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Grammatical feature dissimilarities make relative clauses easier: A comprehension study with Italian children

Flavia Adani [a,c,*], Heather K.J. van der Lely [b], Matteo Forgiarini [a], Maria Teresa Guasti [a]

[a] Department of Psychology, University of Milano-Bicocca, Italy
[b] Department of Psychology, Harvard University, USA
[c] Department of Linguistics, University of Potsdam, Germany

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ABSTRACT

The Relativized Minimality approach to A′-dependencies (Friedmann et al., 2009) predicts that headed object relative clauses (RCs) and which—questions are the most difficult, due to the presence of a lexical restriction on both the subject and the object DP which creates intervention. We investigated comprehension of center-embedded headed object RCs with Italian children, where Number and Gender feature values on subject and object DPs are manipulated. We found that, Number conditions are always more accurate than Gender ones, showing that intervention is sensitive to DP-internal structure. We propose a finer definition of the lexical restriction where external and syntactically active features (such as Number) reduce intervention whereas internal and (possibly) lexicalized features (such as Gender) do so to a lesser extent. Our results are also compatible with a memory interference approach in which the human parser is sensitive to highly specific properties of the linguistic input, such as the cue-based model (Van Dyke, 2007).

1. Introduction

It is a well documented fact in the psycholinguistic literature on head-initial languages that subject RCs (1a) are generally unproblematic whereas object RCs (1b) are more difficult for children to comprehend and they are also costlier for adults to process. Both subject and object RCs involve the interpretation of a constituent (i.e. the RC head, *the dog* in 1) that is displaced with respect to the argument position where, in minimalist terms, it was merged (the position indicated in angled brackets):

1) a. The dog that <dog> is chasing the cat.
   b. The dog that the lion is chasing <dog>.

However, a crucial difference between the two sentence types is the presence (in object RCs) of the embedded subject (e.g. *the lion* in 1b) that appears between the merge and the landing positions of the A′-constituent.

Object RCs have been attested to be hard both in comprehension and production as well as across different populations: adults (Clifton and Frazier, 1989; De Vincenzi, 1990; Gennari and MacDonald, 2009; Gibson, 1998; Gordon et al., 2004, 2001;

* Corresponding author at: Department of Linguistics, University of Potsdam, Karl-Liebknechtstr. 24, 14476 Potsdam, Germany. Tel.: +49 331 977 26 39; fax: +49 331 977 20 59.
E-mail address: flavia.adani@uni-potsdam.de (F. Adani).

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Mak et al., 2002, 2006; Reali and Christiansen, 2007; Traxler et al., 2002), typically-developing children (Adani, in press; Arnon, 2005, forthcoming; Booth et al., 2000; Corre?a, 1995; Crain et al., 1990; de Villiers et al., 1979; Diessel and Tomasello, 2000; Friedmann et al., 2009; Goodluck and Tavakolian, 1982; Kidd and Bavin, 2002; Ozge et al., in press; Sheldon, 1974; Slobin, 1971; Tavakolian, 1981; Utzeri, 2007), children affected by developmental language disorders (Friedmann and Novogrodsky, 2004; Grant et al., 2002; HÍkansson and Hansson, 2000; Novrogodsky and Friedmann, 2006; Stavrakaki, 2001, 2002; Zukowski, 2008) and patients with language breakdown (Caramazza and Zurif, 1978; Garraffa and Grillo, 2008; Grillo, 2009) that are tested with different methodologies (Crain et al., 2001).[1]

Adult processing studies showed that the difficulty with object RCs (as compared to subject RCs) can be modulated by changing the nature of subject and object constituents appearing in the sentence. Specifically, it was shown that object RCs are facilitated when the two constituents are different NP types, e.g. the head is lexically specified and the embedded constituent is a 1st or 2nd person pronoun (Garraffa and Grillo, 2008; Gibson, 1998; Gordon et al., 2001; Grillo, 2009; Reali and Christiansen, 2007; Warren and Gibson, 2002, 2005) or a proper name (Gordon et al., 2004, 2001). Gordon and colleagues conducted a series of self-paced reading experiments on subject and object RCs where the lexical category of the embedded DPs was systematically manipulated as illustrated in (2):

2) a. The barber that admired the lawyer/you/Joe/everyone climbed the mountain.
b. The barber that the lawyer/you/Joe/everyone admired climbed the mountain.

They found that subject RCs (2a) were only significantly easier to parse than object RCs (2b) when the RC head (*the barber*) and the embedded DP were both definite descriptions (*the lawyer*). In contrast, when the embedded DP was a pronoun (*you*), a proper name (*Joe*) or a quantifier (*everyone*) the extra parsing difficulty of object RCs with respect to subject RCs was shown to decrease significantly, if not disappear. The authors explain the subject/object asymmetry through memory-interference account where the processing of object-extracted constructions (such as RCs and clefts) requires two DPs to be held in the memory and subsequently retrieved, whereas this does not happen in subject-extracted constructions. They further claim that having different types of DPs reduces memory interference with order information based on similarity. In fact, when the two DPs are drawn from the same class they can interfere more with each other's processing.

Moreover, animacy dissimilarities of the subject and object constituents also trigger a facilitation effect (Gennari and MacDonald, 2009; Mak et al., 2002, 2006; Traxler et al., 2002). Unsurprisingly, these effects are also attested with children, both for animacy (Corre?a, 1995; Goodluck and Tavakolian, 1982) and DP lexical category (Arnon, forthcoming; Friedmann et al., 2009).

Working within a grammatical approach, Grillo (2005, 2009) proposes that agrammatic patients find object RCs, object wh-questions and object clefts particularly difficult because they are only able to provide an impoverished representation of feature sets associated to A′-constituents.[2] Namely, Grillo claims that scope/discourse related features fail to be represented in agrammatism. Hence, A′-constituents are represented as simple arguments. Grillo's core proposal is that under particular circumstances (such as heavier processing load due to language breakdown), aphasic patients apply a very restrictive version of Relativized Minimality (RM) (Rizzi, 1990, 2004; Starke, 2001). A′-constituents being underspecified for scope-discourse related features, A′-target and intervener result with the same structural type. Hence, RM effect occurs and the sentence cannot be correctly interpreted (see Grillo, 2009 for more details and his formal implementation).

Recently, Friedmann et al. (2009) extended the essence of Grillo's account to the domain of language acquisition. They tested a series of A′-constructions and found that only some of them were difficult for Hebrew-speaking children. They argue that this difficulty is related to the internal structure of the moved constituent and of the intervening subject. The authors introduce the notion of *lexical restriction* [+NP] in order to explain this selective difficulty. Lexically restricted DPs are those where a nominal expression is introduced by a wh-word (e.g. *which cat* in wh-questions) or a determiner (e.g. *the cat* in RCs). In contrast, non-lexically restricted DPs are bare wh-words and/or pronouns. Their data show that children perform more poorly when both the intervening and the moved constituent are lexically restricted. They argue that children at this age are only able to compute A′ dependencies that involve constituents with disjointed feature sets (see next section for a detailed presentation of their data and formal implementation).

In this paper, we build on Friedmann et al.'s proposal and we put forward the hypothesis that a more detailed definition of lexical restriction [+NP] is desirable when finer DP properties are considered. Specifically, we argue that the difficulty with object RCs is modulated by DP-internal features, such as Number and Gender.

Stemming from early typological studies (Greenberg, 1967), a number of linguistic proposals exist that emphasize the different status of Number and Gender features (Bernstein, 2001; Di Domenico, 1997; Harley and Ritter, 2000; Picallo, 2008; Ritter, 1993). These theoretical accounts were experimentally tested by psycholinguists, showing that different features are accessible in different ways during sentence comprehension (De Vincenzi and Di Domenico, 1999; Carminati, 2005). Specifically, Number is always computed faster and more reliably than Gender. In this study, we tested if the same asymmetry holds for A′-dependencies, such as RCs.

