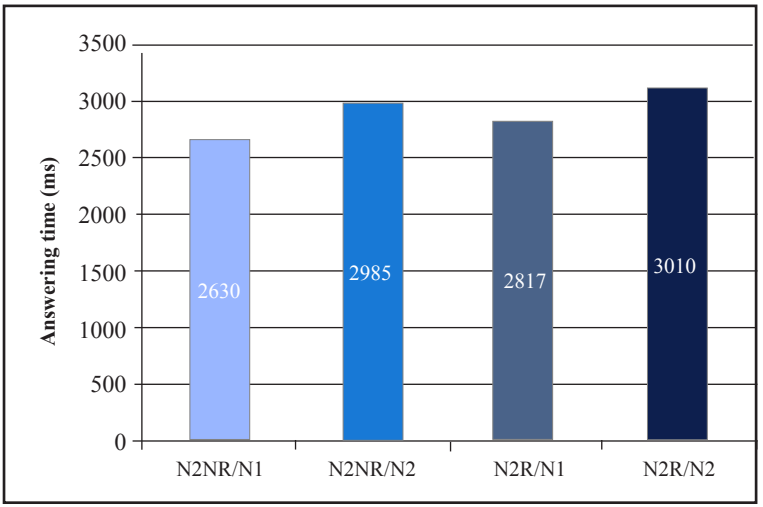
In an attempt to understand the absence of an effect of N2 referentiality, the behavior of subjects before the complex NP itself was also verified. By comparing the reading times for the complex NP under the N2NR condition to the reading times for the complex NP under the N2R condition, the T Test revealed that reading times were significantly longer under the N2R condition ($t(31)=-2.41$; $p<0.02$). This result shows that the subjects computed the determiner in the N2R condition, although it had not affected the processing of the subsequent relative clause. The mean reading times can be seen in Graph 3:

GRAPH 3 – Average reading times for the complex NP



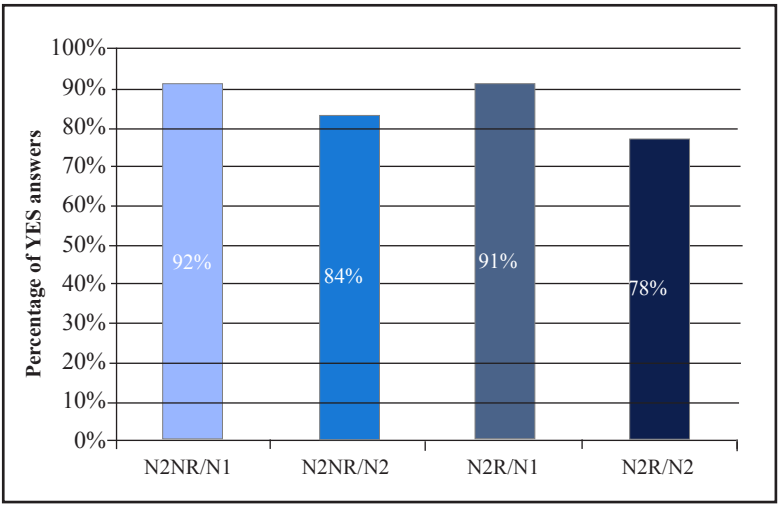
Considering the absence of an effect of N2 referentiality in these online data, the response time and the answers to the comprehension question were analyzed. Analyzing at first the response times, the ANOVA did not reveal a main effect of N2 referentiality ($F(1.31)=0.570$; $p<0.4$), or an interaction effect ($F(1.31)=0.467$; $p<0.4$), but it did reveal a marginal effect of the gender information ($F(1.31)=3.65$; $p<0.06$), with the marginal effect emerging in the comparison N2NR/N1 vs. N2NR/N2 ($t(31)=1.79$; $p<0.08$), but with no significant or marginal effect in the comparison N2R/N1 vs. N2R/N2 ($t(31)=1.12$; $p<0.27$). Along these lines, although not in a significant manner in statistical terms, the times for answering the question were, in general, higher under N2 conditions, as demonstrated in Graph 4:

