MINIMALITY BEYOND LEXICAL RESTRICTIONS: PROCESSING AND ACQUISITION OF FREE *WH*-DEPENDENCIES IN EUROPEAN PORTUGUESE

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Abstract. The Generalized Minimality approach to comprehension difficulties with non-local dependencies (Grillo 2005, 2008) predicts that in non-local dependencies (e.g. object relatives) a partial match in internal structure between the moved and the intervening DP can generate a minimality effect and lead to comprehension difficulties in several populations, including children and agrammatic Broca's aphasics. This paper presents two experiments on headed and free *wh*-movement: a sentence to picture matching task with 4-5 year-old children and a self-paced reading task with adults. In both experiments we observed minimality effects in the absence of lexical restriction in one of the DPs involved; these results shed light on the sensitivity of the minimality principle and bring further support to the feature based approach to intervention effects.

Key words: Generalized Minimality, acquisition, full competence, non local dependencies, free relatives, feature hierarchy.

1. INTRODUCTION

A well-known fact in the studies on language acquisition is that certain movement dependencies may cause difficulties to young children. It is clear that not all movement is problematic, and that difficulties are selective. Previous literature on this topic shows that headed *wh*-dependencies are harder to comprehend and produce than free *wh*-dependencies. The purpose of this paper is to compare the comprehension of headed and free *wh*-dependencies by children and adults, in order to assess whether we are dealing with a developmental issue or with a difficulty that is also present in adult comprehension, because it derives from the different processing costs involved in the two types of dependencies.

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* We gratefully acknowledge the Portuguese National Science Foundation, Fundação para a Ciência e a Tecnologia (FCT), for supporting this project with the research grant PTDC/CLE-LIN/114212/2009 awarded to Nino Grillo and the research grant PTDC/CLE-LIN/099802/2008 awarded to João Costa. We thank Andrea Santi for her precious help with statistical analysis and for extremely valuable comments and suggestions. All errors, goes without saying, are our own.

RRL, **LVII**, *2*, p. 143–160, Bucureşti, 2012

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In topicalization, *wh*-questions and relative clauses, there is a well-documented asymmetry between extraction from the subject position and extraction from the object position. In all these constructions, object dependencies are harder to interpret than subject dependencies (Adams 1990, Adani 2008, 2011, Brown 1972, Contemori and Garraffa 2010, Corrêa 1982, 1995, Costa *et al.* 2011, de Villiers *et al*. 1994, De Vincenzi 1991, Friedmann *et al.* 2009, Friedmann and Novogrodsky 2004, Håkansson and Hansson 2000; McKee *et al*. 1998, Roth 1984, Sheldon 1974, Tavakolian 1981). The asymmetry between subject and object dependencies is an interesting one, since it opens a window into the nature of the difficulties in the comprehension of these structures.

Grillo (2003, 2005, 2008) proposed that the source of the difficulty in the interpretation of object dependencies, and more generally non local dependencies, is the intervention of a noun phrase in between the displaced constituent and its original position, as depicted in (1):

(1) [DPObject [DPSubject [V <DPObject>]]][2]
|_____|

Grillo proposed a generalization of the principle of locality known as Relativized Minimality (Rizzi 1990, 2004, Starke 2001) to explain this pattern. The basic idea behind the Generalized Minimality approach (GM) is that the representation of the full array of morphosyntactic features required to distinguish the moved object from the intervening subject has a processing cost that might simply be too high to pay for e.g. children and agrammatic aphasics. If the processing cost cannot be paid, i.e. if the feature structure of the NP involved is not distinguishable, a Minimality effect is expected to arise, which in turn will generate comprehension difficulties. The same approach can be extended to any situation in which comprehension asymmetries involving movement have been observed, as e.g. in unimpaired adult speakers in stressful situations (Dick *et al.* 2001).