[1] Below chance performance in object RCs (in terms either of accuracy rates or age of acquisition) has been suggested to be a task dependent factor (Adani, in press; Garraffa and Grillo, 2008; Grillo, 2009). As for this paper, what is important is that the subject/object asymmetry usually holds, despite different methods and population under investigation.

[2] Under Grillo's account, difficulty with an A-movement construction (i.e. passive) is also explained.

The paper is structured as follows: first, we present the RM approach as formulated in Friedmann et al. (2009) (section 1). Then, we review some theoretical proposals (section 2) and experimental findings (section 3) on the role of Number and Gender during sentence comprehension. In section 4, the experiment is outlined. A sample of the experimental sentences is the following:

3) Il leone che il gatto sta toccando è seduto per terra.
The lion-SG that the cat-SG is touching is sitting on the ground

4) Il leone che i coccodrilli stanno toccando è seduto per terra.
The lion-SG that the crocs-PL are touching is sitting on the ground

5) Il gatto che il topo sta lavando è salito sullo sgabello.
The cat-M that the mouse-M is washing has climbed onto the stool

6) Il gatto che la capra sta lavando è salito sullo sgabello
The cat-M that the goat-F is washing has climbed onto the stool

We will show that conditions where the two DPs mismatch in terms of feature values (4 and 6) are always more accurate than those where they match (3 and 5). Furthermore, Number conditions (3 and 4) are always more accurate than Gender conditions (5 and 6).

In section 5, the hypothesis that difficulty with object RCs should be analyzed along the lines entertained by Friedmann et al. (2009) will be supported and integrated with the auxiliary hypothesis that selective effects are generated by the DP internal functional structure. We will conclude the paper suggesting that this account makes predictions in line with Van Dyke et al.'s memory-interference model, as both approaches assume a highly specific representation of the properties associated to the linguistic input. These properties, that are named *features* in the former approach, trigger effects similar to those of *cues* in the latter approach.

2. The RM approach to A′-dependencies

Given the following configuration:

7) ... X ... Z ... Y ...

RM predicts that a local structural relation cannot hold between X and Y if Z is of the same structural type and is thus a potential bearer of the same local relation (Rizzi, 1990). In its original formulation, RM accounts for the impossibility of extracting some wh- elements from indirect questions and other weak islands, when a potential candidate for the same local relation intervenes between the extracted element (X) and the site of extraction (Y). Formally, this principle can be expressed as (Rizzi, 2000):

8) Y is a in Minimal Configuration with X if there is not Z such that:
   a. Z is the same structural type as X, and
   b. Z intervenes between X and Y.

Friedmann et al. (2009) present a series of experiments carried out with Hebrew-speaking children (age range: 3; 7–5; 0) on different constructions involving A′-movement. In (9–13a), a sample of their experimental sentences is reported together with a schematic representation of each structure in (9–13b). In (9, 11, 12)b, 'R' designates the relative complementizer. Lexically-restricted DPs (as defined above) are indicated as 'D NP' or 'Wh NP' depending on what the D position is filled with. Non-lexically restricted constituents are indicated as bare 'Wh' or pronoun. When these labels are inserted into angled brackets, this designates the original merge position of the constituent[3]:

9) a. Tare li et ha-pil she-ha-arie martiv.
Show to-me ACC the-elephant that-the-lion wets
'Show me the elephant that the lion is wetting'
   b. D NP R D NP <D NP>

10) a. et eize kelev ha-xatul noshex?
ACC which dog the-cat bites
'Which dog does the cat bite?'
   b. Wh NP D NP <Wh NP>

[3] These notations adopt the copy theory of traces (Chomsky, 1995) and assume a raising analysis of RC as in (Bianchi, 1999; Kayne, 1994; Vergnaud, 1974).

11) a. Tare li et mi she-ha-yeled menaded.
Show to-me ACC who that-the-boy swings
'Show me the one that the boy is wetting'
b. Wh R D NP < Wh>

12) a. Tare li et ha-sus she-mesarkim oto.
Show to-me ACC the-horse that-brush-pl him
'Show me the horse that someone is brushing.'
b. D NP R *pro*arb pronoun

13) a. et mi ha-xatul noshex?
ACC who the-cat bites
Whom does the cat bite?
b. Wh D NP <Wh>

Whereas subject headed RCs and subject which-questions were always extremely accurate, Friedmann et al. found that headed object RCs (9) and which-NP object questions (10) were significantly less accurate than object free relatives (11), headed object relatives with an impersonal arbitrary *pro* subject (12) and *who* object questions (13).

The interpretation of the data proposed by Friedmann et al. relies on two fundamental theoretical assumptions: first, syntactic movement is a feature-driven operation that takes place in order to satisfy certain properties of well-formed derivations (Chomsky, 1995, 2000); second, movement attractors must be minimally specified with the feature that triggers movement ('R' in the case of RCs and 'Q' in the case of wh-questions). But they can also be more complex depending on the featural specifications of their targets (Starke, 2001).

The authors propose that children apply a 'stricter' version of RM that prevents them from correctly establishing a distant dependency between an A′-target specified with a complex feature set (such as [D NP] or [Wh NP]) and its copy when the intervening DP is also lexically restricted (thus, also specified with [D NP]). On the contrary, children successfully establish this distant relation when the lexical restriction is present on only one of the two relevant constituents but crucially not on both[4] (but cf. Arnon (forthcoming) for a different explanation of partially overlapping results).

The reason why children apply a stricter version of RM is not due to a lack of competence but to immature computational resources. In the adult system, an intervener does not block the instantiation of the relation between the RC head and its copy, given that it is only specified with a subset of features with respect to the target. The computation of subset relations is costly as it requires comparing the two feature sets in order to decide which one is included in which. Nevertheless, it is successfully computed by the adult parser. In contrast, Friedmann et al. maintain that the stricter relation which children abide by requires feature disjointedness. This means that this dependency is successfully instantiated if the target and the intervener have non-overlapping feature sets. Computing such a disjointed relation is less costly than computing a subset relation and therefore children initially succeed only in the first type of computation.

However, in the same spirit, it seems natural to ask whether it is exclusively the lexical restriction [+ NP] as a whole that triggers intervention or if the nominal nucleus can, in turn, be seen as a hierarchically organized set of features that contributes to intervention in different ways. In this paper, we test this hypothesis experimentally by investigating the effect of Number and Gender features in comprehension of object RCs.

3. On the representation of Number and Gender in syntactic theory

The relevance of morpho-syntactic features to investigate natural languages has already been pointed out in early typological studies. For instance, observing a wide sample of languages, Greenberg (1967) made the following generalizations and he proposed that they would hold universally (Greenberg, 1967 quoted in Harley and Ritter, 2000):

14) Universal 32: Whenever the verb agrees with a nominal subject or object in gender it also agrees in number.
Universal 36: If a language has the category of gender, it always has the category of number.
Universal 37: A language never has more gender categories in non-singular numbers than in the singular.
Universal 45: If there are any gender distinctions in the plural of the pronoun, there are some gender distinctions in the singular also.

Later, the role of features in the course of syntactic derivation becomes a central notion within the Minimalist Program (Chomsky, 1995, 2000). Namely, different properties are associated with each feature type. In particular, in Chomsky's (1995) terms, Gender is intrinsic, an inherent property, part of the lexical item whereas Number is non-intrinsic and it is chosen via the operation of Numeration (the set of items which constitute the building blocks of the derivation). A crucial

[4] Building up on Starke (2001), lexically restricted constituents must be attracted by a complex attractor, specified for [+Wh, +NP], in case of wh-quesitons, or [+R, +NP], in case of RCs. The attractor of non-lexically restricted constituents is specified with [+Wh] or [+R] features only.

property that distinguishes Gender from Number is the semantic contribution to the interpretation of the noun. Whereas Number signals that a set of entities has cardinality, Gender is largely arbitrary. In turn, Gender values are not always predictable on the basis of some semantic feature property of the noun (Alexiadou et al., 2007; Corbett, 1991).

