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Subject-object asymmetries in the processing of European Portuguese cleft structures: Assessing the role of animacy

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Abstract

This study investigates the intervention effects on the processing of standard clefts by adult speakers of European Portuguese, focusing on the semantic feature of animacy. Using a self-paced reading task combined with a picture selection task, we manipulated the extraction types (subject vs. object) and the animacy of the clefted constituent (animate vs. inanimate). 40 participants took part in the study. We observed a processing and comprehension advantage for subject clefts over object clefts, regardless of animacy. There is also an advantage of the intersection of the animacy feature in object clefts, demonstrated by shortened reading times from the verb phrase onward. No effects of animacy on the assignment of thematic roles were found: the prototypical association of animacy with the subject did not significantly influence processing. Our results suggest that features relevant to the syntactic component such as the +N feature (shared by the object and the subject in all clefts) trigger stronger intervention effects than features that do not affect this component. It is thus plausible

that different theoretical perspectives on intervention effects (featural Relativized Minimality and similarity-based interference models) complement each other, predicting that morphosyntactic features trigger stronger effects than semantic features.

Keywords: intervention effects, animacy, cleft, European Portuguese, sentence parsing.

1. Introduction

In A'-movement (movement to a non-argumental position), for example, in the formation of *wh*-questions, relative clauses (RC) and clefts, an abstract dependency called A'-dependency (Chomsky, 1995) is formed between the non-argumental position to which the extracted constituent is moved and a silent copy left by the moved constituent in the argumental position within the embedded clause. The establishment and interpretation of an A'-dependency is essential for the construction of the syntactic representation. Also known as filler-gap dependency in the field of psycholinguistics, this dependency must be reconstructed in processing: the filler must be maintained in memory until the corresponding gap is found and the dependency is established. Below, we show a pair of sentences in European Portuguese (EP) involving an A'-dependency, with a subject standard cleft (1a) and an object standard cleft (1b), following the analysis of standard clefts in EP by Lobo, Santos & Soares-Jesel (2016). In (1a), the clefted constituent, "*o João*", moves to the specifier position of XP from the subject position of the embedded clause, whereas in (1b), the clefted constituent, "*o bolo*" (the cake), moves from the embedded object position, crossing the subject of the embedded clause.

(1) a. [$_{TP}$ *pro* [$_{T'}$ Foi [$_{VP}$ [$_{V'}$ V^0 ~~foi~~ [$_{XP}$ **o João** [$_{X'}$ [$_{CP}$ [$_{C'}$ que [$_{TP}$ ~~**o João**~~ comeu
be.PST.3SG the João COMP eat.PST.3SG
o bolo]]]]]]]]]
the cake[1]
'It was João that ate the cake.'
b. [$_{TP}$ *pro* [$_{T'}$ Foi [$_{VP}$ [$_{V'}$ V^0 ~~foi~~ [$_{XP}$ **o bolo** [$_{X'}$ [$_{CP}$ [$_{C'}$ que [$_{TP}$ o João comeu
be.PST.SG the cake COMP the João eat.PST.3SG
~~**o bolo**~~]]]]]]]]]
the cake
'It was the cake that João ate.'

Previous studies on A'-dependencies have shown that object dependencies are more challenging than subject dependencies, both in language acquisition (Friedmann & Novogrodsky, 2004; Adani *et al*., 2010; Guasti, Stavrakaki & Arosio, 2012, a.o.), and in adult language processing measured with various experimental methods (e.g., King & Just, 1991; Gordon, Hendrick & Johnson, 2001; Ferreira, 2003, a.o.). The grammatical representation of object dependencies may also be affected in a

[1] Glosses used in the article are as follows: ART = article; COMP = complementizer; PROG = progressive; PST = past; SG = singular.

compromised language system, such as in agrammatic comprehension (e.g. Garraffa & Grillo, 2008). In EP, researchers have observed a later development of structures involving an object A'-movement (Lobo & Soares-Jesel, 2017), greater difficulties in object RC comprehension by children (Costa, Lobo & Silva, 2011), a subject-object asymmetry in the processing of RCs by adults, as well as a higher processing cost for headed object relatives than for free object relatives (Costa, Grillo & Lobo, 2012), even though the grammar of adult speakers does not require a complete disjunction of features between the extracted constituent and the intervener (Friedmann, Belletti & Rizzi, 2009).

In the case of cleft structures, especially, data from spontaneous production (Santos, 2006; Soares, 2006) and elicited production (Lobo, Santos & Soares-Jesel, 2016) of children acquiring EP show that, in standard clefts, the clefting of a subject is more frequent than that of other constituents. When it comes to comprehension, Lobo *et al*. (2019) demonstrate that, within standard clefts, subject clefts are easier to comprehend than object clefts. This asymmetry was attributed to intervention effects, interpreted under the approach of featural Relativized Minimality (fRM, Friedmann, Belletti & Rizzi, 2009, a.o.). In contrast, in pseudoclefts, such as (2), no subject-object asymmetry was found, which indicates that the tested children, aged 4-5 years old, did not adopt an "agent-first" heuristic strategy, that is, the children did not interpret the first DP as the agent and the second DP as the object, based on the canonical word order of EP:

(2) a. [$_{TP}$ [$_{CP}$ Quem **a** **vaca** **lambeu** ~~quem~~] foi
who the cow lick.PST.3SG who be.PST.3SG
[$_{SC}$ [~~quem a vaca lambeu quem~~] [$_{DP}$ **a** **girafa**]]] - **SVO**
who the cow lick.PST.3SG who the giraffe
'Who the cow licked was the giraffe.'

b. [$_{TP}$ [$_{CP}$ Quem **lambeu** **a vaca**] foi
who lick.PST.3SG the cow be.PST.3SG
[$_{SC}$ [~~quem lambeu a vaca~~] [$_{DP}$ **a** **girafa**]]] - **VOS**
who licked the cow the giraffe
'Who licked the cow was the giraffe.'

The authors attribute the asymmetry between standard clefts and pseudoclefts and the fact that only object standard clefts caused comprehension problems to the different syntactic structure of standard clefts and pseudoclefts: only in standard clefts do we have an intervention configuration, with the clefted constituent moving across the intervening subject.