More generally, GM is a theory of syntactic complexity of non-local dependencies. To avoid minimality in non-local dependencies, i.e. to be able to distinguish between a moving DP and an intervening DP, it is necessary to activate, select and maintain activated a richer feature structure than in local dependencies. It is assumed that selection of each morphosyntactic feature has a processing cost. The processing cost associated with the selection of a given feature is a function of several factors, including complexity of the associated semantic representation, frequency, and crucially connected to the position of that feature in an independently motivated hierarchy of morphosyntactic features (see Grillo 2008

[2] Throughout the paper, the copy theory of movement is assumed (Chomsky 1995) and traces are indicated in angled brackets.

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for details). All else being equal, the more features (lexical or functional) are required to distinguish between a moved DP and an intervening DP, the higher the processing cost.[3]

Object relative clauses have been repeatedly shown to be harder to process than subject relative clauses. All experimental measures, ranging from reading time (in both self-paced reading and eye tracking), accuracy of response to comprehension questions, phoneme monitoring, online lexical decision, support this conclusion (King and Just 1991, Gibson 1998, 2000, Gordon *et al*. 2001, 2004, Dyke 2007 and much related work). In the realm of neuropsychology, agrammatic Broca's aphasics have been shown to have selective problems with both comprehension and production of object movement but not with subject movement (Grodzinsky 2000, Grillo 2008). Finally, evidence from brain imaging studies demonstrated a higher involvement of BA44 and BA45 in the processing of object extraction when compared to subject extraction (Santi and Grodzinsky 2007, Grodzinsky and Santi 2008). Altogether, these results support the GM approach and the idea that minimality effects induce difficulties in the comprehension of object dependencies.

A further implication of this approach is that manipulating the internal structure of the DPs involved, i.e. by adding further distinctions between the DPs involved in a crossing configuration, should reduce the chances of intervention effects and ultimately improve comprehension. Support in this sense came from the results of several studies that recently investigated the effect on comprehension of the manipulation of the internal feature structure of the NPs involved. Garraffa and Grillo (2008) demonstrated that animacy mismatch between the moving subject and the intervening object improves comprehension in agrammatic aphasics. In the domain of acquisition, along similar lines, Flavia Adani's work (Adani 2008, 2011, Adani *et al*. 2010) provides ample evidence in support of the claim that manipulating features of the DPs involved in crossing configurations enhances comprehension. In particular Adani *et al.* (2010) show that manipulating number

[3] Notice that this account differs in a crucial way from distance based accounts of locality effects: while the distance between a moved element and its trace might certainly be an additional factor of complexity, it does not represent the crucial factor regulating complexity levels in subject and object relatives in the present model. Once the processing cost necessary to access, select and merge a given feature in the syntactic representation is paid, the distance between the carrier of that feature and its trace doesn't play any particular role in the model. This characteristic of GM makes it a desirable model for two important reasons: one theoretical and one empirical. Empirically, besides correctly predicting processing and comprehension asymmetries in several populations, it accounts for the observation (Gibson 1998) that complexity of non-local dependencies does not increase linearly with the number of intervening DPs. Theoretically, it associates more closely grammaticality and complexity: locality in grammar also does not care about linear distance, but only about the availability of an additional syntactic/semantic distinction. Moreover, in this view, islandhood represents the interaction of an independent principle of the mind with the limited number of available distinctions provided by the grammar as morphosyntactic features.

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and gender may improve the performance in the comprehension of object relative clauses in different degrees which relate to the functional/lexical distinction between them. Following a similar logic, Friedmann *et al.* (2009) tested children's comprehension of free object relatives and object relatives with null subjects, showing that a significant improvement in comprehension of object RCs is observed when one of the DPs lacks a lexical restriction. The fact that sentences are easier to interpret when the subject is null was taken by Friedmann *et al.* to indicate that the intervention of the lexical noun phrase is crucial in generating GM effects.

