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2018

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### How to cite

GUASTI, Maria, VERNICE, Mirta, FRANCK, Julie. Continuity in the adult and children's comprehension of subject and object relative clauses in French and Italian. In: Languages, 2018, vol. 3, n° 3, p. 24. doi: 10.3390/languages3030024

This publication URL: <https://archive-ouverte.unige.ch/unige:148552>

Publication DOI: [10.3390/languages3030024](https://doi.org/10.3390/languages3030024)

Article

# Continuity in the Adult and Children's Comprehension of Subject and Object Relative Clauses in French and Italian

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Received: 5 January 2018; Accepted: 29 June 2018; Published: 5 July 2018



**Abstract:** Subject and object relative clauses have been studied from the point of view of language acquisition and adult sentence processing. In the adult sentence processing literature, subject relative clauses (RCs) are read faster than object RCs (e.g., Frauenfelder et al. 1980 for French; King and Kutas 1995 for English; Schriefers et al. 1995 for Dutch). Similarly, children understand and produce subject RCs earlier and with greater accuracy than object RCs in a variety of languages with head-initial relative clauses, as English, Hebrew and Italian. These findings cannot be a coincidence but reflect the fact that what children acquire first is also easier to process by adults. In this article, we support this observation by investigating subject and object RCs in children and adults speaking French and Italian. These languages display subject and object relatives as in (1), but they also have a type of object relative in which the subject is postverbal. We replicate the observation that subject relatives are easier than object and show that object relatives as in (1b), with the embedded subject in preverbal position are easier than those with the embedded subject in postverbal position, both for children and adults. We offer an account of these findings in terms of Fodor and Inoue's (2000) diagnosis model in light of the fact that acquisition involves processing.

**Keywords:** relative clauses; children; adults; processing; French; Italian

## 1. Introduction

Language acquisition and language processing research have generally proceeded separately, although in the last 15 years, phenomena studied in the adult psycholinguistic literature have been explored in children to document how children solve ambiguities, whether/how they differ from adults and whether aspects of grammatical development may be due to children's limited sentence processing abilities (see [Phillips and Ehrenhofer 2015](#) for a review). One phenomenon that illustrates this trend is subject and object relative clauses.

In the adult sentence processing literature, subject relative clauses (RCs), as in (1a), are read faster than object RCs, as in (1b) (e.g., [Frauenfelder et al. 1980](#) for French; [King and Kutas 1995](#) for English; [Schriefers et al. 1995](#) for Dutch).

1. a. The boy [that *t* kissed the girl] went home
- b. The boy [that the girl kissed *t*] went home.

This subject RC advantage in English is demonstrated by a large number of studies performed with various methods. When processing sentences such as (1b) in comparison with (1a), subjects display poor comprehension in lexical decision tasks (Ford 1983) with up to 35% errors (Villata et al. 2018; see also Carminati et al. 2006), longer reading times in self-paced reading experiments (King and Just 1991), longer fixations in eye-tracking experiments (Traxler et al. 2002), both quantitative and qualitative differences in event-related potentials (King and Kutas 1995), dissimilar brain activations in functional magnetic resonance imaging (Caplan et al. 2002; Cooke et al. 2002; Just et al. 1996) and in positron emission tomography (Stromswold et al. 1996). The preference for subject RCs is uniformly observed in several languages with head-initial relative clauses: Dutch (Frazier 1987; Mak et al. 2002), German (Schriefers et al. 1995; Mecklinger et al. 1995), French (Frauenfelder et al. 1980; Cohen and Mehler 1996; Schelstraete and Degand 1998; Casalis et al. 2013), Spanish (Betancort et al. 2009).

Similarly, children understand and produce subject RCs earlier and with greater accuracy than object RCs in a variety of languages with head-initial relative clauses, such as English, Hebrew and Italian, among others (Adams 1990; Friedmann et al. 2009; Guasti and Cardinaletti 2003; Utzeri 2007; Belletti and Contemori 2010; Contemori and Garraffa 2010; Guasti 2017). Several experiments carried out with an act-out task (De Villiers et al. 1979; Tavakolian 1981), a picture-selection task (Adani et al. 2010; Adani et al. 2014; Arnon 2005; Arosio et al. 2009; Friedmann and Novogrodsky 2004; Volpato and Vernice 2014), a referent/agent selection task (Adani 2011), and self-paced reading and listening tasks (Booth et al. 2000; Arosio et al. 2011) have documented a marked subject/object asymmetry at all ages. While children understand subject RCs quite well at age 3–4, they only understand object RCs above chance around age 5 and are still improving around age 10, with differences among studies depending on the procedure and material used and on the specific properties of RCs in the language. Given the above-mentioned studies indicating that object RCs seem to be critical not only in child language acquisition, but in adult sentence processing, one could propose the following generalization:

2. Child–adult generalization (CHAG): if structure B is more difficult to process (e.g., elicits longer processing time) than structure A by adults, then structure B is mastered later than structure A by children.

The boy [that *t* kissed the girl] went home

Relative clauses are an emblematic example of this generalization, but they are not the only one; the same holds true for *wh*-questions (e.g., adults: De Vincenzi 1991; Kaan et al. 2000 and children: Durrleman et al. 2016) and for some cases of anaphora resolution (see Phillips and Ehrenhofer 2015 for a review).<sup>1</sup> Based on the generalization in (2), if adults and children struggle on the same structures, the same common factors may be responsible for their difficulties.

In this article, we investigate the processing and the comprehension of subject and object RCs by French- and Italian-adults and children. This allows us to bring another type of object RC present

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<sup>1</sup> One reviewer wonders whether our generalization in (2) holds in the other direction, i.e., if all structures that are mastered later are also more difficult to process. This is an empirical question. Certainly, this holds in a banal way for relative clauses and *wh*-questions. We can reframe the question by asking whether what matters is the sequence of acquisition in production and comprehension or both. The available evidence allows us to say that CHAG holds in both directions when comprehension and production are at stake (as it is the case of *wh*-questions and relative clauses). The production of clitic pronouns in some Romance languages reaches adult level at 3 or 4 years of age and thus qualifies as a late acquisition. Little is known about comprehension and even less about adults' processing. This would be an area to further investigate the bidirectionality of CHAG. A second reviewer asks whether the noun phrase accessibility hierarchy (NPHA, Keenan and Comrie 1977) could fall under CHAG. We think that it does. According to the NPAH, the ease of a given relative clause depends on the grammatical function of the relative head. Thus, subjects are easier than objects, these than oblique and these last than genitive relative clauses. Several studies on second language acquisition have supported the hierarchy (see Shirai and Ozeki 2007 for review). Although there is no systematic investigation of relative clauses spanning the whole hierarchy, we know that, in head-initial languages, subject relatives are acquired before all the other relatives and genitive relative clauses are the last (Guasti and Cardinaletti 2003 for evidence from French and Italian; see also Diessel and Tomasello 2000 for evidence from English and German).