GRAPH 4 – Mean times for answering the comprehension question



Let us observe the response pattern. By means of Chi-square tests, a significantly higher number of YES response than that of NO response was identified under all experimental conditions (N2NR/N1: X^2=91.125; p<0.05; N2NR/N2: X^2=60.5; p<0.05; N2R/N1: X^2=87.78; p<0.05; N2R/N2: X^2=40.5; p<0.05). However, a main effect of gender was detected (X^2=390.94, p<0.0003), with the gender forcing attachment to N2 significantly increasing the probability of N2 responses (β=0.7817; SE=0.4096; z=1.909; p<0.05). The percentages of YES response (N1) are shown in Graph 5:

GRAPH 5 – Percentage of YES response to the comprehension question



These results will be discussed in the following sub-section.

3.1.3 Discussion

The obtained data reveal that only prediction (1) was corroborated. We verified that, in structures with "substance" type complex NPs, no systematic preference was observed for the low attachment of the relative clause, as opposed to what would be predicted by the Late Closure principle (FRAZIER, 1979), but there is a general preference for high attachment, previously identified by Gilboy et al. (1995) and Maia and Finger (2007) in a more interpretive stage of comprehension. We assume that the basis for this analysis preference is related to the semantic nature of the "substance" type complex NP. NPs such as "a bolsa de (do) couro" (the bag of (the) leather) reveal that the relation between the N1 and the N2, mediated by the preposition, is that "X is made out of substance Y", and such relation does not favor (or even block) the introduction of two discourse entities in the mental model, favoring, in fact, an analysis in which N2 works only as a modifier for N1, both corresponding to a single discourse entity. The data suggest that the parser has quick access

to the constraint imposed by this semantic relation, hence the resistance[1] that the subjects display regarding the construction of the referential N2.

Such resistance and the absence of an effect of N2 referentiality indicate that the discursive implication of adding the determiner to N2 (its introduction to the discursive model as an N1 independent entity, but related to it via modification) was not the analysis immediately seen by the parser. In fact, considering N2 as a discourse entity seems to require a more reflexive process, given that the definite article in itself carries presupposition (HAWKINS, 1978; HEIM, 1982) and the experiment did not rely on a previous context. It would be possible to object that N1 is also definite and is also being introduced in the discourse model; nevertheless, it is selected as the location for attachment. However, it must be observed that, in the complex NP in focus, N1 and N2 exhibit different syntactic and semantic statuses. In general terms, N1 is the complex NP head and is the target of the restrictive modification, while N2 justifies its presence only in terms of N1. Our hypothesis is that this syntactic-semantic "subordination" of N2 (in relation to N1) may make its accommodation process more difficult (HEIM, 1982), that is, it may make it difficult introducing it in the mental model under construction for the sentence. The parser, therefore, would view such subordination, but not the discourse dimension of the referential N2.

The recognition of this general preference for high attachment leads to the reflection about the moment in which it appears during the comprehension. To achieve this, the gender effect may be observed. In psycholinguistic experiments, the use of disambiguating material is enlightening given that it may indicate an analysis preference: if an X analysis was selected at an ambiguity point, the disambiguating material, if contrary to the initial X analysis, may generate a garden-path effect and a reanalysis process, which causes a higher computational cost if compared to a case in which the disambiguating material only corroborates the X analysis. In the case of this study, the gender is responsible for

[1] Longer reading times under the referential N2 condition are being interpreted as a resistance, given that no effects of this referentiality in processing the relative clause itself were observed. If this influence had been observed, an alternative interpretation would be that the times reflect a cost associated with the insertion and the integration of a new entity in the discourse model (see Warren; Gibson, 2002; Grodner; Gibson; Watson, 2005).

signaling that the X analysis, here, is the attachment to N1. The gender effect was found in the post-critical segment, which also corresponded to the final segment, and could be interpreted either as a spillover effect of a processing occurred in the critical segment itself, or as a late effect, in the sense that it was considered only during a more final stage of the processing, possibly as part of a wrap-up process (JUST; CARPENTER, 1980), which involves the integration of several information sources, reaching the final comprehension of the sentence. This discussion is even more pertinent if one considers that, in the literature, there already exists a debate about the parser's sensitivity to this gender information, with studies proposing that it could be accessed late (DE VINCENZI; DI DOMENICO, 1999) or even disregarded (BRYSBAERT & MITCHELL, 2000) in the processing. In this sense, the gender effect, in itself, does not allow us to state, categorically, if the preference for attachment to N1 was immediate or if there was a lingering syntactic underspecification.