Several studies justified the subject-object asymmetry in A'-dependencies with a grammatical approach, i.e., the principle of fRM (Friedmann, Belletti & Rizzi, 2009; Costa, Grillo & Lobo, 2012; Rizzi, 2013), an extension of the Relativized Minimality (Rizzi, 1990). This approach focuses on the role of morphosyntactic features in determining minimality effects (cf. Generalized Minimality, Grillo, 2008, 2009, a.o.). According to fRM, an element Z structurally intervenes between an extracted element (X) and its copy (Y), when Z c-commands Y but does not c-command X. When Z, the intervener, shares the same morphosyntactic featural specification with the elements that it separates (X and Y), the locality relation is interrupted. In the fRM model, only features triggering movement (such as wh-, focus or number, but not animacy) are

relevant for intervention. Only when the features of the target (X) and the intervener (Z) are identical will the locality relation be blocked:

(3)

	Intervener	
X	Z	Y
A	A	<A>

The identity of features causes ungrammaticality, whereas the inclusion of features, i.e., when the intervener contains a subset of the features of X, is computable for an uncompromised adult grammar, but can hinder the computation in child grammars, which only permit the complete disjunction of features until a certain developmental stage (Belletti *et al*., 2012; Villata, Rizzi & Franck, 2016, Friedmann, Rizzi & Belletti, 2017, a.o.) (see (4)). Expanding on the different configurations of feature relations between the head of the chain formed by movement and the intervening constituent according to the principle of Relativized Minimality (Friedmann, Belletti & Rizzi, 2009), Belletti *et al*. (2012) introduced the concept of "intersection" to describe scenarios in which only some of the features are shared between the intervener and the target, which also have other distinct features. The same study concludes that intersection, just like disjunction, does not raise problems in the grammar of children, and that minimality effects are only applicable to the morphosyntactic features that determine syntactic movement in a given linguistic system. Durrleman and Bentea (2021) found a certain gradience in children's performance regarding the phi-features, with the inclusion relation being the most problematic in their scale: disjunction > intersection > inclusion:

(4) Durrleman & Bentea (2021: 5)

		Intervener			
	X	Z	Y	Adults	Children
Identity	A	A	<A>	*	*
Inclusion	A,B	B	<A,B>	ok	*
Intersection	A,C	C,D	<A,C>	ok	ok
Disjunction	A	B	<A>	ok	ok

The hierarchy proposed by fRM regarding different relations of featural specification shows parallels with other approaches to processing, namely similarity-based and memory-based models of retrieval (Gordon, Hendrick & Johnson, 2001, 2004; Mcelree, 2000; Lewis, Vasishth & Van Dyke, 2006, a.o.). Belletti and Rizzi (2013) interpreted the works of Gordon, Hendrick and Johnson (2001, 2004) in light of the fRM and considered that only the featural specifications involved in the computation of the principle of locality in syntactic dependencies influence reading. However, studies on features that do not trigger syntactic movement in certain languages, such as some semantic features, have yielded inconclusive results collectively. According to a study by Bentea, Durrleman and Rizzi (2016), the difference in the semantic feature of animacy does not help 4- to 5-year-old children process object relatives and object *wh*-questions but facilitates comprehension in 7-year-old children. Durrleman and Bentea (2021) show that the intersection of the

number feature, but not animacy, improves the comprehension of object extraction. Villata and Franck (2016), nonetheless, considered that both syntactic and semantic features shape the interference in *wh*-element extraction, which converges with memory/similarity-based models.

In the literature on sentence processing, the contrast between object extraction and subject extraction, particularly within RCs, has been extensively investigated. For example, the Dependency Locality Theory (DLT, Gibson, 2000; Warren & Gibson, 2002, a.o.) attributes the higher difficulty of processing object RCs compared to subject RCs to the greater distance, more precisely, the greater number of discourse referents that intervene between the extracted element and the embedded verb. The canonicity hypothesis (Friedmann & Novogrodsky, 2004), in line with the NVN strategy (Ferreira, 2003), attributes the processing cost of object extraction to the heuristic interpretation strategy of regarding the first DP of a sentence as the agent, which causes difficulties in recovering from the first analysis for object extraction, since the thematic roles were initially misassigned. Gordon and Lowder (2012) summarized three predominant groups of recent explanatory hypotheses for the asymmetry: (1) models focusing on memory limitations, (2) models focusing on the semantic and pragmatic interpretation, and (3) frequency-based models.

The memory/similarity-based approaches (e.g., Gordon, Hendrick & Johnson, 2001, 2004; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005; Lewis, Vasishth & Van Dyke, 2006) focus on the relations between semantic characteristics of the two DPs during object RC processing, given that the similarity can increase the load on working memory. Gordon, Hendrick and Johnson (2001, 2004) found that the manipulation of the DP type (proper names/pronouns vs. common nouns) affected reading times, since conditions that included DPs with different characteristics facilitated the reading of object RCs. Lewis, Vasishth and Van Dyke (2006) discuss the impact of similarity-based interference on working memory during both the encoding and retrieval stages of sentence comprehension. Similarity-based retrieval interference occurs when the increased syntactic and semantic resemblance between the distractors and the retrieval cues used for accessing the target raises processing difficulty. This is evidenced by increased reading times or higher error rates during retrieval. This type of interference can be retroactive (affected by distractors following the target) or proactive (affected by distractors preceding the target). Lewis, Vasishth and Van Dyke (2006) follow the similarity-based encoding interference hypothesis, arguing that the time required to encode an item increases due to its similarity to previous items.

The semantic/pragmatic accounts focus on the semantic or pragmatic factors that could influence RC processing, such as the animacy of the critical DPs (Traxler, Morris & Seely, 2002; Traxler *et al*., 2005; Mak, Vonk & Schriefers, 2002, 2006; Gennari & MacDonald, 2008, a.o.). These accounts highlight the prototypical association between animacy features and syntactic functions. Essentially, the proponents of these hypotheses argue that a reader tends to attribute the agent semantic role to an animate entity and the theme/patient role to an inanimate entity. The authors found that an extracted inanimate noun (with an animate noun in the embedded subject position) reduced or even eliminated the difficulty associated with object RCs (Traxler, Morris & Seely, 2002; Mak, Vonk & Schriefers, 2002). Traxler *et al*. (2005) expanded these results to the interaction with working memory capacity. Mak, Vonk and Schriefers (2006) found a subject advantage again by changing the internal DP to

inanimate and interpreted the results within a framework where the analysis of RCs in real-time is based on the interaction of animacy with factors such as topicality and the semantic properties of verbs. Research in other languages does not always reach the same conclusion. Baudiffier *et al*. (2011) replicated the disappearance of subject advantage in RCs in French. Meanwhile, Cabral, Leitão and Kennedy (2015), working with Brazilian Portuguese, found contrasts between subject and object RCs but did not find the effects of the prototypical association between animacy features and syntactic functions.

It is important to notice that different models, which offer different explanations for the observed effects, may converge on explaining animacy effects on processing. In fact, experimental conditions do not always allow us to disentangle the explanatory power of different models. For example, an eye-tracking study by Lowder and Gordon (2014) shows that, in object RCs, an animate extracted object is harder to process than an inanimate object, and that the effect of animacy arises relatively early in processing, before the verb has been fixated on. It is important to point out that, in Lowder and Gordon (2014), the embedded subject was kept animate. This way, the increased processing cost could be explained both by the effects of the prototypical association between animacy features and syntactic functions and by a larger semantic similarity, given that both entities are associated with the [+animate] feature.