in these languages to the stage, one with the subject in a postverbal position, and investigate it with respect to the object RC with a preverbal subject and with respect to generalization (2), which we will show holds for this structure as well. Capitalizing on generalization (2), we offer an account of the underlying difficulties experienced by adults and children. The paper is organized as follows. First, we discuss some typological properties of French relative clauses in the light of previous literature and make some predictions about French- and Italian-speaking children's acquisition of RCs and French- and Italian-speaking adults processing of RCs, which we test in three experiments. On the basis of our results, we propose a processing account, whereby children and adults are more willing to revise a preferred and simpler analysis when they have positive information about how to perform the correct analysis (Fodor and Inoue 2000), rather than when they lack this piece of information.

## 2. Setting the Stage: French Adults' Processing of Relative Clauses

We start by recalling some typological properties of French RCs. First, in French, subject and object RCs are obligatorily introduced by distinct relative markers (or complementizers), unlike in the English examples in (1). Consider the examples in (3a) and (3b). In (3a), the subject RC is introduced by the relative marker *qui* 'that', which is used in all cases of subject extraction whereas the object RC in (3b) is introduced by the relative marker *que* 'that', which is used in cases of object extraction. In spite of this early marker of the syntactic nature of the extracted head, object RCs remain more difficult to process than subject RCs (Frauenfelder et al. 1980; Cohen and Mehler 1996). Second, like in English, French object RCs are usually constructed with the subject preceding the verb (OSV RCs), as in (3b). However, and unlike in English, object RCs can also have the subject follow the verb, as in (3c) (OVS RCs).<sup>2</sup>

3. a. Le gardien de but qui critiquait les joueurs de football est tombé  
'The goalkeeper that criticized the soccer players fell.'
- b. Le gardien de but que les joueurs de football critiquaient est tombé  
'The goalkeeper that the soccer players criticized fell.'
- c. Le gardien de but que critiquaient les joueurs de football est tombé  
'The goalkeeper that (whom) the soccer players criticized fell.'

Schelstraete and Degand (1998) performed an experiment on adults' comprehension of these three types of French RCs (3a–c) using a self-paced reading task. They found that both kinds of object RCs were harder to process than subject RCs. In addition, they observed that participants showed shorter reading times in OVS RCs such as (3c) than in OSV RCs (3b). They interpreted this outcome as evidence supporting a functionalist approach: the competition model (Bates 1999; Bates and MacWhinney 1987). According to this model, the form–function mapping in sentence comprehension emerges from a competition based on the strength of language specific cues and on the memory costs of processing these cues. In the subject RC (3a), there is no competition, as the first noun (the head of the relative) comes before the verb and takes the subject role, which canonically occupies

<sup>2</sup> Subject inversion in French occurs in a limited set of syntactic environments, among which in contexts of extraction, as in OVS relative clauses. OVS RCs are an instance of stylistic inversion in French (Kayne and Pollock 1978). In the 1980s, the agreement was that the subject was in a low position of the clause, possibly right-adjoined to the Verb Phrase (VP), regardless of the type of structure. In more recent times, it has been assumed that some instances of postverbal subjects in stylistic inversion contexts are in a high topic position in the Complementizer Phrase (CP) area and the whole clause has moved past to it. It is also possible that not all postverbal subjects in stylistic inversion environments are in the same position (Kayne and Pollock 2001). OVS RCs are rarely used (Noizet et al. 1972) and may be misinterpreted as subject RCs (Holmes and O'Regan 1981). In Italian, postverbal subjects are more common; however, not all postverbal subjects are in the same position. In particular, the postverbal subject occurring in extraction contexts, in contrast to declarative contexts, is in a sort of dislocated position (Guasti 1996), possibly right adjoined to the VP or Inflectional Phrase (IP). We assume that the same holds for French relatives. According to Belletti and Chesi's (2011) corpus analysis, OVS RCs are rare (9%), while subject RCs are much more frequent (66%) and OSV RCs are in between (25%).

a sentence-initial position in French. The OSV RC in (3b) should be more difficult to solve than (3a) for two reasons. First, the word order cue is not valid, as the sentence does not have the canonical word order: the first noun, i.e., the head of the relative, must receive the object role, rather than the subject role. Second, it requires the parser to keep the two nouns (the object and the subject) in working memory before the verb is reached. The OVS RC in (3c) is expected to be harder than (3a), but easier than (3b). As in (3b), word order does not provide a valid cue since the head of the relative, which comes before the verb, has to take the object role, while the post-verbal NP has to take the subject role. However, in terms of memory load, OVS RCs are like subject RCs in that they only require one noun to be stored (the head of the relative) before encountering the verb. In line with these predictions, [Schelstraete and Degand \(1998\)](#) found that participants took more time to read object RCs than subject RCs, and that OSV were slower than OVS RCs. The authors argued that the memory load component, whose burden is heavier in the OSV relative, was the factor responsible for the processing difficulties observed in OSV RCs and that the memory load counted more than the word order cue.

The competition model makes predictions concerning the course of language acquisition: the order of acquisition of a given structure is determined by the validity of its form-function mapping cues. Hence, subject RCs are expected to be acquired earlier than object RCs since word order cues are not valid in the latter. This is in line with the various findings from the cross-linguistic literature. Since OSV sentences involve higher memory demands than OVS sentences and children's memory resources are known to develop over time, the former are expected to be acquired later, in line with the finding that adults are faster to read OVS compared to OSV. Thus, according to the competition model, the hierarchy of difficulties in French, based on adult data, is: subject > OVS > OSV relatives. Data from Italian-speaking children discussed by [Arosio et al. \(2009\)](#), [Adani \(2011\)](#) yield a different hierarchy of difficulties: subject > OSV > OVS relatives. Given that postverbal subjects are less stylistic marked in Italian than in French and likely they are more common in the former than in the latter language, the hierarchy of difficulties ensuing from [Schelstraete and Degand's \(1998\)](#) study is surprising. However, since Italian data are from children and French data are from adults, our first step is to establish whether the Italian hierarchy holds for French-speaking children or not. In the positive case, there would be a discrepancy between French-speaking children and adults and our generalization would be disconfirmed; in the second, there would be a discrepancy between French and Italian (at least as far as children are concerned).