Nevertheless, if it is assumed that there was a more immediate preference for N1, the gender effect could be understood in at least two ways, given the lack of accuracy in the response pattern under the N2 conditions (gender forcing the attachment to N2): this could be the result of a resistance to consider the possibility to attach the relative clause to N2, or it could be seen as a sign of reanalysis, but, in this case, of a partial reanalysis, since N1 eventually ends up being chosen more often. Within the Good-Enough Theory scope (CHRISTIANSON; HOLLINGWORTH; HALLIWELL; FERREIRA, 2001; RIBEIRO, 2008, 2010, 2012), the idea of misinterpretation of garden-path sentences has been considered in association with the performance of incomplete reanalysis, assuming that the Compositionality principle, according to which the meaning of a sentence is the result of the sum of the meanings of its parts, could be violated in the processing.[2] Therefore, the subjects might not even have started the reanalysis, or might have started it, but not finished it, and the gender, in any case, might have been disregarded in the latest part of the comprehension, as shown by the response.

[2] The Garden-Path Theory (FRAZIER, 1979) does not consider this hypothesis, but, in fact, argues in favor of a compositional construction of the sentences' meanings. Along these lines, after a garden path effect, in order for the sentence to be duly interpreted, a full reanalysis process is required.

An eye tracking experiment was conducted to attempt to explain the gender effect and better understand the influence of N2 referentiality. This technique is, in general, characterized as more natural (due to the non-segmented presentation of the sentences, for instance) and more sensitive to the initial syntactic processing in comparison with other techniques, such as self-paced reading. We believe, therefore, that, due to its own nature, eyetracking may assist us in clarifying the data obtained in this experiment.

3.2 Eye tracking

In this second experiment, the N2 referentiality and the relative clause participle gender were also manipulated. The experimental conditions were the same used in the previous test.

a) Nonreferential N2 / Attachment to N1 (N2NR/N1)

O policial confiscou a bolsa de couro que foi importada irregularmente pela empresa.(The police officer confiscated the bag of leather that was irregularly imported (feminine participle) by the company).

b) Nonreferential N2 / Attachment to N2 (N2NR/N2)

O policial confiscou a bolsa de couro que foi importado irregularmente pela empresa.(The police officer confiscated the bag of leather that was irregularly imported (masculine participle) by the company).

c) Referential N2 / Attachmentto N1(N2R/N1)

O policial confiscou a bolsa do couro que foi importada irregularmente pela empresa. (The police officer confiscated the bag of the leather that was irregularly imported (feminine participle) by the company).

d) Referential N2 / Attachment to N2(N2NR/N2)

O policial confiscou a bolsa do couro que foi importado irregularmente pela empresa. (The police officer confiscated the bag of the leather that was irregularly imported (masculine participle) by the company).

The participle form of the verb present in the relative clause is considered to be our area of interest. The initially considered dependent variable was the first pass reading time, which, being associated to the early syntactic processing stages, corresponds to the sum of the durations of the first fixations in an area since the first fixation in this region until the eye moves away, either to the left or to the right. Based on the hypothesis of an immediate effect of the N2 referentiality and of the relative clause participle's gender, the following predictions were made:

1) Longer times in (b) than in (a);

2) Longer times in (c) than in (a);

3) Longer times in (c) than in (d);

4) Shorter times in (d) than in (b).

If the effect of N2 referentiality and the gender did not emerge immediately, the differences predicted above could be found in later measurements, such as the second reading time (which encompasses the times related to all re-readings in an area, corresponding, more specifically, to the sum of all fixations in the area after the first pass time) and in the total reading time (which corresponds to the sum of all fixations, including, therefore, the first pass reading time and the second pass reading time).