Since Abney (1987), the existence of a functional head D that gives rise to the maximal projection DP and to its complement NP is assumed:

15) $[_{DP}$ D $[_{D'}$ NP]]

Assuming a close correspondence between nominal morphological and syntactic properties (Baker, 1985), we observe that at least in partially agglutinating languages such as Spanish, Number morphemes are always expressed more externally than Gender morphemes and overtly realized on the preceding determiner:

16) a. El chico
The-M boy-M
b. La chica
The-F girl-F
c. Los chicos
The-M, PL boy-M, PL
d. Las chicas
The-F,PL girl-F, PL

The same generalization is extendable to Italian although number and gender morphemes are fused in this language (this is a simplification of the actual nominal agreement pattern (cf. De Vincenzi and Di Domenico, 1999 for the full paradigm):

17) a. Il ragazzo
The-M boy-M
b. La ragazza
The-F girl-F
c. I ragazzi
The-M, PL boy-M,PL
d. Le ragazze
The-F, PL girl-F,PL

Different hypotheses have been formulated in order to account for these cross-linguistic regularities (Bernstein, 2001; Di Domenico, 1997; Harley and Ritter, 2000; Picallo, 2008; Ritter, 1991; Ritter, 1993). In the remaining part of this section, we will provide an extensive overview of what had been suggested over the last two decades. These proposals generally agree upon the assumption that Number is encoded in a position higher than Gender in the clausal skeleton and that Number is endowed of its own functional projection, NumP,[5] as illustrated below:

18) $[_{DP}$ D $[_{D'}$ NumP $[_{Num'}$ Num [NP $[_{N'}$ N]]]]]

This proposal was first advocated by Ritter (1991). She argues that NumP, rather than NP, is the complement of D in Hebrew. She presents data on two types of Hebrew genitive nominal constituents – construct-state noun phrases (19) and free state noun phrases (20) – and argues that in both cases the noun (*parat* in 19 and *axila* in 20) must raise from N to a higher position within the DP crossing over the possessor (*ikar* and *shel Dan*, respectively) that occupies the Spec, NP position (examples quoted from Bernstein, 2001):

19) parat ikar
cow farmer
a farmer's cow
20) ha-axila shel Dan et ha-tapuax
the-eating of Dan of the apple
Dan's eating of the apple

[5] [NU] in Picallo (2008).

In order to account for the possibility of the head noun being modified by a definite article in (20) but not in (19), Ritter argues that the head noun raises to different positions within the DP. Namely, the noun raises to D in construct-state noun phrases (19) and to an intermediate position other than D in free state noun phrases (20). She provides evidence for this head being the locus where singular/plural features are encoded and she calls it Num.

Converging evidence coming from Walloon is provided in Bernstein (2001). Before we present her argument, we will emphasize two properties of Walloon. First, unlike French, adjectives in Walloon are strictly pre-nominal. This fact is generally taken as evidence that this language lacks N-movement. Second, nouns are never marked for plural, except in the written form. Building up on work by Morin (1986), Bernstein argues that masculine and feminine orthographic plural markers such as *–s* and *–ès* in (21) are to be analyzed as overt realizations of the functional head Num, rather than adjectival affixes (examples from Bernstein, 2001):

21) a. dès vètès-ouh
some green-F, PL-door
some green doors
b. dès ne?urs-ouy
some black-M,PL-eye
some black eyes

In contrast to Number, the status of Gender is more controversial. Whereas some scholars postulate the existence of a distinct functional head for each of the two features (Picallo, 1991; Picallo, 2008), others (Bernstein, 2001; Di Domenico, 1997; Ritter, 1993) have proposed that this is not the case.

Picallo (2008) elaborates a minimalist approach to grammatical number and gender within which she claims that grammatical gender cannot be a post-syntactic operation but rather it must be directly encoded in the syntactic structure. If gender were only a morpho-phonological entity it would not have an effect at the interpretative component (LF). In this case, it would be possible to interpret the clitic pronoun as a free morpheme in the Catalan sentence (22):

22) Quan un venedor té una calaixera$_i$ la$_i$ /el$_{*i/j}$ /ho$_{*i/h}$ ven.
when a seller-M has a drawer chest-F it-F,SG /it-M,SG /it-Neut sells
When a seller has a drawer chest, he sells it

But this does not happen and the pronoun *la* must be necessarily bound by the antecedent *calaixera*. Furthermore, she shows that gender agreement is overtly realized in high register French wh-constructions such as (23) and Catalan accusative clitic constructions such as (24) (the merge and intermediate position of the moved constituent is indicated as <e>):

23) a. Quelle chaise as-tu <e> repeinte <e>
which-F chair-F have you repainted-F
b. Les chaises que Paul a <e> repeintes <e>
the-F-PL chairs-F-PL that Paul has repainted-F-PL
24) a. (Aquesta pel·lícula) ja l' has vista?
(this movie-F) already it-F have (you) seen-F, SG?
b. (Aquestes pel·lícules) ja les has vistes?
(these movies-F-PL) already them-F-PL have (you) seen-F-PL?

This is taken as further support that gender is necessarily encoded in the predicate projection and it participates in movement operations as a fully realized syntactic head.

This formal interpretable feature is labelled with [CLASS]. [CLASS] heads a functional projection (c) immediately dominating N and licences the formal type the noun belongs to:

25) [$_c$ [CLASS] [$_N$ N]

c merges with a lexical N complement that enters the numeration fully inflected. At the syntactic component, the feature [CLASS] selects and probes N.

Ritter (1993) proposes that, in contrast with Number, Gender is a feature realized on one of the existing functional heads of the noun phrase and that the choice of syntactic head is subject to cross-linguistic variations. Specifically, she proposes that Gender is a feature on Num in Romance languages but on N in Hebrew. Several linguistic facts are presented in support of a different encoding of Gender in Romance languages and Hebrew. First, gender switching in Hebrew is a productive strategy for deriving new nouns from existing nouns (26) and different feminine suffixes can be added to the same stem to generate distinct nouns (27):

26)		Masculine nouns	Feminine nouns
	a.	maxsan	maxsan-it
		warehouse-M	magazine-F
	b.	amud	amud-a
		page-M	column-F

27)		Stem –a	Stem-it
	a.	txun-a	txun-it
		feature-F	linguistic feature-F
	b.	toxn-a	toxn-it
		computer program	plan

In contrast, gender switching in Spanish is fully productive only as far as nouns with human or animate reference are concerned (28) but it is rarer with semantically related inanimate nouns (29) and with unrelated inanimate nouns (30) (examples from (Harris, 1991) quoted in Ritter (1993):

		Masculine	Feminine
28)	a.	muchacho	muchacha
		boy-M	girl-F
	b.	jefe	jefa
		chief-M	chief-F
29)	a.	cerezo	cereza
		cherry tree-M	cherry-F
	b.	manzano	manzana
		apple tree-M	apple-F
30)	a.	paso	pasa
		step-M	raisin-F

Further, Ritter shows that Hebrew plural affixes are specified only for Number whereas Romanian irregular plural affixes are specified for both Number and Gender. Finally, she provides evidence that gender marking is always realized on the head noun in Hebrew whereas in a Romance language such as Walloon, Gender and Number are realized together on pre-nominal adjectives or determiners but, crucially, not on the lexical head.