### 3. Experiment 1: French Children

In this experiment, we tested 5 to 7 year-old French-speaking children's comprehension of RCs using the same method used by [Adani \(2011\)](#) with Italian children; i.e., a referent selection task. The research was approved by the school commission of the Département de l'Instruction Publique de Genève and parents had to provide written consent for their child.

#### 3.1. Participants

Fourteen monolingual French-speaking children attending various schools in Geneva, Switzerland participated in the experiment, ranging in age from 5;5 to 7;4 with a mean age 6;5 (standard deviation SD = 6;3). Two participants were discarded because they answered incorrectly to filler items most of the time (at least 83% incorrect answers).

#### 3.2. Materials and Design

The experiment consisted of 24 spoken right-branching RCs, 8 subject RCs (4a), 8 OSV RCs (4b) and 8 OVS RCs (4c).

4. a. SVO relative clause (Subject RC)  
 Montre-moi [le lion qui mord les chameaux]  
 'Show me the lion that bites the camels.'
- b. OSV relative clause (Object RC)  
 Montre-moi [l'oie que les lapins poursuivent]  
 'Show me the goose that the rabbits chase.'
- c. OVS relative clause (Object RC)  
 Montre-moi [les lions que bat le cheval]  
 Show me the lions that hits the horse.  
 'Show me the lions that the horse hits.'

All sentences included transitive reversible verbs. The relative head and the other argument in the RCs were always mismatched in number; one in the singular and the other in the plural, with singular and plural being counterbalanced. All RCs included a verb inflected for either third person singular or third plural agreement (counterbalanced across items) and plural agreement was always phonetically audible. Sentence length was similar across items. We used verbs with audible agreement to make this experiment parallel to the Italian one, where agreement is always audible. We acknowledge that in [Schelstraete and Degand's \(1998\)](#) experiment agreement was not audible and this may be a limitation, although in unpublished work we found that there is no difference between relatives with or without audible agreement. Experimental items were interspersed with 12 fillers, which were either subject RCs with intransitive verbs (3 items) or simple descriptions of individuals (e.g., *Les hommes sur les arbres* 'The men on the trees'). All the sentences were recorded by a female native speaker of French. All the sentences were introduced by *show me ...* and were spoken along with a picture displaying three sets of characters, as in [Figure 1](#).



**Figure 1.** Sample of stimuli used in Experiment 1.

For instance, (4c) appeared together with the event represented in [Figure 1](#), involving a horse in the center that beats two lions on its left and that is bitten by two lions on its right. Therefore, for each picture, the target response was either the character(s) on the left or that/those on the right, and never the one in the center. Left and right were counterbalanced across pictures. Correct responses for fillers involved, instead, the character in the center. The relevance of these pictures, as compared to classical pictures used in experiments testing comprehension of RCs and involving only two sets of characters, is that they make relativization pragmatically felicitous: two sets of identical characters are depicted that can be singled out by the relative clause ([Crain and Thorton 1998](#)).

### 3.3. Procedure

Before the experiment started, children's lexical knowledge of the nouns and verbs used in the experiment was assessed. Then, children went through a familiarization session during which they heard intransitive RCs and received feedback on their responses. The experiment was run on a computer and stimuli were presented with E-Prime 1.0 (Psychology Software Tools, Sharpsburg, PA, USA). Responses were recorded via a touch screen. The experiment took place in a quiet room in the school. While pictures were displayed on the screen, children heard sentences presented binaurally via headphones. Children were instructed to carefully listen to sentences, at the end of which they were invited to touch with their finger to the character that matched the sentence they heard. Responses were registered through the E-prime software.

### 3.4. Results and Discussion

The means and SD of correct responses for each type of sentence are presented in Table 1. Correct responses are more frequent for subject (SRC) than for both object RCs. We observed also a difference between the two types of object RCs with a better performance for OSV than for OVS.

**Table 1.** Mean correct responses and standard deviations for each type of sentence in Experiment 1.

Type of RC	Mean (SD)
SRC	0.87 (0.33)
OSV RC	0.58 (0.49)
OVS RC	0.23 (0.42)

SRC: subject relative clause (RC); OSV RC: object RC with preverbal subject; OVS RC: object RC with post-verbal subject.

Performance was considered above chance when the child answered correctly to at least 6 out of the 8 items in each type of sentence, as predicted by the binomial distribution ( $p = 0.01$ ). Looking at children's individual performance, all children are above chance in the comprehension of SRCs, less than half (5/12) were above chance in the comprehension of OSV RCs, and none were above chance in the comprehension of OVS RCs. As response accuracy is a categorical variable, we submitted our data to a series of mixed effects logit models, run in R (R Development Core Team 2011). We established whether one predictor significantly contributed to the model's fit by comparing a model including that predictor against another that did not involve it using a  $\chi$ -square test (Jaeger 2008). Then, we computed the  $z$  value, based on the Wald statistic, allowing for an estimation of the statistical significance of each predictor in the model. Our analyses included sentence type as a within-participant factor and participants and items as random factors. In the analyses performed, the reference category was subject RC. Sentence type ( $\chi(2) = 35.4, p < 0.001$ ) added significant information to the model. Subject RCs were easier to understand than OSV RCs (estimate =  $-1.92$ , st.err =  $0.49$ ,  $Z = -3.92, p < 0.001$ ) and than OVS RCs (Estimate =  $-3.93$ , St.Err =  $0.55$ ,  $Z = -7.1, p < 0.001$ ) (log-likelihood =  $-165.2$ ,  $N = 336$ , SD for subject =  $0.58$ , SD for item =  $1.03$ ). By changing reference category, we have been able to establish that OVS was more difficult than OSV RCs (estimate =  $2.00$ , st.err =  $0.46$ ,  $Z = 4.3, p < 0.001$ ).

When children did not provide the correct answer, they typically provided two types of errors: middle errors, which consist in choosing the middle character (either the subject or the object), and reversal errors, which consist in reversing the thematic roles. The distribution of these two types of errors in the various structures tested is illustrated in Table 2. Reversal errors were the most frequent error in object RCs, especially in OVS structures, suggesting that they were interpreted as SRCs. The level of individual analysis reveals that 6 children (out of 12) were above chance in making these errors (6 out of 8 times) when presented with an object OVS RC, showing that they consistently went for the SRC interpretation.