A third type of account explains the subject-object asymmetry with the different frequency effects of each syntactic structure - since subject RCs are generally more frequent than object RCs (Gordon & Hendrick, 2005; Levy, 2008, a.o.) -, and of the lexical items, e.g., type of pronouns (Reali & Christiansen, 2007, a.o.). Belletti and Chesi (2011) investigated the frequency effects on the production of relatives in corpora and concluded that the frequency *per se* does not explain the distribution of relatives with different types of extraction, nor does it correlate with some results from the experimental studies. What is particularly pertinent to our study is that, in the experimental part of the aforementioned study, the manipulation of the combination of animacy features did not influence the production of object RCs. Finally, Samo and Merlo (2021) investigated intervention effects in cleft constructions across three languages (English, French, and Italian) based on corpora, and their results corroborated the theory of intervention locality. They found that subject clefts are produced more frequently than object clefts in all the languages studied, and that configurations with mismatched morphosyntactic features occur more frequently in object clefts than in subject clefts.

Studies focusing on A′-dependency processing and on subject-object asymmetries, such as some of those presented above, have predominantly centered on RCs. In contrast, cleft structures have received less attention in Psycholinguistic research. Research on cleft processing has focused on semantic incongruence and violation of information structure (Cowles, 2003; Cowles *et al*., 2007; Reichle, 2010, 2014, a.o.). In the context of Portuguese, Alves *et al*. (2015) studied the processing of standard clefts in Brazilian Portuguese using data from an eye-tracking experiment. They concluded that subject clefts are less costly when encoding informational focus, and that object clefts are more compatible with contrastive focus. In EP, the processing of clefts, especially regarding intervention effects, remains understudied. In this context, the current study aims to examine the existence of intervention effects in EP standard clefts, particularly focusing on the effects of a semantic feature - animacy.

In sum, different theoretical hypotheses predict different effects of the role of animacy on the processing of sentences with A'-dependencies. fRM (in Friedmann, Belletti & Rizzi, 2009 version) predicts that object extraction will be harder than subject extraction but does not expect animacy features to have an impact on processing, since only formal features that trigger movement are expected to be relevant for the computation of dependencies. Similarity-based models, on the other hand, predict that the similarity of the moved constituent and of the intervener can increase the load on working memory, but, in these models, all features, including animacy, will be relevant for processing dependencies. Finally, models that take into account frequency and prototypical syntactic-semantic relations predict that sentences where the subject is animate and the object inanimate will be easier to process than sentences with different syntactic-semantic mappings.

2. Experimental study

To investigate the processing of EP standard clefts, we designed a self-paced reading task followed by a picture selection task. More specifically, the study aims to address the following research questions:

1. Is there a subject-object asymmetry in the processing of standard clefts by adult speakers of EP?
2. Does animacy influence the processing of standard clefts in adult speakers? If so, in what way?
3. Should there be intervention effects and effects of prototypical association between animacy features and syntactic functions, which of these factors has a larger impact on the processing of standard clefts?

To address Questions 2 and 3, the experimental design must tease apart the intervention effects from those of prototypical association, as each theoretical account — fRM, similarity-based interference, and prototypical association — leads to different predictions. The prototypical association account predicts a facilitative effect of animate subjects and inanimate objects across both cleft types. Only this account makes predictions among subject clefts. Since the animacy feature of the extracted subject is at play, keeping the embedded object in a subject cleft as [-animate] reduces its likelihood as a candidate for the subject role, which helps eliminate confounding factors. While both the fRM and similarity-based interference models predict an advantage for subject clefts over object clefts, they do not make specific predictions for subject clefts alone. For object clefts, the fRM model does not predict an intervention effect of animacy, as this is a semantic rather than morphosyntactic feature. In contrast, the similarity-based interference model does predict such an effect, expecting higher processing costs when the extracted constituent and the intervener share animacy features, whether animate or inanimate. If we test object clefts with an animate subject as the intervener, similarity-based interference predicts reduced processing costs when the extracted object is inanimate rather than animate. In this case, the prototypical association hypothesis makes a similar prediction: inanimate elements are expected to be in object positions, whereas the animate ones are expected to be the subject, requiring reanalysis upon encountering the animate embedded

subject. Conversely, testing object clefts with an inanimate subject allows similarity-based interference models to predict higher processing costs when the extracted element, the object, is also [-animate], while the prototypical association account suggests reduced processing costs. Thus, our experimental design tests subject clefts with an inanimate object and object clefts with an inanimate subject to best differentiate between these accounts.

2.1. Materials

The self-paced reading task with picture selection crossed the following variables: *type of clefted constituent* (subject vs. object) and their *animacy feature* (+animate vs. –animate). The animacy feature of the *in-situ* argument was kept constant as [- animate]. The two arguments in each sentence always shared the same gender and number features, which created the conditions of match and mismatch, i.e. inclusion and intersection in fRM terminology with regard to object extraction (Belletti *et al*., 2012; Durrleman & Bentea, 2021). Thus, we created four conditions:

1) subject clefts with an inanimate subject and an inanimate object (feature match);
2) subject clefts with an animate subject and an inanimate object (feature mismatch);
3) object clefts with an inanimate object and an inanimate subject (feature match);
4) object clefts with an animate object and an inanimate subject (feature mismatch).

To make the sentences more natural for the picture selection task, the verbs were in the present progressive tense. In all conditions, the thematic roles of the subject and object were reversible, and for this purpose, the following verbs were used: *tapar* "cover", *encobrir* "cover up", *proteger* "protect", *esconder* "hide", and *ocultar* "conceal".

We constructed six items for each condition, totalling 24 test items. Each item contained 16 words, with syllable counts ranging from 26 to 31 (mean = 28.17, SD = 1.71). Additionally, we created 48 fillers, designed to match the experimental items in length, with 16-18 words and 27-33 syllables. The fillers included sentences with the passive construction, pseudoclefts and subject and object RCs, to disguise the experiment's purpose. In the comprehension task, the participant had to select the image that best matched the sentence. Example items for each condition are provided in (5), and Figure (1) shows an example of the pictures used in the comprehension task following the self-paced reading task.

(5) Example items[2]

(a) Condition 1: subject cleft, feature match, [-animate] [-animate]:

Na | imagem correta, | é | a coluna | que | está a tapar | a estátua | no | meio do museu.
'In the | correct image, | it is | the column | that | is covering | the statue | in the | middle of the museum.'

(b) Condition 2: subject cleft, feature mismatch, [+animate] [-animate]:

Na | imagem correta, | é | a menina | que | está a tapar | a estátua | no | meio do museu.
'In the | correct image, | it is | the girl | that | is covering | the statue | in the | middle of the museum.'

(c) Condition 3: object cleft, feature match, [-animate] [-animate]:

Na | imagem correta, | é | a coluna | que | a estátua | está a tapar | no | meio do museu.
'In the | correct image, | it is | the column | that | the statue | is covering | in the | middle of the museum'

(5d) Condition 4: object cleft, feature mismatch, [+animate] [-animate]:

Na | imagem correta, | é | a menina | que | a estátua | está a tapar | no | meio do museu.
'In the | correct image, | it is | the girl | that | the statue | is covering | in the | middle of the museum.'

[2] Two anonymous reviewers raised the question of whether, in sentences like (5a), the postverbal DP may be interpreted as a postverbal subject, potentially making the cleft sentence ambiguous between a subject cleft reading and an object cleft reading with a postverbal subject. In EP, particularly with transitive verbs, the latter interpretation is highly marginal. For example, a sentence like (i), in which verbal agreement forces the postverbal DP to be interpreted as the subject, seems highly marked in EP:

(i) ??Na imagem correta, é a coluna que estão a tapar as estátuas no meio
in.the image correct is the column that are covering the statues in.the middle
do museu.
of.the museum.