3.2.1 Method

a) Participants

The experiment participants were twenty-eight undergraduates from the Federal University of Rio de Janeiro, all of which were native speakers of Brazilian Portuguese, with an average age of 22. The subjects were awarded two hours in their course-load in their Language majors for the voluntary participation in the test.

b) Material

Similarly to the previous experiment, the material comprised four experimental sets, each with sixteen experimental sentences (four per condition) and thirty-two fillers. The distribution of the experimental items responded to the Latin square design logic and to the intra-subject design, so that all participants were in contact with all experimental conditions, but not with more than one version of the same experimental item.

The experimental items had the same structure used in the previous experiment, except for one aspect that had been changed: the adverb was now placed after the disambiguating material.[3] Regarding the lexical items, in all of them, N1 corresponded to the feminine gender, while N2 corresponded to the masculine gender. After each experimental sentence, a comprehension question was shown (focusing on the relative clause), as well as two response options: N1 and N2, such as "*O que a empresa importou? ( )Bolsa ( ) Couro*" (What did the company import? ( ) Bag ( ) Leather),[4]for the examples provided. In the experimental sentences, the responses were always shown with N1 on the left and N2 on the right; in the filler sentences, however, half of the correct response were shown on the left and the other half on the right.

c) Procedures

The equipment used in data collection was an *EyeLink*1000 model tracker, with a 1000Hz precision camera, set up for monocular

[3] Intuitively, we believed that, with the anticipation of the disambiguating material, the gender effect could be faster and stronger. Ferreira and Henderson (1991) propose, along these lines, that the distance between the point at which an analysis is attributed and the point at which the disambiguating material is introduced may influence the initial analysis strength in the memory and, consequently, the reanalysis process: the greater the distance, the greater the strength of the first analysis in the memory, which does not favor reanalysis. In a self-paced reading study (unpublished), this change was made, but no significant difference was found regarding the gender effect.

[4] In response to one of the anonymous proofreaders: we used a different type of question than that used in the previous experiment, since, in an unpublished experiment, we detected evidence that the type of question may influence the subjects' behaviors, with a question such as that in experiment 1, for instance, reducing the probability of N2 answers.

recording, attached to a 32-inch screen, with 1920x1080 px resolution. A head and forehead apparatus was used on the volunteers, while their eye movements were recorded during the sentence reading. The program "*EyeTracke*r 0.7.10m" was used to present and record the stimuli, and the programs "*Robodoc.py*" and "*EyeDry*" were used in the analysis.

The experiment was conducted at the Experimental Psycholinguistics Laboratory – Lapex room, at the UFRJ's School of Languages. Each participant was instructed to read the sentence, while his/her eyes were monitored by the equipment. After receiving the task instruction, the participant was positioned in the equipment. The experimenter adjusted the volunteer's head and forehead in the apparatus, since it was important that the volunteer's head be still during the test application. After the due adjustment, the volunteer's pupil was calibrated and validated. In this process, the participant was instructed to stare at a black circle that initially appeared in the middle of the screen and moved to 9 different points. After that, the participant went through the validation phase, in which the equipment checked all eye fixations captured during calibration. This phase was extremely relevant, given that it was not possible to continue with the procedure until the volunteer's pupil had been perfectly calibrated and validated.

Before each sentence, a black square was shown on the middle left corner of the screen, indicating that the participant should stare at this location, so that the sentence could appear on the screen. The sentence would only appear if the participant were staring at the black square. This happened before each sentence was shown. After reading the sentence, the participant was instructed to press a button on the joystick, enabling the appearance of the interpretation question. Afterwards, the participant answered by pressing the left or right button, and, after that, a new black square was shown, indicating that a new sentence would be shown, and so on. Each participant read 48 sentences (16 experimental sentences and 32 filler sentences, along with their respective interpretation questions). The experimenter was required to stay in the room with the participant, to handle the main monitor, through which the calibration and validation processes were performed, as well as the acceptance of the volunteers' fixations. In the process of accepting eye fixations, the experimenter clicked on the volunteer's pupil image using the mouse, whenever the experimenter was sure that the participant was, in fact, looking at the correct area. Such a procedure always happened before

the black square appeared, and it consisted of the appearance of a black circle in the middle of the screen, where the participant was supposed to stare, so that the experimenter could accept his/her fixation. Each test lasted approximately 30 minutes. Before each experiment, a practice activity was applied, to train volunteers and to explain the task, which lasted 10 minutes.