Di Domenico (1997) maintains, contrary to Picallo (1991, 2008) and in harmony with Ritter (1991, 1993), that only Number is a syntactic head and that it can be projected autonomously in the syntax. However, Di Domenico proposes a differentiation of two types of Gender: variable gender and fixed gender. She argues that variable gender is projected in the syntax under the Num head whereas fixed gender is projected under the lexical head N. Following Chomsky (1995), a feature is independently represented in the lexicon only if it has a semantic content and if it can be varied. Let us explain Di Domenico's proposal using some Italian examples:

31)		NOUN	Semantic Content	Variability
	a.	ragazza	+	+
		girl		
	b.	donna	+	–
		woman		
	c.	sedia	–	–
		chair		

The three nouns in (31) are all singular and feminine. However, only the gender of *ragazza* can be varied (i.e. it has a masculine counterpart, *ragazzo* 'boy'). Both *donna* and *sedia* cannot be varied, although *donna* has a semantic content and its masculine counterpart is available in the lexicon, *uomo* 'man'. They can all be pluralized (i.e. Number on nouns has a semantic content and it can always be varied). The essence of Di Domenico's proposal is that variable gender (31a) behaves like Number and its checking enters into the syntactic computation. On the other hand, the gender of nouns such as (31)b and c is a property of the noun and not of its referent. Therefore, it cannot be separated from the noun and it must be present in the lexical entry.

In the next section we will review some experimental work in which these theories have been tested.

4. On the psycholinguistic relevance of Number and Gender features during sentence comprehension

A large body of cross-linguistic experimental evidence shows that Number and Gender are processed differently by the human parser (AntŒn-Méndez et al., 2002; Barber and Carreiras, 2005; Carminati, 2005; De Vincenzi and Di Domenico, 1999; Nicol, 1988). We will limit our discussion to the Italian data.

De Vincenzi and Di Domenico (1999) investigated the effect of number and gender information in antecedent-pronoun resolution in Italian using a visual lexical priming task. The rationale behind this technique is that a probe semantically related to the antecedent DP will be primed by the pronoun position, if the pronoun correctly reactivates its antecedent. Gender and Number were investigated in separate experiments. A sample of the experimental sentences is reported below, (32a) for the Number experiment, (32b) for the Gender experiment, respectively:

32) a. Lo sposo disse agli alunni che il vecchio generale in pensione voleva salutare lui/loro quanto prima.
The bridegroom-SG told the pupils-PL that the old retired general wanted to greet him/them as soon as possible.

b. L'operaio disse alla cuoca che la padrona di casa che guardava la televisione non poteva sentire lei/lui certamente.
The worker-M told the cook-F that the landlady that was watching TV could not hear her/him clearly.

A priming effect was only found in the Number experiment. The authors suggest that the reactivation of antecedents is restricted by number information. Conversely, gender information is not initially used by the processor to select the appropriate antecedent, at least not at the same time as when number information is used.

Carminati (2005) draws conclusions in line with those of De Vincenzi and Di Domenico (1999), by testing the effect of Number, Gender (and Person) information in the resolution of the null subject pronoun (*pro*) in Italian. The following conditions were tested using a self-paced listening technique:

33) a. Quando Maria lo cerca, diventa ansioso.
When Maria-F him-M-looks for, pro becomes anxious-M
'When Maria looks for him, he becomes anxious'

b. Quando i Rossi lo cercano, diventa ansioso.
When the Rossis-PL him(SG)-look for, pro becomes anxious (SG).
'When the Rossis look for him, he becomes anxious'.

Assuming that preference for a subject reading of *pro* holds (and this was shown in a separate experiment), a processing penalty for forcing an object referent is significantly reduced when the pronoun is disambiguated by Number (33b) rather than when it is disambiguated by Gender (33a). Carminati concludes that Number acts better than Gender in order to direct the processor to the appropriate antecedent, as the Feature Strength Hierarchy hypothesis predicts.[6]

In summary, both De Vincenzi and Di Domenico (1999) and Carminati (2005) propose that Number being a functional head and occupying a position higher than Gender within the DP, makes it more easily accessible by the human parser during sentence comprehension. According to the working hypothesis that we introduce, an effect supporting the higher accessibility of Number should also be attested in the processing of RCs where Gender and Number are manipulated.

5. An experiment on object RCs in Italian with manipulation of grammatical features

We present an experiment carried out with three groups of Italian-speaking children age 5, 7 and 9. Center-embedded object RCs are tested where number and gender features are systematically manipulated.

5.1. Method

5.1.1. Participants

Fifty children participated in the experiment and were divided according to their age, as reported in Table 1.

From now on, we will refer to the 5-year-old group as G5, 7-year-old group as G7 and 9-year-old group as G9.

Parental consent forms were collected and the children were happy to take part in this study. Only children whose parents wrote that they were/had been exposed only to Italian are included in the sample. In order to make sure that each participant did not significantly fall below the language abilities expected for their age, at least one standardized language

[6] Carminati also points out that a potential confound in this result could be that number information in (b) is encountered earlier than gender information in (a) hence, re-analysis is less costly in the former condition than in the latter. Although this interpretation is difficult to rule out due to intrinsic properties of Italian verb morphology (where gender markers always occur later than number markers), she tests this possibility in later unpublished work and finds no evidence that the penalty for violating the antecedent bias of *pro* via gender manipulation is modulated by the early/late encounter of this information. We will come back to this point in the discussion section (for more details, cf. the original source).

Table 1
Mean ages and SD (in months) and age range for each group of children.

	5-Year-old ($N = 15$) mean (SD)	7-Year-old ($N = 18$) mean (SD)	9-Year-old ($N = 17$) mean (SD)
Mean Age	5;9 (3,4)	7;7 (3,3)	9;8 (2,9)
Range Age	(5;3–6;2)	(7;2–8;0)	(9;2–10;1)

test was administered to them. Participants in G5 and G7 were given a test for the assessment of morpho-syntactic abilities (Chilosi et al., 1995) whereas a test measuring receptive vocabulary (Stella et al., 2000) was administered to participants in G7 and G9.

5.1.2. Design

Two experimental factors and one counterbalancing factor were manipulated. The counterbalancing factor (that we will call Head for simplicity) was only introduced for our design to be orthogonal but we did not predict it to be significant. Each of these factors had two levels. The experimental factors are: Feature (Gender vs. Number) and Match (match vs. mismatch). Hence, eight conditions were tested. Table 2 illustrates the experimental design:

5.1.3. Material

For each of these eight conditions, there were 6 trials, making 48 experimental sentences in total. The experimental trials were constructed using five unaccusative verbs (*cadere (fall), salire (climb), saltare (jump),volare (fly), entrare (enter)*) and three reflexive verbs (*sedersi (sit), nascondersi (hide)* and *distendersi (lie down)*) as main verbs. The last three verbs were used intransitively (e.g. *Il gatto è seduto per terra* 'The cat is sitting on the ground'; *La mucca è distesa nella pozzanghera* 'The cow is lying in the pond'; *La tigre è nascosta sotto il letto* 'The tiger is hidden under the bed'). Each of these eight verbs was paired with eight transitive verbs in the embedded clause (*tirare* (*pull), bagnare (splash), lavare (wash), accarezzare (stroke), salutare (wave), spingere (push), pettinare (comb), toccare (touch)*). We ensured that across sentences the same pair of verbs never co-occurred with the same pair of nouns. The sentences were digitally recorded in a sound-proof booth and they were administered through loud-speakers connected to a laptop computer.

Nouns for subject and object NPs were all animal names. For all sentences the subject and object NPs were semantically reversible. Furthermore, we made the decision not to include humans or inanimate objects in our trials in order to control for human/non-human and animate/inanimate confounding effects. In order to neutralize the reciprocal effect of the two features within Number manipulation, we used only masculine nouns (i.e. unmarked value for Gender in Italian) whereas for the Gender manipulation, only singular nouns were used (i.e. unmarked value for Number in Italian). The marked/unmarked distinction comes from typological studies (Corbett, 2006). For an agreement system such as the Italian one, "masculine" and "singular" are claimed to be unmarked (or default forms) whereas "feminine" and "plural" are their marked counterparts. For most nouns we used the more transparent ending affix for number and gender (namely '–o' for singular; '-i' for plural; '-A' for feminine; '-o' for masculine). In a smaller subset of cases we used nouns whose ending was '–e', which is neutral for Gender (this happened in 3/48 cases in Number conditions and 8/48 in the Gender conditions). However, the preceding determiner was always unequivocally marked for Gender and/or Number.