Much like in the literature on language acquisition, several factors have been shown to modulate these effects, reducing the processing advantage for subject relatives. A mismatch in animacy between the subject and the object DPs, for example, makes object extraction significantly easier for both unimpaired adult speakers (Mak *et al.*2002, 2006) and agrammatic aphasics (Garraffa and Grillo 2008); crucially, these results cannot simply be interpreted as a preference for inanimate DPs to be interpreted as objects, since when an inanimate object DP is moved over an inanimate subject DP the usual processing advantage for subject extraction is found. Similar effects have been discussed in acquisition literature by Philip et al. (2001), based on a comprehension pattern first observed in O'Grady (1997). Importantly for the present work, the manipulation of referential properties (Gordon *et al.* 2001, 2004) produces similar results, i.e. no subject extraction advantage, when the subject referential DP in an object RC is replaced by either a pronoun or a proper name.

The subject-object asymmetry was tested in the acquisition of relative clauses in European Portuguese in Costa *et al.* (2009) and Costa *et al.* (2011), and the results found for other languages were replicated: children were very good both in the production and comprehension of subject relatives, but their performance dropped in the production and comprehension of object relative clauses. In Costa, Friedmann, Silva and Yochini (2012), the comprehension of subject relatives was compared with the comprehension of object relatives with or without a preposition. Again, the performance on subject relatives was better than on both types of object relatives.

Friedmann and Novogrodsky (2011) compared the comprehension of object relatives and coordinated sentences with a null subject and intervening object, and found independent evidence for the relevance of the type of intervention effects argued for in the other works cited here.

As mentioned above, Friedmann *et al.* (2009) work showed an essential role of lexical restriction in modulating minimality effects in language acquisition. A relevant question, still, is the following: do we find any evidence of minimality effects in the absence of lexical restriction in one of the DPs involved in nonlocal dependencies?

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The relevance of the lexical restriction for minimality effects to obtain can be further tested if one looks at free *wh*-dependencies, as in (2):

(2) Mostra-me quem a mãe abraça
show-me who the mother hugs

The free relative in (2) contrasts minimally with a headed relative, as in (3), in which the antecedent of the relative is lexically present:

(3) Mostra-me a menina que a mãe abraça
Show me the girl that the mother hugs

The simplest analysis for free dependencies would assume that they are quite similar to headed dependencies: in both cases, there is A-bar movement involved. One crucial difference is that the operator movement in the free dependency does not contain a lexical restriction:

(4) Mostra-me [quem$_i$ a mãe abraça <quem$_i$>]
show-me who the mother hugs who

Despite the fact that they do not contain a lexical restriction, *wh*-pronouns such as *quem* (*who*), however, still possess an internal structure, which might still cause a (albeit reduced) minimality effect in case of non-local movement.

Quem (*who*), in fact, has a rich internal structure which specifies at least the following properties: Noun, +animate, +human (or humanized), (default) singular, Nominative/Accusative. That *quem* (*who*), and more generally *wh*-pronouns, possesses a rich internal structure, and must be distinguished from complementizers such as *que/that* and in particular have Nominal properties follows from the fact that they can be inflected for case (*quem* vs. *cujo*, *who/whom/whose*), number (*cujo* (sg) */cujos* (pl.)), and gender (*cujo* (m.)*, cuja* (f.)). That *quem* (*who*) has a (default) singular marking is clear from the fact that it cannot agree with a plural verb (**ho visto chi e arrivato*/**sono arrivati* /*Eu vi quem chegou*/**chegaram*; *I saw who arrived*$_{sing}$/**arrived*$_{pl}$).

Given these properties, the GM approach would predict that moving *quem* (*who*) over an intervening lexical DP might still generate an intervention effect because of the partial match in internal structure of the two (N, +animate, +human, singular, Nominative/Accusative).

Portuguese free dependencies, therefore, offer an interesting testing ground for intervention effects: a case in which we might have partial matching of feature structure despite the absence of a lexical restriction in one of the two DPs involved.

Our purpose in this paper is two-fold. First, we want to investigate whether children acquiring European Portuguese comprehend headed and free subject and

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object dependencies differently. This is relevant for the identification of the atoms of interventions. GM would predict intervention effects to arise in both conditions, albeit more strongly so in presence of a lexical restriction; while a perspective that focuses on the lexical restriction only might predict intervention effects to disappear in free dependencies.