3.2.2 Results

Focusing the first pass reading data, the ANOVA[5] revealed a main effect of gender ($F(1.99)=8.910$; $p<0.003$), a main effect of N2 referentiality ($F(1.99)= 7569.304$; $p<0.001$), and an effect of variable interaction ($F(1.99)=29.024$; $p<0.001$). The paired T-Tests revealed that the following comparisons were significant: N2R/N1 vs. N2R/N2 ($t(99)=28.899$; $p<0.001$), with the N2R/N1 condition exhibiting longer reading times; N2NR/N1 vs. N2R/N1 ($t(99)=-59.700$; $p<0.001$), with the N2R/N1 condition exhibiting longer reading times; and N2NR/N2 vs. N2R/N2 ($t(99)=64.116$; $p<0.001$), with the N2NR/N2 condition exhibiting longer reading times. The N2NR/N1 vs. N2NR/N2 did not reveal a significant difference ($t(99)=-1.291$; $p<0.1$), although there was a numerical difference in the expected direction. These data show the pertinence of predictions (2), (3), and (4) previously listed here. The mean reading times for each condition are shown in Graph 6:

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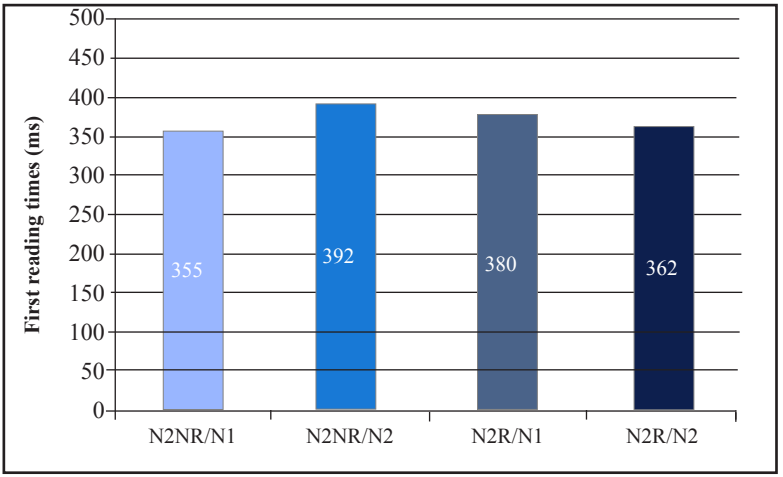
[5] The data for all eye-tracking measurements taken into account in the analysis did not present normal distribution originally. Therefore, to conduct the ANOVA and the T-Test, a data transformation was conducted, which was done by means of the Box-Cox transformation resource, provided by the statistical program *Action*.

GRAPH 6 – Mean of first pass reading time for "*importado(a)*"
(imported - masculine and feminine genders)

