Children's comprehension and processing of Dutch relative clauses disambiguated by number and the role of memory resources

Chantal van Dijk

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Supervisors:
Dr. Luisa Meroni
Dr. Sergio Baauw

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Inhoudsopgave

1. Introduction

A well-studied phenomenon within the fields of language acquisition and psycholinguistics is the offline and online comprehension of the relative clause structure. Online studies have indicated that the processing of object-extracted relative clauses (from here on ORCs) as in (2) is more difficult than the processing of subject-extraced relative clauses (from here on SRCs) as in (1) (a.o. King & Just, 1991). For children, a similar picture arises in offline comprehension studies that show relatively unproblematic comprehension of structures as in (1) and low accuracy on ORCs as in (2), which has been attested for many different languages (e.g. De López, Olsen & Chondrogianni, accepted for Danish; Arosio, Yatsushiro, Forgiarini & Guasti, 2012 for German; Guasti, Stavrakaki & Arosio, 2012 for Greek and Italian; Arosio, Adani & Guasti, 2009; Friedmann, Belletti & Rizzi, 2009 for Hebrew; Corrêa, 1994 for Portugese; Özge, Marinis & Zeyrek, 2010b for Turkish).

(1) The cat that bit the dog.
(2) The cat that the dog bit.

In the field of language acquisition little attention has been paid in the past to children's real time behaviour during sentence processing. One of the first studies to look at how children deal with temporal ambiguities during sentence parsing is the well-known "put-the-frog-on-the-napkin" study by Trueswell, Sekerina, Hill & Logrip (1999). Trueswell et al. have suggested that the lack of real-time studies with children are caused by the limited online methods available for young children as the majority of exisiting studies relied on reading abilities which are not or only limitedly present in young children. However, in spite of the development of new technologies suitable for child language research as used by Trueswell at all, little seem to have changed as Clahsen & Felser (2006) mention that "psycholinguistically informed research into language learners' processing mechanisms and strategies is comparatively scarce" (pp. 3-4, 2006). This is supported by the fact that there exist only a limited amount of research so far that use online techniques to study children's moment-by-moment behaviour during relative clause processing (Arosio, Guasti & Stucchi, 2011 for Italian; and Booth, MacWhinney, Harasaki, 2000 for English).

There exist several accounts that explain the greater difficulties (for adults) with ORCs compared to SRCs. In this study three accounts will be discussed with respect to the subject-object asymmetry in relative clause comprehension and processing: the Active Filler Strategy (AFS; Frazier & Flores D'Arcais, 1989) and the Minimal Chain Principle (MCP; De Vincenzi, 1990). The question remains whether children's poor offline comprehension of relative clauses is caused by them parsing these sentences in a qualititavely different way compared to adults. Or whether their poor performance is caused by their limited processing capacities making it more difficult for them to integrate different sources of information during processing and to revise early commitments and whether it is caused by lexical access and retrieval being slower for children (Clahsen & Felser, 2006; and Trueswell et al., 1999).

Hence, psycholinguistic research into relative clause processing has mainly focussed on adults, whereas developmental studies have mainly employed offline methods to study children's comprehension and the acquisition of relative clauses. Although the subject-object asymmetry for children in the comprehension studies seems to be a robust finding, methods used and/or conclusions drawn from them could be questionable for a number of studies. For example, Hamburger & Crain (1982) critized earlier studies for the way, among others, an act-out design was employed to study children's relative clause comprehension. An important point of critism was that the researchers in these studies did not create a felicituous situation for the use of (restrictive) relative clauses. In addition, tasks used by more recent studies into children's comprehension of relative clauses disambiguated by number in Italian do neither seem to create the pragmatic correct context for the use of certain relative clause types (Adani, 2009; Adani, Van der Lely, Forgiarini & Guasti, 2010; and Arosio, Adani & Guasti, 2009).

In the present study, the focus is not so much on the question whether children are able to correctly interpret ORCs, but whether they are sensitive to number as disambiguating cue during real-time

processing and how this is reflected in their offline error patterns. In order to do so 5- and 7-year old Dutch children's offline and online processing of relative clauses of the types in (1) and (2) were tested using an act-out task and a self-paced listening task. Although the act-out task design has some limitations (see for example Hamburger & Crain, 1982; and Adani, 2009) we believe that it can be a helpful instrument in determining children's prefered strategies to deal with relative clauses. In contrast to, for example, a picture- or agent-selection task it offers children the freedom to give any interpretation of the structures they like. Furthermore, in order to avoid problems, such as children skipping the relative clause while acting out, the experimental sentences were made as less complex as possible. In addition, although the self-paced listening task has been criticized for sounding unnaturel as it provides segmented and slower speech than natural speech it can be used to study children's online behaviour during sentence processing (Marinis, 2010). Furthermore, results from Arosio et al. (2011) show that this task type is suitable to use in studying children's online relative clause processing. In addition, as previous studies have indicated that (working) memory capacity might play a role in offline and online sentence processing (Arosio et al., 2011; Arosio, Yatsushiro, Forgiarini & Guasti, 2012; Booth et al., 2000, Clahsen & Felser, 2006; and King & Just, 1991), we also measured children's forward and backward word span.

Our results suggest, first of all, that not only children fail to assign the correct interpretation to ORCs: the majority of the adults failed to correctly interpret this relative clause structure in the act-out task. Furthermore, error patterns were similar for the children and the adults in this task. Word span did not affect children's performance on neither the SRCs or the ORCs. In the self-paced listening task the adults and (some of) the children showed sensitivity to number as disambiguating cue: a difference was found between the SRC and the ORC condition after the disambiguating segment was listened to. Furthermore, both forward and backward word span and age influenced children's performance: the effect disappeared for the 5-year olds and was in analyses for the separate memory groups only present in the low span groups. We therefore like to argue that these results support the view that language acquisition is continuous and children are, like adults, sensitive to number cues in relative clauses, although this is not reflected in their offline comprehension of this structure.

In chapter 2 an overview will be given of three accounts explaining the subject-object asymmetry found in comprehension of relative clauses. In chapter 3 the Dutch relative clause structure – in relation to the three accounts – will be discussed. Chapter 4 will tap into theories explaining why (young) children are poor comprehenders of ORCs compared to adults. Chapter 5 will give an overview of a number of studies that looked at relative clauses disambiguated by number marking on the embedded verb. In chapter 6 Arosio et al.'s (2011) online study is discussed. In chapter 7, 8 and 9 respectively, an overview of the research questions and hypotheses, method and procedure, and the results will be given. Finally, chapter 10 will discuss the results of this study and its consequences on the knowledge of relative clause processing.

2. General theories on the subject/object asymmetry

Although most scholars agree that SRCs are easier to process than ORCs in general (but see Carreiras, Andoni Duñabeitia, Vergara, de la Cruz & Laka (2010) for evidence for an opposite effect in Basque), different explanations have been proposed to account for the asymmetry between these two structures (a.o. Gordon, Hendrick & Johnson, 2001; Mak, Vonk & Schriefers, 2002; Sheldon, 1974; Tavakolian, 1981; and de Villiers, Tager Flusberg, Hakuta & Cohen, 1979). In this chapter, however, only three different theoretical approaches will be discussed: (1) an account based on the Active Filler Strategy (Frazier & Flores D'Arcais, 1989) and the Minimal Chain Principle (De Vincenzi, 1991); (2) The Dependency Locality Theory (Gibson, 1998; 2000); (3) and the Similarity-Based Interference Account (Van Dyke & Lewis, 2003 & Van Dyke, 2007). These accounts will be discussed in light of the English relative clause examples in (1) and (2) repeated below in (3) and (4).

(3) The dog that bit the cat.
(4) The dog that the cat bit.

There are a number of reasons for the choice to discuss only the accounts mentioned above. First of all, they are not specific to relative clause processing: they apply to a wider range of linguistic structures. Second, these theories focused on SRCs and ORCs which contain two lexical animate DPs, which are also the structures of interest in this study – in contrast to, for example, relative clauses featuring one animate and one inanimate DP. A third and final consideration was that these three theories offer different perspectives on the issue: the first account is purely structural; the second focuses on processing resources; and the third ascribes sentence processing difficulties to interference effects.

Before discussing different accounts on processing of relative clauses it is important to consider the temporal ambiguous nature of the relative clause structure. When the structures in example (3) and (4) are being parsed, upon encountering the the relative pronoun "that" it is not clear which interpretation to assign to the structure. From the relative pronoun the parser can predict a relative clause structure. It is unclear at this point, however, whether it should have subject-extracted or an object-extracted structure (5).

(5) The dog that (bit the cat / the cat bit).

It is the constituent following the relative pronoun that disambiguates between a SRC and an ORC: either the verb "bit" in (3) or the second DP "the cat" in (4).

In languages that do not use word order to disambiguate between relative clauses, such as German and Dutch, the ambiguity can persist even longer, and may even not be resolved structurally. For example, Dutch relative clauses can remain ambiguous for a subject or an object reading, even after the whole relative clause is being parsed:

(6) De hond die de kat beet.
the dog-SG that the cat-SG bit-SG
"The dog that bit the cat." / "The dog that the cat bit."

In the example in (6) the first DP "de hond" can either be extracted from the subject position or the object position of the relative clause. As word order does not disambiguate Dutch relative clauses and the number features on the two DPs are similar, the ambiguity cannot be resolved based on (morpho)syntactic cues. In chapter 3 Dutch relative clauses will be discussed into more detail.

A critical task and strategy of the parser is therefore to assign either a subject or an object structure to relative clauses at some point during sentence processing, which occurs, according to accounts discussed

below, in the region of ambiguity (Frazier & Flores D'Arcais, 1989; De Vincenzi, 1991; Gibson, 1998; and Van Dyke & Lewis, 2003) – by predicting a SRC structure.

2.1 A structural perspective on the subject/object asymmetry

The first account introduced is based on the *Active Filler Strategy* (AFS) proposed by Frazier & Flores D'Arcais (1989) and the *Minimal Chain Principle* (MCP) proposed by De Vincenzi, 1991):

> AFS. Assign an identified filler as soon as possible; i.e., rank the option of a gap above the option of a lexcial noun phrase within the domain of an identified filler. (Frazier & Flores D'Arcais, 1989, p. 332)
>
> MCP. Avoid postulating unnecessary chain members at S-structure, but do not delay required chain members. (De Vincenzi, 1991, p. 13)

According to these two proposals listeners postulate a gap – an empty position – in the sentence structure as soon as a moved element has been encountered and the grammatical structure allows it, so that the moved element can be linked to its base position in the structure. This gap is assigned to the next first possible position, such that the moved element should be kept in memory for the least amount of time. Hence, the parser, in order to do so, predicts a structure, which is the most economic in terms of memory demands. For relative clause sentences such as (1) and (2), repeated as (7) and (8), the AFS and the MCP would predict that the parser, when it encounters the relative pronoun, after encountering the extracted DP, would assign a gap to the leftmost position in the relative clause structure, which would be the immediate position after the relative pronoun (9). Hence, the relative pronoun "that" signals a relative clause modifying the head DP "the dog". In addition, when the relative pronoun is parsed it becomes clear that "the dog" has moved out of the relative clause. For this moved element a gap can and has to be established, according to the AFS and the MCP. Furthermore, this gap has to be postulated as soon as possible in the structure to decrease memory demands. The first possibility in the relative clause is the subject position directly following the relative pronoun.

(7) The dog that bit the cat.
(8) The dog that the cat bit.
(9) The dog that ___ bit the cat.
(10) The dog that the cat ___ .

In the case of a SRC such as in (7) the postulation of a gap in the subject position would be correct as "the dog" is indeed the subject of the relative clause and therefore extracted from the subject position. As a result, the new material – the verb of the relative clause and the second DP – can be easily integrated in the predicted structure. In the case of an ORC, such as in (8), this prediction would be problematic, as the subject position following the relative pronoun is already occupied by the subject "the cat", causing a temporal ungrammaticality or incongruity when the parser encounters this second DP. At this point the parser has to discard the structure and assign a new gap position for the extracted DP at the next possible location, which would be the object position in (10).

The revision makes the ORC structure more costly than the SRC structure. Firstly, because the gap position for the relative pronoun is further to the right of the relative clause in the object sentences than in the subject sentences. Hence, the filler has to be kept in memory for a longer period in the ORC structure, increasing the demand on memory capacity. Secondly, the reanalysis necessary for ORCs adds additional costs in terms of economy principles as the predicted structure has to be revised and rebuild while its elements have to be kept active in memory. Hence, predictions made about the structure of relative clauses based on strategies that deal with temporal ambiguous sentences, which favor an SRC interpretation lead to greater processing demands in ORCs compared to SRCs. As a result, the postulation of

a gap at the left-most position in the relative clause structure as predicted by the AFS and the MCP creates a (highly local) garden-path effect for ORCs: the parser predicts a SRC structure at the relative pronoun which has to be revised at the constituent immediately following the relative pronoun.

2.2 A storage-based perspective on the subject/object asymmetry

A different account is proposed by Gibson (1998), according to whom the difference in processing difficulty between sentences like (1) and (2), repeated below as (11) and (12), cannot be attributed to a garden-path effect in ORCs as there should be no reanalysis necessary in this structure. Furthermore, he argues that other theories explaining the asymmetry – which will not be discussed in this paper – can only account for parts of the data found in existing studies. He therefore proposes a more comprehensive theory: the Dependency Locality Theory (DLT; Gibson 1998 & Gibson 2000). He argues that this theory should be preferred over the AFS or the MCP as it not only accounts for the same data these theories account for, but also for other data not related to ambiguity resolution.

The main focus of the DLT is on resource use in sentence comprehension and key-elements are locality and decay. Two components of the DLT draw on the same resource pool: the structural integration component and the storage component. Structural integration cost depends on the integration of two dependencies within a structure. This draws heavily on locality: integration is cost free when it is local and there is little or no intervening material between the two elements. When a constituent and its attachment site are separated by material that is structurally complex or contains new discourse referents – in the form of a verb or a DP – integration is no longer cost free. Furthermore, the more (complex) the intervening material, the more likely it is that the attachment site has already decayed in memory, and – in other words – is no longer available to create attachments with, leading to unsuccessful integration and processing of the structure. The second component of the DLT, the storage cost, is associated with the number of predicted categories necessary to complete a sentence. Gibson assumes that in English this would include at least two categories: subject and verb.

The DLT predicts that the higher the storage cost, the slower the integration process, as both components draw from the same limited pool of resources. The theory also predicts that the intuitive complexity of a sentence depends on the point in the sentence with the maximal amount of integration cost. Gibson measures the complexity of sentences in terms of energy units (EU). The more EU's necessary at one point in the sentence, the more resources are necessary, and the higher the complexity of the sentence.

The way the difference in processing difficulty between SRCs as in (11) and ORCs as in (12) can be explained in terms of integration and storage is as follows:

(11) The dog that bit the cat.
(12) The dog that the cat bit.

Table 1 reports the EUs necessary for the SRC in (11) and table 2 reports the EUs necessary for the ORC in (12). As it is clear from table 1, the maximal amount of EUs necessary during processing of the SRC is 3EU. Whereas for the ORC the maximal amount of EUs is 4EU. This is due to the higher storage cost associated with the second DP “the cat” and the higher integration cost at the embedded verb “bit” in the ORC. The higher storage cost in the ORC can be explained by the higher number of categories that are necessary to construct a grammatical sentence and that have to be predicted at the point when the parser encounters the determiner “the” in the relative clause: in addition to a filler corresponding to the relative pronoun “that”, an embedded verb and a main verb – as predicted as well in the SRC condition at the relative pronoun – a subject noun is predicted. The higher structural integration cost at the embedded verb in the ORC is due to the attachment of the object position to the right of the verb with the relative pronoun “who”: in order to form a dependency it has to cross the embedded verb “bit” and the subject of the relative clause “the cat”, which are both new discourse referents. Hence, structural integration of the embedded verb is not cost free in the ORC, as it is in the SRC.

Table 1

Cost type	Input word						
	The	dog	that	bit	the	cat	(barked)
New discourse referent	0	1	0	1	0	1	(1)
Structural integration	0	0	0	0	0	0	(2)
Storage	2	1	3	2	2	1	(0)
Total	2	2	3	3	2	2	(3)

Prediction of costs in EUs for the SRC "The dog that bit the cat (barked)" at each point during integration.

Table 2

Cost type	Input word						
	The	dog	that	the	cat	bit	(barked)
New discourse referent	0	1	0	0	1	1	(1)
Structural integration	0	0	0	0	0	2	(2)
Storage	2	1	3	4	3	1	(0)
Total	2	2	3	4	4	4	(3)

Prediction of costs in EUs for the ORC "The dog that the cat bit (barked)" at each point during integration.

An advantage of the DLT over the AFS and the MCP is its ability to explain the difference in processing difficulties between center-embedded sentences with a (first- or second-person) pronoun (13) and a proper name (14) and a lexical DP (15).

(13) The student who the professor who **I** collaborated with had advised copied the article.
(14) The student who the professor who **Jen** collaborated with had advised copied the article.
(15) The student who the professor who **the scientist** collaborated with had advised copied the article.

(Gibson, 1998)

Gibson argues that doubly nested sentences containing a first- or second-person pronoun in the most embedded clause are easier to process than sentences containing a proper name, lexical DP or a non referential pronoun – such as "they" - in the most embedded clause. According to Gibson, these findings follow naturally from the DLT as a pronoun does not constitute a new discourse referent, whereas the use of a proper name or lexical noun phrase does. The advantage of a first- or second-person pronoun is, first of all, that it does not add "new discourse referent" costs and, second, it does not lead to additional structural integration costs when it intervenes between two dependencies.