In addition to the 48 experimental sentences, a further list of 12 sentences was constructed to be used as fillers. From the first list of 60 sentences, a second list was then constructed in which the subject and the object NPs were reversed. Half of the participants were presented with List1, the other half was presented with List 2. The creation of two lists with reversed NP

Table 2
Experimental design.

Feature	Head	Match	Test sentences
Gender		M	*Il gatto che il topo sta lavando è salito sullo sgabello* The cat-M that the mouse-M is washing has climbed-M
		MM	*Il gatto che la capra sta lavando è salito sullo sgabello* The cat-M that the goat-F is washing has climbed-M
		M	*La capra che la mucca sta lavando è salita sullo sgabello* The goat-F that the cow-F is washing has climbed-F
		MM	*La capra che il gatto sta lavando è salita sullo sgabello* The goat-F that the cat-M is washing has climbed-F
Number		M	*Il leone che il gatto sta toccando è seduto per terra* The lion-SG that the cat-SG is touching is sitting –SG
		MM	*Il leone che i coccodrilli stanno toccando è seduto per terra* The lion-SG that the crocs-PL are touching is sitting-SG
		M	*I coccodrilli che i cammelli stanno toccando sono seduti per terra* The crocs-PL that the camels-PL are touching are sitting-PL
		MM	*I coccodrilli che il leone sta toccando sono seduti per terra* The crocs-PL that the lion-SG is touching are sitting-PL

order aimed at controlling for the potential confounding effect of a noun to be a more suitable subject (or object) over the others. Trials were individually randomized.

Each sentence was paired with four pictures that represented all combinations between argumental NPs (subject and object) and the two actions (embedded and main verbs). The same characters and actions were depicted in each set of pictures. One was correct and the other three were pictures that represented possible but incorrect (i.e. non-adult-like) interpretations of the sentence. For instance, given the sentence:

34) Il gatto che la capra sta lavando è salito sullo sgabello
The cat that the goat is washing has climbed onto the stool

the following set of pictures appeared on the screen (Fig. 1):

Picture position on the screen was random. See also section 5.2 for more details.

5.1.4. Procedure

The experiment was programmed with E-Prime (Schneider et al., 2002a,b) and administered using an Acer 4101 laptop computer. Participants were tested individually in a quiet room of their school. Familiarization with the experimenter and the material preceded the testing session. During familiarization, a small group of children per time was introduced to the puppet Camilla, a little snail that is willing to learn Italian although too shy to talk to grown-ups. Then, only one child stayed in the room with the experimenter and the testing session started. Camilla was sitting next to the child for the whole experimental session and he/she was encouraged to show Camilla the correct picture. Camilla was also used to interact with the children during the experimental session, in case they got a bit distracted or lost interest in the game. Each child was rewarded with a colourful stone that Camilla gave as sign of friendship.

First, we wanted to make sure that all children (but especially the 5-year olds) knew the meanings of the embedded verbs. We showed four pictures on a booklet (cf. Fig. 2) and asked the child: *Dimmi dove c'è qualcuno che sta spingendo* (Tell me where someone is pushing) and the child had to point to the correct picture. We did the same for each embedded verb.

Then, the computer-based game started. Participants were instructed to look at the four pictures on the screen, listen carefully to the sentence and then press one out of four buttons on the keyboard. The experimenter said: *Adesso compariranno sullo schermo quattro figure in cui ci sono degli animali che fanno diverse attivitÁ. Poi, sentirai una voce che dice qualcosa sugli animali. Tu dovrai guardare attentamente tutte e quattro le figure e mostrare a Camilla dov'è l'animale descritto dalla voce* ('Now, four pictures will appear on the screen. There will be animals that are performing different activities. Then, a voice will say something about the animals. You have to look at all four pictures carefully and show Camilla where the animal described by the voice is').

Each picture was associated with a number from one to four, which corresponded to the same number reported on each response button. Each response button was highlighted with bright-coloured stickers which corresponded to a picture number.

Fig. 1. A sample of experimental pictures.

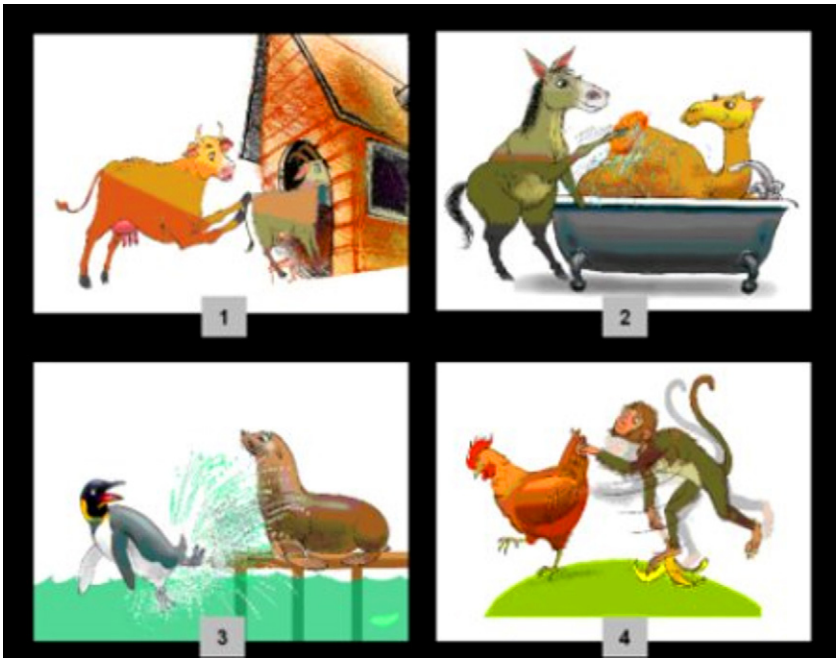

Fig. 2. A sample of the verb familiarization trial.

Four practice trials were presented to begin with and the experimenter made sure that the child understood the task. Preliminary instructions emphasized the importance of looking carefully at all pictures and of being accurate rather than fast. A break was programmed halfway through the trials but the child was free to have more breaks if needed. The experimenter controlled the presentation of the next item after the response by clicking the mouse, hence it was possible to maximise the child's attention to trials.

In order to make sure that the child paid attention to the RC (and avoid an incorrect response due to a general processing load), the main clause was always elicited in the preamble uttered by the experimenter. This was also done in order to make sure that children are aware that two identical animals are depicted in the experimental setting. Their task is to find out which one is performing the action expressed by the embedded verb (e.g. only one of those cats is washing the goat, see Hamburger and Crain, 1982).

For example, when the set of pictures depicted in Fig. 1 appeared on the screen, the experimenter uttered: *Guarda, qui ci sono dei gatti e delle capre. In queste figure la capra è salita sullo sgabello* (pointing to 1 and 3), *mentre qui il gatto è salito sullo sgabello* (pointing to 2 and 4). *Adesso ascolta quello che dice la voce e dimmi dov'è il personaggio giusto* (Look, here there are cats and goats. In these pictures, the goat has climbed onto the stool (pointing to 1 and 3) whereas in these pictures the cat has climbed onto the stool (pointing to 2 and 4). Now, listen to what the voice says and show me where the right animal is). Only at this point, did the sentence start.

Children were tested in two separate sessions. In each session one standardized language test and one RC test were administered. Each session lasted between 30 and 40 min, depending on the child's attention and speed. Only results from the first RC test are included in this paper. In the other test, subject and object center-embedded RCs were compared (cf. Experiment 2 in Chapter 4 in Adani, 2008). We decided not to include the results of this test in the present paper given that two of the tested conditions were ambiguous between a subject and object RC reading, which added some noise in the results.