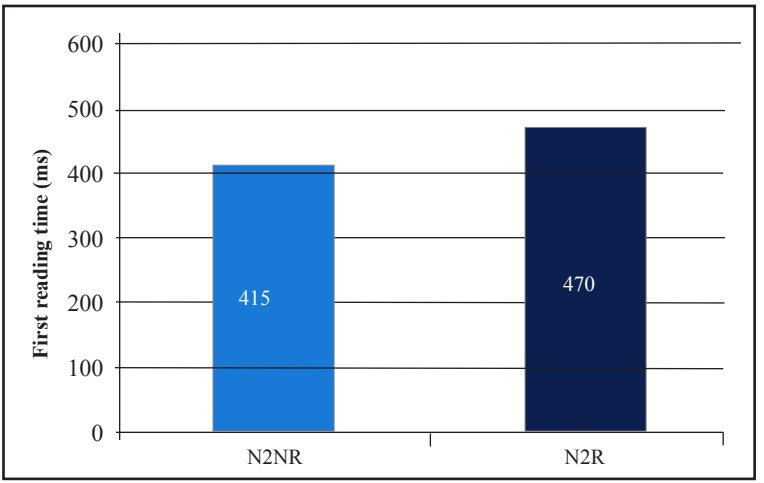


Upon analyzing the second pass reading times, the ANOVA revealed a main effect of gender ($F(1.67)=439.432$; $p<0.001$), a main effect of N2 referentiality ($F(1.67)=433.157$; $p<0.001$) and an effect of variable interaction ($F(1.67)=422.247$; $p<0.001$). The paired T-Tests revealed that the following comparisons were significant: N2NR/N1 vs. N2NR/N2 ($t(67)=21.138$; $p<0.001$), with the N2NR/N2 condition exhibiting longer reading times; N2R/N1 vs. N2R/N2 ($t(67)=1.926$; $p<0.001$), with the N2R/N1 condition exhibiting longer reading times; and N2NR/N1 vs. N2R/N1 ($t(67)=20.685$; $p<0.001$), with the N2R/N1 condition exhibiting longer reading times. The total reading time analysis revealed a main effect of gender ($F(1.99)=4.086$; $p<0.04$) and an effect of variable interaction ($F(1.99)=4.857$; $p<0.02$), with the T-Test revealing that the following comparisons are significant: N2NR/N1 vs. N2NR/N2 ($t(99)=-3.071$; $p<0.002$), with the N2NR/N2 condition exhibiting longer reading times; and N2NR/N1 vs. N2R/N1 ($t(99)=-2.126$; $p<0.03$), with the N2R/N1 condition exhibiting longer reading times.

For a better understanding of how the subjects dealt with the referential N2 in itself, a second area of interest was chosen: the prepositional phrase (PP) in the complex NP – "de (do) couro" (of (the) leather), for instance. Upon analyzing the first pass reading times, by

means of the T-Test, it was detected that conditions with referential N2 generated a higher processing cost than conditions with nonreferential N2 conditions (t(193)=-2.140; p<0.03), as shown in Graph 7:

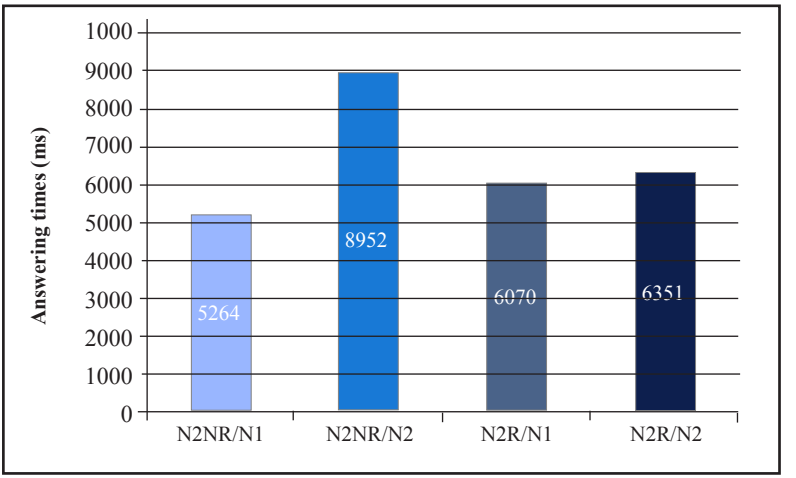
GRAPH 7 – Mean first reading times for the PP



The same additional cost detected in the N2R conditions was identified in the total reading times for the PP (t(193)=-3.815, p<0.0001), but not in the second pass reading times (t(145)=-1.323; p<0.1).