In the case of object clefts, ambiguity does not arise, as these structures are compatible with an object cleft interpretation and incompatible with a reading where the clefted constituent is interpreted as the subject and the other DP as a preverbal object. This is illustrated by the ungrammaticality of (ii), where the verb agrees with the clefted constituent and not with the preverbal DP:

(ii) *Na imagem correta, é a coluna que as estátuas está a tapar no meio do museu.
in.the image correct is the column that the statues is covering in.the middle of.the museum

Figure 1. Pictures to be selected in the comprehension task

2.2. Predictions

The way we manipulated the features of subject-object DPs allows us to evaluate the different predictions of three models: i) the fRM, ii) similarity-based interference models, and iii) the hypothesis of the effects of the prototypical association between animacy features and syntactic functions.

The fRM model (e.g., Friedmann, Belletti & Rizzi, 2009; Belletti & Rizzi, 2013) predicts a greater difficulty in processing object clefts due to the intervention of the subject DP, which should result in longer reading times and lower accuracy in comprehension compared to subject clefts. However, this grammatical approach predicts that only morphosyntactic features triggering movement should be problematic. Since animacy does not trigger syntactic movement in EP, the fRM model does not predict any difference in accuracy or in reading times between conditions with different configurations of animacy features (i.e., there should be no differences between Conditions 3 and 4).

Similar to the fRM, similarity-based models (e.g., Lewis, Vasishth & Van Dyke, 2006) also predict an asymmetry between subject and object extraction. Nonetheless, Lewis, Vasishth and Van Dyke (2006) propose that both structural (syntactic) and semantic features can cause intervention effects. According to this approach, in the configurations where intervention occurs, the greater the similarity (i.e., more similar cues shared between the extracted constituent and the intervener), the greater the difficulty in processing. Therefore, in object clefts, this approach predicts more processing difficulties when the extracted DP and the intervener DP share the same animacy features (Condition 3) compared to when the DPs have different animacy features (Condition 4). This should be reflected in lower accuracy on comprehension questions and longer reading times. In subject clefts, where the configurations do not involve intervention, no effects of animacy are expected.

The effects of the prototypical association between animacy features and syntactic functions suggest a tendency to initially assign the thematic role of agent to animate entities and patient to inanimate entities (Mak, Vonk & Schriefers, 2002, 2006; Lowder & Gordon, 2014). Consequently, subject clefts involving an animate subject and an inanimate object (Condition 2) are expected to be easier to process than those with an inanimate subject (Condition 1). In parallel, object clefts with an animate object and an inanimate subject (Condition 4) are also expected to be more difficult to process than object clefts in which both the subject and the object are inanimate (Condition 3).

In Tables 1 and 2, we summarize our experimental conditions and the predictions of each theoretical model.

Table 1. Synthesis of conditions

Conditions
1. subject cleft, feature match, [-animate] [-animate]
2. subject cleft, feature mismatch, [+animate] [-animate]
3. object cleft, feature match, [-animate] [-animate]
4. object cleft, feature mismatch, [+animate] [-animate]

Table 2. Synthesis of predictions of each theoretical hypothesis

fRM	**Similarity-based interference**	**Prototypical association between animacy and syntactic function**
Condition 1 = Condition 2;	Condition 1 = Condition 2;	Condition 1 > Condition 2;
Condition 3 = Condition 4;	Condition 3 > Condition 4;	Condition 3 < Condition 4
Conditions 1,2 <[3] Conditions 3,4	Conditions 1,2 < Conditions 3,4	

2.3. Participants

The participants were 42 adult native speakers of EP (23 female, 19 male) from continental Portugal (30 from the Lisbon Metropolitan Area, 5 from the North, 5 from the Centre, 1 from Alentejo, and 1 from Algarve). All participants reported to have been raised in monolingual environments by indicating that their primary guardians were monolingual EP speakers. The average age of the participants at the time of the experiment was 30.4 years (SD = 9.03), ranging from 18 to 62 years old. Among them, 3 participants did not speak any foreign language, while 39 spoke at least one foreign language: English (38 participants), French (13), Spanish (11), Italian (4), German (6) and Dutch (1). Despite being exposed to different languages, all these participants met our inclusion criteria by having grown up in monolingual households and having acquired the other language(s) later in life. Therefore, they are considered EP native and EP dominant. Participants were recruited through course mailing lists, social media groups of students from various faculties in Lisbon, and through participant referral. A random draw of 12 FNAC gift cards (€10 each) was conducted using the codes of participants who completed the study, and the selected participants were gifted the cards.

[3] The symbol "<" indicates that the condition on the left is less difficult than the condition on the right.

2.4. Procedure

Data was collected remotely using the Gorilla Experiment Builder platform (www.gorilla.sc) between June and October 2023. Before performing the task, all participants signed a consent agreement allowing their data to be used anonymously for the study.

We adopted a Latin Square design to mitigate order and fatigue effects. The stimuli were organized into four lists, each containing six test items and 18 fillers. Lists 1 and 2 had some fillers in common, as did lists 3 and 4. The task was administered to each participant on two separate occasions, at least one week apart, with participants being tested on either lists 1 and 3 or lists 2 and 4.

The stimuli were presented in a left-to-right, non-cumulative manner, with each sentence segmented into nine regions. Each stimulus began with the fixed initial segment '*Na*' ('in the') on the screen. Subsequent segments, including spaces and punctuation, were initially masked and revealed one at a time by pressing the space bar, which simultaneously concealed the previously visible segment. After viewing all the segments of a sentence, another display screen with two images automatically appeared. Participants were then asked to select one of the two images according to their understanding of the sentence, by clicking on the desired image. The positions of the correct images, indicating the expected responses, were counterbalanced across all trials, with half appearing on the left and half on the right side of the screen. Before the experimental trials, participants received instructions and completed five warm-up trials. Each experimental list was divided into six blocks, each comprising four items, with only one test item per block. Between blocks, participants were given the option to pause or proceed to the next block.