2.3 An interference-based perspective on the subject/object asymmetry

The third and final theoretical account that will be discussed here with regard to the subject/object asymmetry in relative clauses, is by Van Dyke and colleagues. Van Dyke & Lewis (2003) argue that the DLT focuses too much on the storage component of sentence processing. Instead, they claim, it is interference that plays a key role in sentence processing, as this influences chances of successfully retrieving the attachment sites necessary for structural integration. They therefore propose a different model of parsing on which their similarity-based interference account (SBIA; Van Dyke & Lewis, 2003; Van Dyke, 2007) is based.

According to the SBIA the initial interpretation and reanalysis of structures is relatively

unproblematic if two criteria are met: firstly, the relevant items should maintain a sufficient degree of activitation in working memory so that they are available for further operations. Secondly, any material intervening between two dependencies should cause minimal interference: the retrieval cues used by a linguistic element that needs to be integrated into the existing structure should unambiguously identify its dependent. An important feature of this cue-based parsing model is that reanalysis is considered to be working in a parallel fashion: it considers all potential attachment sites. When an intermediate attachment site is an incomplete match with the retrieval cues, though, it is ruled out. However, retrieval can only succeed when the appropriate attachment site has not yet decayed in working memory. Furthermore, when interference is high, and, hence, retrieval cues do not unambiguously identify the correct attachment site, the parser might fail in ending up with the correct interpretation of a structure (as well as in the initial interpretation as in the reanalysis).

Van Dyke and colleagues do not directly discuss their account with respect to the SRC and ORC constructions discussed in this paper. However, it can be used to explain the differences in processing these structures. Let's consider the examples in (1) and (2), repeated below in (16) and (17):

(16) The dog that bit the cat.
(17) The dog that the cat bit.

“The dog” is integrated with “that”. This integration is local - “the dog” is therefore sufficiently activated in memory and there is not intervening material, hence, there are no intervention effects – and is therefore relatively unproblematic. Now two options are available to the parser[1]: the structure being followed by a verb, resulting in a SRC, or followed by a DP, resulting in an ORC . When the parser encounters the next word “bit” an SRC structure will be build, and an empty subject position will be integrated between the relative pronoun and the verb. Again this integration is local and will proceed without any difficulties. Finally the second DP “the cat” is processed an attached to the verb: again a local integration (schematically represented in Table 3). Hence, following Van Dyke's theory, processing of the SRC structure – at least in English – is relatively unproblematic as all integrations are local and no intervention effects occur.

Table 3

(The dog)	that	bit	the cat
(+N, +Sing, +Nom)	+N, +Sing, +Nom	Retrieval cues subject {Nom, sing, N}	+N, +Sing, +Acc
		Retrieval cues object {Acc, sing, N}	

Example of features and retrieval cues on different elements of the SRC “(The dog) that bit the cat”.

This is different for the ORC sentence in (17). The first steps – integrating “the dog that” - are similar to the ones ascribed above. When the parser encounters the second DP “the cat” it builds an ORC structure and integrates “the cat” in the subject position. Difficulties in processing arise when the verb “bit” is encountered. First of all, the embedded verb sends out retrieval cues for a subject (see Table 4). This will be relatively unproblematic as the subject “the cat” is closest to the verb “bit” and will therefore probably have a higher activation than other potential candidates. Furthermore, there is no actual intervening material between the verb and its subject. In order for the integration of the embedded verb to finish it should also link its object position to the relative pronoun. However, “the cat” is intervening between the extracted element “the dog” and the object position. As, according to the SBIA, the parser considers both potential dependents in parallel, they compete for a higher activation value, based on their features' (partial) match with the retrieval cues send out by the probe “bit”. As the features of the first DP “the dog” – or the relative pronoun – are more similar to the retrieval cues than the features of “the cat”, the object position will be linked to “that”. However, this integration is relatively more difficult – as it is not local – and therefore more costly in terms of processing in the ORC structure than in the SRC sentence.

1 This is of course a simplification. For matters of clarity, though, I will assume throughout this paper that at the relative pronoun only two options – or lexical frames – are considered by the parses: SRC or ORC.

Table 4

(The dog)	that	the cat	bit
(+N, +Sing, +Nom[2])	+N, +Sing, +Acc	+N, +Sing, +Nom	Retrieval cues subject {Nom, sing, N}
			Retrieval cues object {Acc, sing, N}

Example of features and retrieval cues on different elements of the ORC "(The dog) that the cat bit".

Notice that the interference-based account shares some similarities with Gibson's DLT: they share locality and decay as key components. The difference is in their explanation of the role these components play in sentence processing. An important aspect of the DLT is the assumption that storage and structural integration draw on the same resource pool: if resources necessary for storage are high, relatively little resources are left for integration and sentence processing is more likely to fail. Van Dyke and colleagues, on the other hand, relate failure or success of sentence processing to the chances of identifying the correct attachment site during integration of new elements. The more similar intervening material is to the actual goal, the less likely the correct attachment site is to be sufficiently activated in order for its dependent to be attached to it.

Summarizing, the first account, based on the temporal ambiguous nature of relative clauses, would ascribes the greater difficulties related to the ORC structure to the greater distance between the filler and its gap, which results into (a short) reanalysis. As for the SRC structure, the gap is already at the leftmost position compared to the relative pronoun, and, hence, no difficulties are predicted here. The second theory, Gibson's DLT, holds the higher amount of resources – both consumed by storage and structural integration – necessary for ORC processing compared to SRC processing, responsible for the problematic nature of the ORC structure. Finally, the SBIA, would explain the subject/object asymmetry in relative clauses to the higher interference effect within ORCs compared to SRCs. Important is, that although these three accounts explain the differences in processing between SRCs and ORCs from a different perspective, they all predict that ORCs are more difficult to comprehend than SRCs.

Although accounts discussed below might agree on the locus of SRC and ORC assignment, they differ in their explanation of what this decision is based on. Predictions following from the *Active Filler Strategy* (Frazier & Flores D'Arcais, 1989) and the *Minimal Chain Principle* (De Vincenzi, 1991) are based on economy principles and purely structure-based, whereas Gibson's Dependency Locality Theory (Gibson, 1998) is concerned with storage costs and the integration of new discourse material. Van Dyke & Lewis, on the other hand, focus in their cue-based interference account on the ability of new constituents to unambiguously identify their attachment sites, based on retrieval cues/interference and decay.

One consequence of the first strategy, which is assigning an (subject) interpretation to the relative clause at the ambiguous region, is that it might fail when the disambiguating region is encountered. At this point reanalysis of the structure is necessary. This process might further explain ORC difficulties as reanalysis might not always lead to the correct interpretation. This will be further explained below on the basis of Fodor & Inoue's account on positive and negative symptoms in reanalysis (2000) and Van Dyke & Lewis's cue-based interference account (Van Dyke & Lewis, 2003; Van Dyke, 2007).

2 The extracted DP "the dog" has a nominative feature here, because in a main clause it would serve as the subject. Following the SBIA this might add additional difficulties to the processing of an ORC structure as the relative pronoun is linked to the head DP. Van Dyke and colleagues might also indirectly explain why sentences with elements in similar functions in the main and the relative clauses are better understood than elements in different functions as found by Sheldon (1974).

3. Dutch relative clauses

In the previous chapter, the temporal ambiguous nature of relative clauses was emphasized. The first account we discussed claimed that the subject-object asymmetry in relative clauses is due to ambiguity. However, as also mentioned by Gibson (1998), it might be arguable whether the English examples in (1) and (2) truly cause a garden-path effect: the temporal ambiguity on the relative pronoun is very local, as it is immediately resolved by the word following the relative pronoun. As a result, it is questionable whether English language users are truly garden-pathed when they encounter an ORC structure as the ambiguity is already resolved early on in the relative clause. The fact that the ambiguity at the relative pronoun in English sentences is so quickly resolved results from the difference in word order between SRCs and ORCs. In many other languages, relative clause types are not (always) distinguished by word order. This would be, for example, the case for Dutch, German, Greek and Italian. Although the later three languages can make use of different (morpho)syntactic cues to disambiguate relative clauses, Dutch can only use number marking on the embedded verb.

In this chapter, we will discuss the case of Dutch relative clauses. First, the ambiguity of Dutch relative clauses will be illustrated, then, the Dutch versions of the English relative clauses in (1) and (2) will be given and compared. Finally, the three accounts discussed in the previous chapter will be applied to the Dutch case.

Dutch relative clauses have a different structure than English relative clauses when it comes to the base position of the extracted subject or object element. In Dutch, both the subject and the object are generated in a preverbal position as the canonical word order is SOV. When the subject and object of a relative clause are both lexical noun phrases and similar in number, the structure is ambiguous between a subject and an object interpretation. Let us consider the sentence in (18):

(18) De hond die de kat beet.
the dog-SG that the cat-SG bit-SG
“The dog that bit the cat.” / “The dog that the cat bit.”

As both the subject and the object are in preverbal position, the word order in (18) does not distinguish between a SRC or an ORC. If the first DP “de hond” has originally moved from the specifier position of the TP of the embedded clause as in (19), the RC in (18) is subject-extracted. However, if “de hond” has moved from the complementizer position to the right of the second DP “de kat” as in (20), the relative clause in (18) should be interpreted as an ORC.

(19) De hond die ___ de kat beet.
the dog-SG that the cat-SG bit-SG
“The dog that bit the cat.”

(20) De hond die de kat ___ beet.
the dog-SG that the cat-SG bit-SG
“The dog that the cat bit.”

The only way to structurally disambiguate these type of relative clauses is by using two DPs which are different in number – singular versus plural. This makes it possible for the number features on the embedded verb to identify the correct subject. In (21) and (22) below this distinction is made between the DP “de hond”, which is singular, and the DP “de katten”, which is plural.

(21) De hond die de katten beet.
the dog-SG that the cats-PL bit-SG

"The dog that bit the cats."

(22) De hond die de katten beten.
the dog-SG that the cats-PL bit-PL
"The dog that the cats bit."

In (21) the extracted element "de hond" agrees in number (singular) with the relative clause verb "beet" - and of course the relative pronoun shares these features. Therefore, only the DP "de hond" can be the subject of the relative clause and the plural DP "de katten" is then assigned the role of object, resulting in a SRC. In (22) the extracted element "de hond" does not agree in number with the relative clause verb "beten", which carries a plural marking. The second DP "de katten" carries a plural feature and agrees with the verb, resulting into an ORC: the second DP is the subject of the relative clause and the relative pronoun – hence, the extracted element – is the object.

The examples in (21) and (22) clearly illustrate how the temporal ambiguous nature of relative clauses can be disambiguated by number in Dutch: it is only at the embedded verb that the correct subject and object of the relative clause can be identified. As the embedded verb always follows the two DPs in the relative clause, due to properties of Dutch, the disambiguating cue comes relatively late – especially when additional material intervenes between the subject/object and the verb. As a result, Dutch relative clauses are ambiguous for a subject or an object interpretation when the relative pronoun and the second DP are parsed. The question remains how the parser deals with these type of clauses. Let us consider now how the accounts previously introduced will explain the Dutch relative clauses.

According to the AFS and the MCP the parser predicts a gap when it encounters the relative pronoun "die" in both sentences the sentences in (21) and (22) repeated below in (23) and (24).

(23) De hond die de katten beet.
the dog-SG that the cats-PL bit-SG
"The dog that bit the cats."

(24) De hond die de katten beten.
the dog-SG that the cats-PL bit-PL
"The dog that the cats bit."

As both strategies claim that the parser will predict the gap at the leftmost position in the structure, it will be directly after the relative pronoun, which is the subject position of the relative clause:

(25) De hond die ___ de katten beet/ beten.
The dog-SG that the cats-PL bit-SG bit-PL

Hence, these strategies predict a SRC structure during the initial parsing of Dutch relative clauses. As we have seen earlier in the case of the ORC structure in English, this would immediately lead to an incongruity or ungrammaticality when the next (DP) segment in the ORC is parsed. However, in Dutch the order of words is similar for both types of relative clauses and the word following the relative pronoun in Dutch does not give the parser any indication whether the gap is postulated in the correct position. Hence, in the ORC sentence in (24), the subject reading does not cause any incongruity at the second DP "de katten". When the embedded verb is parsed, the prediction of the gap being in the subject position is checked by agreement between the verb and the relative pronoun which shares the features of the extracted DP. In (23) the verb and the first DP "de hond" – or the relative pronoun "die" – both carry singular features. Hence the number feature on the verb can be checked and an agreement relation between the subject and the verb can be established. This results in a grammatical SRC interpretation.

In (24), on the other hand, the parser's prediction would result in an agreement violation: the verb and the first DP "de hond" carry different number features – the first DP carries a singular number feature whereas the verb is plural –, rendering a SRC structure ungrammatical. According to this account, a process

of reanalysis is necessary and the extracted element is linked to the next possible gap, which is located in the object position (26). As a verb does not have to agree in number with its object, the relative pronoun can be linked to the object position of the relative clause. However, this leaves the embedded verb without a subject. The only other candidate is the second DP “de katten”, which can be integrated into the subject position. Again the subject and the verb are checked for agreement and this time both elements agree in number features, leading to a grammatical sentences with the first DP “de hond” being extracted from the object-position.

(26) De hond die de katten ___ beten.
the dog-SG that the cats-PL bit-PL
“The dog that the cats bit.”

Similarly to the English scenario, it could be concluded that the reanalysis resulting from the incorrect postulation of a gap in subject position for Dutch ORCs as predicted by the AFS and the MCP that make the ORC structure more demanding than the SRC structure. First of all, because in the ORC structure the gap has to be postulated at a position which is further to the right into the structure than the gap in the SRC, resulting in increased memory demands. Second, the reanalysis process in itself increase processing demands as the initial structure has to be (partially) detached and rebuild.

Following Gibson's DLT, the ORC in (28) would be a more problematic and demanding structure compared to the SRC in (27) as well. Table 3 gives an overview of the costs associated with processing the SRC in (27).

(27) De hond die de katten beet.
the dog-SG that the cats-PL bit-SG
“The dog that bit the cats.”

(28) De hond die de katten beten.
the dog-SG that the cats-PL bit-PL
“The dog that the cats bit.”

In (27), three new discourse referents are introduced: the two DPs “de hond” and “de katten”; and the verb “beet”, which are therefore all assigned 1EU. As most of the attachments are local, only one time during structural integration a new referent intervenes between two dependents: the second DP “de katten” intervenes between the verb and its subject position, which costs again 1EU at the verb position. Finally, the storage costs are counted. At the first determiner “de”, two elements are minimally required to finish the sentence[3]: a noun and a verb. This results in a storage cost of 2EU. At “hond”, only a verb is necessary to form a grammatical sentence. The relative pronoun “die” introduces an increase in storage costs: not only a main verb is required, but also a minimum of an empty subject position and an embedded verb to form a relative clause. The second determiner “de” introduces an object which requires an additional noun. The second noun “katten” fulfills the requirement of a noun to finish the second DP. Then the embedded verb “beet” finishes the relative clause. The only necessary component left is a main verb, which is “blafte”, setting the storage cost to zero. The maximal total cost associated with the SRC in (27), which calculation is based on the DLT, is 3EU, which is found at different positions in the relative clause: at the relative pronoun, the embedded DP and the embedded verb (see Table 5).

Table 5

Cost type	Input word							
	De	hond	die	(___ subj)	de	katten	beet	(blafte)

3 For Dutch, like Gibson for English, I assume that the minimal requirement to form a grammatical sentence is the presence of a subject and a tensed verb.

New discourse referent	–	1	–	(–)	–	1	1	(1)
Structural integration	–	–	–	(–)	–	–	1	(2)
Storage	2	1	3	(2)	3	2	1	(-)
Total	2	2	3	(2)	3	3	3	(3)

Prediction of costs in EUs for the SRC "De hond die de katten beet (blafte) / The dog that bit the cats (barked)" at each point during integration.

This table is slightly more complicated for the ORC in (28) compared to the SRC in (27). Costs associated with new discourse referents and structural integration are similar to the SRC in (27). However, the maximal storage cost differs for the ORC under the DLT. Table 6 illustrates the cost associated with sentence (28). Up until the relative pronoun, storage costs are similar for sentence (27) and (28). However, whereas in sentence (27) the presence of an empty subject position decreased the number of obligatory elements to finish the sentence – an embedded an a main verb – the presence of the second determiner "de" in (28) increases the processing cost: it introduces an additional element necessary to form a grammatical sentence. Hence, at this point in the sentence a main verb is necessary to finish the main clause, and an embedded verb, empty subject position and a noun to build a grammatical relative clause. "Katten" fulfills the requirement of a second noun to form an object DP. The embedded verb finishes the relative clause. The final requirement is satisfied by the main verb "blafte".

Table 6

Cost type	Input word							
	De	hond	die	de	katten	(___obj)	beet	(blafte)
New discourse referent	–	1	–	–	1	(–)	1	(1)
Structural integration	–	–	–	–	–	(–)	1	(2)
Storage	2	2	3	4	3	(2)	1	0
Total	2	3	3	4	4	(2)	3	(3)

Prediction of costs in EUs for the ORC "De hond die de katten beet (blafte) / The dog that the cats bit (barked)" at each point during integration.

Following the DLT, the difference between a Dutch SRC and ORC lies in their different requirements of storage cost: the maximal amount of storage cost at one point during processing is 3EU for the SRC structure, against 4EU for the ORC structure. Due to the higher maximal storage cost, the ORC has a higher maximal total cost than the SRC.