5.2. Scoring & error coding

Children's responses were scored into one of four categories, one of which is the target response and the remaining are errors. The three error categories are created on the basis of how children interpret the relationship between the subject and the object DPs and verbs. The following error categories are considered and an explanation for each error follows:

a. *Local*: when both DP-verb relations are interpreted locally, but one relation is the target and the other is reversed;
b. *Distance*: when both DP-verb relations are interpreted at a distance, but one relation is the target and the other is reversed;
c. *Double Reversal*: when both DP-verb relations are erroneously interpreted.

The arrows in the following examples indicate which DP is the subject of which verb, as they were depicted in the pictures. They are meant to help the reader understand how we constructed distractor pictures, but they do not indicate a

relation between moved constituents and their copy in the original position. The copy of the relative head is indicated by '<copy>' in the original position.

Given (35) as a target response for object RCs:

35) The cat that [the goat is washing < cat>] has climbed onto the stool.

This response is depicted in '2' in Fig. 1.

An error was categorized as Local, if the chosen picture depicted the following grammatical relationships:

36) The cat that [the goat is washing < cat>] has climbed onto the stool.

This response is depicted in '1' in Fig. 1.

An error was categorized as Distant, if the chosen picture depicted the following grammatical relationships:

37) The cat that [the goat is washing < cat>] has climbed onto the stool.

This response is depicted in '4' in Fig. 1.

An error was categorized as Double Reversal, if the chosen picture depicted the following grammatical relationships:

38) The cat that [the goat is washing < cat>] has climbed onto the stool.

This response is depicted in '3' in Fig. 1.

5.3. Response analysis

This table summarizes the result for each response type: Correct, Local, Distant, Double Reversal (Table 3).

Percentages of correct responses show that, in each group, Number conditions are always more accurate than Gender ones and that Mismatch conditions are always more accurate than Match ones. The performance of 5-year olds ranges between 36% and 64% whereas 7-year olds and 9-year olds are more accurate (G7: 74–88%; G9: 85–95%). An asymmetry in non-target responses is also attested between 5-year olds, on the one hand, and 7- and 9-year olds, on the other hand. In particular, in the two older groups, the only non-target response which is virtually always chosen is the Distant Error (ranging between 9% and 16% in G7 and between 7% and 1% in G9). The occurrence of other error types is considerably lower: on average, 2.75% for Local and 3.5% for Double Reversal in G7 and 2.25% for Local and 3% for Double Reversal in G9. We can therefore conclude that the Distant Error is the most commonly attested strategy (when the target response is not provided) in these two age groups. It is considerably lower in the older group but it still has a special status in comparison with the other error types. In contrast, 5-year olds show a different response pattern: Distant error is still the most frequent (ranging from 22% and 44%) but the other two errors are also much more frequent in this age group compared to the G7 and G9. Namely, Local ranges from 9% to 18% and Double Reversal ranges from 5% to 19%. In the next part of the analysis we will estimate how significant these differences are.

In our study, the dependent variable (Response) is a categorical factor with four levels (Correct, Local, Distant, Double Reversal), which are not independent (for each trial, only one of the four categories can be chosen). Also, apart from Group which is a between-subject factor, all other variables were within-subject factors. Because of the statistical dependency of responses, we obtained the logistic regression parameters and the associated inferential tests with GEE methodology (Liang

Table 3
Group percentages across conditions. Within each group and for each of the four conditions: C + L + D + DR adds up to 100%.

Feature	Match	G5 $N = 15$				G7 $N = 18$				G9 $N = 17$			
		C	L	D	DR	C	L	D	DR	C	L	D	DR
Gender	M	36	16	29	19	74	5	15	6	85	2	7	5
	MM	38	10	44	7	81	2	16	2	90	2	5	2
Number	M	41	18	24	17	79	3	13	4	85	4	7	3
	MM	64	9	22	5	88	1	9	2	95	1	1	2

M: Match; MM: Mismatch.
C: correct; L: local; D: distant; DR: double reversal.

Table 4
Logistic models.

Model	Event	Non-event
(1) Non-target vs. Target	Non-target responses	Target responses
(2) Local vs. Distant	Local responses	Distant responses
(3) Local vs. Double Reversal	Local responses	Double reversal responses
(4) Distant vs. Double Reversal	Distant responses	Double reversal responses

and Zeger, 1986) by estimating a repeated measure logistic regression model, as implemented by the SAS system. Logistic models calculate the experimental factor effects on the odds of an event over a non-event. The odds are the ratio between the event probability and the non-event probability. As for the present study, we estimated four repeated measure logistic models, with the following Response categories as the event/non-event distinction. The four models are reported in the following table (Table 4).

To answer experimental questions, we estimated model 1 by contrasting Non-target and Target responses (which add up to 100% of subjects' responses) and models 2–4 by selecting relevant sets of subjects' responses for each model. Obviously, for each model the effects we are testing are limited to the subjects' choices that we are comparing. For example in the Local/Distance response model, the interpretation is the following: given an error which is not the "Double Reversal response", is there a difference in the probability of choosing the Local or Distance errors?

In order to evaluate a learning effect, we introduced the variable Item in the model, in order to consider that each condition has 6 occurrences. A value between 1 and 6 was assigned to the variable Item on the basis of the order of appearance of the stimulus (within condition). If Item were to be significant, it would mean that a learning effect from the first trials to the last ones has occurred.

5.4. Results

The following table summarizes the significant effects in each model. Statistical details are reported in the subsequent sections (Table 5).

5.4.1. The Non-target/target response comparison

The comparison between Non-target and Target confirms that our preliminary data description is statistically grounded. In particular, 5-year olds are significantly less accurate than 7- and 9-year olds, Number conditions are significantly more accurate than Gender ones and Mismatch conditions are significantly more accurate than Match ones. Furthermore, a Feature by Match interaction shows that Mismatch Number conditions are more accurate than Mismatch Gender conditions.

In the first part of the analysis we calculated the probability of choosing an error rather than a correct response, for each factor and each group. We found main effects of Age ($\chi^2(2) = 21.47$, $p < 0.001$), of Match ($\chi^2(1) = 18.50$, $p < 0.001$), of Feature ($\chi^2(1) = 11.04$, $p < 0.001$) and two significant interactions: Feature by Match ($\chi^2(1) = 9.10$, $p = 0.0026$) and Head by List ($\chi^2(1) = 4.03$, $p = 0.0447$). Item was not significant ($\chi^2(5) = 7.42$, $p = 0.191$) nor was List ($\chi^2(1) = 0.48$, $p = 0.4869$).

Because a significant χ^2 test does not provide information about the direction or the strength of the effects, we indicate this information with odds ratios, which are the ratio of the probability of an occurrence in one category compared to another (e.g. the probability of choosing a Non-target response divided by the probability of choosing a Target response). An odds ratio of 1 indicates that that the probability of a particular occurrence is equal in both categories. The summary of the significant effects of the model is reported in Table 6.

For Age, contrast estimate results show that, from G5 to G7, the odds ratio Error/Correct significantly decreases at a 0.18 rate ($p < 0.001$); this means that for G5, errors (rather than a correct response) was 5.5 times more frequent than for G7. From G5 to G9, the Error/Correct odd significantly decreases at a 0.08 rate ($p < 0.001$); this means that for G5, errors (rather than correct responses) are 12 times more frequent than for G9. For Feature, contrast estimate results show that, from Gender to Number, the Error/Correct odds ratio significantly decreases at a 0.61 rate ($p < 0.001$); this means that for Gender,

Table 5
Significant effects.

Model	Significant effects[a]: post hoc contrasts
Non-Target/Target	Age: G5<G7 = G9; Match: Match < Mismatch; Feature: Gender < Number; Feature × Match: Mismatch conditions are more accurate when Feature = Number; Head × List: In List1 the factor Head is significant (but this interaction won't be explained)
Local/Distant	Age: G5 choose Local; G7 choose Distant
Local/Double Reversal	n.s.
Distant/Double Reversal	n.s.