3. Results

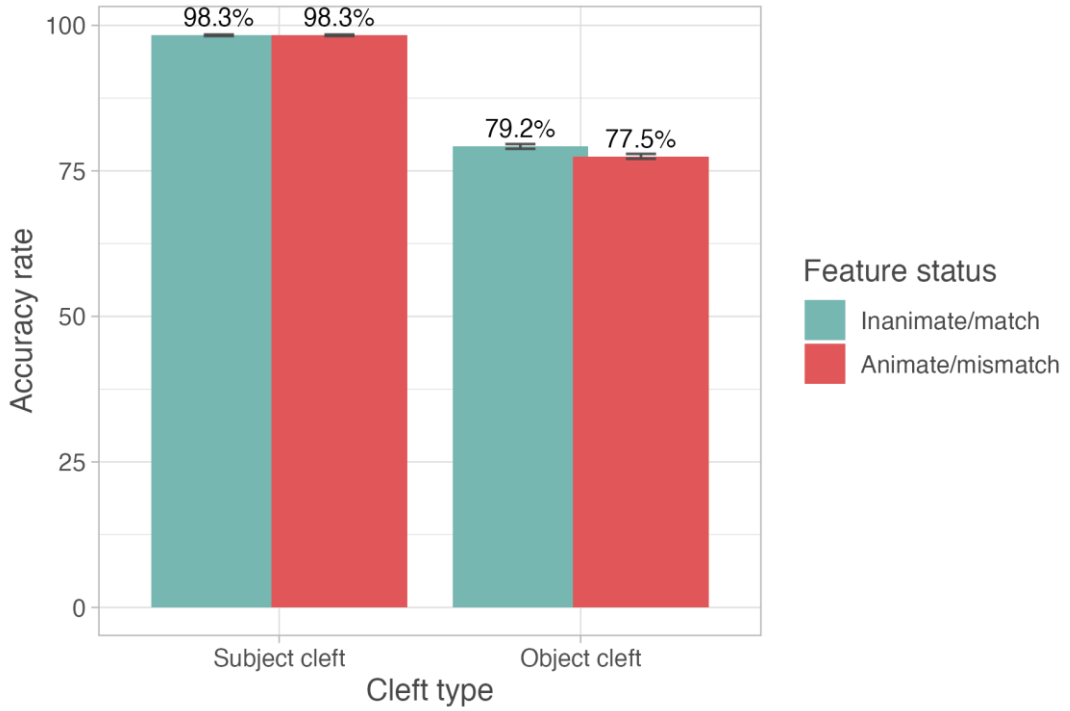
For the data analysis, we excluded the responses from two participants with an accuracy rate on all stimuli below 80%. The remaining data were included in the accuracy rate analysis. For the reading times analysis, items with incorrect responses in the picture selection (56 trials, 11.7% of the data) and reading times below 100 milliseconds or beyond 10,000 milliseconds were excluded. Additionally, reading times more than 3 standard deviations from each subject's mean per region and condition were eliminated, corresponding to 1.8% of the correct response data. All analyses and visualizations were conducted using R Statistical Software (v4.3.2; R Core Team, 2021). The results of these analyses are presented below.

3.1. Comprehension

The answers obtained from the comprehension task (i.e. the picture selection task) were coded as "1" for correct answers and "0" for incorrect answers. The data revealed notable differences in accuracy rate between the different conditions. Subject clefts in both the feature match condition (Condition 1) and the feature mismatch condition (Condition 2) achieved a high accuracy rate, with 98.3% in both cases. In contrast, object clefts showed a relatively lower accuracy rate, with 79.2% in Condition 3 (match) and 77.5% in Condition 4 (mismatch). Figure 2 shows the mean accuracy rate

per condition, with error bars indicating the standard deviation above and below the average value for each condition.

Figure 2. Mean accuracy rate per condition



The accuracy rate was analyzed with a Generalized Linear Mixed Model (GLMM) using the *lme4* package (Bates *et al*., 2015). The binary accuracy response served as the dependent variable, modeled as a function of the fixed variables: *extraction type* (subject or object) and *animacy of the cleft constituent*, as well as the interaction between these two factors. The extraction type and animacy were contrast-coded. The model also included random intercepts for each subject and item, as well as random slopes that capture the variation in the effects of extraction type and animacy between subjects.

The analysis revealed a significant effect of the extraction type on the accuracy rate ($\beta = 8.92$; SE = 4.34; $z = 2.06$; $p = .040$). However, neither animacy ($\beta = 0.78$; SE = 0.71; $z = 1.10$; $p = .27$) nor the interaction between extraction type and animacy ($\beta = -0.48$; SE = 5.09; $z = -0.10$; $p = .92$) showed statistical significance. Therefore, the extraction type was the only significant predictor of the probability of a correct response. Subject clefts exhibited a higher accuracy rate compared to object clefts. In contrast, the animacy of the clefted constituent did not significantly influence the probability of a correct interpretation.

Following this, we analyzed the response times of correctly answered items, defined as the interval between the presentation of pictures and the selection of the picture by the participants. The response times were log-transformed, centralized and standardized. A Linear Mixed Model (LMM) was employed using the *lme4* package (Bates *et al*., 2015), with t-tests conducted according to Satterthwaite's method. The model examined variations in log reaction times (logRT) based on the fixed variables: *extraction type* (subject or object) and *animacy*, as well as the interaction between these two variables. Random intercepts were included for each subject and item, as

well as random slopes for the interaction between extraction type and animacy per subject.

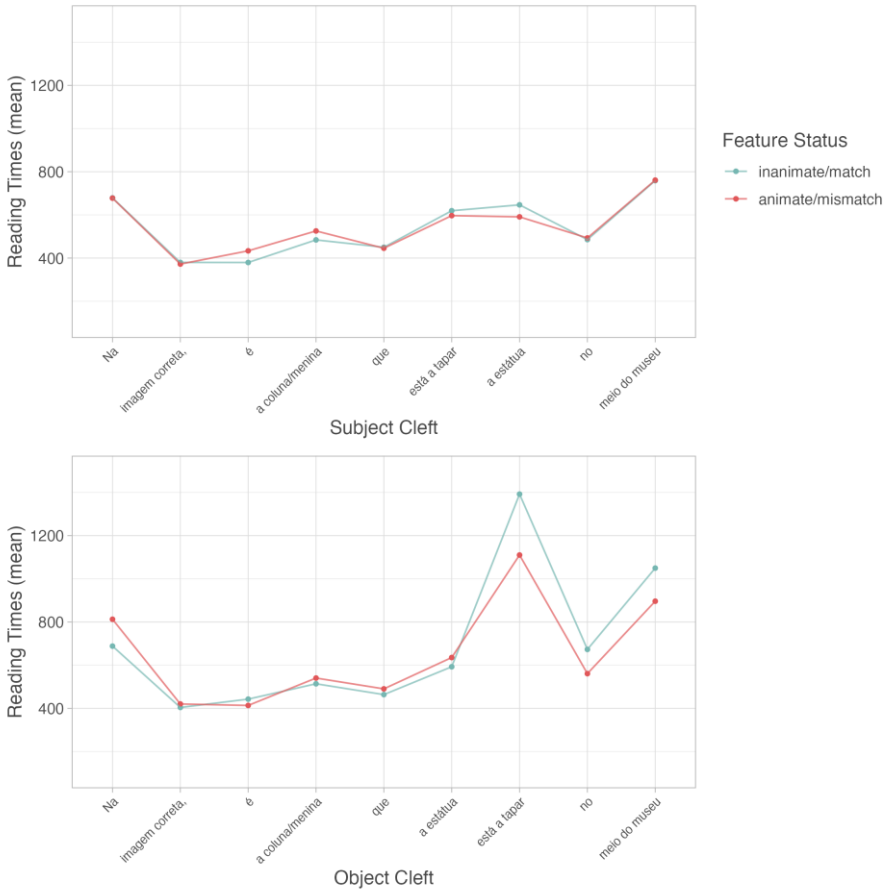
The results revealed that the extraction type had a significant effect on response times (β = -0.47; SE = 0.14; t = -3.52; p < .01), indicating that subject clefts are associated with a decrease in response times compared to object clefts. However, animacy (β = 0.02; SE = 0.14; t = 0.16; p = .87) and the interaction between extraction type and animacy (β = -0.16; SE = 0.18; t = -0.92; p = .37) did not show statistical significance. Thus, the faster responses to subject clefts indicate a greater ease of processing. The animacy of the clefted constituent and its interaction with the extraction type did not influence response times, reflecting a trend similar to that observed in the accuracy rate analysis.