This is only half of the explanation that the DLT could offer for processing difficulties of Dutch ORCs. As mentioned earlier the Dutch relative clauses in (21) and (22), repeated below, are clearly ambiguous until the embedded verb is encountered. The DLT deals with ambiguity by initially choosing the structure that requires the fewest resources. Hence, it will favor the SRC interpretation when encountering the second DP. When the embedded verb is parsed, integration should fail due to a mismatch in number between the presupposed subject and the verb. As a result, the ORC in (22) needs to be reanalyzed, whereas the SRC in (1) can be processed without additional resources spent.

The explanation the interference-based account might offer for difficulties with Dutch ORCs is less straightforward. Gibson directly discussed his DLT in relation to Dutch relative clauses (Gibson, 1998; and 2000) as did Frazier (1987a) for the AFS. On the other hand, neither Van Dyke and Lewis (2003), nor Van Dyke (2007) directly address the subject-object asymmetry in relative clauses in relation to their account. Furthermore, an explanation based on interference alone seems to be a poor predictor of ORC difficulties. Let us consider examples (29) and (30):

(29) De hond die de katten beet.

the dog that the cats bit-SG
"The dog that bit the cats."

(30) De hond die de katten beten.
the dog that the cats bit-PL
"The dog that the cats bit."

If interference effects would make ORC processing more costly in (30) compared to (29), this should be attributed to the moment the embedded verb is integrated. At this point a referent is necessary to assign the subject and the object position to of "beet/beten". In the SRC sentence, the subject position and the relative pronoun are separated from the verb by the object "de katten". As both "de hond" and "de katten" share similar features – Noun; 3rd person; potentially nominative case – they might compete for being assigned the thematic agent role. It is likely, though, that "de hond" - or the relative pronoun – reaches a higher activation as it shares the number feature, which is singular, with the verb. Then, the object position of the verb has to be integrated. This is a local attachment as the verb and its object "de katten" are adjacent. Hence, no interference effect is expected here.

In the ORC condition it might be arguable whether the attachment of the embedded verb with its subject "de katten" is considered local – or at least local enough to avoid interference effects. "De katten" and "beten" are adjacent, without an intervening DP. However, the empty object position is in between both dependencies. It is possible that this intervenes and competes for attachment with the actual subject. As the subject shares its number feature with the embedded verb, this is solved in favor of "de katten". Finally, the verb has to create a dependency with its object, which is the first DP "the dog" or the relative pronoun. Now, the second DP "de katten" intervenes between the verb and its empty object position and the relative pronoun. However, this DP is already assigned nominative case, whereas the retrieval cues send out by the verb for its object have to be matched for accusative case. Therefore, the correct attachment with the relative pronoun should receive higher activation.

In summary, Van Dyke and colleagues might predict higher processing difficulties in terms of intervention effects in Dutch ORCs compared to SRCs: for the SRC in (29) intervention effects are predicted only once, when the verb has to be attached to its object. For the ORC in (30) intervention effects are predicted for both the subject and the object attachment to the verb. However, it is not entirely clear whether this is actually the case, as it could be argued whether the empty object position actually creates an interference effect in the ORC sentence. Furthermore, Van Dyke and Lewis (2003) have argued that intervening elements that do not exactly match the retrieval cues of the element to be integrated are not considered by the parser as attachment site. If this is true, neither in the SRC, nor in the ORC sentence, intervention effects would be predicted as the two DPs never share the same number or case feature with the retrieval cues of the embedded verb at the same time.

The difference between Dutch SRCs and ORCs are therefore likely to stem from the way the SBIA deals with ambiguities. According to Van Dyke and Lewis, initial sentence parsing is serial. When the parser encounters an ambiguous structure it chooses the most frequent lexical frame in that language. Hence, when the relative pronoun is parsed in sentences like (29) and (30) the parser has to decide whether to analyze the structure as a SRC or an ORC and whether it has to assign the second DP nominative or accusative case. Mak, Vonk & Schriefers conducted a Dutch corpus study and looked, among other things, at the appearance of sentences containing a relative clause with an animate DP modifying an animate head DP. They found that out of the 794 relative clauses found, only 21 matched these criteria. Furthermore, all relative clauses with two animate DPs were SRC structures. Hence, their corpus study suggests that the SRC frame is more common in (written) Dutch than the ORC frame. The SBIA would therefore predict that the parser would assign accusative case to the embedded DP and initially analyze relative clauses as SRCs structures. It would be only at the verb that an incongruity would arise for the ORC in (30) as the relative pronoun does not match in number with the embedded verb. At this point, as predicted as well by the other two accounts, reanalysis is necessary. Parsing the SRC structure in (29), would be, according to this theory, unproblematic.

Although all three accounts use a different perspective to explain the subject-object asymmetry in

Dutch relative clauses, they would, according to the above, predict the necessity of reanalysis in ORCs as a result of a garden-path effect. According to the AFS and the MCP this is due to the incorrect prediction of a gap in the subject position after encountering the relative pronoun. The DLT would predict fewer resource costs for Dutch SRCs and would therefore assign a SRC interpretation to ORCs of the type in (30), what unavoidably leads to reanalysis of the structure. Van Dyke and colleagues are likely to predict that Dutch ORCs are initially parsed as SRCs, due to frequency effects of relative clauses with two lexical DPs. A second similarity between the three accounts for Dutch relative clauses is that they would all predict processing difficulties for the ORC structure to arise at the embedded verb. Hence, the locus of higher processing costs is predicted by all three theories on the embedded verb, as it is here that the initial interpretation fails and the ORC has to be reanalyzed.

4. Child-specific accounts ORC difficulties

Many studies have looked at children's comprehension of relative clauses. The general outcome of these studies is that children struggle with ORCs until relatively late in acquisition. The three accounts discussed in the above can explain the general asymmetry between SRCs and ORCs. They do not directly address, however, children's difficulties in comprehending ORCs compared to adults'. In this chapter, theories underlying differences between adult and child comprehension of relative clause sentences and differences and similarities in their strategies to deal with these type of structures will be discussed. Firstly, a brief discussion will be given of theoretical perspectives on child relative clause processing that are based on a difference in children's and adults' competence grammar. Second, the role of differences in general processing capacity between children and adults will be emphasized as an explanation for children's difficutlies with ORCs. Finally, an acquisition specific theory by Friedmann et al. (2009), in which children's poor comprehension of ORCs is ascribed to them being bound by a stricter version of a linguistic strategy used by adults, will be discussed.

4.1 Grammaticality-oriented (specific to the child's grammar)

It is tempting to account for child and adult differences on ORC comprehension by blaming children's limited grammatical knowledge: children's grammar not yet being adult-like. As a result children fail to correctly parse relative clauses as they might lack the grammatical competence – the operation of relativization – in doing so. Instead they might use other strategies than adults use to deal with these type of sentences. This might work for SRCs, for example because in many languages they display the canonical word order, but fail for ORCs. Hence, these type of explanations would predict a qualitative difference between adult and child language processing.

The suggestion of a child-specific strategy to deal with relative clauses is not new. In 1974, Sheldon proposed her Parallel Function Hypothesis, which claims that co-referential DPs that have the same grammatical function in different clauses – respectively a subject or object role in the main clause and a subject or object role in the relative clause – are easier to process than co-referential DPs that have different grammatical functions in different clauses. De Villiers, Tager Flusberg, Hakuta and Cohen (1979) found evidence that suggested that (1) children interpret N-V-N sequences as subject-verb-object and (2) they tend to interpret the DP immediately preceding the relative verb to be the subject of it. Another account explaining children's comprehension of relative clauses is the Conjoined-Clause Analysis proposed by Tavakolian (1981). According to this account, children treat sentences containing a relative clause as a conjoined sentence structure.

These older theories and the studies they are based on have not been free of critique (e.g. Corrêa, 1995; Goodluck & Tavakolian, 1982; and Hamburger & Crain, 1982). One important point of criticism by Goodluck and Tavakolian is that the studies here mentioned focused too much on finding children's strategies that could explain their poor comprehension of ORCs and therefore failed to uncover children's linguistic competence. As a result, their hypotheses could be argued to be too structure-specific, which is in this case specific to relative clauses. Furthermore, the comprehension studies on which the theories are based on are often claimed to use infelicitous scenarios for the use of a relative clause, resulting in an underestimation of children's relative clause comprehension. In the studies by Sheldon, De Villiers et al. and Tavakolian an act-out design was used with for each animal type only one referent present. As pointed out by Hamburger & Crain (1982) this would make the use of a restrictive relative clause pragmatically odd as there was no need to restrict the number of animals. Hence, it is unclear from results based on these and other experiments that did not create a felicitous scenario for the use of relative clauses whether children's poor performance on ORCs should be ascribed to a lack of competence in relative clause comprehension or to the infelicitous context itself.

Another problem with purely basing children's difficulties with ORCs compared to SRCs on a lack of grammatical competence, is that adults' (online) issues with this structure are ignored. As discussed in

chapter 1, adults have greater difficulties in processing ORCs compared to SRCs, even though their linguistic competence should allow them to correctly interpret these type of sentences. It would be superficial to simply assume that children are unable to interpret ORCs due to their limited grammatical knowledge, whereas a different mechanism has to account for adults' difficulties with ORCs, even though they possess fully developed adult linguistic competence. Hence, it would be more parsimonious to provide an explanation that can account for both adult and child processing of relative clauses.

4.2 Processing-oriented

An obvious explanation for children's relative difficulty in comprehending ORCs compared to adults, is their limited processing capacity. As explained in chapter 1, the ORC is rather demanding in terms of processing resources such as WM. As children have limited resources they have at their disposal during sentence processing, they might simply fail in getting at the correct interpretation of the ORC structure when processing demands are too high. This is further illustrated in this section by discussing the three accounts introduced in chapter 1.

The AFS and the MCP, Gibson's DLT and Van Dyke and colleagues' interference-based account apply to sentence processing by adults. This does not mean, though, that they are useless when it comes to addressing children's poor comprehension of ORCs compared to adults'. One way to do this would be to extend the accounts by focusing on children's lower processing capacities. This is, for example, already suggested by Gibson (1998) for his DLT. Importantly, it could be argued that under all three accounts the Dutch ORC structure is more costly than the SRC structure as additional (memory) resources have to be spent during reanalysis at the embedded verb. As reanalysis is unnecessary for the SRC, no additional costs are made here.

In the case of the AFS and MCP and the DLT account an additional reanalysis mechanism is necessary to reanalyze the structure, detach dependencies and create new attachments. This implies that, whereas in the SRC structure the relative clause structure is finished in terms of attachments and interpretations at the embedded verb, in the ORC structure resources have to be spend, at this point, to keep the relative clause active in memory in order to reanalyze the attachments being made. The initial subject-verb dependency – between the embedded verb and the incorrect attached subject – has to be detached and thematic roles given to the gap position and the embedded DP have to be reconsidered. Finally, new dependencies have to be created. Hence, memory costs are higher for the ORC than the SRC structure[4].

Processing capacity, among which memory capacity, is still developing in (young) children. As a result, they should have fewer resources to spend on sentence processing than adults. If, as argued in the above, it is indeed the case that reanalysis as a result of a garden-path effect in the ORC structure caused by strategies as the AFS and the MCP or the DLT causes additional memory costs, children might fail in correctly reanalyzing the ORC structure. Hence, children might lack the memory resources necessary for keeping the initial relative clause structure in mind, while reanalyzing it, detaching incorrect dependencies and creating new attachments. This is supported by other studies in child language processing, such as, for example, the well-known “put the frog on the napkin” study by Trueswell, Sekerina, Hill & Logrip (1999). Their findings suggest, according to them, that children showed little or no ability to reanalyze the structure they initially committed to (although see Meroni & Crain (2003) for criticism on this study).

The SBIA differs in some respects from the AFS and the MCP and the DLT. First of all, it is not a storage-based account – neither are the AFS and the MCP, however, a separate reanalysis mechanism in addition to these strategies is discussed in the above – and ascribes processing difficulties to interference effects. Second, the SBIA is a reanalysis mechanism on its own, besides its function as a (initial) sentence processing account. One of the consequences is that the failure to attach the subject position of the verb to the relative pronoun in the ORC structure – which would result in an ungrammatical sentence – follows automatically from the SBIA: the first DP or relative pronoun cannot reach the activation threshold in order

4 Other processing resources than memory could also add to the additional processing costs of ORCs compared to SRCs. As this is not the focus of this paper, this will be left out for the sake of simplicity.

to be attached to the subject position as its features are not sufficiently similar to the retrieval cues of the embedded verb. Furthermore, the intervening embedded DP, which is the actual subject of the relative clause – competes for activation with the the extracted DP or the relative pronoun. Now, earlier assigned thematic roles have to be reconsidered and the embedded DP can be attached to the relative clause verb as it matches the retrieval cues. Again, this follows naturally from the SBIA.

Even though the SBIA does not directly focus on memory resources to explain difficulties in ORC processing it does contain an important storage component, which is decay. If an element that is necessary for creating a dependency has decayed in memory it can no longer be activated sufficiently to create an attachment with. Furthermore, although not mentioned by Van Dyke and Lewis (2003) or Van Dyke (2007), it could also be argued that cues on attachment sites decay, making it either more difficulty or easier to create dependencies. For example, if the number cue on the first DP or the relative pronoun, in an ORC has decayed from memory the parser might fail to notice the mismatch in number with the embedded verb. Or, if the first or second DP has decayed entirely, problems may arise during reanalysis as they can no longer be sufficiently reactivated in order to create the correct dependencies.

In the last scenario, the picture for children is similar to the one described for the AFS, the MCP and the DLT: as they only have a limited amount of (memory) resources available, they might fail in reanalyzing ORCs due to decay of the elements necessary for establishing the correct dependencies. If the other scenario is possible, children are more likely to lose certain cues which are stored together with their linguistic element, as, again, they have a more limited memory capacity than adults. As a result, they might more easily accept an incorrect SRC interpretation of the ORC in (9), as chances are that the number cue (and perhaps other cues as well) has decayed and no longer blocks a sufficient activation of the incorrect attachment site. The role of children's limited cognitive capacities, such as working memory, in the processing of ambiguous sentences and syntactic dependencies is also highlighted in Felser's and Clahsen's keynote article on grammatical processing in language learners (2006). They argue that children's parsing mechanism does not seem to be qualitatively different from adults' and that differences in sentence processing between children and adults are caused by other factors, such as children's limited working memory capacity and less efficient lexical retrieval.

4.3 Friedmann et al.'s intervention-based account

Another explanation for the subject-object asymmetry in relative clauses found for children is given by Friedmann, Belletti and Rizzi (2009). They offer an acquisition-specific account for children's difficulties with ORCs. Importantly, the explanation they provide differs in some respects from a processing-oriented perspective discussed in the above. According to them, children are in some sense more restricted than adults when encountering an ORC containing two lexical DPs. As a result, the object interpretation of a relative clause structure is blocked for children, whereas it is only more demanding in terms of processing for adults.

Friedmann et al. (2009) studied children's comprehension of a range of different types of relative clauses in Hebrew. Relative clauses in Hebrew are similar in word order to English relative clauses, such as (1) and (2), repeated here in (31) and (32). They found that children performed relatively poor on ORCs containing two similar, lexical, DPs compared to, for example relative clauses containing a lexical extracted DP and an embedded pronoun. They, therefore, suggest that children have difficulties understanding relative clauses in which there is an intervener between the base-position of a moved element and the moved element itself, when the intervener and the moved element both carry a lexical restriction. Hence for the English examples in (31) and (32) this would mean that processing the SRC is unproblematic for children as there is no intervening lexical element between the subject-extracted DP and its base position. The ORC would be problematic, on the other hand, as the embedded lexical DP intervenes between the object-extracted DP and its base position.

(31) The dog that <the dog> bit the cat.
(32) The dog that the cat bit <the dog> .

In order to account for their findings Friedmann et al. elaborate on Rizzi's principle of Relativized Minimiality (RM: 1990). A RM effect is argued to appear when a structure has a structural configuration of the shape like (33):

(33) X … Z … Y

"RM states that Y and X cannot be bound in a local relation when Z intervenes, and when Z is a potential candidate for the the local relation" (Friedmann et al., 2009, p.68). RM, for example, can account for the ungrammaticality of (34):

(34) *How do you wonder who behaved ___?

According to Friedmann et al., their finding of an interference effect of the embedded lexical DP in ORC sentences, blocking an object interpretation for children, and the similarity of this structure to (33) is no coincidence. They claim that it is the RM principle that is at work in child and adult processing of ORCs and that this same principle influences their (in)ability to process and comprehend this structure. Friedmann et al. schematically represent (Hebrew) ORCs as follows:

(35) D NP [+R, +NP] …..... D NP …..... <D NP>

According to them, the head of the relative clause is attracted by the complex attractor [+R, +NP], which results in the object-extraction in ORCs. The +NP indicates the lexical restriction. The base position of the extracted element is represented by <D NP>. Finally the middle D NP represents the intervening DP. Notice that this schematic representation of the ORC structure has the same configuration as in (32). So, compared to (32), the first D NP represents the extracted element "the dog", the second D NP the embedded DP "the cat", and the third D NP the base position of "the dog". This shows that the lexical restricted element "the dog", while moving from its base position to its target position, crosses over another lexical restricted position: "the cat".