**Table 2.** Percentages and raw middle errors and reversal errors for each type of sentence in Experiment 1.

SVO SRC		OSV ORC		OVS ORC	
Middle	Reversal	Middle	Reversal	Middle	Reversal
4% (5)	8% (9)	13% (15)	26% (31)	8% (9)	68% (77)

To sum up, the results show a subject/object asymmetry, with subject RCs being comprehended more accurately than object RCs, in line with the prediction of the Competition model. However, OSV object RCs are comprehended more accurately than OVS object RCs, contrary to the predictions of the competition model. Most of the errors, especially with object OVS RCs, were reversal errors consisting in interpreting the first noun phrase as the subject and the last noun phrase as the object, which amounts to re-establishing the canonical order. This latter finding fails to replicate the results of French-speaking adults (Schelstraete and Degand 1998) but is in line with those reported for Italian-speaking children (Adani 2011; Arosio et al. 2009, Arosio et al. 2011; Volpato and Vernice 2014).

In order to preserve the competition approach, one may hypothesize that children's unexpected performance in object RCs is due to a developmental change in the ranking of cues. Schelstraete and Degand (1998) argued that OSV RCs are harder than OVS RCs for adults because the former require keeping two NPs in memory before the verb is encountered. One may entertain the possibility that the memory load involved in OSV structures is not an issue for children; however, this is not plausible given the wide evidence showing lower memory resources for children than adults. Another more plausible hypothesis is that children and adults make different use of verbal cues. Indeed, OSV and OVS object RCs differ in that the critical information that the sentence is an object relative (besides the complementizer 'que', which is common to both OSV and OVS) is the presence of the second NP (the subject) following the object in OSV sentences, while in OVS it is the agreement cue for the verb (provided that the object and the subject mismatch in number, which was the case in our materials). Therefore, one could stipulate that, whereas children grant a stronger role to the word order cue, available in OSV (NP (comp) NP V) than to the agreement cue, available in OVS (NP (comp) V NP), adults would grant a stronger role to the verbal agreement cue. This would explain why French-speaking children acquire OSV RCs earlier than OVS RCs, while French-speaking adults process OVS faster than OSV. Under that hypothesis, the developmental change consists in a change in the ranking of cues. The hypothesis, grounded in the competition model, that language development involves changes in the ranking of cues predicts that Italian-speaking children should behave like French-speaking children, which we already know is the case. It also predicts that Italian-speaking adults should behave like French-speaking adults and demonstrate easier processing of OVS than OSV RCs. If this prediction would hold, it would falsify our generalization in (2), according to which children and adults should show the same hierarchy of difficulty, such that a structure that is more difficult to understand by children, should also be slower to process by adults. Since generalization (2) holds for other cases, as discussed earlier, it is important to establish whether there are exceptions and why. Therefore, in order to examine the fate of our generalization, we carried out two experiments. Experiment 2 was conducted on French-speaking adults: we wanted to replicate the faster processing for OVS compared to OSV observed by Schelstraete and Degand (1998) and determine whether this finding may be due to the particular data analyses conducted by the authors. Experiment 3 was conducted on Italian-speaking adults, since no data were available on adults in that language.

#### 4. Experiment 2: French Adults

##### 4.1. Participants

We tested a group of 32 French university students of the University of Geneva. All subjects were native speakers of French, had normal vision, and received credits for their participation. Written consent was collected from them.

#### 4.2. Materials and Design

We constructed 36 sets of three center-embedded relative clauses each, a subject RC (5a), an OSV RC (with a preverbal subject) (5b) and an OVS RC (with a postverbal subject) (5c). Each sentence started with the head of the relative clause phrase followed by the relative marker. Two prepositional phrases (PPs) were introduced before the main verb in each of the three conditions, and all sentences ended with a PP. The first PP was introduced in order to control for spillover effects. It can be expected that the most difficult structure is read slower not only at the disambiguating segment but at the following segment as well, i.e., the first PP. At the second PP, there is no reason to expect an additional effect and all structures should elicit similar reading times. The embedded verb was conjugated in the past perfect (an auxiliary plus the past participle). The main verb was conjugated in the passive present perfect. The subject and the object of the relatives always mismatched in number, and their number was counter-balanced across items. All verbs in the relative clauses were reversible and only animate nouns were used in the test items. Verbs and nouns were chosen so that no pragmatic disambiguation could favor one interpretation over the other. Examples with the segmentations used during the self-paced reading are given below.

##### 5. a. Subject RC

[ <sub>NP</sub> Les mannequins <sub>1</sub> ]	[ <sub>RC</sub> qui avaient séduit le couturier <sub>2</sub> ]	[ <sub>PP1</sub> à chaque défilé <sub>3</sub> ]
The models	who had seduced the designer	at each show
[ <sub>PP2</sub> de mode <sub>4</sub> ]	[ont été interviewés <sub>5</sub> ]	[ <sub>PP3</sub> à la TV <sub>6</sub> ]
of fashion	have been interviewed	on the tv

‘The models who had seduced the designer at each show of fashion have been interviewed on the tv.’

##### b. OSV RC (Object RC)

[ <sub>NP</sub> Les mannequins <sub>1</sub> ]	[ <sub>RC</sub> que le couturier avait séduit <sub>2</sub> ]	[ <sub>PP1</sub> à chaque défilé <sub>3</sub> ]
The models	who the designer had seduced	at each show
[ <sub>PP2</sub> de mode <sub>4</sub> ]	[ont été interviewés <sub>5</sub> ]	[ <sub>PP3</sub> à la TV <sub>6</sub> ]
of fashion	have been interviewed	on the TV

‘The models who the designer seduced at each fashion show have been interviewed on TV.’

##### c. OVS RC (Object RC)

[ <sub>NP</sub> Les mannequins <sub>1</sub> ]	[ <sub>RC</sub> qu’avait séduit le couturier <sub>2</sub> ]	[ <sub>PP1</sub> à chaque défilé <sub>3</sub> ]
The models	who had seduced the designer	at each show
[ <sub>PP2</sub> de mode <sub>4</sub> ]	[ont été interviewés <sub>5</sub> ]	[ <sub>PP3</sub> à la TV <sub>6</sub> ]
of fashion	have been interviewed	on the TV

‘The models who the designer seduced after the fashion show have been interviewed on TV.’