Second, we want to test whether similar asymmetries between headed and free dependencies are found in self-paced reading tasks for adults. This comparison is important to further understand the nature of the intervention effect in adults and to check the role played by processing capacities as an explanatory device. If adults exhibit the same pattern as children, and no independent factor is responsible for it, we have some evidence in favour of the parsing account. If, on the other hand, children and adults exhibit a different behaviour, and adults score better than children, we can suppose that no processing issues are at stake, and that there is some language specific aspect that is going to mature and develop.

The paper is structured as follows: Section 2 presents a sentence to picture matching (SPM) experiment on the comprehension of sentences containing headed and free dependencies by children acquiring European Portuguese. Section 3 presents pilot results on an experiment on the comprehension of the same structures in a self-paced reading task run on adult speakers of European Portuguese. Notice that, as standard, a control group of adults was tested also in the SPM, any asymmetry between the conditions still present in adults are likely to be obscured by the nature of the SPM technique (offline) but are expected to emerge more clearly with self-paced reading. In section 4, a discussion of the results is proposed, relating them to the issues discussed in this introduction, that is, clarifying whether the results on comprehension of free dependencies in adults and children argue in favour of a specific type of intervention effects in the comprehension of object dependencies.

2. EXPERIMENT 1: COMPREHENSION OF HEADED AND FREE DEPENDENCIES BY CHILDREN ACQUIRING EUROPEAN PORTUGUESE

2.1. Method

The participants' comprehension of sentences containing *wh*-dependencies was assessed using a sentence-picture matching task (modeled after Friedmann and Novogrodsky 2004, 2007, 2011). The participants heard a sentence read by a native speaker of European Portuguese, and saw two pictures on the same page. One picture matched the sentence, whereas in the other picture the roles of the figures were reversed. The participant was asked to point to the picture that correctly described the sentence.

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A total of 80 European Portuguese sentences were tested for each participant. These sentences included 20 headed subject dependencies, 20 free subject dependencies, 20 headed object dependencies, and 20 free object dependencies. We illustrate these sentences in the following examples:

(5) a. *Headed subject relative*
Mostra-me o menino que seca o hipopótamo
show-me the boy that dries the hippo.
b. *Headed object relative*
Mostra-me o menino que o hipopótamo seca
show-me the child that the hippo dries
c. *Free subject relative*
Mostra-me quem seca o hipopótamo
show me who dries the hippo.
d. *Free object relative*
Mostra-me quem o hipopótamo seca
show me who the hippo dries

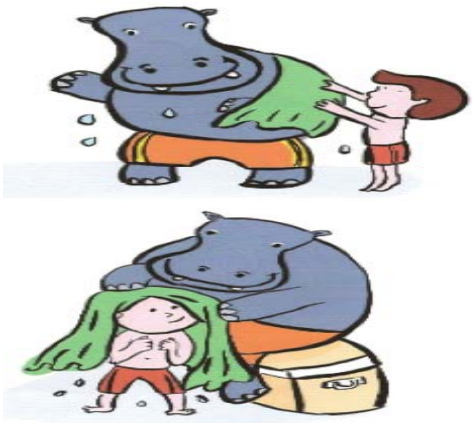

Fig. 1. An example for a picture pair used in the comprehension task.

The child was requested to point to the picture that matched the sentence, for example, the object dependency *Show me the hippo that the boy dries*. All the sentences were semantically reversible so that comprehension of the meaning of the words alone could not determine the meaning of the sentence (namely, we did not use irreversible sentences like *Show me the girl who is eating ice cream*, only reversible ones like *Show me the girl that grandma hugs*). The sentences were randomly ordered. The participant saw 20 picture pairs four times; each pair appeared with the four sentence types. The correct picture in each set was randomized (the matching picture in each set appeared randomly in one of the two positions on the page).