Friedmann et al. argue that it is exactly this operation that is blocked for children by RM, whereas it is not for adults. This is the result of a stricter version of RM that children are bound to. For adults it is sufficient that Z and Y are distinct in their featural representation: a RM effect only appears when the intervenor fully matches the featural representation of the attractor. As this is not the case for "the dog" and "the cat" in (32) – for example because they carry different case information – movement of "the dog" from its object position to its target position while crossing the intervening DP "the cat" is grammatical. Children's stricter version of RM, on the other hand, demands, according to the authors, a disjoint specification of the features of the intervener and the attractor: the features on the attractor should not be similar to features on the intervener. As the intervener "the cat" and the moved element "the dog" share the feature of lexical restriction, moving "the dog" from its base position over the embedded DP "the cat" to its target position would be blocked for children by the stricter version of RM.

The explanation based on a stricter version of RM used by children can also be used to predict a greater difficulty for children in comprehending Dutch ORCs. In (36) and (37) the examples given of a Dutch SRC and ORC sentence in chapter 2 are repeated:

(36) De hond die ___ de katten beet.
the dog-SG that the cats-PL bit-SG
"The dog that bit the cats."

(37) De hond die de katten ___ beten.
the dog-SG that the cats-PL bit-PL
"The dog that the cats bit."

In the SRC in (36) the extracted element “de hond” has been moved from its base position without crossing over the embedded DP “de katten”. Hence, no blocking effect would be predicted in a SRC structure as there is no intervener between the moved element and its base position with a lexical restriction. In the ORC, the extracted DP “de hond” has been moved from the object position, crossing over the embedded DP “de katten” in the subject position. Therefore, “de katten” serves as an intervenor as it is in between the moved element and its base-position. As the embedded DP is lexically restricted, which the moved element “de hond” is as well, the features of the attractor – which carries a +NP feature – and the intervener are not disjoint, only distinct, and the movement operation is blocked for children by the stricter version of RM that requires disjointness.

Although Friedmann et al. argue in favor of different strategies used by children and adults when parsing relative clauses, they does not directly suggest a qualitative difference in language competence for children: children are restricted by the same mechanism, namely RM, as adults are. The only difference is, that RM is more restrictive for children than for adults. This difference does not have to be ascribed to a difference in grammatical competence, though, as the authors suggest that children's use of a disjointness requirement might be related to their working memory capacity: determining whether the target and the intervener are distinct is harder and therefore more costly than to determine whether they are disjoint. Furthermore, larger memory demands for adults in order to check for distinctness, is reflected, according to them, in the online asymmetry they display between SRCs and ORCs. This suggests that children adhere to a stricter version of RM due to limitations in their memory resources. When their memory capacity is sufficient, they switch to the adult version of RM which is based on distinctness rather then disjointness.

Probably the most important difference between a processing-oriented account and Friedmann et al.'s explanation for children's difficulties in ORC comprehension is that the latter introduces a mechanism or strategy that entirely blocks the correct object interpretation: children either adhere to the strict version of RM or to the adult version. The problem is created by the embedded lexical DP in ORCs that intervenes between the extracted lexical DP out of the relative clause and its base position. Under a processing-based theory it should be the lack of processing resources that make children poor comprehenders of ORCs. Still, these differences do not make the accounts discussed entirely incompatible: insufficient resources for reanalysis, as discussed in the first part of this chapter, might result in children using a non-adultlike strategy, such as adhering to a stricter version of RM, to process ORCs, resulting in a failure to comprehend this type of sentences.

5. Number agreement as disambiguating cue

As explained in chapter 2, Dutch relative clauses can only be disambiguated by number cues on the embedded verb – given that both DPs are animate and lexical. Children's (offline) comprehension of relative clauses with number as disambiguating cue has been fairly recently studied in a number of different languages: German (Arosio et al., 2012); Greek (Guasti et al., 2012); and Italian (Adani, 2011; Adani et al., 2010; Arosio et al., 2009; Arosio et al., 2011; and Guasti et al., 2012). These studies have shown that number cues are often not sufficient for children to correctly interpret ORCs. In addition, these – and other – studies have shown that structural and morphological cues contribute in a different way to disambiguating relative clauses. In the first part of this chapter studies looking at number and other structural and morphological information – if considered –, namely word order, case and gender marking, as disambiguating cue will be discussed to illustrate this. In the second part of this chapter, some theoretical perspectives will be given on children's relative poor comprehension on relative clauses disambiguated by number marking compared to case marking and word order; and the even weaker gender marking as disambiguating cue.

5.1 Structural and morphological disambiguating cues in children's relative clause comprehension

Adani (2009) studied children's comprehension of Italian right-branching relative clauses disambiguated by word order and number marking on the verb. According to Adani, as Italian has relatively flexible word order, ORCs can either be preverbal or postverbal. The first are distinguished from the SRC structure by its difference in word order; the latter is similar to the Dutch scenario in that it can only be distinguished by number marking on the embedded verb[5]. Below, examples are given of the sentences Adani used in his study. (38) is a SRC, (39) is an ORC with a preverbal subject, and (40) is an ORC with a postverbal subject.

(48) Indica il cavallo che sta inseguendo i leoni.
point to the horse-SG that is-SG chasing the lions-PL
"Point to the horse that is chasing the lions."

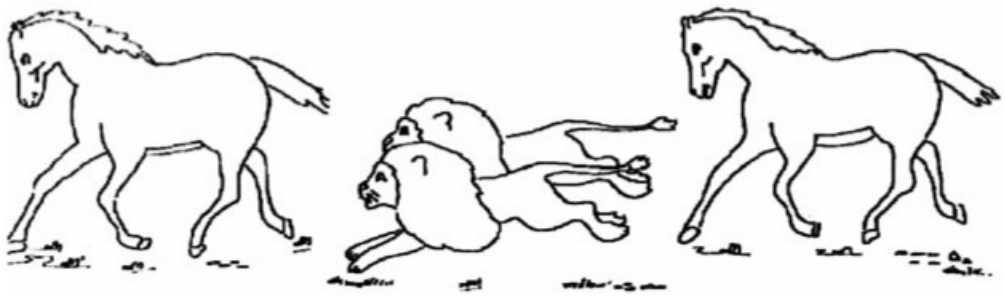
(49) Indica il cavallo che i leoni stanno inseguendo.
point to the horse-SG that the lions-PL are-PL chasing
"Point to the horse that the lions are chasing."

(50) Indica il cavallo che stanno inseguendo i leoni.
point to the horse-SG that are-PL chasing the lions-PL
"Point to the horse that the lions are chasing."

Adani created 24 experimental sentences and used them in combination with a picture. Each picture displayed one animal of type X on the left, two animals of type Y in the middle, and one animal of type X on the right. So for example, a picture could show a horse on the left being chased by two lions in the middle, who are being chased by a horse on the right (see Figure 1). As it was an agent selection task, children were asked to point to the agent of the experimental sentence they were listening to. Hence, if they heard sentence (38) they had to point to the horse on the right, and if they heard either (39) or (40) they had to point to the horse on the left.

5 Like in Dutch, Italian relative clauses are ambiguous for a SRC or a postverbal ORC interpretation when both lexical DPs used are similar in number.

Figure 1



Example taken from Adani (2009).

Adani tested 116 Italian monolingual children between the age of 3 and 7, divided over 5 age groups (3-years; 4-years; 5-years; 6-years; and 7-years old). He found that children performed highly accurate and significantly better on SRCs, than on the other sentence types: all age groups scored at least 90% on this structure. Secondly, children performed better on preverbal than postverbal ORCs. For the preverbal ORC condition the youngest age group performed above 50% - which is, according to Adani, above chance, as 4 potential referents were present in each picture[6] –, with the four year olds already being accurate in more than 80% of the trials. For the postverbal ORCs, 60% of the 3-year olds pointed to the patient instead of the agent and only 36% gave a target response. The 4-, 5- and 6-year olds all scored just above 50%. It is only the 7-year olds that seem to have a better comprehension of this clause type, scoring at 70%.

These results show that children as young as 3-years old correctly comprehend SRCs, whereas at the same age they still struggle with ORCs – both preverbal, although less, and postverbal. They vastly improve on preverbal ORCs from 4-years on. However, interpreting postverbal ORCs, only disambiguated from SRCs by number agreement on the embedded verb, continues to be problematic as even at age 7 30% of the children chooses the patient over the agent.

Similar results were obtained by Arosio et al. (2009). They tested 139 Italian monolingual children divided over 4 age groups – 5-; 7-; 9-; and 11-year olds – on the same relative clause structures as Adani (2009), namely SRCs, preverbal ORCs and postverbal ORCs, such as in (19), (20) and (21). They used a slightly different method than Adani, which was a picture selection task. Instead of asking children to point at one out of three possible referents, children had to choose between two pictures with one correctly describing the experimental sentence and the other depicting the opposite action. In addition they performed a grammaticality judgment task to test children's sensitivity to number agreement violations and a backward word repetition span task in order to tap into children's memory capacity.

The results of this study show, like Adani's study, that Italian SRCs are easier to comprehend by children than ORCs and that preverbal ORCs are less dificult than postverbal ORCs. Furthermore, a difference in the developmental pattern between the preverbal and postverbal ORC structure was found: whereas children from the age of 5 already show a good comprehension of preverbal ORCs, they continue struggeling with the postverbal relative clause order at least until the age of 11. In addition, Arosio et al.'s results also showed that children's comprehension scores on the ORC sentences were positively correlated during certain stages in development by their memory capacity, measured by backward word span.

Adani et al. (2010) did, in contrast to these two studies, not focus on differences in children's comprehension of SRCs and ORCs. They, on the other hand, tested whether gender and number features modulated Italian monolingual children's accuracy on preverbal ORCs. As the gender manipulation was not relevant for the relative clause itself – as it was only potentially facilitating the main clause (see the

6 It could be argued whether this is truly the case as it seems that, at least, in the SRC and the postverbal ORC conditions the animals in the middle are not considered as potential agents by children, with only 1% of the SRC answers being 'middle' answers, and only 5% of the postverbal ORC answers.

examples in (41) and (42) – only Adani et al.'s results with respect to the number disambiguated sentences will be discussed. Sentences (43) and (44) show an ORC in which there is respectively no mismatch in number between the first and the second DP and in which there is a mismatch. Notice that, in contrast to the Adani (2009) and the Arosio et al. (2009) studies, the relative clauses used are center-embedded.

(41) Il gatto che il topo sta lavando è salito sullo sgabello.
the cat-M that the mouse-M is washing has climbed-M onto the stool
(42) Il gatto che la capra sta lavando è salito sullo sgabello.
the cat-M that the goat-F is washing has climbed-M onto the stool

(43) Il leone che il gatto sta toccando è seduto per terra.
the lion-SG that the cat-SG is-SG touching is sitting on the ground
(44) Il leone che i coccodrilli stanno toccando è seduto per terra.
the lion-SG that the crocodiles-PL are-PL touching is sitting on the ground

The authors tested 50 children divided over three age groups (5-; 7-; and 9-year olds) on these type of sentences. In addition another factor was introduced, which they called 'Head' to test whether the gender/number on the head DP influenced outcomes. Children participated in a picture selection task, in which each sentence was accompanied by four pictures – in contrast to Arosio et al. (2009) who used only two pictures – depicting all possible combinations of the subject and object performing the two action – the action in the relative clause and in the main verb. Adani et al. found that children performed better on ORCs with a number mismatch between the subject and the object than on matched sentences. The most common error for all age groups was the interpretation of the ORC as an SRC. Finally, the 5-year olds made significantly more (SRC) errors than the 7- and 9-year olds. Importantly, Adani et al. found that even though children could choose from four options – instead of two/three in Adani (2009) and Arosio et al. (2009) – the most common error made by them was to assign a subject interpretation to the ORCs.

The purpose of the next study, by Guasti et al.'s (2012), is twofold: the authors show in their first experiment that number agreement is similar in strength as disambiguating cue in different languages, in both Greek and Italian. In their second experiment they look more closely into case and number as disambiguating factors in Greek relative clauses. Their study is based on previous findings that Greek right-branching ORCs are better comprehended by children than their subject-extracted counterparts. This is clearly different from children's accuracy scores in Italian experiments, such as the first two studies discussed in this chapter. Guasti et al. claim that the divergent Greek results are a result of the incorporation of case marking in previous studies. The aim of their study is to separate the influence of number and case marking on relative clause comprehension, to study their disambiguation strength individually.

In their first experiment, Guasti et al. compared Greek and Italian monolingual children's comprehension on postverbal relative clauses disambiguated by number – hence, case marking in Greek was neutralized. 27 Italian children and 43 Greek children in the age range of 4,5 – 6,5 years participated in the study. 6 experimental sentence pairs were created, with each pair including one SRC and one ORC. Each sentence pair was linked to one picture. The type of pictures and the method used were similar to Adani's (2009) and children were asked to point to the correct referent on the pictures. The results show that without case marking Greek children are less accurate on ORCs than on SRCs (49% and 69% respectively), like the Italian children. Their performance on the ORC sentences did not differ significantly[7]. Furthermore, a correlation was found for the Greek children between age and accuracy on the ORC structure, but not for Italian children.

These results, first of all, show that number is a weak cue in disambiguating relative clauses not only for Italian, but also for Greek children, as Greek children scored below 50% on comprehending ORCs. Second, the data suggest that number marking as disambiguating factor has the same strength cross-

7 Performance on the SRC condition was significantly different between Italian and Greek children, with Italian children being more accurate on SRCs than Greek children. Furthermore, this effect was modulated by age for the Greek children, but not for the Italian children. This will not be further discussed here and I would like to refer to the original paper (Guasti et al., 2012) for the authors' explanation.

linguistically – or at least for Greek and Italian – as comprehension cue for ORCs, as the Italian and Greek children had a similar score.

In their second experiment, Guasti et al. tested the same Greek children that participated in experiment 1 on Greek relative clauses disambiguated by case marking on the embedded DP. Examples are given in (45) and (46):

(45) Dhikse mou ti maimou pou pleni tin arkouda.
show me the monkey that is washing the-ACC bear
"Show me the monkey that is washing the bear."

(46) Dhikse mou ti maimou pou pleni i arkouda.
show me the monkey that is washing the-NOM bear
"Show me the monkey that the bear is washing."

Example (45) contains a SRC: the determiner of the embedded DP carries accusative case marking, hence the DP "tin arkouda" gets assigned the patient role. In example (46), the Greek ORC, the determiner of the embedded DP "i arkouda" carries nominative case, hence it is the subject of the relative clause. The materials and method used were similar to the one in experiment 1, so that the results on the Greek sentences of both experiments could be directly compared. Imporantly, number marking was neutralized in experiment 2 as in each sentence pair both DPs were singular. Hence, only the influence of case marking on relative clause comprehension was measured in experiment 2. Guasti et al. found, again, that children were more accurate on SRCs disambiguated by case, than on ORCs. Children's accuracy scores did improve, though, on the ORC construction in the second experiment: 60% versus 49% in the first experiment. In addition, no developmental effect was found in experiment 2 as children did not improve significantly with age.

These results show that, in contrast to previous studies, Greek children display the subject-object asymmetry in right-branching relative clause comprehension as has been attested in other languages, when disambiguating cues are singled out. Importantly, the results suggest that number marking as disambiguating factor in ORC comprehension is as informative in different languages as Italian and Greek children were evenly (in)accurate on this structure. Finally, Guasti et al.'s Greek data also provide evidence that case marking is a stronger morphological cue than number marking for disambiguating relative clauses and ORC comprehension.

Finally, Arosio et al. (2012) studied German children's sensitivity to case marking and number agreement as disambiguating cues in relative clause comprehension and the influence of short-term memory on comprehension scores. Like in Greek, German relative clauses can be disambiguated by number marking on the embedded verb, case marking on the embedded DP, or both. As the order of German relative clauses are similar to Dutch relative clauses, the disambiguating cue resulting from case marking on the embedded DP ((47) & (48)) is encountered earlier by the parser than disambiguation resulting from number agreement ((49) & (50)), as the verb or auxiliary is the final constituent of the embedded clause.

(47) Die Frau, die die Kinder gesehen hat.
the woman-SG who the children-PL seen has-SG
"The woman who has seen the children."

(48) Die Frau, die die Kinder gesehen haben.
the woman-SG who the children-PL seen have-PL
"The woman who the children have seen."

(49) Die Frau, die den Clown gesehen hat.
the woman who the-ACC clown seen has
"The woman who has seen the clown."

(50) Die Frau, die der Clown gesehen hat.
the woman who the-NOM clown seen has

"The woman who the clown has seen."

In the SRC in (47) and the ORC in (48), the situation is similar to the one in Dutch: in (47) the head DP "die Frau" is singular, whereas the embedded DP "die Kinder" is plural. As the embedded auxiliary "hat" has singular marking it agrees with the first DP and a SRC structure is confirmed. In (48) there is a mismatch in number between the first DP and the auxiliary as the latter carries plural number marking. It does agree, therefore, with the embedded DP and forms an ORC structure. In the SRC in (49), the embedded DP "the Clown" carries accusative case marking and is therefore assigned the patient role. In the ORC in (50), the embedded DP cannot serve as object of the relative clause as it carries nominative case marking, and hence it has to be attached at the subject position of the embedded clause.

Arosio et al. tested German monolingual 7-years old children's comprehension on the type of sentences illustrated in the above by using a picture selection task, similar to the one used by Arosio et al. (2009). In addition, a digit span test was administered to all children, to tap into their short-term memory capacity. Like in the previous studies, the authors found that children were more accurate on SRCs than ORCs and, like in the Greek study, case marking was a stronger disambiguating cue for relative clause comprehension than number marking on the embedded verb. Children's accuracy on ORCs disambiguated by number marking was at chance level (49%) and slightly higher on case disambiguated ORCs (59%). In addition, their results show that children's memory capacity, measured by digit scores, predicts children's accuracy on ORC sentences, but not in SRC sentences, as was found by Arosio et al. (2009) as well. This study adds that the d-span effect found makes different predictions for the effect of case and number marking as disambiguating cue: children with a d-span of 5 perform much better on ORCs disambiguated by case (71%), than ORCs disambiguated by number agreement (44%).