[a] A<B means "A is less accurate than B".

Table 6
Summary of the target/ non-target model.

Predictors	DF	Exp(b)	Chi-square	*p*
Match	1	0.52	18.50	<.001
Feature	1	0.61	11.04	.0009
Head	1	1.10	0.99	.3192
Age, contrast 5/7 y.o.	1	0.18	21.52	<.001
Age, contrast 7/9 y.o.	1	0.47	3.41	0.06
Age, contrast 5/9 y.o.	1	0.08	64.01	<.001
Interaction = feature by match	1	0.53	9.10	.002
Interaction = Head by list	1	0.66	4.03	.044

errors (rather than correct responses) are 1.6 times more frequent than for Number. For Match, contrast estimate results show that, from Match to Mismatch, the Error/Correct odds ratio significantly decreases at a 0.52 rate ($p < 0.001$); this means that for Match, errors are almost twice as frequent than for Mismatch conditions.

As for the interaction Feature by Match, further comparison shows that for both feature values (Gender and Number), the factor Match is always significant ($p = 0.018$ for Gender and $p < 0.001$ for Number). However, in Match conditions, there is no difference between the two feature values (0.16), whereas in Mismatch, Feature is significant ($p < 0.001$) and in particular, Number conditions are more accurate than Gender.

A significant Head by List interaction was also attested. In particular, for List = 1, the factor Head was significant ($p = 0.05$), whereas for List = 2, the factor Head was not significant ($p = 0.27$). All the analyses were conducted on the whole sample, given that the factor List does not interact with any other factor. The Head by List interaction and the main effect of Head (as far as List 1 is concerned) are reported but not discussed. In fact the interaction of List only with head is hardly explicable and it does not influence the overall result interpretation.

5.4.2. The Local/Distance response comparison

By comparing Local vs. Distant responses we found that 5-year-olds differentiate themselves from 7 and 9-year olds in that they choose the Local error significantly more often. In contrast, 7 and 9-year olds choose the Distant error almost exclusively.

We only found main effect of Age ($\chi^2(2) = 6.07$, $p = 0.048$). Contrast estimate results show that from G5 to G7, the Local/Distant odds ratio significantly decreases at a 0.37 rate ($p = 0.03$); this means that for G5, Local errors (rather than Distant) are 2.7 times more frequent than in G7.

5.4.3. The Local/Double reversal response comparison

No comparison was significant in this model.

5.4.4. The Distance/Double reversal response comparison

No comparison was significant in this model.

6. General discussion

In this study, we addressed the question as to whether Number and Gender features modulate the comprehension of object RCs by Italian children and, if so, in what way. Importantly, the aim of this study is not to assess the age of acquisition of RCs. Notably, previous studies have shown that, using a pragmatically appropriate task that also minimizes lexical access and processing load, children as young as 3–4 years of age perform well on right-branching RCs (most recently, Adani, in press).

Furthermore, it is generally assumed that center-embedded clauses are harder to parse than right-branching clauses (Chomsky, 1957, 1965; Chomsky and Miller, 1963). Converging experimental evidence was originally found with English children by Slobin (1971) and recently confirmed by Kidd and Bavin (2002) and by Corre?a (1995) with Brazilian Portuguese-speaking children. Thus, we decided to investigate the hardest sentence type (center-embedded RCs) in order to prevent a possibly subtle effect, such as the novel manipulation of grammatical features, from disappearing, given the expected ceiling performance on right-branching RCs.

The main findings of this study are, first, the prominence of Distant error (over other error types) and, second, the asymmetric effect of Number and Gender features in modulating children's accuracy. These results will be discussed in turn.

The Distant Error consists of interpreting the sentence in (39) as (40):

39) The dog that the turtle is splashing has climbed on the rock.

40) The dog that is splashing the turtle has climbed on the rock.

Previous studies aimed at assessing comprehension of RCs using two pictures (Arosio et al., 2009; Friedmann et al., 2009; Friedmann and Novogrodsky, 2004) showed that children tend to interpret object RCs as subject RCs. However, in these experimental settings no other option is available, given that one picture depicts that 'character A is verb-ing character B' and the other 'character B is verb-ing character A'. Although children in the current study were tested with a more

complex visual setting (as compared with the two-picture one), they always perform above chance and, importantly, they still tend to prefer the interpretation of an object RC as a subject RC, rather than other possible errors.[7] The Distant error is the most widely attested strategy that children adopt from the youngest age under investigation and it can last for years. We suggest that this error results from the failure to build up a dependency due to the intervention of the embedded constituent.[8]

Let us now move to the second result i.e. the role played by Number and Gender features in children's comprehension of RCs. The study presented in this paper replicates and extends another study that was carried out with English-speaking children (Adani, 2008). In the English study, the effect of Number was tested on the comprehension of subject and object center-embedded RCs. We found that mismatch conditions were significantly more accurate than those conditions where subject and object DPs have the same Number value.

Testing both features at the same time, we have now found that not only Number but also Gender triggers what we called the mismatch effect. However, these effects are quantitatively different and specifically, the contribution of Gender to facilitate comprehension of object RCs is milder than that of Number.

The DP hypothesis in its original version (Abney, 1987) postulates the existence of a functional head D that gives rise to the maximal projection DP and to its complement NP. This hypothesis is illustrated in (41) and represents the level of structural complexity that had been assumed in Friedmann et al.'s account:

41) $[_{DP}\ D\ \ [_{D'}\ \ NP\ \ ]]$

Friedmann et al. convincingly showed that not all types of object A′-structures are equally difficult and, specifically, that headed object RCs and wh-questions are the hardest. The authors relate this difficulty to the presence of a lexical restriction [+NP] on both the raising DP and the intervening DP (cf. (42a) for a schematic representation of an object RC and (42b) for that of an object which-question). Crucially, they argue that, until some point in development, children adhere to a stricter version of RM and they are only able to compute distant dependencies when the target and the intervener have a disjointed feature specification:

42) a. D NP R ... D NP ... <D NP>
b. Wh NP Q ... D NP ... <Wh NP>

The Italian data show that not all types of headed object RCs are difficult or, crucially, that they are not all difficult to the same extent. Building on Friedmann et al.'s RM approach, we suggest that a finer-grained notion of lexical restriction is needed in order to capture the Italian facts. In order to do so, we will follow theoretical proposals (Bernstein, 2001; Picallo, 1991, 2008; Ritter, 1991, 1993) that postulate the existence of more DP-internal functional heads, Num, where singular/plural properties associated to the lexical item are checked, as in:

43) $[_{DP}\ D\ [_{D'}\ NumP\ [_{Num'}\ Num\ \ [\ NP\ ]]$

By integrating (38) in the schematic representation of an object RC such as (37a),[9] we obtain:

44) $D\ [Num_{+/-\ PL}\ [NP]]\ \ R\ \ \ldots\ \ D\ [Num_{+/-\ PL}\ [NP]]\ \ \ldots\ \ <D[Num_{+/-PL}\ [NP]]>$

'+/− PL' indicates that the value of the feature Number checked on the corresponding functional head can be either 'singular' (i.e. –PL) or 'plural' (+PL). Following this hypothesis, we suggested that the intervention effect is reduced when the A′-target and the intervener are specified with a feature Number with different values, as in:

45) Mismatch conditions: Intervention reduced
a. $D\ [Num_{+\ PL}\ [NP]]\ \ R\ \ \ldots\ \ D\ [Num_{-\ PL}\ [NP]]\ \ \ldots\ \ <D[Num_{+PL}\ [NP]]>$
b. $D\ [Num_{-\ PL}\ [NP]]\ \ R\ \ \ldots\ \ D\ [Num_{+\ PL}\ [NP]]\ \ \ldots\ \ <D[Num_{-PL}\ [NP]]>$

Likewise, the intervention effect is stronger when the A′-target and the intervener are specified with the same Number value, as in:

[7] We are assuming that the embedded subject, in this case, is reconstructed as an embedded object. However, this could also be a task-dependent result (given that the two possible referents are always depicted in each picture). It is still possible that the intervener plays an even more disruptive role, by being completely ignored and thus the child resorts to a coordinated strategy, as: *The dog is splashing and has climbed on the rock.* Further work is necessary to disentangle this issue, possibly by comparing these two alternative interpretations directly.