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2.2. Participants

40 children participated in the experiment. We tested 21 boys and 19 girls. The age range was from 4;0 until 5;11. All the children are monolingual speakers of European Portuguese, and have no history of social, emotional, cognitive or hearing impairment. All children are from the Lisbon area. The adult control group consisted of 20 adults (9 male, 11 female), aged between 24 and 47. All adults had a university background and no specific training or education in the area they were being tested for. All participants were tested individually in a quiet room. No time limit was imposed, and no stimulus or correction was given depending on the type of response, besides general encouragement to pursue the task and a final reward after completion of the task (for the children only). The responses were registered by an experimenter during the session.

2.3. Results

In the following tables, we present the group results for the children in the four conditions: headed subject, free subject, headed object and free object free dependencies. The first aspect to be noted is that adults performed at ceiling in all conditions:

Table 1

Control group results

	Headed	**Free**
Subject	100%	100%
Object	100%	100%

This is in line with the results of Costa *et al.* (2011), who show that adults perform at ceiling in the comprehension of subject and object dependencies clauses when a Sentence to Picture Matching Task is used.

Let us now consider the performance of children. In Table 2, we present the global results grouping 4 and 5 year olds:

Table 2

Children's group results

	Headed	**Free**
Subject	98,1%	94%
Object	81,8%	82,25%

The global results reveal the usual asymmetry between subject and object dependencies, but no clear preference for free over headed dependencies. In particular, we found no clear case for stating that free object dependencies are easier than headed object headed dependencies. However, if we separate 4 and

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5 year olds, the results are different. Table 3 presents the data for the twenty 4 year-old children whom we tested; Table 4 presents the data for the twenty 5 year-old children whom we tested:

Table 3

4 year- old children's results

	Headed	**Free**
Subject	96,5%	91,5%
Object	76,75%	83,5%

Table 4

5 year- old children's results

	Headed	**Free**
Subject	99,75%	96,5%
Object	87%	87%

As can be seen in Tables 3 and 4, there is a difference between headed and free object dependencies for 4 year olds, which disappears at age 5. At age 4, the most difficult condition is headed object dependencies. Free dependencies are easier, although not comparable to subject dependencies. This is confirmed by the individual data for 4 year olds presented in Table 5:

Table 5

Individual scores for the 4 year-old group

Participant's age	**headed subject**	**Headed object**	**free subject**	**free object**
4;0	20	15	20	17
4;1	20	15	16	17
4;3	18	18	18	18
4;3	20	13	18	15
4;3	20	16	19	18
4;4	18	13	20	20
4;5	17	11	17	18
4;5	18	11	16	9
4;6	20	17	20	20
4;8	20	20	18	18
4;8	20	17	20	18
4;9	19	16	18	17
4;9	20	16	19	15
4;9	20	16	20	14
4;9	19	13	17	17
4;10	20	18	20	16
4;10	13	8	11	11
4;11	20	19	20	20
4;11	20	17	19	16
4;11	19	18	20	20

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2.4. Analysis

As a group, children performed *above chance level* in all conditions. A repeated measure ANOVA crossing *headedness* (headed vs. free RCs) with *extraction site* (subject vs. object) revealed a significant effect of the latter F (1, 19)= 44.812, p < .0001, and no effect of the former F (1,19)= .668, p = .42. The analysis also revealed a significant interaction between the two factors F (1,19) = 12.340, p = .002. The analysis of the interaction revealed a significant effect of extraction site in both headed F (1, 19)= 60.350 p < .0001, and free dependencies, F (1,19)=9.651, p=. 006; and a significant effect of headedness in opposite directions in subject and object extraction: subject RCs were comprehended significantly better in the headed than the free condition; object RCs, on the other hand, were comprehended significantly better in the free than the headed condition. This might be responsible for the apparent lack of *headedness* effects.