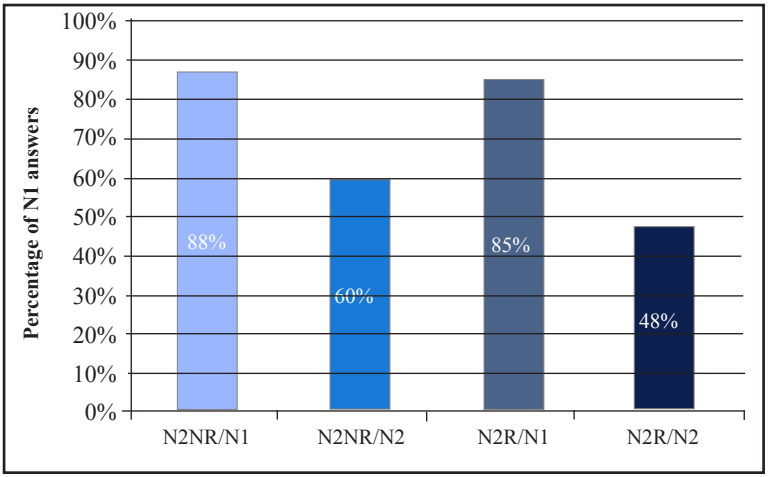
Finally, the response data were also analyzed: Regarding the response times, the ANOVA revealed a main effect of gender (F(1.111)=3428.890; p<0.001), a main effect of N2 referentiality (F(1.111)=3471.358; p<0.001), and an effect of variable interaction (F(1.111)=2069.417; p<0.001). The paired T-Tests revealed significant effects in the relevant comparisons:N2NR/N1 vs. N2NR/N2 (t(111)=152.373; p<0.001), with the N2NR/N2 condition exhibiting longer times; N2R/N1 vs. N2R/N2 (t(111)=52.190; p<0.001), with the N2R/N2 condition exhibiting longer times; N2NR/N1 vs. N2R/N1 (t(111)=-52.716; p<0.001), with the N2R/N1 condition exhibiting longer times; and N2NR/N2 vs. N2R/N2 (t(111)=-175.743; p<0.001), with the N2NR/N2 condition exhibiting longer times. The mean response times are shown in Graph 8:

GRAPH 8 – Mean response times



Regarding the responses themselves, the Chi-square test for adherence revealed a higher number of N1 responses for the conditions N2NR/N1 (X^2=63; p<0.001), N2NR/N2 (X^2=3.9729; p<0.04), and N2R/N1 (X^2=54.32; p<0.001), but no difference between the N1 and N2 responses for the N2R/N2 condition (X^2=0.1428; p<0.7). Along these lines, a main effect of gender (X^2=485.01; p<0.001) was detected, with the probability of obtaining an N2 response that is significantly higher when the gender forces attachment to N2 (β=1.5629; *SE*= 0.3450; z=4.531; p<0.001), as shown in Graph 9:

GRAPH 9 – Percentage of N1 responses to the comprehension question



This set of data will be discussed in the following sub-section.

3.2.3 Discussion

The results reported above revealed immediate effects of gender information and N2 referentiality: when N2 is referential, there is an immediate preference for attaching the relative clause to N2, with the condition with gender forcing N1 attachment leading to a higher processing cost. When N2 is not referential, however, an immediate preference for N1 attachment is suggested. Along these lines, the initial association proposed by the Construal hypothesis (FRAZIER; CLIFTON, 1996) would be quickly resolved, producing an attachment. These data are compatible with the Referentiality Principle (GILBOY et al., 1995), according to which, in the case of "substance" complex NPs, the chance of low attachment of the relative clause would be much higher when N2 was referential than when N2 was not referential. Considering the "substance" nature of the complex NP on which the focus is placed, the additional cost found in the complex NP containing a referential N2 provides interesting material for reflection. In the previous experiment, this cost was associated with resistance to a referential N2; however, in this second experiment, N2 referentiality appears to have influenced the processing of the relative clause in itself, so that such a cost could be associated with resistance and an attempt to integrate the referential N2

into the discourse model. In this sense, the higher cost for the N2R/N1 condition in the participle area (detected in the first pass reading times, in the second pass reading times, and in the total reading times) would be related exactly to a break in the discourse analysis of N2: considering that a sentence such as "O policial confiscou a bolsa do couro" (The police officer confiscated the bag of the leather) is not well formed in Brazilian Portuguese, a referential N2 in this type of complex NP is only possible in the presence of a restrictive modifier, which would be responsible for establishing the referent (see Hawkins (1978) for a discussion about "*Referent-Establishing relative clauses*" cases, that is, cases in which the NP "requires" a relative clause since it, by itself, is not able to introduce a referent); therefore, when the participle gender blocks this analysis, the N2 discursive integration is impaired, and it may be reanalyzed as nonreferential (which explains the comparable number of N1 answers under the N2NR/N1 and N2R/N1 conditions).