We constructed three experimental lists such that each condition was represented by 12 items in each list, but participants only saw one version of each item. Each list also contained 45 fillers, 15 of which were declarative sentences, 15 right-branching RCs and 15 center-embedded RCs, containing either one inanimate NP or a thematically biased verb. Experimental sentences were divided into six segments as indicated to the right of the square brackets in (5). The critical segment containing the relative marker, the verb and the NP in the relative clause was segment 2 for all three types of relatives. We adopted this particular segmentation such that segment 2 always includes the same material across the three conditions, allowing for a direct comparison among them. An alternative, which is adopted in the literature, consists in segmenting the verb and the NP in the relative clause, such that reading times can be measured more specifically at the verb. However, this way of segmenting has the disadvantage

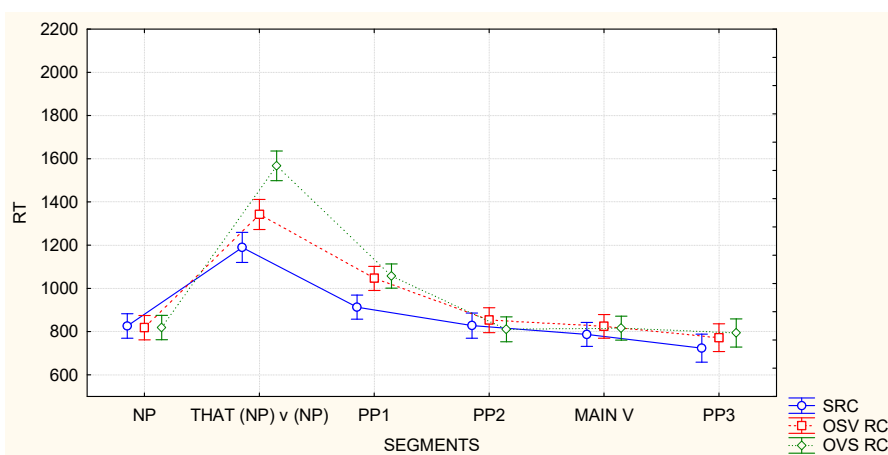
that whereas the verb comes before the object in the subject relative, it comes after the object in the object relatives OSV and OVS, which makes comparison across structures non-minimal and therefore problematic. Segment 3 contains the spillover region, which may or may not extend until segment 4. To make sure that participants paid attention during the experiment, they were asked to respond to a yes/no comprehension question following 75% of the experimental sentences. Participants chose the “yes” or “no” response by pressing the left and right arrow buttons on the keyboard. Half of the questions were true, half were false. These questions never concerned the thematic relations between noun phrases so no attention was drawn to the goal of the experiment. Line breaks were always placed after PP1 and PP2 to make sure that no critical region would occur at the beginning of a new a line.

#### 4.3. Procedure

Subjects were tested individually in a quiet room. Sentences were presented in the middle of the screen on a portable computer using E-Prime. Subjects were informed about the procedure and asked to pace their way through the sentences reading as normally as possible. Subjects were requested to press the space bar only after they had read and understood each segment. The experiment started with 6 practice trials. Each sentence was preceded by an asterisk after which the first segment appeared. The space bar was used to move to the next segment; after pressing the space bar the first segment was replaced by lines (one line for each word). Reading times and response accuracy to the comprehension questions were recorded.

#### 4.4. Results and Discussion

Reading times beyond or above 3 SD from the mean were discarded, representing 2.5% of the data. Data were log-transformed to correct for normality. In general, subjects read the sentences carefully, showing an average response accuracy of 96%. Mean reading times by segment and by Sentence Type are reported in Figure 2.



**Figure 2.** Mean reading times (RT) per segment in each experimental condition of Experiment 2 (French). SRC: subject relatives; OSV RC: object relatives with a pre-verbal subject; OVS RC: object relatives with a post-verbal subject. NP: noun phrase; PP: prepositional phrase. Vertical bars indicate confidence intervals at 0.95.

The data of each segment were submitted to a series of mixed effects logit models with subjects and items as random factors and sentence type and number of characters in the segment as fixed factors. The reference category for sentence type was SVO RCs. By changing it, we were also able to compare the two object RCs. At the critical segment 2, sentence type contributed to the model’s fit, ( $\chi^2(2) = 33.99, p < 0.001$ ), indicating that the three structures significantly differed: subject RCs were read faster than the two object RCs and OSV RCs were read faster than OVS RCs. Number of

characters also contributed significantly to the model ( $\chi^2(1) = 10.52, p < 0.01$ ). That is, the higher number of characters the segment contained, the longer it took to read it. At the following segment 3, the PP1, sentence type again contributed to the model's fit ( $\chi^2(2) = 16.65, p < 0.001$ ) as well as number of characters ( $\chi^2(1) = 10.65, p < 0.01$ ). Subject RCs elicited shorter RTs than the two object RCs, which did not differ. No sentence type effect was found at the PP2 (segment 4) or at the main verb (segment 5). At these two segments, only number of characters contributed to the fit of the model:  $\chi^2(1) = 8.65, p < 0.01, \chi^2(1) = 10.79, p < 0.01$ , respectively. At the last segment 5, number of characters ( $\chi^2(1) = 14.08, p < 0.01$ ) and sentence type contributed to the model's fit ( $\chi^2(2) = 8.41, p < 0.05$ ) with subject RCs eliciting shorter RTs. In Appendix A, we report a summary of the fixed effects for those segments where sentence type contributed a significant fit and had to be included as a predictor in the model. To sum up, in line with the children's data reported in Experiment 1, French-speaking adults appear to read subject RCs faster than object RCs and OSV RCs faster than OVS RCs. The finding that OSV relatives are read faster than OVS relatives is at odds with the data reported by Schelstraete and Degand (1998). Where does the discrepancy come from? We suggest that it lies in the way reading times were measured. In our experiment, the critical region (segment 2) involved the same content across the three conditions (6b), although the linear order and the syntactic status of the NPs varied. Schelstraete and Degand (1998) used a different segmentation: the region corresponding to our segment 2 was segmented in 3 regions, as illustrated in (6a):

6. a. Schelstraete and Degand's (1998) segmentation
- |                                 |                              |                             |
|---------------------------------|------------------------------|-----------------------------|
| OSV [RC ... that <sub>2</sub> ] | [ NP <sub>-subject 3</sub> ] | [V <sub>4</sub> ]           |
| OVS [RC ... that <sub>2</sub> ] | [ V <sub>3</sub> ]           | [NP <sub>-subject 4</sub> ] |
- b. Segmentation in this study
- |                  |                        |                            |
|------------------|------------------------|----------------------------|
| OSV [RC ... that | NP <sub>-subject</sub> | V <sub>2</sub> ]           |
| OVS [RC ... that | V                      | NP <sub>-subject 2</sub> ] |