In summary, from the studies discussed in the above three important conclusions can be drawn. First of all, number agreement on the relative clause verb is a relative weak disambiguating cue in (young) children's ORC comprehension cross-linguistically. The German, Greek and Italian results all show that children continue to perform below or at chance level on this structure until relatively late into childhood and the earliest signs of improvement are found at age 7 by Adani (2009). The studies by Arosio et al. (2009; 2012) suggest, though, that the difficulty with ORCs might persist even longer into childhood as their subjects do not perform better than at chance level at the age of 7 and a clear improvement is only found by Arosio et al. (2009) at age 11.

A second observation that can be drawn from the studies discussed above is that different structural/morphological disambiguation cues in relative clauses have different strengths. Results from Adani (2009) and Arosio et al. (2009) clearly show that unambiguous word order is more helpful for children to disambiguate relative clauses than unambiguous number marking. The same holds for case marking as Guasti et al. (2012) and Arosio et al. (2012) found that children performed better on relative clauses disambiguated by case marking on the embedded DP than by number marking on the embedded verb.

A final conclusion that can be drawn from the two Arosio et al. (2009; 2012) studies is that children's memory capacity measured as (forward/backward) digit span might influence their comprehension of the ORC construction: both studies found that digit span was positively related to accuracy scores on ORCs – not SRCs. Arosio et al. (2009) also found that memory capacity correlated with ORCs disambiguated by word order or number agreement for children at different ages. Furthermore, Arosio et al.'s (2012) results provide evidence that children's digit span differently affects their accuracy on ORCs with different disambiguating cues (case versus number marking).

There are three important concerns with the studies discussed above. First of all, in all studies only children were tested and no adult participants served as a control group. This is problematic, as the authors therefore cannot provide adult data from their experiments as a baseline and it remains unclear whether adults would be at ceiling on the number disambiguated ORCs. If adults would not be highly accurate on the type of sentences tested it would not be very surprising that children are often highly inaccurate on (some of) the ORC structures.

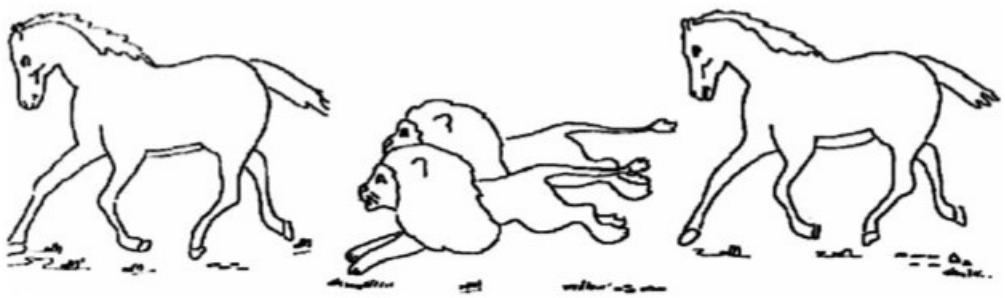
A second issue concerns the Italian studies. As discussed earlier, there exist two ways to form a ORC in Italian: either with a preverbal subject or with a postverbal subject in the relative clause. This is illustrated by the examples taken from Adani (2009), repeated below:

(51) Indica il cavallo che i leoni stanno inseguendo.
point to the horse-SG that the lions-PL are-PL chasing
"Point to the horse that the lions are chasing."

(52) Indica il cavallo che stanno inseguendo i leoni.
point to the horse-SG that are-PL chasing the lions-PL
"Point to the horse that the lions are chasing."

The preverbal ORC structure is the default option in order to describe a situation in which a horse is being chased out of the two ORC structures as shown by children's relatively accurate performance on this sentence type. The postverbal ORC structure, on the other hand, is highly marked. More importantly, by positioning the subject of the ORC after the relative clause verb/auxiliary the function of the ORC changes and the use of it could be argued to be pragmatically odd in Adani's (2009) experiment. Figure 1 is repeated here in Figure 2. The use of sentence (51) to describe the horse that is being chased by the lions is felicitous. However, the use of sentence (52) is not. The focus in this ORC is not so much on whether the horse chases or is being chased, but on the horse being chased by the lions and not by some other kind of animal. Hence for this scenario a different type of picture would be more facilitating and would make the use of the type of ORC felicitous – for example, with one horse being chased by lions and one horse being chased by dogs.

Figure 2



Example taken from Adani (2009).

A final problem arises with the use of number in the SRCs and ORCs studied. In all studies, except for Adani et al. (2010), described above the sentences were similar in structure such that the first DP would always be singular and the second DP would always be plural (consider for example the examples in (51) and (52)). This resulted in the SRCs always having a singular subject and the ORCs always having a plural subject. As we know, children struggled more on the ORC structures than the SRC structures. This clearly confounds with the number features on the subject: children might prefer a singular subject over a plural subject. This preference (in combination with a SRC expectation) might also explain why children have difficulties assigning the correct interpretation to the ORCs tested in the studies above.

These three issues will be addressed in the present study.

5.2 Strength of disambiguating cues during reanalysis and intervention

In the remainder of this chapter two general explanations will be given to account for the findings just summarized. The first is largely based on Fodor & Inoue's (2000) theory on positive and negative symptoms of case and number marking as disambiguating cues in garden-path sentences and Arosio et al.'s (2012) explanation of the differences in children's accuracy on relative clauses disambiguated by case and number agreement. As argued by the latter, the different memory contributions to different cues found will then be explained automatically. I will also argue that the strength of word order as disambiguating cue follows from

this account. The second explanation is an extension of Friedmann et al.'s (2009) proposal and in line with the interference-based account by Van Dyke and colleagues, as suggested by Adani et al. (2010). In addition, differences in ORC comprehension disambiguated by word order and number agreement will be explained in terms of agreement operations as adopted by Adani (2009) and Guasti et al. (2012). As Adani et al. (2010) does not address gender marking cues in relative clause comprehension, gender will not be further discussed.

The finding that number is a relatively weak cue in relative clause comprehension compared to case marking is supported by Fodor & Inoue (2000). They argue that number is a negative symptom within the Diagnosis Model of garden-path processing (Fodor & Inoue, 1994; and 1998): it triggers reanalysis, however it does not guide the parser towards a correct interpretation. Consider the German number marking examples in (53) and (54), repeated below.

(53) Die Frau, die die Kinder gesehen hat.
the woman-SG who the children-PL seen has-SG
"The woman who has seen the children."

(54) Die Frau, die die Kinder gesehen haben.
the woman-SG who the children-PL seen have-PL
"The woman who the children have seen."

Fodor & Inoue assume that the parser will initially try to analyze these sentences as SRC structures by placing the trace of the moved element in the subject position of the relative clause. As discussed earlier, this is unproblematic for a SRC, such as in (53). In (54), however, this would lead to an ungrammaticality at the auxiliary as agreement is being violated between the number feature of the trace – which it receives from the head DP – in the subject position and the number feature on the auxiliary. The parser now has to revise the structure and the only way to repair the temporal incongruity is by detaching the trace from the subject position. Now the parser is left with two tasks: to coindex the head DP with its gap and to attach another DP to the subject position of the embedded clause. So far the number cue on the embedded auxiliary has been informative, as it signalled the temporal ungrammaticality, however it does not offer any further information on how to rebuild the structure. Hence, number is considered a negative symptom for reanalysis by Fodor & Inoue.

In addition, they argue, thematic role assignment has already taken place and the trace of the head DP – even though detached from the subject position – still carries a nominative feature. As a result, the parser would still strongly favor attaching the trace again at the subject position. The only way to solve this, is by attaching the embedded DP to the embedded subject position and assign it nominative case. Hence, thematic role reassignment is necessary, which brings additional costs with it. Now case has been removed from the trace, it can be reassigned to the next leftmost position, which is the object position. Finally, additional costs come, according to Arosio et al. (2012) from the necessity to reactivate the embedded DP in memory during revision.

Case as disambiguating cue is, on the other hand, a different matter, according to Fodor & Inoue (2000). In example (55) the initial SRC interpretation is, again, unproblematic, as the embedded DP carries accusative case. In example (56), this interpretation would lead to a temporal ungrammaticality when the parser encounters the embedded DP, which now carries nominative case. At this point, the parser is obligated to put the embedded DP in the subject position, which was originally occupied by the trace of the moved DP "die Frau".

(55) Die Frau, die den Clown gesehen hat.
the woman who the-ACC clown seen has
"The woman who has seen the clown."

(56) Die Frau, die der Clown gesehen hat.
the woman who the-NOM clown seen has
"The woman who the clown has seen."

In contrast to the example in (29) which is disambiguated by number marking, case marking in (31) does not only signal a garden-path, it also automatically offers a solution: it directly results into the detachment of the trace from the subject position, and also immediately provides the relative clause with a new subject. The only (leftmost) position left to the trace is, again, the object position, and the trace is forced to be attached here. Hence, Fodor & Inoue consider case cues as a positive symptom. In addition, Arosio et al. (2012) consider relative clauses disambiguated by case marking also as being less costly because thematic role reassignment is not necessary, as, according to them, assignment has not taken place yet when the embedded DP is being parsed, and, in addition, because the revision is local, the embedded DP does not have to be reactivated in memory.

As also briefly, but not explicitly, mentioned by Fodor & Inoue, word order could be considered a positive symptom of garden-path reanalysis as well. Consider for example the English ORC structure in (2), repeated below.

(57) The dog that the cat bit.

In accordance with the AFS and the MCP, Fodor & Inoue take this structure to be temporal ambiguous at the relative pronoun. Hence, the trace of the moved head DP is placed in the subject position of the relative clause. When the next element, the determiner of "the cat" is encountered, this prediction no longer holds, as English word order demands the parser to place the second DP in the subject position. As a result, the trace is detached and is placed in the leftmost possible position, which is the object position. Hence, like case marking, word order not only signals an ungrammaticality, but also directs the parser towards the right structure.

From the steps that have to be taken in order to rebuild an ORC structure it follows rather automatically that ORCs disambiguated by number marking are more demanding than ORCs disambiguated by case (or word order). According to Arosio et al. (2012) it is the complexity of the revision process itself, the necessity to reassign theta roles, and the reactivation of the embedded DP in memory all together that place high demands on processing resources in reanalyzing number disambiguated ORCs. This, they argue, explains why only the children they tested with a relatively high digit span were able to comprehend these type of clauses. ORC structures disambiguated by case marking introduce a less complex revision process – as case is a positive symptom –, no thematic reassignment and only local revision. Hence, less processing resources are necessary in reanalyzing case disambiguated ORCs. According to Arosio et al., this is supported by their data showing that children with a medium digit span were in general already able to comprehend these type of ORCs.

Another potential explanation for the results found in the studies above are derived by extending Friedmann et al.'s (2009) theory on intervention effects. Briefly repeated, they argued that when a lexical DP intervenes between another lexical DP and its base position, the creation of a dependency between the two is blocked in children as both available DPs are not disjoint, but share the feature of lexicalization. Altough this perspective explains why children struggle wit ORCs in general, it does not account for differences in strength between word order, case and number marking.

Adani et al. (2010) argue that the internal properties of the lexical restriction feature as proposed by Friedmann et al. should be considered in more detail and be further specified. They suggest that relative clause structures containing a singular and a plural DP (hence, containing a mismatch in number) could be schematically represented as:

(58)	D [Num+PL [NP]]	R	…	D [Num-PL [NP]]	…	<D[Num+PL [NP]]>
(59)	D [Num-PL [NP]]	R	…	D [Num+PL [NP]]	…	<D[Num-PL [NP]]>

Hence, a mismatch in number features on the subject and object DP of an ORC might facilitate comprehension as it makes the intervener more disjoint from the target and its base position. As young children are shown to be highly inaccurate on ORCs disambiguated by number, it seems that only older children and adults can exploit features when establishing a non-local dependency. This is in line with Guasti et al. (2012), who argue that locality, in terms of Friedmann et al.'s intervention effects, is always violated in

(Italian) ORCs disambiguated by number, indirectly suggesting that a mismatch in number is not sufficient to children to regard both DPs as being distinct.

Guasti et al. propose that overt morphological case on the relevant DPs, on the other hand, removes the blocking effect of the intervening DP and enables the child's parser to create a dependency between the relative head and its base position. According to them, due to a difference in case marking on the intervener and head DP, the intervener is no longer considered a potential goal of the dependency. Hence, this suggests that case marking on DPs containing a lexical restriction makes the DPs sufficiently distinct to children so that they can parse these type of relative clauses without being restricted by the principle of RM. Guasti et al. propose that children might not be completely able to exploit case information to account for the children in their experiment not performing at ceiling on the ORCs disambiguated by case marking.

As already noticed by Adani et al. (2010), it is a small step from the notion of features based on Friedmann et al.'s intervention account towards the notion of cues in Van Dyke's and colleagues' cue-based model (Van Dyke, 2007; and Van Dyke & Lewis, 2003). As discussed in chapter 2, Van Dyke and colleagues propose that the more similar the retrieval cues of the probe that is looking for its attachment site are to the cues on the intervener, the higher the activation of the intervener, the lower the chances are that the actual attachment site is sufficiently activated, and the higher the intervention effect is. Hence, in the case of number disambiguation, the head DP might not reach sufficient activation in children's memory in order to be linked to it base position, due to high similarities of the intervener's cues and the retrieval cues – regardless of the mismatch in number. As, if Guasti et al. (2012) are correct, a mismatch in case marking is sufficient to distinguish the intervener from the correct attachment site, the first will not be considered by the parser to create a potential dependency with, as argued by Van Dyke & Lewis (2003). As a result, case disambiguated ORCs should be relatively unproblematic to interpret – except for the necessary reanalysis due to a garden-path effect. It is only when case is for whatever reason not exploited by children, as suggested by Guasti et al., that the intervening DP competes for the highest activation and is considered by the parser.

In addition, Adani (2009) and Guasti et al. (2012) explain the difference in children's comprehension scores on ORCs disambiguated by word order (preverbal) and by number (postverbal) by the absence of an agreement operation in the latter. They argue that Italian preverbal and postverbal relative clauses are both vulnerable to the establishment of an incorrect agreement relation between the auxiliary and the object of the relative clause. In preverbal relative clauses, this is corrected during spec-Head agreement, as the correct subject moves to the specifier position of the maximal projection where the auxiliary is in the head position. In postverbal relative clauses, the subject does not move to the specifier position and therefore features of the subject and the auxiliary are not checked in a spec-Head agreement operation. As a result, the agreement violation of which ORCs are vulnerable to during AGREE, can be detected and resolved in preverbal relative clauses due to spec-Head agreement, but not in postverbal relative clauses, as this operation is absent.

Summarizing, Fodor & Inoue's (2000) account explains differences in disambiguating strength between structural and morphological cues in terms of positive and negative symptoms within the Diagnosis Model. Case and word order cues do not only help the parser to detect grammatical violations, but also guide the parser during garden-path recovery by providing information on how to reanalyze the structure. Number agreement, on the other hand, is considered by this account as a negative symptom: it does trigger reanalysis in ORCs, however, it does not offer further information to the parser on how to rebuild the sentence. In addition, case and word order information triggering reanalysis are provided during thematic role assignment and the necessary revision is local, not leading to additional processing costs. Reanalyzing ORCs disambiguated by number marking is more demanding though – in addition to its more complicated revision process – as thematic reassignment is necessary and the embedded DP has to be reactivated in memory.

Adani et al's (2010) account, which is influenced by Friedmann et al.'s (2009) proposal, assigns differences in strength of case and number marking on ORC interpretation to their different attributions to intervention effects. When children are sufficiently able to exploit case information, no intervention effect

of an embedded DP with unambiguous case marking is expected, according to Guasti et al. (2012). Number information, on the other hand, is, according to Adani et al. (2010), specified in terms of features on the relevant DPs and unambiguous number marking distinguishes the head DP from the intervening embedded DP. Studies testing children's comprehension on relative clauses disambiguated by number show, however, that young children probably are not able to make use of this information, or at least less than case information. Further breaking down intervention effects in terms of features seems to be in line with Van Dyke's and colleagues' cue-based parsing model. Finally, differences in preverbal and postverbal ORC comprehension can be attributed to the absence of the final step of the agreement operation in the latter structure.

5.3 Children's repair strategies

The findings of the studies discussed in this chapter and the accounts explaining general difficulties with the comprehension of ORCs disambiguated by number marking on the embedded verb leave some questions open. The first question is, as (young) children show poor accuracy – even at chance level – on number disambiguated ORCs, whether children actually notice the number disagreement between the relative clause verb and the head DP in ORCs, when the number feature on the extracted DP is different from the number feature on the verb. A potential answer to this question is indirectly provided by the data found in the studies in the above. If children would fail to notice the disagreement in number between the relative clause verb and the head DP, the prediction would be that they would always assign a SRC interpretation to the relative clause structure – or at least as often as they would assign a SRC interpretation to the SRCs they were tested on. As this is not the case in the results found, it could be argued that children are aware of the mismatch in number. To further test this, online methods should be used, to directly tap into children's strategies during actual processing of relative clause sentences. This will be further discussed in the next chapter.