[8] In 5-year-olds, the prominence of Distant Error is less clear-cut than for the other age groups Local and Double Reversal also being consistently present. However, Distant is still the predominant error.

[9] In the remaining part of the paper, we will leave aside wh-questions given that only RCs were tested in Italian. However, we predict that the Number/Gender facilitation will also hold in wh-questions.

46) Match conditions: Intervention occurs

a. D [Num$_{+\ PL}$ [NP]] R ... D [Num$_{+PL}$ [NP]] ... <D[Num$_{+PL}$ [NP]]>

b. D [Num$_{-\ PL}$ [NP]] R ... D [Num$_{-PL}$ [NP]] ... <D[Num$_{-PL}$ [NP]]>

In other words, we are suggesting that internal properties of Friedmann et al.'s notion of lexical restriction can be factored out and be available to the child parser during the computation of featural subset/superset specifications. What generates intervention is still the lexical overt noun phrase within the DP, but not as a whole. Our manipulation allowed us to distinguish (at least) one property of noun phrases that also seems to be visible by the developing language system.

What about Gender? As we have seen, contrasting theoretical proposals exist as to whether Gender is an independent head with a dedicated functional projection (Picallo, 1991, 2008) or not necessarily (Bernstein, 2001; Di Domenico, 1997; Ritter, 1993). In any case, Gender is always assumed to be encoded more internally than Number. We found that Gender information is less salient than Number in triggering a facilitation effect. These results are amenable with those that De Vincenzi and Di Domenico (1999) and Carminati (2005) have found in antecedent-pronoun resolution in Italian and they can be taken as evidence that asymmetries between features are already at work during development. These authors interpret their findings within a serial model of sentence processing (Frazier and Fodor, 1978) in which syntactic information is accessed faster and more reliably than any other cues available to the parser.

In our 'extended' version of the RM approach, at least three factors can be envisaged as potential competitors to explain the origin of such asymmetry. First, a role could be played by *structural depth* i.e. the hypothesis that Gender is more deeply embedded in the nominal domain than Number. Second, it could also be argued that Number and Gender distinguish themselves with respect to their *syntactic activation* in the course of the derivation. Number being an independent functional projection it is accessible by the human parser during sentence processing. In contrast, Gender could not project its own functional projection and therefore is accessible by the parser later or to a lesser extent. This second hypothesis is the one entertained by De Vincenzi and Di Domenico (1999) and Carminati (2005). Third, Number is *semantically* more *salient* than Gender as it signals the cardinality of the noun and its computation requires the instantiation of one (singular) vs. more than one (plural) entities in the reference discourse context. A similar argument was put forward by Carminati (2005) while discussing the correlation between saliency in syntactic representation and in human cognition of 1st/2nd person vs. 3rd person. We extend this observation to Number vs. Gender asymmetry. These three potential explanations make predictions in the same direction at this level of the analysis. Thus, further investigation is needed in order to disentangle them.

However, an additional observation is in order. In the sentences under investigation, when the two DPs have different Number values this difference is also spelled out on verbal morphology, as indicated below with the auxiliary verb underlined:

47) Il leone che i coccodrilli stanno toccando è sedut**o** per terra.
The lion-SG that the crocs-PL are touching is sitting on the ground

This indicates that the auxiliary verb *stanno* requires a plural subject (*i coccodrilli*) whereas the subject of *è* must be singular (*il leone*). The same cues are not available for Gender, given that this feature is not spelled out on auxiliary verbs in Italian but only on the past participle. For instance, the bolded 'o' in *sedut-o* signals that the subject of *è seduto* must be masculine (*il leone*). An analogous problem was pointed out by Carminati (2005) (cf. footnote 5). She re-ran her experiment accommodating for this problem and obtained comparable response patterns between the two experiments. Moreover, the headed object RC with an impersonal arbitrary *pro* subject condition tested by Friedmann et al. could be affected by the same confound (cf. their footnote 4). The authors refer to results found by Arosio et al. (2009), where number agreement morphology did not seem to be an effective feature to resolve ambiguities in object RCs with post-verbal subjects for Italian children. Although these explanations suggest that the hypothesis presented in this paper is on the right track, further experimental research in a language that makes these predictions systematically testable is desirable.

As we have seen in section 1, several authors have proposed that various types of dissimilarity facilitate comprehension of RCs and, in particular, object-extracted ones. The main contribution of this paper is that dissimilarities of grammatical features also trigger such an effect. This possibility was, nevertheless, already envisaged by Gordon and colleagues within their similarity-based memory interference approach. In their discussion Gordon and colleagues state that other "possible sources of similarity-based interference exist on both syntactic and semantic levels of representation. Possible syntactic features of NPs that could contribute to similarity include gender, number, animacy, case and person" (Gordon et al., 2001:1421).

Stemming from a theoretical perspective different from Gordon's and colleagues, Rizzi himself argues that "RM has desirable properties and appears to be a natural principle of mental computation. It is the kind of principle that we may expect to hold across cognitive domains: if locality is relevant at all for other kinds of mental computation, we may well expect it to hold in a similar form: you must go for the closest potential bearer of a given local relation (Rizzi, 2004:224).[10]

Importantly, recent work by Van Dyke and colleagues (Van Dyke, 2007; Van Dyke and Lewis, 2003; Van Dyke and McElree, 2006) has proposed a formal account of the role of memory in sentence processing. This model is called the 'cue-based model' in that it directly addresses the importance of various sentential cues in building up expectations and

[10] See also Grillo (2009).

subsequent retrieval of new or old linguistic constituents. Thus, these cues mediate the creation of grammatical dependencies during parsing and they enable direct access to relevant memory representations. At the same time, the activation of less salient memory representations can be forbidden or delayed. Without entering into the details of their implementation, we would like to mention that their notion of *cue* is, in several ways, analogous to what theoretical linguists call *feature*. Hence, a formal model such as the one elaborated by Van Dyke and colleagues could also conceivably predict the effects presented in this paper. Therefore, a way to reconcile a syntactic locality principle such as RM and a formal computational model of sentence processing is foreseeable.

7. Conclusions

We have tested the comprehension of center-embedded RCs in 5–9-year-old Italian children. Our experiment specifically distinguishes itself from previous manipulations in that Number and Gender feature values on subject and object constituents are systematically manipulated. We found that the predominant deviant response that children adopt at all ages under investigation is to interpret an object RC as a subject RC. This error is interpreted as a consequence of intervention by the intervener DP, along the lines proposed by Grillo (2005, 2009) and Friedmann et al. (2009).

Furthermore, we proposed a finer definition of Friedmann et al.'s (2009) notion of lexical restriction in order to capture a gradient of accuracy in the children's responses. We showed that the intervention effect is sensitive not only to the presence of the lexical restriction (as previously proposed) but also to DP-internal structure. Our results support the idea that children's performance is grammatically constrained and that these effects can be tested experimentally.

A sketched hypothesis is that intervention could be seen as the source of deviant responses (in terms of lower accuracy, or slower response times) that are generally found in other language research studies. It is suggested that a feature-driven approach such as the one originally proposed by Grillo, then revised by Friedmann et al. and here essentially tested with respect to an auxiliary hypothesis is in harmony with recent proposals coming from the memory-interference literature, such as the cue-based model.

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