Schelstraete and Degand (1998) found that the verb in OSV RCs (V<sub>4</sub>) elicited slower reading times than the verb in OVS (V<sub>3</sub>) and capitalized on that finding to conclude that OSV RCs were harder to process than OVS RCs. However, the authors also compared reading times at the subject noun, which is in segment 3 in OSV RCs (NP<sub>-subject 3</sub>), i.e., before the verb, and in segment 4 in OVS, i.e., after the verb (NP<sub>-subject 4</sub>). In that segment, reading times were actually longer in OVS than in OSV RCs, although the difference is not as high as that found at the verb.<sup>3</sup> That is, participants took longer to read the post-verbal subject in OVS than to read the pre-verbal subject in OSV. Since comprehension is incremental, it is possible that the precise locus of the difficulty differs across the two object relatives. The authors capitalized on the reading times at the verb and concluded that OVS relatives are easier than OSV relatives. However, their finding that the effect is reversed at the subject noun, which is read faster in OSV than in OVS, suggests that the reason why reading times were so fast at the verb in OVS may be that the parser did not yet have to integrate the subject as an argument of the verb or did not do anything. This integration would come at a cost, which would manifest in terms of longer reading times once the subject is reached. In contrast, in OSV the difficulty lies at the verb, since both its arguments have been encountered and therefore have to be integrated once the verb is reached.

In summary, Schelstraete and Degand (1998) found opposite effects at the verb and at the subject when comparing OSV and OVS, but capitalized only on the effect observed at the verb, to conclude that OVS are easier. By measuring reading times on a bigger region including both the verb and the subject, we were able to estimate the overall cost of having to process the OVS structure compared to the OSV structure. Before discussing the theoretical consequences of this finding, we first wanted

<sup>3</sup> By looking at Schelstraete and Degand's (1998) Figure 1, we can notice that the verb takes 1000 ms in OSV RC and about 650 ms in OVS RCs. The subject takes about 650 ms in OVS RCs and 580 ms in OSV RCs.

to determine whether Italian adult speakers would also process relative clauses as French-speaking adults do in order to have the full picture. This was the aim of Experiment 3.

## 5. Experiment 3: Italian Adults

### 5.1. Participants

A group of 28 Italian university students of the Università degli studi di Milano-Bicocca took part in the study. All subjects were native speakers of Italian, had normal vision, and received credits for their participation. Written consent was collected from them.

### 5.2. Materials and Design

The materials consisted of the Italian translation of the French materials from Experiment 2. Since the subject and the object of the relatives were always mismatched in number, the number morphology on the embedded auxiliary, which agrees with the subject, was the only cue to disambiguate SVO subject relatives from OVS object relatives since the relativizer is always *che* ‘that’ in Italian. This contrasts with French, in which the relativizer provides an additional cue (*qui* ‘that’ in SVO vs. *que* ‘that’ in OVS). Examples of items in the three conditions are presented in (7). Forty students of the University of Milano-Bicocca (none of which participated in the self-paced reading experiment) ranked the plausibility of the Italian items on a 1 to 5 scale. One item turned out to be significantly different from the others ( $p < 0.05$ ), so this sentence was adjusted before running the experiment. This plausibility experiment was done before running the French experiment and the change was included in the French material.

#### 7. a. Subject RC

[NP Le modelle 1] The models	[RC che avevano sedotto il designer 2] who had seduced the designer	[PP2 dopo la sfilata 3] after the show
[PP2 di moda 4] of fashion	[sono state intervistate 5] have been interviewed	[PP3 alla TV 6] on the tv

‘The models who seduced the designer after the fashion show have been interviewed on TV.’

#### b. OSV RC (Object RC)

[NP Le modelle 1] The models	[RC che il designer aveva sedotto 2] who the designer had seduced	[PP2 dopo la sfilata 3] after the show
[PP2 di moda 4] of fashion	[sono state intervistate 5] have been interviewed	[PP3 alla TV 6]. on the TV

‘The models who the designer seduced after the fashion show, have been interviewed on TV.’

#### c. OVS RC (Object RC)

[NP Le modelle 1] The models	[RC che aveva sedotto il designer 2] who had seduced the designer	[PP2 dopo la sfilata 3] after the show
[PP2 di moda 4] of fashion	[sono state intervistate 5] have been interviewed	[PP3 alla TV 6] on the TV

‘The models who the designer seduced after the fashion show, have been interviewed on TV.’

Lists, segments definition and comprehension questions were identical to the French materials in Experiment 2.

### 5.3. Procedure

The same procedure as Experiment 2 was adopted.

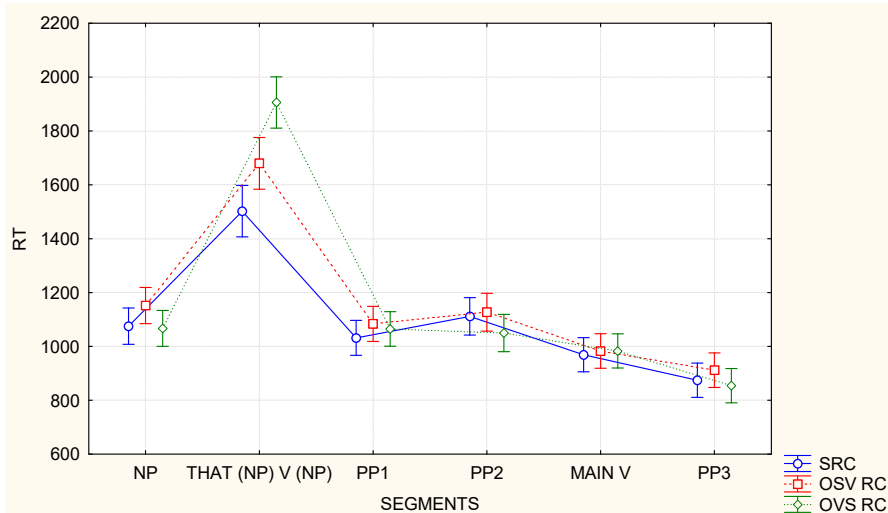
#### 5.4. Results and Discussion

Reading times beyond or above 3 DS from the means were discarded, representing 2% of the data. Raw data were log-transformed to correct for normality. In general, subjects were accurate in answering to the comprehension questions, displaying an overall response accuracy of 97%. Mean reading times (RTs) for each segment by sentence type are reported in Figure 3.