The above interpretation implies the need for further reflection on two results: the higher cost found under the N2NR/N2 condition (especially for the second pass reading times and the total reading times) and the lower cost found under the N2R/N2 condition (especially for the first pass reading and second pass reading times). In the first case, the issue is whether the cost may or may not be associated with a reanalysis process, as the response data also revealed a preference for N1. It is possible that, considering the nonreferential N2, the subjects have resisted low attachment, performing the reanalysis process in some experimental items but not in others. It also seems appropriate to consider the possibility of the gender forcing N2 attachment as responsible for installing a "doubt" in the processing, with the longer answer times under this condition being associated with a process of determinion of analysis. Regarding the lower cost under the N2R/N2 condition, which would be related to the convergence of the manipulated variables, it is worth noting that, despite the online influence of the N2 referentiality, there was a comparable number of N1 and N2 responses to the comprehension question, since a higher number of N2 responses was expected. A possible explanation here would be that the relative clause was, in fact, attached to N2 under this condition, and the responses would show that this attachment does not eliminate the conceptual unity corresponding to the complex NP: the process "a bolsa feita de (do) couro que foi importado irregularmente" (the bag made of leather that was irregularly imported)

implies the product-unit "a bolsa de couro" (the leather bag), and, the leather being imported, the bag would also have been imported, and this inferential process could be associated with longer answering times under this condition.

The results in this experiment are positive, since they reveal an immediate influence from both factors focused by this research: the participle gender, which has the potential to reveal an analysis preference, and the N2 referentiality, which enables investigating the influence of non-structural principles in sentence processing. This study has demonstrated that the relative clause processing is influenced by the referential status of the nouns that compose the complex NP, as predicted by the Construal hypothesis and by the Referentiality Principle (GILBOY et al., 1995; FRAZIER; CLIFTON, 1996), and that the syntactic underspecification process involved in the processing of secondary phrases may be quickly resolved when useful information is available (in this case, the referential information would be available in the complex NP itself).

4 General discussion

A key question motivated the performance of the self-paced reading experiment: can the non-structural referentiality information influence the parser's initial decisions? The results in this study have demonstrated a general preference for N1 attachment, with N2 referentiality, in particular, having no effect on the relative clause processing. These data do not allow for the simple conclusion that referentiality does not influence the initial processing, given that the immediate preference for the high attachment that we found would also reside in the very referential nature of N1, as argued by Gilboy et al. (1995) for off-line data, rather than being the result of the systematic application of a structural principle. Therefore, following the Construal hypothesis, we assume that the parser, upon meeting the relative clause, proceeds to an association and quickly attaches it based on the N1 referentiality.

Two key questions motivated the performance of the eye-tracking experiment: (1) is the gender information immediately accessed by the parser? and (2) can N1 and N2 referentiality influence the initial processing of the relative clause? The results allowed for clarifying, first, that there is no delay in accessing the gender information, which leads us to interpret the gender effect in the self-paced reading experiment as

a spillover effect, and, secondly, that N1 and N2 referentiality influences the relative clause processing: when only N1 is referential, the high attachment would be preferred, but when N2 is referential, the low attachment would be initially preferred.

Nevertheless, both experiments also reveal that the participle gender and the N2 referentiality may occasionally be disregarded by the parser, especially at the most interpretive moment of the sentence processing, in favor of an analysis that seems to be predominant in the type of structure being studied: N1 attachment. Furthermore, the difference between the experiments, regarding the N2 referentiality results, indicates how the use of different experimental methodologies may help in understanding a phenomenon. The stimuli presentation manner, in this sense, could play an important role: it seems appropriate to consider the hypothesis that the non-segmentation of stimuli in eye-tracking may favor the understanding and the discourse integration of the referential N2 more than the segmentation present in the self-paced reading, in which the complex NP was isolated, possibly increasing the resistance to the referential N2 and favoring a more immediate decision not to introduce it in the discourse model. Finally, the different measurements provided by the eyetracking enabled seeing more clearly what an immediate or late effect of the variables would be.

In summary, this study provides evidence that the processing of relative clauses associated with "substance" type complex NPs is influenced by the referentiality of the heads that make up such NPs. Certainly, the resistance to referential N2, observed especially in the first experiment, for instance, needs to be better understood. As presented above, the syntactic-semantic relation established between N1 and N2 may not favor the introduction of the referential N2 in the discourse model, and a more precise explanation is being sought.

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