A second question that arises has to do with children's repair strategies when failing to revise the relative clause structure after detecting a number agreement violation or, in terms of intervention effects, when the correct object interpretation is blocked by RM. If children are indeed sensitive to number agreement violations during relative clause comprehension, they should be aware of the ungrammaticality of assigning a subject interpretation to an ORC structure. The question is what kind of strategy they would employ to repair this ungrammaticality. Arosio et al. (2009) argue that children unconsciously correct the number morphology on the embedded verb in ORCs, such that the number agreement violation between the head DP and the verb disappears. As suggested by Arosio et al. (2012), this strategy would be cheap as no revision, thematic reassignment or reactivation would be necessary. Furthermore, it would lead to a grammatical subject interpretation, as initially preferred. This strategy would also explain why some studies found a correlation between memory resources and ORC comprehension: children with low memory capacity would rather opt for the quick repair strategy which is less costly than reanalyzing the structure, leading to an incorrect SRC interpretation.

Adani (2009) looked, in addition to accuracy scores, at the type of errors children made. Remember that Adani used a referent-selection task with pictures containing three potential referents: one animal of type X on the left, 2 animals of type Y in the middle, and one animal of type X on the right. One of the animals of type X in the picture would be the agent of the action described by the verb (for example, the chaser of the animals of type Y) and the other animal of type X would be the patient of the action (the animal being chased by the animals of type Y). The animal described by the relative clause was always of type X. Hence, two error types were possible per picture besides from the target answer: a reversed error – pointing at the wrong animal of type X – and a middle error – pointing at the animals of type Y. A reverse error suggests that a child has interpreted a SRC as an ORC and an ORC as a SRC. A middle error would indicate that children somehow misinterpreted the main clause of the sentence (Point to “animal X”...). Adani's results show that when children fail to point to the target animal in the ORC condition[8] the reversed

8 As discussed in the above, Adani (2009) tested children's comprehension on both preverbal and postverbal ORCs. As I am only interested here in ORC disambiguated by number, only the errors made on postverbal ORCs are

error is the most prevalent and the middle errors are almost absent. This finding suggests that (young) children indeed prefer to interpret ORCs as SRCs, in accordance with a agreement repair strategy on the relative clause verb.

Although Adani's results offer evidence in favor of a strategy children employ of repairing the number agreement violation between the embedded verb and the head DP during ORC interpretation by correcting the number feature on the verb, it could be questioned whether they could be interpreted as such. In theory, Adani's referent-selection task offers participants three choices: the animal on the left, the animals in the middle and the animal on the right. It is arguable, though, whether children truly considered the two animals in the middle during the experiment as potential referent. The experimental sentences clearly asked children to point to one of the animals of type X, which were positioned on the left or the right side of the picture, regardless of the relative clause. Even if children would be entirely unable to parse a relative clause, they should still understand they had to pick one of the animals of type X. Furthermore, even if children would consider the pair of animals in the middle of the pictures, this would not directly be informative in terms of relative clause processing, but probably more so of sentence processing in general – as this concerns the comprehension of the main clause as well. If children indeed not truly consider the middle pair of animals as a potential referent, only two animals to choose from are left. As a result, children's errors would no longer be very informative on children's exact repair strategies, as apart from the target response – which is hard to derive at in the ORC structure – only one option is left. In the other studies discussed, Guasti et al. (2012) used a similar task as Adani (2009); and Arosio et al. (2009; and 2012) used a picture selection task with only two pictures to choose from for each experimental sentence.

Hence, even though children might prefer a subject interpretation for ORCs over an object interpretation as shown by the data from the studies discussed here, it does not automatically follow that this is the actual grammatical structure children have build. As children are forced by the task designs used to choose one of the available interpretations, their own interpretation, if divergent from the two options given, is ignored. In other words, children might use a different repair strategy when they fail to derive at the correct interpretation in the ORC condition. If this would be the case, this would not become clear from the type of tasks used in the studies discussed above however. A potential strategy could be that children, when, following Van Dyke and colleagues (Van Dyke & Lewis, 2003; and Van Dyke, 2007), maintaining the head DP and the embedded DP in parallel active in memory, swap number features of both DPs in order to make the head DP agree in number with the embedded verb. Another strategy could be that children correct the number feature on the head DP, for similar reasons.

One of the main goals of this study is to discover which repair strategies children adhere to when they encounter the number agreement violation between the embedded verb and the head DP in ORCs disambiguated by number marking. In order to do so, I believe that children should not be limited by the available options given: they should be as free as possible in showing their own interpretation of these type of clauses. The use of a picture- or referent-selection task would be impractical with this goal in mind, mainly because too many pictures, or referents within one picture, would be necessary to depict all potential interpretations children could assign to Dutch ORCs[9]. Therefore, in this study an act-out task as experimental method is adopted to test children's comprehension of relative clauses disambiguated by number. Although this type of task has been argued to have a number of limitations in language acquisition studies (cf. Hamburger & Crain, 1982; Corrêa, 1995; and recently by Adani, 2009), it is, to my knowledge, the best alternative to test young children's repair strategies in ORCs in the present study.

Assuming children can make use of different repair strategies when failing to revise an initial SRC interpretation when parsing an ORC structure, the question can be asked of how children's processing capacities influence these strategies. Arosio et al. (2009; and 2012) found that memory resources correlate with children's comprehension of ORCs. It might be possible that memory capacity not only predicts

considered here.

9 When only an object-extracted head DP is considered with its relative clause, such as in (i) below, 8 potential combinations could be derived at: dog-SG/dog-PL biting cat-SG/cat-PL; and cat-SG/cat-PL biting dog-SG/dog-PL.

(i) De hond die de katten beten.
the dog that the cats bit

children's ability to correctly interpret ORCs, but also the repair strategy they adhere to when they fail to reanalyze an ORC structure. Hence, a second aim of this study is to look at the role memory resources play, not only in target versus non-target ORC comprehension, but also in the choice of repair strategies by children.

6. Children's online relative clause comprehension

The studies in the above show that number is a relatively weak cue for children to correctly interpret ORCs and improvement on these sentence types is only relatively late into childhood. Another question which needs to addressed, perhaps even before the question stated in the above about repair strategies, is whether children actually notice the agreement violation at the embedded verb when a SRC interpretation is given to an ORC structure. Arosio et al. (2009) tested children's sensitivity to agreement violations, to make sure children were sensitive to number. However, it is a possibility that, although children are sensitive to agreement violations, they fail to take number on the embedded verb or DPs into account in relative clause structures, for example, due to a processing overload. Hence, in order to get a better understanding of children's actual parsing strategies during relative clause processing, their online behaviour should be studied.

In contrast to offline comprehension studies, only few studies have been conducted looking at children's online comprehension of relative clauses, let alone studies that specifically look at children's sensitivity to different structural and morphological cues in relative clauses. To my knowledge there exists only one study that tested children's sensitivity to number marking as disambiguating cue in relative clauses by using an online method, which is by Arosio et al. (2011). They looked at Italian SRCs and ORCs disambiguated by animacy and number marking. As the present study focuses on relative clauses with two animate DPs, Arosio et al.'s study will only be discussed with respect to these type of sentences. In the first part of this chapter, the study by Arosio et al. will be discussed in more detail. In the second part of this study, some possible caveats will be discussed in combination with the consequential aim of the current study.

6.1 Arosio et al. (2009)

Arosio et al. studied sentence pairs of the type in (60) and (61):

(60) Il pasticcere osserva i gatti che stanno rincorrendo il topolino.
the baker watches the cats-PL that are-PL chasing the mouse-SG
"The baker watches the cats that are chasing the mouse."

(61) Il pasticcere osserva il topolino che stanno rinocrrendo i gatti.
the baker watches the mouse-SG that are-PL chasing the cats-PL
"The baker watches the mouse that the cats are chasing."

Both relative clauses are postverbal and disambiguated by number marking on the auxiliary. In sentence (60) the first DP "i gatti" agrees in number with the verb "stanno", whereas the second DP "il topolino" does not, resulting in a SRC. In (61) the first DP "il topolino" does not agree in number with the embedded verb "stanno". The second DP "i gatti", however, does agree with the verb "stanno", resulting in an ORC. Based on the accounts discussed in the above, children will interpret both relative clauses in (60) and (61) as being SRCs. At the embedded auxiliary "stanno" in (61) an ungrammaticality arises due to an agreement violation between the singular "il topolino" and the plural "stanno". The trace of il topolino is removed from the subject position and – finally, when "i gatti" is encountered – linked to the object position. The question of interest here is whether children show online sensitivity to the number agreement violation at the auxiliary.

The authors divided the sentences into 6 segments (62), in order to be able to collect response times (RTs) on each individual segment by conducting a self-paced listening experiment.

(62) 1 2 3 4 5 6
Il pasticcere osserva / i gatti / che / stanno / rincorrendo / il topolino.

Segment 4 constitutes the disambiguating segment as it contains the embedded auxiliary: at this segment

the parser should detect a number agreement violation between the auxiliary and the first DP. Whereas the sentence pairs are similar up and including the third segment in the SRC and the ORC condition, they differ on the fourth segment. The SRC structure is considered to be unproblematic at segment 4, as the initial subject interpretation corresponds to the number marking on the auxiliary. Processing costs are, on the other hand, predicted to be higher in the ORC condition at segment 4, due to various reasons as explained in chapter 2. If this is, indeed, the case for children, this should be reflected in increased reaction times (RTs) at segment 4 compared to the SRC condition.

Each sentence in Arosio et al.'s design was accompanied by a comprehension question of the type in (63) that asked who was the patient in the sentence it followed.

(63) Chi viene rincorso?
"Who is chased?"

Apart from the self-paced listening task, the authors also conducted a digit span and listening span task to measure short term and working memory capacity respectively. 51 9-years old monolingual Italian-speaking children participated in the study.

The accuracy scores show that children performed rather well on SRCs, regardless of their digit- or word-span. They were significantly less accurate on ORCs. Furthermore, the children who fell in the group with the lowest digit-span performed significantly worse in the ORC condition than children with a higher digit-span. An effect of word-span was not found. The authors did not find a significant difference in response times between the SRC and ORC condition on the disambiguating segment 4. They did find an effect for segment 5, on the gerundive verb, though: children responded faster to segment 5 in the SRC condition than in the ORC condition. No effect was found for digit- or word-span.

Arosio et al. explained the absence of an effect on the actual disambiguating segment and children's slower response times on the next segment in the ORC condition in terms of a spill-over effect. According to them it shows that children initially treat all relative clauses as SRCs. When parsing segment 4, they do notice the number mismatch between the first DP and the embedded verb in ORC condition, reflected by longer RTs on segment 5. Arosio et al. therefore conclude that 7-year old Italian children are sensitive to number cues on the verb in relative clause structures, even though this is not always reflected in their offline comprehension which is caused by some children's inability to succesfully reanalyze the structure.

Although Arosio et al.'s explanation for the effect of relative clause type they found on segment 5 sounds plausible, there might be a confounding factor. In the sentences in (34) and (35) the subject of the action of the relative clauses is both times "i gatti". "Il topolino" is the object. Children's slow-down on segment 5 in the ORC condition could also represent a dispreference for the first DP to be the agent of the embedded verb, caused by the implausibility of the first DP – in this case "il topolino" – to perform the action of the gerundive verb "chasing". In sentence (12) the parser first encounters "i gatti", which is, according to the Active Filler Strategy the presupposed subject of the relative clause. When the parser parses the gerundive verb, "i gatti" is a plausible actor as cats are likely to chase something. In sentence (35) the first DP and presupposed subject is "il topolino". Now, when the parser encounters the gerundive verb some kind of incongruity might arise between "il topolino" and the VP, as "il topolino" might be a rather implausible actor when it comes to chasing. Hence, higher RTs on segment 5 in the ORC condition might be caused by children's (dis)preference for one of the DPs as actors, regardless of the number match or mismatch between the presupposed subject and the embedded verb.

6.2 Dutch children's online ORC comprehension

One of the goals of the current study is to test Dutch children on a similar task and to find out whether sensitivity to number marking as disambiguating cue in relative clauses as found by Arosio et al. is replicated for Dutch. As in the Arosio et al. study only 7-year old children were tested, their data only reflects children's ability at one point during language acquistion, and no developmental data was collected. In order to test whether children's online comprehension of relative clauses disambiguated by number

changes over age, this study reports data from two age groups: 5-year olds and 7-year olds. In order to prevent an effect of semantic preference, only sentences will be used in which the head DP and the embedded DP are equally likely to be the agent of the embedded verb. Furthermore, the order of the segments of Dutch relative clauses makes it possible to directly test whether the action of the infinitive verb – the gerundive in Italian – or the number on the auxiliary causes a slow-down in RTs:

(64) De hond die de katten aan het bijten is.
the dog-SG that the cats-PL biting is-SG

In the Italian study the auxiliary preceded the gerundive verb, whereas in Dutch relative clause structures the auxiliary always follows the (infinitive) verb. If Arosio et al. measured what they assumed to measure – a slow-down in the ORC condition caused by children being sensitive to number violations – RTs in Dutch ORCs should be slower at the auxiliary or the segment following the auxiliary. If the children in the Arosio et al. study slowed down at the gerundive verb due to the semantics of the segment, no slowdown in the Dutch ORC condition is predicted as plausibility is controlled for.

Finally, Arosio et al. did not find an effect of memory span on children's RTs in the self-paced listening task for the animate relative clauses, even though memory span interacted with children's offline accuracy. This is in contrast to Booth et al. (2000), who found that RTs of children with a high digit span patterned differently from RTs of children with a low digit span. A final goal of this study is, therefore, to test whether Dutch children's online comprehension is influenced by their memory capacity, measured by their forward and backwards word recall span.

7. Research questions and hypotheses

As mentioned earlier, many studies in different languages have been conducted testing children's comprehension of SRCs and ORCs. Although scholars disagree on the exact cause, there seems to exist a general consensus on the existence of subject-object asymmetry in the acquisition and processing of relative clauses: the ORC structure is more demanding in terms of processing resources, such as memory capacity, and is therefore more difficult to comprehend – as reflected in online measurements for adults – and later acquired, at least for comprehension, during acquisition – as reflected in offline measurements for children – than its subject-extracted counterpart. In a number of recent studies, researchers have focused on the effect of certain structural and morphological cues on children's ORC comprehension. These studies show that number marking on the embedded verb, which is the only morphological disambiguating cue available for Dutch relative clauses, is relatively weak, and often not sufficient for children to correctly interpret the ORC construction. Although children's comprehension of number disambiguated ORCs continues to be rather inaccurate until late into childhood, results from Arosio et al.'s (2011) online study suggest that children already at age 7 are sensitive to number agreement violations. Regardless of this, they somehow fail to correctly (re)construct an ORC structure and possibly resort to a cheaper repair strategy.

The aim of this study is threefold: (1) to uncover which repair strategies Dutch children use when their initial interpretation of the ORC structure fails; (2) to replicate Arosio et al.'s online study with reversible DPs, to test whether Dutch children also show sensitivity to number agreement during relative clause processing; and (3) to find out whether children's short term memory (STM) and working memory (WM) capacity, as measured by forward word span and backward word span respectively, predicts children's offline and online behaviour on relative clauses. In this chapter the research questions and their associated hypotheses will be discussed.

7.1 Children's repair strategies for ORCs (offline)

Findings of previous studies suggest that young children prefer to interpret ORCs as SRCs. Hence, the Dutch ORC in (66), is therefore predicted to be interpreted as the SRC in (65). According to this account, children 'choose' to correct the number feature on the embedded verb by matching it to the number feature on the head DP, which would results in a singular number feature on verb in (66). This results in the structure in (66) in which the head DP “de hond” agrees in number with the verb “beet”.

(65) De hond die de katten aan het bijten is.
the dog-SG that the cats-PL biting is-SG
“The dog that bit the cat.”

(66) De hond die de katten aan het bijten zijn.
the dog-SG that the cats-PL biting are-PL
“The dog that the cats are biting.”

As discussed in chapter 5, the methods used in recent studies considering number disambiguation in relative clauses are highly limited in allowing children to give their interpretation of the ORC sentences used. This is due to the use of either a picture or referent selection task, which provides participants with a limited set of options. It is therefore unclear whether children always opt for the repair strategy as described here when revision fails, or whether they have more or different strategies available. The first research question, therefore is:

> *Q1. Which strategies do Dutch children employ while parsing ORCs when they fail to derive at the correct interpretation?*

In order to answer this question, children's comprehension of ORCs was tested by conducting an act-out

task in which children had more freedom to display their interpretation of relative clauses compared to a picture or referent selection task. Not only will children's accuracy scores, measured in terms of target versus non-target answers, be looked at, but also the type or errors made by them will be taken into account. If Arosio et al. (2009; and 2012) are correct in assuming that children correct the number feature on the embedded verb in order to repair the number agreement violation, the hypothesis will be that children only make errors of the type in (65) and (66): interpreting an ORC structure as a SRC structure. If children can employ other repair strategies, such as correcting the number feature on the head DP in (66), by making it plural or by switching number features of both DPs, this should be visible from different errors made, such as (67) and (68) instead of (66).

(67) De honden die de katten aan het bijten zijn.
the dogs-PL that the cats-PL biting are-PL
"The dogs that are biting the cats."

(68) De honden die de kat aan het bijten zijn.
the dogs-PL that the cat-SG biting are-PL
"The dogs that are biting the cat."

Hence, the alternative hypothesis would be that children employ different repair strategies, which should be visible from different types of errors made in ORCs comprehension.