Summarizing the results, we found:

a) As a group, children performed above chance level in all conditions.

b) An asymmetry between subject and object extraction, independently of their status as headed or free in the two age groups, with better comprehension of subject extraction.

c) An asymmetry between free and headed dependencies in the object condition at age 4 only. At this age, free object dependencies are understood more easily than headed object dependencies.

d) A disappearance of the advantage of free over headed dependencies at age 5.

In sum these results show a cumulative effect at age four of two conditions: headed vs. free and subject vs. object. For five year olds, only the subject object difference persists as a factor for making the comprehension of dependencies more difficult.

For adults, no effect was found. However, if the persisting effect on 5 year olds is a side effect of a difficulty imposed on the parsing of object dependencies, we may expect that it persists in adults, and should be found when a more sensitive task is employed. With these issues in mind, while we write, we are conducting a pilot self-paced reading study on the processing of headed and free dependencies in adult speakers of Portuguese. While the testing is still ongoing, so far we have only tested twenty-five subjects, we already obtained some significant results, which we anticipate in the next section.

3. A SELF-PACED READING EXPERIMENT ON HEADED AND FREE DEPENDENCIES IN EUROPEAN PORTUGUESE

3.1. Method

A self-paced reading experiment was carried out in European Portuguese at the Psycholinguistics Lab of the Centro de Linguística da Universidade Nova de Lisboa.

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Materials and design

Twenty sets of target sentences with four conditions were constructed, interspersed by sixty pseudo-randomized filler sentences, with four version for each sentence, in a 2x2 design crossing *headedness* (free vs. headed) and *extraction site* (subject vs. object) dependencies.

All the target sentences were preceded by a short intro of the form: NP1 told NP2 (e.g., *A advogada contou ao juiz* / *The lawyer told the judge*). This preliminary material was judged necessary to a question interpretation of *quem* (*who*). The intro was followed by either *quem* (*who*) or *que NP* (*that/which NP*) introducing the clause (e.g., *quem/que politico estava a corromper o presidente* / *who, which politician was corrupting the president*). Each sentence was closed by a PP modifier selected to preferentially modify the embedded verb (e.g., *com dinheiro public/with public money*).

(6) a. *Free subject dependency*
A advogada contou ao juiz quem estava a corromper o político com dinheiro público.
'The lawyer told the judge who was corrupting the politician with public money.'
b. *Free object dependency*
A advogada contou ao juiz quem o político estava a corromper com dinheiro público.
'The lawyer told the judge whom the politician was corrupting with public money.'
c. *Headed subject dependency*
A advogada contou ao juiz que político estava a corromper o presidente com dinheiro público.
'The lawyer told the judge which politician was corrupting the president with public money.'
d. *Headed object dependency*
A advogada contou ao juiz que político o presidente estava a corromper com dinheiro público.
'The lawyer told the judge which politician the president was corrupting with public money.'

The critical regions for the analysis consisted of the embedded clause excluding the final PP. We also analyzed the embedded verb in isolation and the performance on comprehension questions. One item was eliminated from the analysis because of a typo.

Procedure

The experimental task was a word-by-word self-paced reading with a moving window display paradigm (Just *et al.* 1982). The experimental materials were counterbalanced to ensure that each subject would see only one instance of each

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sentence. The experiment was run on a PC using the Linger software developed by Doug Rodhe (http://tedlab.mit.edu/ dr/Linger/).

Instructions on the modality of the experiment were given by the researcher and presented on the computer screen. The subjects were instructed on the functioning of the moving window display: a line of dashes would appear on the screen, covering words of a sentence. Each time they pressed the space bar a word would appear on the screen, and replace the dashes. At a second press of the space bar a new word would appear and the previous word would be replaced by dashes again. The time required to press the space bar for each word was recorded by the software. To ensure that the participants indeed comprehended the target sentences, a *yes-no* comprehension question would appear after reading the last word of the sentence. Comprehension questions followed each sentence and feedback was given to the participant whenever an incorrect answer was produced. 50% of the questions had 'yes' as a correct answer. The questions targeted thematic relations between different arguments of the verb.