In summary, the extraction type significantly predicts both accuracy and response speed, with subject clefts being interpreted more easily and correctly than object clefts. Meanwhile, the animacy of the clefted constituent was not a significant predictor for either accuracy or response speed.

3.2. Reading Times

When analyzing reading times, only the reading times of critical and spillover regions were considered. Critical regions consisted of the two segments immediately following the complementizer, and the spillover regions were the last two segments of the sentence. Figure 3 shows the reading times per condition and per segment.

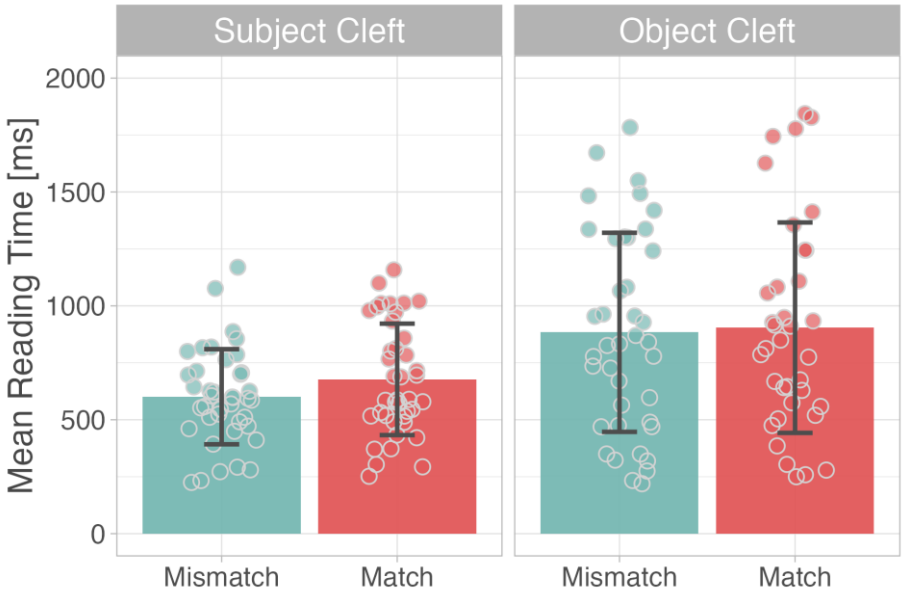
Figure 3. Mean reading times by condition and by segment



We analyzed the log-transformed, centralized and standardized reading times using Linear Mixed Effects Models (LMM) with the *lme4* package (Bates *et al*., 2015). To minimize the potential impact of item distribution, the following were established as fixed variables: *distributed lists, trial order, extraction type* (subject or object) and *the animacy of the clefted constituent*, as well as the interaction between the extraction type and animacy. In addition, random intercepts for each subject and item were integrated into the model, as well as random slopes capturing the interaction between extraction type and animacy per subject. Model comparisons using ANOVA justified the inclusion of the list and trial order as fixed variables, as they significantly improved the explanatory power of the models in relation to the data ($p < .05$). When a significant difference was found, we conducted a nested effect analysis of animacy within each extraction type (Schad *et al*., 2020) to focus on the effect of animacy within each extraction type without averaging across all conditions. This is theoretically driven, since animacy is not expected to affect subject and object clefts in the same direction within the framework of the similarity-based interference models or in the model that advocates effects of the prototypical association between animacy features and syntactic functions. The nested effect analyses also included random intercepts per subject and item, and random slopes for the interaction between extraction type and animacy per subject.

In the critical regions (combination of verb phrase and embedded DP), extraction type showed a significant effect on reading times ($\beta = -0.38$; SE = 0.10; $t = -3.76$; $p < .01$), suggesting that object clefts are processed more slowly than subject clefts. However, animacy showed no statistical significance ($\beta = 0.17$; SE = 0.10; $t = 1.752$; $p = .08$), although it came close to the significance threshold of .05. There was also no significant interaction between the two variables ($\beta = 0.00$; SE = 0.13; $t = 0.017$; $p = .99$). Additionally, the nested effects analysis suggested that, in these two segments of the subject clefts, animacy showed statistically significant effects, albeit subtle ($\beta = 0.17$; SE = 0.09; $t = 2.00$; $p = .045$), and that among the object clefts, animacy showed no significant effects. In other words, in the critical regions, subject clefts were easier to process than object clefts. Among the subject clefts, those with an inanimate subject had longer reading times compared to those with an animate subject, i.e. the animacy of the extracted subject facilitated reading. Among the object clefts, animacy did not influence reading. Figure 4 shows the reading times in the critical regions by condition.

Figure 4. Reading times by condition in critical regions



Subsequently, we included the spillover regions (the prepositional phrase) alongside the critical regions in the analysis. In these four regions, the extraction type again demonstrated significant effects (β = -2.407e-01; SE = 6.782e-02; t = -3.55; p < .01), as did animacy (β = 1.577e-01; SE = 6.760e-02; t = 2.33; p = .02). The interaction of the two variables, however, did not show a significant effect (β = -5.928e-02; SE = 9.171e-02; t = -0.65; p = .51). Regarding the nested effects at each extraction type level, animacy showed no significant effects in subject clefts (β = 9.838e-02; SE = 6.005e-02; t = 1.64; p = .10). Meanwhile, within object clefts, the inanimate feature match significantly slowed down reading (β = 1.577e-0; SE = 6.760e-02; t = 2.33; p = .02). In summary, from the critical regions to the spillover regions, subject clefts remained easier to read than object clefts. Animacy did not impact reading times in subject clefts across these regions. In contrast, in object clefts, matching inanimate features of the two DPs slowed down processing compared to conditions where the animate extracted object resulted in a featural mismatch.[4] Figure 5 presents the reading times per condition in the critical and spillover regions.

[4] We thank an anonymous reviewer for suggesting an analysis of 3-way interaction of region (critical vs. spillover), extraction type (subject vs. object) and animacy (animate vs. inanimate). The maximal model could not converge. In the model that did converge, the random effects only consider random intercepts for subject and for item, and a random intercept for trial with a random slope of region under trial. This model yielded significant main effects of cleft type (p < .01) and of animacy (p = .006), as well as a significant interaction between region and cleft type (p = .028). Additionally, there were no significant two-way interactions between animacy and region, nor any significant three-way interactions among animacy, region, and cleft type. We fitted a subsequent model that included animacy nested within the levels of cleft type. This model also incorporated the main effects and interaction of region and structure, along with the three-way interactions between region, structure and animacy. The results showed a statistically significant effect of animacy within object clefts (p = .018), but no significant effect within subject clefts (p = .150). However, since the lack of random slopes might lead to inflation (Barr et al., 2013), we opted for reporting the original analyses.