7.2 Developmental pattern Dutch children (online)

Although offline data suggests that children are sensitive to number as disambiguating cue during relative clause processing, this has only been tested in one online study by Arosio et al. (2011). Results of this study suggest that children indeed show sensitivity to number agreement violations during real-time processing, reflected by slower RTs on the segment following the disambiguating segment in the ORC condition compared to the SRC condition. However, as it is not entirely clear whether this is a result of a spill-over effect from the auxiliary or whether it is caused by the semantics of the gerundive verb, further research is necessary. The second research question investigated in this study is therefore:

> *Q2. Do Dutch children show sensitivity to number marking on the embedded verb as disambiguating cue in relative clauses with reversible DPs?*

In order to test the second research question a self-paced listening task was conducted with Dutch SRC and ORC structures divided into segments. The idea behind this task is that greater integration difficulties are reflected by slower RTs. Hence, as integration of the embedded verb is expected to be more problematic in the ORC condition than in the SRC condition for children – either due to reanalysis or intervention effects –, slower RTs are expected at this segment in the ORC condition, reflecting children's sensitivity to number agreement violations. Hence the hypothesis is that Dutch children, like the Italian children tested by Arosio et al., show sensitivity to number marking on the embedded verb as disambiguating cue during relative processing, reflected in slower RTs at the disambiguating segment.

7.3 Role of memory capacity on offline and online comprehension

The offline results by Arosio et al. (2009; 2011; and 2012) have shown that memory capacity as measured by digit span is a predictor of children's comprehension of ORCs disambiguated by number marking. Furthermore, Booth et al. (2000) found that memory capacity correlated with children's online behaviour on English relative clauses. Arosio et al. (2011), on the other hand, did not find an effect of memory capacity on online processing. The third and final research question addresses the effect of children's individual memory resources on online and offline comprehension:

Q3. What is the effect of short-term memory (STM) and working memory capacity (WM), as measured by forward word span and backward word span respectively, on Dutch children's repair strategies in ORCs, as measured by the type of errors they make, and their online behaviour on relative clauses.

If children indeed employ different repair strategies and these strategies bring different processing costs with them, a correlation with memory resources is expected. If results obtained for the online study are similar to Arosio et al.'s (2011), no effect of memory is expected on the RT patterns.

8. Method

8.1 Participants

One group of 20 5-year olds and one group of 22 7-year old monolingual Dutch children participated in the experiment. All children were recruited at a primary school in Apeldoorn in the east of the Netherlands after parental consent was asked. 20 Dutch monolingual adults served as a control group. All adults were between 20 and 30 years of age and were living or had spent a considerable amount of their lives in the same area as the children were living in.

8.2 Materials act-out task

For the act-out task 4 quartets of experimental sentences were constructed. Each sentence consisted only of a DP and a relative clause modifying this DP:

DP1 [$_{RC}$ die DP2 V].

The DP pairs were selected based on them being masculine/feminine – and therefore preceded by the determiner "de" in the singular -, conjugated by -en in the plural, and by their plausibility to be the performer of the action. In addition, as the DPs were always masculine or feminine, the relative pronoun was always "die"[10]. The animal pairs had to be available as toy animals and they had to be of a similar size. Each RC contained a unique transitive verb indicating present tense. Furthermore, each quartet contained the same sentence in 4 conditions by using two factors: RC type (SRC vs. ORC) and number (singular vs. plural), resulting in 16 trials. An example of a quartet is given in Table 7.

Table 7

	Singular	**Plural**
SRC	De kip die de geiten aan het duwen is. the chicken-SG that the goats-PL pushing is-SG "The chicken that is pushing the goat."	De kippen die de geit aan het duwen zijn. the chickens-PL that the goat-SG pushing are-PL "The chickens that are pushing the goat."
ORC	De kip die de geiten aan het duwen zijn. the chicken-SG that the goats-PL pushing are-PL "The chicken that the goats are pushing."	De kippen die de geit aan het duwen is. the chickens-PL that the goat-SG pushing is-SG "The chickens that the goat is pushing."

Example of a quartet of sentences used in the act-out task.

In addition eight filler items were created: 4 simple active and 4 simple passive sentences; 2 active and 2 passive sentences with a singular subject; and 2 active and 2 passive sentences with a plural subject (see Table 8). The passives were used to encourage children to pay attention to other cues than word order. Half of the filler items were used as practice items. Three animal types were used twice in a story: the piglets, the geese and the pigs. The first two were used twice in the practice stories and "the pigs" once as practice item and once as filler item. All the other animals, including the ones used for the experimental items, were only used once. The same verbs used in the experimental trials were used in the four filler items, to check whether children's behaviour on the experimental items was not caused by them having trouble with particular verbs.

Table 8

10 In Dutch the form of the relative pronoun depends on the gender of the DP it modifies. For masculine/feminine nouns it is "die", and for neuter nouns it is "dat". In order to keep everything constant only DPs were used that combined with "die".

	Singular	**Plural**
Active	Het kalfje duwt de nijlpaarden. the calf-SG pushes-SG the hippos-PL “The calf pushes the hippos.”	De schapen schoppen het paard. the sheep-PL kick-PL the horse-SG “The sheep kick the horse.”
Passive	De bever wordt door de herten geborsteld. the beaver-SG is-SG by the dears-PL brushed “The beaver is being pushed by the dears.”	De pony's worden door het varken geduwd. the ponies-PL are- by the pig-SG pushed “The ponies are being pushed by the pig.”

Examples for each type of filler item used in the act-out task.

Every act-out sentence was introduced by a short story, introducing the animals and the relevant action in the act-out sentence (A) and the number of animals performing the action (B).

A. Op de boerderij zijn geiten en kippen. Zij duwen elkaar soms.
“On the farm are goats and chickens. They push each other sometimes.”
B. Dan duwt één van de kippen een paar geiten. En een paar geiten duwen een andere kip.
“One of the chickens then pushes a a couple of goats. And another couple of goats push another chicken.”

The act-out sentence was led in by a short sentence asking the children to perform the action, of the kind: “Doe jij nu/nog eens” (Now you do/You do again); and “Laat nog eens zien” (Show again).

Every type of animal in each sentence was accompanied by three toy animals of that type. Hence, six animals were present in each act-out story. The number of three animals per animal type was chosen to make sure the use of relative clauses would be felicitous. Creating a felicitous condition in order to test children's comprehension of relative clauses has been (and still is, see Adani, 2009) an important topic of criticism of earlier RC studies, especially the ones in which an act-out task has been used (e.g. Hamburger & Crain, 1982). If only one toy animal in the singular condition or two toy animals in the plural condition would be present, there would have been no need to further specify the individual animal or group of animals by a relative clause, causing the presence of a relative clause to be pragmatically infelicitous. With three toy animals available, a relative clause could be used to describe either one or two animals.

The choice to use structures with only a DP modified by a relative clause in the act-out task was to make the task as easy as possible for the children. In previous act-out experiments with sentences containing a center-embedded or right-branching relative clause a common 'error' made by the children was not acting out the relative clause. As in this study I am not interested in the integration of a relative clause in a main clause, this was one important reason not to use whole sentences. Furthermore, as previous studies have shown that memory capacity plays a role in the comprehension of relative clauses and center-embeddedness is known to put a relative large burden on memory capacity, sentences were kept as short as possible.

Four lists were constructed with one sentence for each quartet in one list. Each list was paired with another list, differing only on the auxiliary used (singular versus plural). Hence, between two lists that formed a pair sentences only differed between the relative clause conditions (SRC versus ORC). In addition, as the animal pairs were not checked on reversibility, every animal pair was reversed, creating four additional lists. Finally, for each list another list was constructed in which the actions in B were situated in the reverse order: the first action became the second action and the second action became the first action. This resulted in 16 lists in total. To each list the four filler items were added, making sure that the each list started with a filler and that no experimental trial was directly preceded by another experimental trial.

Finally, adults were presented with similar items, except that the experimental items did not contain an auxiliary to indicate whether the sentence was a SRC or an ORC, but a main verb. An example of the sentences are given in Table 9 below. These data were already collected in a previous experiment. Although these sentences are slightly different to the ones the children were given, the principle behind them remains the same and therefore I believe that the use of this data is still appropriate.

Table 9

	Singular	**Plural**
SRC	De kip die de geiten duwt. the chicken-SG that the goats-PL pushes-SG "The chicken that pushes the goat."	De kippen die de geit duwen. the chickens-PL that the goat-SG push-PL "The chickens that push the goat."
ORC	De kip die de geiten duwen. the chicken-SG that the goats-PL push-PL "The chicken that the goats push."	De kippen die de geit duwt. the chickens-PL that the goat-SG push-SG "The chickens that the goat pushes."

Example of a quartet of sentences used in the act-out task for the adult control group.

8.3 Procedure act-out task

All the toy animals were placed on a table and before the test started the child was asked to name each animal type. If the child did not know one of the animals, the experimenter would tell its name. Then the child was introduced to a puppet, Ernie, and was told that the experimenter was going to tell and act-out some stories. They were then told that Ernie was a bit forgetful (what most of them agreed on) and that he either always forgot the beginning – part 1 of B – or the end – part 2 of B – of the stories the experimenter would tell him. The children were then asked whether they could help Ernie by acting out one part of the story again. As Ernie was a bit shy, he would only whisper to the experimenter which part of the story he would like to see again and therefore the experimenter would tell the children the sentence they had to act out. As they had to repeat the experimenter's action they were told to pay close attention to what was going on in the story.

Each story began by the experimenter naming the animal types that participated (as in A). The child was encouraged to get involved by helping to find and place the animals in front of them at the table. All three animals of the same type were placed in a row opposite to a row of animals of the other type. The position of the animal types and the individual animals varied. Then the experimenter told and acted out the actions in B. After this, Ernie was asked which part of the story he had forgotten or wanted to see again. Finally the child was asked by the experimenter to act out one of the act-out sentences.

Before the test started, children were able to practice. Some children did three practice stories, some four, depending on how quickly they understood the task. If a child did not act out the practice sentences correctly, the experimenter would give feedback until the child was able to act out the correct event[11]. After the practice session the children were told they had practiced enough and that they were going to start with the eight stories. During the testing phase, children sometimes received additional feedback in the form of a repetition of the act-out sentence or a question ("how many animals did it?") to remind them of what they had learned during practicing after acting-out the filler items, in case they fell back on wrong strategies such as one-to-one matching[12].

In session 2 the children were asked to tell what they remembered from the first session and the experimenter explained the task again in addition to what the child told. The second session started, like the first session, with the practice stories, to make sure the child (still) understood the task. Usually with the older children the second practice session did go very quickly as they remembered what they had to do. The further course of the task was similar to the first session.

8.4 Materials self-paced listening task

For the self-paced listening task 10 quartets of sentences were created. Each sentence began with "I saw

11 In some cases, often with the 5-year olds, children did not get it, even with the feedback. Especially the number of animals that were participating (singular vs. plural) was very challenging for young children. In these cases the experimenter continued to the next practice item. Sometimes the experimenter would repeat the actions in B or show the correct action to the child.

12 This type of error will be further explained in the Results section.

that" and consisted of a main clause and a center-embedded relative clause. The structure of all sentences was as follows:

Ik zag [$_{MC}$ dat DP1 [$_{RC}$ die DP2 AUX PP] PP V].

Every sentence contained a unique animal pair. All animals used were either masculine or feminine, which meant that they were all accompanied by the same determiner, "de" and the relative pronoun "die"; they all had the regular plural conjugation "-en"; and they were all matched on reversibility. Every sentence also contained two unique verbs: a transitive RC verb and an intransitive main verb. The actions in the RC always happened in the present. The action described by the main verb was always in the past. The preposition used in the main verb indicated a place where the specific action took place. Furthermore, in order to measure potential spill-over effects and to avoid sentence wrap-up effects at the end of the relative clause the choice was made to use center-embedded relative clauses.

For each sentence four different conditions were created, based on the factor RC type (SRC vs. ORC) and Number (singular vs. plural). When a sentence was marked singular, it would mean that the first animal present in the sentence would be singular and the second animal plural. The reverse applied to the plural sentences. An example of a sentence quartet is given in Table 1. Notice that the singular conditions (the SRCsg and the ORCsg) and the plural conditions (the SRCpl and the ORCpl) are minimally distinctive: they only differ on the auxiliary, which indicates whether the sentence is a SRC or an ORC.

Whole sentences were recorded and afterwards each sentence was cut into segments – the boundaries are indicated by the dashes in Table 1 – such that response times (RTs) could be measured at these points. All sentences of each quartet are similar at segment 1, segment 2, segment 4, segment 6 and segment 8. Differences between the plural and the singular conditions (SRCsg versus SRCpl, and ORCsg versus ORCpl) are on segment 3, segment 5, segment 7 and segment 9. Finally, the different relative clause conditions (SRCsg versus ORCsg, and SRCpl versus ORCpl) differ only on segment 7.

Each experimental sentence was followed by a comprehension question, that asked whether one animal type is doing something to the other animal type. This question could either be true or false. Half of the sentences in each condition were followed by a yes-question and half of the sentences in each condition were followed by a no-question. Examples of these questions are given in Table 10.

Table 10

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
SRCsg	Ik zag I saw	dat that	de leeuw the lion-SG	die that	de honden the dogs-PL	aan het wassen washing	is is-SG	door het bos through the forest	wandelde walked-SG
	"I saw that the lion that is washing the dogs walked through the forest."								
Yes-probe	Is de leeuw de honden aan het wassen? - "Is the lion washing the dogs?"								
No-probe	Zijn de honden de leeuw aan het wassen? - "Are the dogs washing the lions?"								
SRCpl	Ik zag I saw	dat that	de leeuwen the lions-PL	die that	de hond the dog-SG	aan het wassen washing	zijn are-PL	door het bos through the forest	wandelden walked-PL
	"I saw that the lions that are washing the dog walked through the forest."								
Yes-probe	Zijn de leeuwen de hond aan het wassen? - "Are the lions washing the dog?"								
No-probe	Is de hond de leeuwen aan het wassen? - "Is the dog washing the lions?"								
ORCsg	Ik zag I saw	that dat	de leeuw the lion-SG	die that	de honden the dogs-PL	aan het wassen washing	zijn are-PL	door het bos through the forest	wandelde walked-SG
	"I saw that the lion that the dogs are washing walked through the forest."								
Yes-probe	Zijn de honden de leeuw aan het wassen? - "Are the dogs washing the lion?"								
No-probe	Is de leeuw de honden aan het wassen? - "Is the lion washing the dogs?"								

ORCpl	Ik zag I saw	dat that	de leeuwen the lions-PL	die that	de hond the dog-SG	aan het wassen washing	is is-SG	door het bos through the forest	wandelden walked-PL
	"I saw that the lions that the dog is washing walked through the forest."								
Yes-probe	Is de hond de leeuwen aan het wassen? - "Is the dog washing the lions?"								
No-probe	Zijn de leeuwen de hond aan het wassen? - "Are the lions washing the dog?"								

Example of a quartet of sentences used in the self-paced listening task.

8.4.1 Reversibility test

In order to make sure both animals of all animal pairs were equally likely to perform the action indicated by the relative clause verb, a questionnaire was constructed and filled out by a group of adults. Each relative clause was transformed into two active sentences: one in which DP1 was the agent and DP2 the patient; and one in which DP2 was the agent and DP1 the patient. One sentence of the sentence pair was placed on the left side of the questionnaire and the other one on the right side. In between the sentences was a scale from 1 till 5 on which subjects could indicate their preference for one of the animals performing the action, with 1 representing a strong preference for the sentence on the left side of the scale; and 5 representing a strong preference for the sentence on the right side of the scale and 3 representing no preference at all (see Table 5 for an example). 18 fillers were included with a similar structure, but with different animal pairs, some of which very strongly biased towards one of the animals performing the action.

For 6 out of the 10 test sentences subjects did not show any significant preference for one of the animals performing the action over the other animal. In 4 sentences there was a significant bias towards one of the animals performing the action of the relative clause verb. For each of these animal pairs new active sentences were constructed with three different verbs. 13 adults filled out a new questionnaire and from these results four new quartets were created of which there was no significant preference for one of the two animals performing the action.

Table 11

	←←	←		→	→→	
De leeuw wast de hond. "The lion washes the dog."	1	2	3	4	5	De hond wast de leeuw. "The dog washes the lion."
Het paard borstelt de man. "The horse brushes the man."	1	2	3	4	5	De man borstelt het paard. "The man brushes the horse."
De beer krabt de wolf. "The bear scratches the wolf."	1	2	3	4	5	De wolf krabt de beer. "The wolf scratches the bear."
….	1	2	3	4	5	….

Example of the reversibility test.

8.4.2 Filler items

In addition to the test sentences, 20 filler items were constructed: 10 active sentences; and 10 passive sentences; 10 contained a singular subject and 10 contained a plural subject. See Table 12 for an example of every filler type. Again, the sentences were cut into segments – the boundaries are indicated by the dashes in table 6. The passive sentences were chosen to stimulate children not to solely focus on word order to establish agent-patient relationships. The adverbial phrases served to add an additional segment to the filler items to decrease the difference in length with the experimental items.