All nouns and verbs in the questions had been used in the actual sentences. To familiarize the participants with the task, a few practice items were presented before the actual experiment. The experiment took approximately 20 minutes to complete. Participants were instructed to take breaks only after answering the comprehension question. A mandatory break was planned in the middle of the experiment. Because of the currently poor soundproof conditions of the Lab, and to avoid the potential confounds of external noise, *white noise* was used through headphones during the experiment. We reasoned that any possible effect (negative or positive) of white noise over the task would be present for all the experimental conditions and therefore would overall disappear.

3.2. Participants

Twenty-six students and staff members of the UNL participated in the experiment after signing an informed consent form. Course credits or a small reward were given as compensation for the participation. All the participants were native speakers of European Portuguese and were naïve as to the goals of the study. One of the participants was excluded from the analysis because he scored at chance (46.5%) in the comprehension questions. All other subjects performed significantly above chance (72.73% to 93.18%).

3.3. Results

Comprehension questions

As a group, participants answered correctly 79.8% of the questions. Table 6 summarizes the percentages of correct answers per condition.

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Table 6

Percentage of correct answers

	Headed	**Free**
Subject	77.6%	87.2%
Object	64.0%	90.4%

Analysis of comprehension questions

A 2x2 repeated measure ANOVA by subjects crossing headedness (free vs. headed) and extraction site (subject vs. object) revealed a significant effect of headedness. Questions about headed movement were significantly harder to comprehend than questions about free movement both in the analysis over subject (70.8% vs. 88.8%, F (1, 24)=27.000, p 20 < .001) and in the analysis over items (F (1, 19)=25.396, p < .001). The interaction of *headeness*extraction site* was significant in the analysis by item (F (1, 19)=6.257p = .022) and close to significance in the analysis by subject (F (1, 24)= 2.725 p = .112), with better performance with free object than headed object extraction. No effect of extraction site was found in the analysis by subject when all the data where taken into account (F (1, 24) =1.798 p = .193), an almost significant effect was found when only the headed relatives where considered (p =. 094). As the analysis by item reveal, the asymmetry between subject and object extraction was smaller in the case of free extraction.

Reading times

As standard in self-paced reading studies, residual reading times were calculated from the raw reading time of each subject, and for both fillers and experimental items, to adjust for differences in sentence length across conditions and reading time differences between participants. Following Ferreira and Clifton (1986) (Trueswell et al., 1994, see also) we calculated a regression equation that allowed us to predict reading times from word length for each participant. We did this by calculating the slope and intercept of the raw reading time and the number of characters for each participant at each word position. Residual reading times were calculated by subtracting from the actual reading time the sum of the intercept plus the product of the slope by the number of characters for each word.

Analysis of RT

The residual reading times obtained in this way were analyzed using a Mixed Model Regression analysis in open-source codeR with the lme4 library (Bates and Sarkar, 2007). Subjects and Items were treated as random effects and Independent Variables as fixed effects. This has the advantage of considering covariates that contribute to the structure of the data (other than the independent variables) including those associated with both items (e.g. frequency, complexity) and subjects (e.g. age, sex) with two Fixed factor (headedness and extraction site) and

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random intercepts for subject and items were performed for the duration of the regions of interest. The regions of interest were the whole embedded clause (excluding the PP) and the embedded verb.

All reading times exceeding five standard deviations from the norm were not considered for the analysis. This brought us to exclude 5 data points. The analysis of the whole embedded clause shows a significant effect of headedness (t value = 4.215) with significantly faster reading times for free than headed dependencies. The analysis also shows a significant effect of extraction site (t value = -3.329), with subject read significantly faster than their object. No interaction was found with this analysis. Analysis at the embedded verb shows a significant effect of headedness (t value = 2.037), but no effects of extraction site (t value = -3.329) and no interaction (t value = 1.146).

4. DISCUSSION

Let us summarize the results of the two experiments.