The data were submitted to mixed logit models with subject and item as random factors and sentence type and number of characters as fixed factors. The reference category for sentence type was subject RCs. By changing it, we have been able to compare the two object RCs.

At segment 1, only numbers of characters contributed to the fit of the model:  $\chi^2(1) = 22.37$ ,  $p < 0.001$ . At the critical segment 2, sentence type contributed to the model's fit ( $\chi^2(2) = 34.6$ ,  $p < 0.001$ ): subject RCs were read faster than the two object RCs, and OSV object RCs were read faster than OVS object RCs. Number of characters ( $\chi^2(1) = 7.34$ ,  $p < 0.01$ ) also contributed to the model's fit.

In all the following segments, only number of characters contributed to the fit of the models (Segment 3:  $\chi^2(1) = 33.45$ ,  $p < 0.01$ ; segment 4:  $\chi^2(1) = 21.09$ ,  $p < 0.01$ ; segment 5:  $\chi^2(1) = 36.90$ ,  $p < 0.01$ ; segment 6:  $\chi^2(1) = 28.89$ ,  $p < 0.01$ ). Sentence type was never significant. In Appendix B, we report a summary of the fixed effects only for segment 2, as only in that region did the sentence type factor contribute a significant fit. The findings of Experiment 3 show that Italian-speaking adults process subject relatives faster than object RCs, and that they process OSV RCs faster than OVS RCs. The data are in line with the results from Experiments 1 and 2 for French-speaking children and adults, as well as with the data reported in the literature for Italian-speaking children. Experiments 1, 2 and 3 all invalidate the prediction of the competition model that OVS sentences should be easier given the reduced memory demands (only one argument has to be kept in memory until the verb is reached). Moreover, results from Experiments 2 and 3 also invalidate the hypothesis, developed within the framework of the competition model, that children and adults grant different ranks to cues. Rather, the data are compatible with our generalization in (2), according to which processing time in adults reflects order of acquisition in children. In the next section, we develop an alternative account of our results in line with that generalization.



**Figure 3.** Mean RTs per segment in each experimental condition of Experiment 3 (Italian). Vertical bars indicate confidence intervals at 0.95.

## 6. Discussion

We carried out three experiments aiming at examining how French-speaking children as well as French- and Italian-speaking adults understand and process relative clauses. In particular, we were interested in the relative difficulty in the processing and acquisition of OSV and OVS relatives in



modulated by the mode of disambiguation or the type of information encountered. Following [Fodor and Inoue's \(2000\)](#) diagnosis model (see also [Bader and Meng 1999](#); [Arosio et al. 2009](#)), we propose that OSV relatives are easier to process than OVS relatives because, whereas the former ones involve positive information as to how the initial parse has to be revised, the latter does not. In OSV relatives, the subject, situated in the preverbal canonical subject position, informs the parser that a subject RC analysis is not correct and it also indicates what expression must be the subject: the preverbal NP itself. The additional time needed to process this structure, as compared to subject relatives, is the time needed to reassign the thematic role of the subject (see also [Frauenfelder et al. 1980](#)). The processing cost observed by [Schelstraete and Degand \(1998\)](#) at the verb in OSV may reflect a spillover effect of the reanalysis initiated at the subject of the relative clause. In OVS, instead, the information that comes after the first noun phrase (despite the complementizer) is the verb. Here, verbal agreement provides information for reanalysis, if the verb fails to agree with the initial NP. In that case, the information comes in a negative form: it tells the parser that the relative head is not the subject, but it does not tell the parser what expression the subject is. The parser must look for a subject in this case. In other words, the parser knows that the analysis is wrong, but no information is provided about how to repair the initial parse. It is only at the postverbal NP that the parser can engage in reanalysis: if that NP agrees with the verb, it can be analyzed as its subject, and the relative head can thus be reanalyzed as the object. In other words, parsing is doubly difficult in OVS: on the one hand, the parser is left without a solution at the verb (while it has a solution at the preverbal subject, i.e., at the point, which triggers reanalysis); on the other, when a solution is found, an additional operation of agreement checking has to be performed. The fact that [Schelstraete and Degand \(1998\)](#) found a processing cost at the postverbal subject in OVS may reflect the fact that only when the subject is found the parser engages in a new analysis. Under this view, the course of acquisition could be explained by assuming that children also start with the simpler analysis, that of subject RCs. It is known that at young ages, children are reluctant to abandon a preferred response, i.e., they have weak inhibitory skills ([Mazuka et al. 2009](#); [Choi and Trueswell 2010](#)). Hence, their overall difficulty with object RCs may be due to a difficulty to engage in a revision process. As they grow older, they may be better equipped to abandon the subject RC analysis, because inhibitory skills have improved. The higher difficulty they show with OVS structures may be due to the negative nature of the information that leads to the revision. This view is congruent with results from [Guasti et al. \(2012\)](#) on Greek and by [Arosio et al. \(2012\)](#) on German for children and by [Meng and Bader \(2000\)](#) for adult German. We illustrate this point by relying on Greek. [Guasti et al. \(2012\)](#) investigated children's comprehension of subject and OVS RCs in Greek, a language that can mark nominal elements with morphological case (as German). Two types of OVS RCs were tested, illustrated in (8):

8. a. Dhikse mou To alogo pou kinigoun ta liontaria  
 Show me the.NEUT.SG horse that pull.3PL the.NEUT.PL lion  
 'Show me the horse that the lions are pulling.'
- b. Dhikse mou ti maimou pou pleni I arkouda  
 Show me the.ACC.FEM.SG monkey that wash.3SG the.NOM.FEM.SG bear  
 'Show me the monkey that the bear is washing.'

(8a) is like the OVS RC that we tested in French and Italian: the two nouns are marked with neuter case (specifically on the article), which is compatible with a subject or an object role. The information that indicates that the sentence is an object RC is verbal agreement: the verb does not agree with the relative head. This is a piece of negative information. (8b), instead, has the relative head morphologically marked with accusative case and the postverbal NP marked with nominative case. This information provides positive evidence that the preverbal NP is the object (it has accusative case) and the postverbal NP is the subject (it has nominative case). [Guasti et al. \(2012\)](#) found that 5-year-old Greek-speaking children were better at comprehending subject than OVS RCs, as in Italian. In addition, they found that the same children comprehended OVS RCs as in (8b) better than OVS RCs as in (8a). The fact that subject RCs

are easier indicates that children engage in a subject RC analysis (even if the relative head is marked accusative case (by the main verb). The difference between the two types of OVS RCs can be explained if we assume that morphological case is a positive piece of information that tells the parser who the subject and object are, while verbal agreement is a negative piece of information, that signal that the preferred subject relative clause analysis is wrong, but still requires the parser to find the subject and check agreement. On a similar vein, [Meng and Bader \(2000\)](#), based on German, found that adults are quicker at revising wh-questions disambiguated by morphological case than those disambiguated by agreement. Notice that this fact further supports our generalization (2), in that it also shows that children and adults are similarly affected by the type of information that disambiguate a given sentence.