Figure 5. Reading times per condition in critical and spillover regions

Another set of nested effects analyses was conducted to examine the effects of extraction type at each level of animacy of the clefted constituent. These analyses covered both critical and spillover regions, specifically Segments 6 and 7 for the former, and Segments 6, 7, 8, and 9 for the latter. In conditions with an inanimate clefted constituent, i.e., feature match, extraction type showed significant effects in both the critical regions and all regions after the complementizer ($p < .01$ in all cases), indicating that subject clefts were read faster. Similarly, in conditions with an animate clefted constituent (i.e., feature mismatch), the significant effects persisted, with subject clefts being processed faster ($p < .01$ in all cases). Thus, a consistent advantage of subject clefts over object clefts is observed in terms of processing speed, regardless of the animacy of the clefted constituent.

To summarize, we observed a deceleration in reading times for object clefts compared to subject clefts, possibly starting at the latest when the reader encountered the embedded verb phrase. This subject-object asymmetry extended to the end of the sentence. A facilitating effect of an animate subject approaching significance was also observed in subject clefts. Furthermore, in object clefts, the [-animate] feature in the extracted elements, which matched the animacy feature of the embedded DP, caused a slowdown that started when the reader encountered the verb phrase, while differences in the animacy features between the two DPs facilitated reading. In addition, we recognize that the analyses conducted may not have accurately captured the subtle effects on smaller units due to the temporal and progressive nature of reading.

4. Discussion

The results from the self-paced reading and picture selection task demonstrated significant differences in the processing and comprehension of EP standard clefts based on the type of extraction. In the processing of object clefts, we observed

intervention effects, which outweighed the possible effect of the prototypical association between animacy features and syntactic functions.

A statistically significant subject-object asymmetry, i.e. a subject advantage, was observed in the processing of standard clefts, reflected in both reading speed and accuracy rates in comprehension questions. Regarding the first research question, we can conclude that adult speakers of EP exhibit a subject-object asymmetry in processing standard clefts, paralleling trends seen in the acquisition and development of EP (Lobo, Santos & Soares- Jesel, 2016; Lobo *et al.*, 2019). These results are in line with previous studies, which have indicated that subject extraction has cognitive advantages over object extraction in processing and comprehension, in both clefts and RCs (Gordon *et al.*, 2002; Ferreira, 2003; Mak, Vonk & Schriefers, 2006; Alves *et al.*, 2015; Cabral, Leitão & Kennedy, 2015; Delgado, Raposo & Santos, 2021, among others). Although our study did not aim to examine the frequency factor, the discrepancy in the occurrence of standard clefts - high frequency of subject clefts and the low productivity of clefts of other constituents in both spontaneous and elicited production (Lobo *et al.*, 2019; Martins & Lobo, 2020) - suggests that our results are consistent with the facilitating effect of frequency on processing.

With regard to the animacy of the extracted element, our results indicate that this factor did not influence the accuracy rate in the comprehension questions, irrespective of the syntactic functions of the clefted constituents. However, the reading times do not allow us to completely rule out the effects of the prototypical association between animacy features and syntactic functions. Note that the proponents of such effects (e.g. Traxler, Morris & Seely, 2002; Traxler *et al*., 2005; Mak, Vonk & Schriefers, 2002) argue that, during reading, there is a tendency to interpret an inanimate antecedent as the object of the embedded clause and an animate antecedent as the subject. Therefore, as discussed in Section 2, it could be predicted for our study that: 1) subject clefts with an animate subject would be easier to process than those with an inanimate subject, i.e., Condition 1 would show longer reading times than Condition 2; and 2) among object clefts, those with an inanimate object would be less taxing than those with an animate object. Our results only showed a marginal statistically significant deceleration in reading times for Condition 1 (inanimate subject clefts) compared to Condition 2 (animate subject clefts), which may indicate a difficulty arising from the tendency to associate the animate entity with the subject of the sentence, similar to the findings of Lowder and Gordon (2012).[5] As for object clefts, contrary to the predictions focused on animacy, the results did not show longer reading times for Condition 4 (animate object clefts) compared to Condition 3 (inanimate object clefts), despite the need for re-analysis of the former. Instead, reading times for Condition 3 exceeded those for Condition 4 in the critical and spillover regions. Thus, while our results do not categorically exclude the effects of

[5] However, the use of the progressive may have influenced the reading, given that, according to Cunha (2013), a process typically has an agentive nature. As agentivity is typically associated with the semantic feature [+animate] (Raposo, 2013), the progressive construction *estar a + infinitive* "be + gerund" may favor a reading with an animate subject and disfavor an inanimate one. It is therefore impossible to determine whether the observed advantage of an animate subject results exclusively from the animacy effects, in which readers assume that it is the subject of the subordinate clause in the initial analysis, or whether it results from the interaction between the progressive and animacy. In object clefts, on the other hand, the progressive does not affect the reading, and the embedded subject is always inanimate.

the prototypical association between animacy features and syntactic functions, they suggest that, if such effects exist, they are tenuous and not the most determining factor in the processing of standard clefts.

It is important to note that, in the present study, there was a statistically significant difference in reading times between subject and object clefts even when the object was inanimate, which contrasts with some previous studies (e.g., Mak, Vonk & Schriefers, 2002; Gennari & MacDonald, 2008; Baudiffier *et al*., 2011). In other words, our results show that an object with a [- animate] feature did not reduce the difficulty associated with object clefts, while the intervention effects were maintained.

Regarding intervention effects, the difference found in this study in comprehension accuracy and reading speed between subject and object clefts, regardless of the combination of animacy features, can be explained by the existence of an intervening subject in object clefts. This subject-object asymmetry is in line with previous studies for EP, both on the acquisition of clefts (e.g., Lobo *et al.*, 2019), and on the processing of clefts and other A'-dependency structures (e.g., Alves *et al.*, 2015; Delgado *et al.*, 2021). For subject clefts, the similarity-based approach makes no predictions regarding the properties of the entities involved. Regarding object clefts, it is predicted that the processing of clefts in which the object and subject share the [- animate] feature (Condition 3), i.e., clefts that present an intersection where the animacy feature overlaps, is more demanding than that of clefts in which only the object has the [- animate] feature (Condition 4), i.e, conditions involving a semantic featural disjunction. Our results corroborate this prediction by showing a statistically significant slowdown in reading times in Condition 3 compared to Condition 4, specifically in the critical and spillover regions.