Experiment 1, on the comprehension of free and headed subject and object dependencies by Portuguese children, yielded the following results:

a) An asymmetry between subject and object extraction, independently of their status as headed or free in the two age groups, with better comprehension of subject extraction.

b) An asymmetry between free and headed dependencies in the object condition at age 4 only. At this age, object free dependencies are understood more easily than object headed dependencies.

c) A disappearance of the advantage of free over headed dependencies at age 5.

Experiment 2, a pilot study on the comprehension of free and headed subject and object dependencies by adults in a self-paced reading task, yielded the following (preliminary) results:

a) An asymmetry between subject and object extraction was found with better comprehension of subject extraction;

b) An asymmetry between subject and object extraction was found with faster reading times for subject extraction;

c) An asymmetry between free and headed dependencies was found with better comprehension of free dependencies;

d) An asymmetry between free and headed dependencies was found with faster reading times for free dependencies.

The combination of these results is interesting, as they shed some light on the development of dependencies by children. Recall that we were interested in answering the following questions:

i. How sensitive to the internal structure of different DPs is the principle that regulates intervention effects? Is it still active in absence of lexical restriction in one of the DPs?

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ii. If present, does intervention in absence of lexical restriction apply in the same way in adults and children?

The results which we obtained help clarifying these issues.

The present work shows that the strength of intervention effects can be modulated by a manipulation of the internal structure of the moved DP and the intervening DP. As in previous work, the intervention effect is significantly stronger when a lexical object DP is moved over a lexical subject DP. Importantly, however, we show that the intervention effect does not disappear in dependencies that involve a relative pronoun that lacks a lexical restriction, even if it is significantly attenuated. This is expected when we consider the internal feature structure of *quem*, which is composed by at least the following features: N, +animate, +human, and of course *wh*.

That *quem* and other operators, such as *who* in English or *quien* in Spanish, have a rich internal structure and crucially contain a nominal specification is readily justified when a few properties of operators are taken into account: just like other Nouns, operators can be case marked (*who*, *whom*, *whose*), they can be inflected for number (*quien* vs. *quienes*) and gender (Portuguese possessive op.: *cujos* vs. *cujas*, which also shows number marking *cujo* vs. *cujos*). Operators, moreover, appear in all syntactic environments in which DPs can appear. The internal structure of the operator, therefore, partially matches the structure of the intervening subject in object extraction; which can explain the persistence of intervention effects, albeit of a significantly lower intensity, in both children and adults with non headed object dependencies. The fact that adults display a better capacity than children in dealing with object headed *wh*-dependencies in the offline method can readily be explained by the development of processing capacity.

The higher complexity of headed object extraction is readily explained under GM: headed RCs require lexical access, as opposed to access to the functional lexicon of free / pure operator movement. Accessing the lexical restriction of the moved element involves the usual steps of lexical access: activation of a pool of candidates, competition among them, and finally selection. It is a costly process in itself and, importantly, it is a time consuming process, which can reasonably be assumed to slow down the whole process and reduce chances of successful selection of higher order features. This in turn would result in underspecified representation of the DP which would generate a minimality effect. Since minimality is involved, which is a grammatical constraint, it is expected that these processing costs emerge not only in comprehension, but also in production, which is indeed the case, as mentioned in the works referred in the introduction that looked at subject-object and free-headed asymmetries in production.

Operator movement also involves these steps, but it operates purely at the level of functional lexicon and for this reason it is faster and has less chances of generating a minimality effect. Still, a partial overlap between the feature structure of the *wh*-pronoun and the intervening DP in object extraction can be expected to generate occasional minimality effects.

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5. CONCLUSIONS

In support of the GM approach, this work shows that intervention effects are modulated by the internal feature structure of the elements involved: higher similarity leads to stronger intervention effects. Importantly, the studies presented here also show that intervention effects also emerge in the absence of lexical restriction, albeit in a weaker form. Despite the pilot nature of the SPR study presented here, it appears that children and adult speakers behave similarly with respect to intervention effects, which supports a processing approach to intervention effects.

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