So far, we have capitalized on the similarities between Italian and French RCs. However, there is one relevant difference. The complementizer in French RCs tells one whether a subject or an object RCs is to be expected. If this piece of information would immediately have been taken into account, we should not have observed a subject/object asymmetry. Whether or not they did at some point, we cannot tell on the basis of our data.<sup>5</sup> In any event, the finding that even adults still struggle with object relatives in French suggests that the information provided by the complementizer is actually not, or only weakly, taken into account. One reviewer notices that the reading times are generally higher all over the segments in Italian than in French and wonders whether this depends on the fact that, in French, the complementizer signals what type of relative clause is to be expected. We cannot exclude this, but we find it unlikely that the different reading times depend on the different nature of the complementizers in the two languages, because reading times are already shorter in French, at the first NP before the complementizer. In order to find out if and how the information concerning the complementizer is used by the parser, we would need to carry out an experiment with German relatives and manipulate the information on the complementizer. In (9a), the complementizer *den* ('that'+ACC) indicates that the relative head is an object. In (9b), the complementizer *das* ('that'+NEUTER) can be nominative or accusative. It is only at the embedded subject *den Mann* that the sentence is disambiguated. If the information on the complementizer is immediately used, (9a) should be easier or elicit shorter reaction time than (9b).

9. a. Zeig mir den Mann, den am Montag das Kind  
 Show me the.ACC man that. ACC on Monday the.NEUTER child  
 getroffen hat  
 found has  
 'Show me the man that the child found on Monday.'
- b. Zeig mir das Kind, das am Montag der Mann  
 Show me the.NEUTER Child that.NEUTER on Monday the.NOM man  
 getroffen hat  
 found has  
 'Show me the child that the man found on Monday.'

In conclusion, we have shown that French- and Italian-speaking children and adults behave similarly when they have to comprehend subject and object RCs. In particular, beyond the well-known subject advantage, we have provided evidence that OSV RCs are easier than OVS RCs for adults to process and for children to comprehend. We have also contributed to reinterpreting the previous report on French-speaking adults by [Schelstraete and Degand \(1998\)](#) that suggested that OVS structures were easier to process: a fine analysis of the data suggests that their conclusion was invalid. Although based on different type of measures (reading time and accuracy), our data converge toward the conclusion

<sup>5</sup> We observed that, in adults, the revision process spanned several segments in French, but not in Italian. This is likely due to the fact that there are differences in the verbal system between Italian and French. For example, agreement is always audible in Italian, but not in French.

that children and adults are more likely to abandon a preferred analysis (subject RC analysis) when they encounter positive evidence as to what they have to do, i.e., the information that leads to abandon the preferred analysis also indicates how to revise it, rather than when they encounter a negative piece of information that only indicates that the preferred analysis is wrong. The difference between adults and children can be traced back to the ability to inhibit a preferred response. Children are known to have weak inhibitory skills. However, when they are able to abandon a preferred analysis, for them, as for adults, it is less difficult if they can rely on information that indicates what to do.

**Author Contributions:** M.T.G. conceived and designed the experiments with the help of J.F.; students performed the experiments; M.V. and M.T.G. analyzed the data; M.T.G. author wrote the paper with the help of J.F.

**Funding:** This research received no external funding.

**Acknowledgments:** We would like to thank the child and adult participants in the study. We would also like to thank the students who collected the data.

**Conflicts of Interest:** The authors declare no conflict of interest.

**Appendix A. Summary of the Fixed Effects of the Mixed Logit Models in Segments 2, 3 and 6 of Experiment 2 (French)**

**Table A1.** Summary of the analyses.

Predictor	Coefficient	SE	df	t Value	p
Segment 2 (that (NP) V (NP))					
Log-likelihood = -4939.8 (N = 1114)					
Intercept	57.35	8.1	80.3	8.25	<0.01
Sentence (ref. cat. = subject RC)					
OSV	3.50	1.38	1046.3	2.54	<0.01
OVS	8.05	1.39	1060.8	5.76	<0.001
Sentence (ref. cat. = OSV)					
OVS	4.52	1.38	1058	3.26	<0.001
Subjects and items had SD of 15.14 and 6.34 respectively.					
Segment 3 PP1					
Log-likelihood = -4802.7 (N = 1105)					
Intercept	71.10	3.72	55.7	19.08	<0.001
Sentence (ref. cat. = subject RC)					
OSV	4.47	1.3	1038.3	3.44	<0.01
OVS	4.76	1.3	1038.7	3.64	<0.001
Sentence (ref. cat. = OSV)					
OVS	0.28	1.3	1038	0.22	0.82
Subjects and items had SD of 10.16 and 4.03 respectively.					
Segment 6 PP3					
Log-likelihood = -3333.8 (N = 819)					
Intercept	53.91	4.55	48.7	11.83	<0.001
Sentence (ref. cat. = subject RC)					
OSV	2.5	1.12	771.2	2.25	<0.05
OVS	3.06	1.13	763.9	2.71	<0.01
Sentence (ref. cat. = OSV)					
OVS	0.51	1.12	769.7	0.46	0.64
Subjects and items had SD of 9.64 and 5.58 respectively.					

## Appendix B. Summary of the Fixed Effects of the Mixed Logit Models in Segment 2 of Experiment 3 (Italian)

Table A2. Summary of the analyses.

Predictor	Coefficient	SE	Df	t Value	p
Segment 2 (that (NP) V (NP))					
Log-likelihood = −7569.8 (N = 1023)					
Intercept	712.8	203.20	71.4	3.5	<0.001
Sentence (ref. cat. = Subject RC)					
OSV	70.99	28.5	965.4	2.48	<0.001
OVS	169.9	28.32	963.7	5.99	<0.001
Sentence (ref. cat. = OSV)					
OVS	98.92	28.44	963.3	3.47	<0.001
Subjects and items had SD of 234.93 and 91.16 respectively.					

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