Therefore, returning to research question (2), which focused on the influence of animacy on the processing of standard clefts, we can conclude that, in the case of object clefts (Conditions 3 and 4), the matching of the animacy feature between the extracted constituent and the intervener causes a higher processing cost, which is consistent with similarity-based models and is not in line with the predictions of the fRM. However, it should be noted that these effects are weaker than those of the subject-object asymmetry, i.e., a featural intersection involving the syntactic feature of the DPs, which may indicate that the different theoretical perspectives on intervention effects complement each other, predicting that morphosyntactic features trigger stronger effects than semantic features. The results from the processing of object clefts also suggest that there are no strong prototypical association effects between animacy features and syntactic functions in these structures, since object clefts with an animate object and an inanimate subject were not more difficult to process than those in which both constituents bear the [- animate] feature. As for subject clefts (Conditions 1 and 2), we only observed an acceleration in reading time close to statistical significance in the condition where the subject is animate and the object is not animate, and thus there seems to be a very tenuous prototypical association effect between animacy and syntactic functions.

As for research question (3), our results show that intervention effects have a major impact on the processing of standard clefts, outweighing the effects of the prototypical association between animacy features and syntactic functions. The results also show that, although the intervention of the animacy feature can influence processing, its impact is less pronounced than the impact of the syntactic function of the cleft constituent, since subject-object asymmetries are observed in accuracy rates,

response times, and reading times, whereas the intervention effects of the animacy feature are only apparent in reading times when we consider the critical and spillover regions simultaneously.

In relation to previous studies on the effects of the animacy feature on language acquisition, these effects do not present difficulties from the age of 4 to 5 years old (Bentea, Durrleman & Rizzi, 2016; Durrleman & Bentea, 2021), nor do they influence intact adult grammar, but they can be crucial in building the correct syntactic representation in a compromised linguistic system (Garraffa & Grillo, 2008). In the current study, in the processing by adults with an intact linguistic system, we found subtle effects in the sense that the inclusion/match of this semantic feature prolonged the reading of object clefts, compared with the intersection, i.e., mismatch of animacy. These results are in line with those of Lowder and Gordon (2014). However, while Lowder and Gordon kept the embedded DPs always animate, in our study, the embedded DPs are constantly inanimate. Like Lowder and Gordon (2014), we can explain our results with memory-based or similarity-based models (e.g., Gordon, Hendrick & Johnson, 2001, 2004; Lewis & Vasishth, 2005; Lewis *et al.*, 2006). In the terminology of similarity-based interference (Lewis *et al.*, 2006), the distractor, i.e., the second DP, and the intervening subject in our case, when semantically more similar to the target cues, increases the difficulty in retrieving the target, the extracted object. In parallel with the interference in retrieval, the encoding of the intervening subject semantically similar to a preceding item, i.e., the extracted object, can be cognitively more taxing and result in longer reading times. In the proposal of fRM, nonetheless, since the animacy feature is not a featural specification involved in operations that trigger movements in EP, it is not considered in the computation of locality in movement-related syntactic dependencies (Belletti & Rizzi, 2013), just like gender in Italian (Belletti *et al.*, 2012), case in Hebrew (Friedmann, Rizzi & Belletti, 2017) and animacy in French (Bentea, Durrleman & Rizzi, 2016; Durrleman & Bentea, 2021). From this perspective, our results suggest that the animacy feature influences the processing of clefts possibly in terms of working memory but does not affect the syntactic component. By revealing a strong subject-object asymmetry, which surpasses the intervention effects caused by animacy, our results suggest that features relevant to the syntactic component such as the +N feature (shared by the object and the subject in all clefts) trigger stronger intervention effects than features that do not affect this component.

5. Conclusions

In this study, we aimed to investigate how adult EP speakers process standard clefts, focusing on intervention effects and the semantic feature of animacy. We conducted an experiment using a self-paced reading and picture selection task. The experimental design manipulated the extraction types (subject vs. object) and the animacy feature of the extracted constituent (animate vs. inanimate), while keeping the constituent in the embedded clause always inanimate.

A significant advantage for subject clefts was identified in both reading speed and accuracy rate on comprehension questions compared to object clefts, regardless of the semantic feature specification, showing that object extraction is cognitively more demanding. This result is in line with previous studies and suggests a consistency in

the subject-object asymmetry in standard clefts in both language acquisition and processing in adults, which can be explained by the intervention effects of the +N feature of the intervening subject in object clefts (Friedmann, Belletti & Rizzi, 2009). The manipulation of the animacy feature, in turn, did not influence comprehension accuracy. In object clefts, intervention effects were found in the match/inclusion condition of the feature ([-animate], [-animate]), prolonging the reading times in the regions containing and succeeding the verb phrase, compared with the feature mismatch/intersection condition ([+animate], [-animate]). No significant interaction effect was found between extraction type and animacy, which shows that the effect of animacy is not present in a consistent manner in the two cleft types. This result corroborates the similarity-based interference approaches (Lewis, Vasishth & Van Dyke, 2006) and does not support the position that the effects of the prototypical association between animacy features and syntactic functions condition processing due to the tendency to consider an animate entity as the subject and an inanimate entity as the object (Mak, Vonk & Schriefers, 2002). Should the effects of prototypical association exist, they were outweighed by the intervention effects of animacy. In subject clefts, an acceleration in reading time was observed at a threshold of significance in the animate subject and inanimate object condition, contrasting with the condition where both constituents are inanimate, specifically in regions spanning from the verb phrase to the embedded object. All things considered, our data suggest that intervention effects influence adult processing, making object clefts more difficult to process than subject clefts. In addition, the results indicate that the animacy feature can impact the processing of clefts, causing intervention effects based on the similarity between the two DPs, potentially with regard to the cognitive system, more precisely, working memory. However, it does not affect the construction of syntactic representations (Belletti & Rizzi, 2013). The perspectives of fRM and similarity-based interference models complement each other in the light of our results, together allowing us to predict not only the advantage of subject extraction over object extraction, but also a hierarchy of effects, with morphosyntactic features triggering stronger effects than semantic features.

Our results recall the study of Villata and Franck (2016), which demonstrates that features that do not trigger movement— in their study, animacy and the reversibility of thematic roles — also affect the acceptability of weak wh-islands in French. The authors found that the syntactic features of lexically restricted wh-elements had a stronger impact on modulating wh-island acceptability than animacy and reversibility, which parallels our findings, where the cleft type modulates processing in a much stronger way than animacy. To fully understand the extent and manner in which syntactic configurations and semantic similarities affect sentence processing, especially the processing of A' movement, we need further research bringing together different combinations of features—from morphosyntactic to purely semantic ones. Ideally, studies should consider different languages, as this could allow features to assume different roles in movement in each language, similar to the work by Belletti et al. (2012).

One of the limitations of the present study lies in the lack of factoring in the information structure of the cleft sentences. As a syntactic strategy for focus marking, clefts can provoke different reading behaviors compared to other A′ dependency structures, such as RCs. Based on the present data and previous studies, future research could explore the differences between the processing of clefts and of RCs, especially

regarding intervention effects. The distribution of data points indicates that it is possible that some outliers have influenced the results, which could restrict the generalization of our conclusions, despite having applied a relatively consensual data treatment (Jegerski, 2014). Finally, to increase the understanding of the role of animacy features in the processing of these structures, future research could explore the interaction of this semantic feature with other grammatical or cognitive aspects.

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