Table 12

	1	**2**	**3**	**4**	**5**	**6**	**7**

Active sg	Ik zag I saw	dat that	het paard the horse-SG	de varkens the pigs-PL	opeens suddenly	schopte kicked-SG	
	"I saw that the horse suddenly kicked the pigs."						
Yes-probe	Heeft het paard de varkens geschopt? - "Did the horse kicked the pigs?"						
No-probe	Hebben de varkens het paard geschopt? - "Did the pigs kick the horse?"						
Active pl	Ik zag I saw	dat that	de hanen the roosters-SG	de kalkoen the turkey-PL	heel hard really hard	pikten pecked-PL	
	"I saw that the roosters pecked the turkey really hard."						
Yes probe	Hebben de hanen de kalkoen gepikt? - "Did the roosters peck the turkey?"						
No probe	Heeft de kalkoen de hanen gepikt? - "Did the turkey peck the roosters?"						
Passive sg	Ik zag I saw	dat that	de egel the hegdehog-SG	heel zachtjes very softly	door de eekhoorns by the squirrels-PL	geduwd pushed	werd was-SG
	"I saw that the hedgehog was very softly pushed by the squirrels."						
Yes-probe	Hebben de eekhoorns de egel geduwd? - "Did the squirrels push the hedgehog?"						
No-probe	Heeft de egel de eekhoorns geduwd? - "Did the hedgehog push the squirrels?"						
Passive pl	Ik zag I saw	dat that	de kalfjes the calves-PL	voorzichtig carefully	door de ezel by the donkey-SG	gebeten bitten	werden were-PL
	"I saw that the calves were carefully bitten by the donkey."						
Yes-probe	Heeft de ezel de kalfjes gebeten? - "Did the donkey bit the calves?"						
No-probe	Hebben de kalfjes de ezel gebeten? - "Did the calves bit the donkey?"						

Examples of the different types of fillers used in the self-paced listening task.

For 10 filler items a simple yes/no statement was created, probing which animal performed the action or how it performed the action. Half of the sentences were true; and half of the sentences were false; half of the sentences were questioning a passive construction; and half of them an active construction (see Table 2).

Out of the experimental sentences 4 lists were created, with each list containing only one condition of each quartet of sentences. One pair of lists contained 5 SRCs, 5 ORCs, 6 singular DP1's and 4 plural DP1's. The other pair of lists also contained 5 SRCs and 5 ORCs, however 4 of these sentences were in the singular condition and 6 of these sentences were in the plural condition. Every individual sentence in one of the lists was exactly similar to another sentence in one of the other lists, except for the number marking on the verb, hence these were sentences coming from the same sentence quartet. As a result each list formed a pair with another list. So for example, assuming list 1 forms a pair with list 2, the singular ORC condition of a sentence in list 1, would be matched with the plural SRC condition in list 2; the singular SRC condition of a sentence in list 1, would be matched with the plural ORC condition in list 2; etc. (see table 13). Each participant was given a pair of lists, hence, each participant had to listen to 20 experimental items in total.

Table 13

List 1	**List 2**
(...) de leeuwen die de hond aan het wassen is … the lions-PL that the dog-SG washing is-SG (…) "the lions that the dog is washing …" (ORCpl)	(...) de leeuwen die de hond aan het wassen zijn … the lions-PL that the dog-SG washing are-PL (…) "the lions that are washing the dog …" (SRCpl)
(...) de beer die de wolven aan het krabben is …	(...) de beer die de wolven aan het krabben zijn …

the bear-SG that the wolves-PL scratching is-SG (…) “the bear that is scratching the wolves …” (SRCsg) …	the bear-SG that the wolves-PL scratching are-PL (…) “the bear that the wolves are scratching …” (ORCsg) ...

Example of corresponding lists used in the self-paced listening task.

For the 7-year olds and the adults the 20 filler items were added to the 4 lists, resulting in 30 trials in total per list. The filler items were added in such a way that none of the lists started or finished with a test item and none of the test items was followed by another test item. Every list was divided in two blocks, separated by a break, with again none of the blocks starting of ending with a test item. For the 5-year olds shorter lists were created such that the length of the test was adjusted to their shorter attention span. Instead of 20 filler items, only 10 filler items were added. 8 of these filler items were accompanied by a yes/no question The experimental items and filler items were distributed over the lists in such a way that each block started with a filler and that all the experimental items were separated by a filler item. The order of the sentences was similar in each list and the position of the experimental sentences in the lists was the same for each item of a quartet.

All sentences were recorded in a sound booth using Audacity. The segments were cut in Praat (Boersma, 2001) and the experiment was programmed in E-Prime (Schneider, Eschman & Zuccolotto, 2002a; and Schneider, Eschman & Zuccolotto, 2002b).

8.5 Procedure self-paced listening task

Children were seated in front of a laptop and listened to the sentences through headphones. Before the test started in session 1, children listened to an introduction. In the introduction a girl, Merel, introduced herself and told that she is going to tell some stories about the animals that live on the farm she works at. Children were explained that they would only hear pieces of the story and that they had to push a blue button (the space bar) in order to hear the next part. They were told they would have to pay close attention to the stories as they might get a question about it. In order to answer the question they had to press a green button if the question was true or a red button if the question was false (respectively the left and right mouse button on the mouse pad). In addition the experimenter told them not to press the space bar before the whole segment was played, as they might get in trouble answering the questions if they hadn't heard everything.

After the introduction was played, the children were able to practice pressing the space bar and answering the statements by hearing 6 practice items. Half of these items contained a question, half of them not. While practicing the experimenter would encourage the children to press the space bar. If necessary the children were told to wait for the whole segment to play before pressing the space bar. After the last practice item was done children saw pictures and heard the corresponding names of the animals that would appear in the experimental and filler sentences. After this, children were asked: “Are you ready?” and the test began.

After the first block of 15 sentences – 10 sentences for the 5-year olds – children were were asked if they wanted to take a break. Usually this only took about half a minute. During the break children were asked what they thought of the task and whether it went well. Then again the children saw the pictures and the corresponding names of the animals that were going to appear in the final block. Before the second block started they were asked again whether they were ready.

In the second session the same procedure was repeated, except that children did not see the introduction for the second time. Instead the experimenter asked them whether they remembered what they had to do and explained the procedure. Then children immediately started with the practice items.

8.6 Materials & procedure memory tasks

Two tasks were conducted to assess children's memory skills: a forward word-recall task and a backwards

word-recall task. Both tasks were based on the Automated Working Memory Assessment (AWMA) battery (Alloway, 2007) and used by Kolkman, Kroesbergen & Leseman (2014) among others. As the forwards task only asks children to repeat sequences of words and does not require additional actions I will assume this tasks taps into (verbal) short term memory (STM). In addition, as the backwards task requires children to remember sequences of words, and requires them to reverse the order of the words, I will assume this task taps into (verbal) working memory (WM).

In both tasks children had to listen to blocks consisting of sequences of words through head phones. The smallest sequence of words in the forward task was 1 and in the backwards task was 2. After a sequence was played children were asked to repeat the sequence. In the backwards task they had to repeat the words in the reverse order. If a child recalled 4 sequences in a block correctly it would move on to the next block. For each block the number of words that had to be recalled increased with 1. When a child incorrectly recalled 3 sequences within one block the test would stop. The blocks were preceded by two practice items on which children would receive feedback if necessary.

Scoring was as follows: the child received a score similar to the number of words in the sequences of the last block it completely finished. In addition, if the child was able to recall at least 2 sequences correctly in the final block, half a point was added to the child's score. Hence if a child was able to successfully repeat 4 sequences consisting of 3 words in one block and 2 sequences of 4 words in the next block, it would obtain a score of 3,5.

8.7 General procedure

Children were tested individually at a quiet room at their school. The tasks were divided over two sessions. In session 1 each child conducted first the forward word-recall task, than one list of the SPL task and finally one list of the act-out task. In session 2 each child conducted the tasks in the same order as the first session: first the backwards word-recall task, than the lists of the SPL and act-out task that formed a pair with the lists used in the previous session. Before participating, the teachers told the children they were going to play some games. The first test session took generally a couple of minutes longer than the second session. After finishing the tasks children were rewarded with a sticker. At least two weeks were between the two testing sessions for each child to prevent children from remembering the sentences from the first task during the second session. For only one child the intervening period lasted longer than three weeks as she was sick during the final test round and had to be tested for the second time after the Christmas break.

9. Results

9.1 Word span forwards

On the forward word recall task children's performance ranged over a word span from 2 to 5. The total scores and the scores per age group are presented in Table 14. The majority of the 5-year olds had a word span of 3, whereas the majority of the 7-year olds either had acquired a score of 3, 3,5 or 4. Only two 5-year old children are missing from Table 14: the first child was not able to participate in the task as he did not talk and the second child was not able to finish at least the first block of the task succesfully. The mean scores between the two groups were slightly different, with the 5-year olds having a mean word span of 3,14 (N = 18; and σ = ,819) and the 7-year olds of 3,52 (N = 23 and σ = ,612). A One-way ANOVA was conducted to test whether the 7-year olds significantly outperformed the 5-year olds on this task. The difference between the two groups turned out to be insignificant (F = 1,814; and p = ,186). In this study children's forward word span will be assumed to reflect children's STM and will therefore be refered to as STM in the remainder of this chapter.

Table 14

	Word span forwards						
	2	**2,5**	**3**	**3,5**	**4**	**4,5**	**5**
5-years	1	2	8	3	1	1	1
7-years	-	2	6	7	6	1	1
Total	1	4	14	10	7	2	2

Children's scores on the forward word span task for each age group and both age groups combined.

9.2 Word span backwards

Table 15 shows children's performance on the backwards word span task for each age group. Almost all 5-year olds had obtained a backward word span of 2. Only one 5-year old scored higher with a span of 2,5. The backwards word span of the 7-year olds showed more variety with 9 children obtaining a score of 2, 6 children obtaining a score of 2,5 and 7 children having a word span of 3. Four 5-year olds are missing in the table: two children were not able to participate in the task as they refused to speak; and two children were not able to finish at least the first block succesfully. Like for the forward word spans a One-way ANOVA was conducted to test whether scores obtained by both age groups differed. The mean score of the 7-year olds on the backwards word span task was 2,46 (N = 22; and σ = ,129), which was higher than the 5-year olds' mean score of 2,03 (N = 15; and σ = ,033). According to the results of the ANOVA the 7-year olds scored significantly higher than the 5-year olds (F = 13,225; and p = ,001). However, this result should be interpreted with caution as the assumption of a normal distribution of the backwards words span score was not met (Levene Statistic = 27,541; and p = ,000). In this study children's backward word span will be assumed to reflect children's WM and will therefore be refered to as STM in the remainder of this chapter.

Table 15

	Word span backwards		
	2	**2,5**	**3**
5-years	14	1	-
7-years	9	6	7

Total	23	7	7

Children's scores on the backwards word span task for each age group and both age groups combined.

9.3 Act-out task

9.3.1 Accuracy scores

The outcome of the accuracy scores are either 0, indicating an incorrect answer, or 1, indicating a correct answer. Therefore the data is dichotomous and a normal ANOVA cannot be used for analysis unless percentages of some sort are calculated. In order to analyze these data the decision was made to use a logistic regression that can be used with a binary outcome variable. This analysis is used to calculate the probability of either scoring 0 or 1 based on the sentence types compared to the other sentence types.

Adults

The accuracy scores for the adults on the different sentence types of the act out task are shown in Table 16. A first observation is that adults were at ceiling for the singular actives, the plural passives and the singular SRCs. Furthermore, adults were relatively accurate at the plural actives and the plural SRC. Finally, the adults were rather inaccurate on the singular and plural ORC structures compared to the other sentence types.

Table 16

Active		**Passive**		**SRC**		**ORC**	
Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
100	88	73	96	100	88	19	12

Adults' accuracy scores on the act out task for each sentence type in percentages.

In order to test whether there were significant differences between the different sentence types in accuracy, a logistic regression analysis was conducted. Unfortunately, because the adult group was never inaccurate on the singular active and singular SRC sentences, the model could not calculate the odds of being accurate on these sentence types compared to the other categories. However, it is assumed that if the plural passive sentence is significantly different from another category, this difference also holds for the singular actives and SRCs in the same direction, as adults were highly accurate (96%) on the plural passive category as well. Results are shown in Table 17.

First of all, a significant difference was found between each category and the singular and plural ORC structures (except between these two categories). The partial regression coefficient was always negative, indicating that the odds of being accurate decreased for the ORC sentence types compared to the other sentences. Second, there was a difference in adults' accuracy between the singular passive and the plural passive sentences. The partial regression coefficient indicates that adults' performance increased in the plural condition. As adults scored even better on the singular actives and the singular SRCs, the same conclusion is drawn for these two categories as well for the plural passives compared to the singular passives and to the singular and plural ORCs. No other significant differences were found.

Table 17

			Active		**Passive**		**SRC**		**ORC**	
		Intercept	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
Active	Singular	?	x	?	?	?	?	?	?***	?***

	Plural	2,037*** (,614)		x	-1,038 (,757)	1,182 (1,190)	?	,000 (,868)	-3,472*** (,790)	-4,074*** (,868)
Passive	Singular	,999** (,442)			x	2,220** (1,112)	?	1,038 (,757)	-2,434*** (,666)	-3,035*** (,757)
	Plural	3,219*** (1,020)				x	?	-1,182 (1,190)	-4,654*** (1,135)	-5,256*** (1,190)
SRC	Singular	?					x	?	?***	?***
	Plural	2,037 (,614)***						x	-3,472*** (,790)	-4,074*** (,868)
ORC	Singular	-1,435*** (,498)							x	-,602 (,790)
	Plural	-2,037*** (,614)								x

Relations between the different sentence types and their predictive power on adults' accuracy scores. Numbers shown are partial regression coefficients, numbers between brackets the standard error. Note: R^2 = ,423 (Cox & Snell); ,578 (Nagelkerke). Model $X^2(1)$ = 85,88; and p = ,000
*p < 0,1; **p < 0,05; ***p < 0,01

Children

Children's accuracy scores on the act out task are shown in Table 18. A number of initial observations can be made from these data. First of all, children were relatively accurate on the singular active sentences and the singular SRCs, of which they correctly acted out 75% on average. Second, children were highly inaccurate on acting out the ORCs as they scored only 5% out of all singular and plural ORCs correctly. Third, children's performance was around chance level for the plural active sentences and the plural SRCs. Finally, children were rather weak on the singular passive sentences (34%).

Table 18

Active		**Passive**		**SRC**		**ORC**	
Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
75	51	34	61	75	51	5	5

Children's accuracy scores on the act out task for each sentence type in percentages.

When the results are analyzed separately for each age group (see Table 19), it becomes clear that it is mainly the 5-year old group that struggled with the plural active (32%) and the plural passive (47%) sentences on which they performed below chance. The 7-year olds did seem to perform above chance on both sentence types. In addition, the older children were rather accurate on the plural passive sentences (72%), whereas the 5-year olds performed at chance level on this sentence type (47%). Finally, both groups seemed to have difficulties with the singular passives, and the ORC structures.

Table 19

	Active		**Passive**		**SRC**		**ORC**	
	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
5-years	76	32	21	47	66	32	3	3
7-years	74	67	44	72	83	67	7	7

Children's accuracy scores on the act out task for each age group for each sentence type in percentages.

In order to check whether the differences in accuracy between the age groups and sentence types were significant a logistic regression analysis was conducted. In addition to the sentence types and Age, STM and WM were added to the regression model. First of all, Age turned out to be a significant predictor of children's chances of success (B = ,536; S.E. = ,111; and p = ,000). The positiveness of the partial regression coefficient indicates that the chances of being accurate increased for the older age group compared to the 5-year olds. No significant results were found for STM and WM.

In addition, the predictive strength of each sentence type compared to the other sentence types are shown in Table 20. First of all, the results indicate that there was a significant difference between children's performance on the singular active sentences and their performance on the singular passive sentences, the plural SRCs and the singular and plural ORCs. In addition, a marginal difference was found for children's performance on plural passives compared to the active singular sentences. As all the partial regression coefficients are negative, the chances of being accurate were higher for the singular active sentences than for the other sentence types, with the exception of the singular SRCs, as this category was similar to the singular active sentences.

Second, similar effects were found for the singular SRC structure: children performed significantly better on this sentence type than on the plural actives, the singular passives, the plural SRCs and both ORC categories. Like for the singular actives a marginal significant difference was found between the singular SRC structure and the passive plurals: chances of being accurate increased for the singular SRCs compared to the passive plural sentences.

A third finding is that there exists a significant difference between both ORC structures and the other sentence types. The direction of the partial regression coefficient indicates that the chances of being successful decreased for both the singular and the plural ORC structure compared to the other sentence types. No difference was found between the two ORC categories.

Fourth, the plural active sentences were performed significantly different on than on the singular passives. Children were more accurate on the plural actives than on the plural passives. No difference was found between children's performance on the plural actives and the plural SRCs. Neither was there a significant difference between the plural actives and the plural passives.

Other significant effects were found for the singular passives. Children performed better on the plural passives and on the plural SRCs than on the singular passive sentence type, indicated by the positive regression coefficient between these sentence types.

Finally, no significant difference was found between the plural passives and the plural SRCs.

Table 20

			Active		**Passive**		**SRC**		**ORC**	
		Constant	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
Active	Singular	-1,772** (,727)	x	-1,026*** (,346)	-1,801*** (,355)	-,655* (,349)	,000 (,367)	-1,026*** (,346)	-4,204*** (,580)	-4,204*** (,580)
	Plural	-2,797*** (,733)		x	-,775** (,331)	,371 (,326)	1,026*** (,346)	,000 (,323)	-3,178*** (,565)	-3,178*** (,565)
Passive	Singular	-3,572*** (,749)			x	1,146*** (,336)	1,801*** (,355)	,775** (,331)	-2,403*** (,569)	-2,403*** (,569)
	Plural	-2,426 (,728)				x	,655* (,349)	-,371 (,326)	-3,549*** (,567)	-3,549*** (,567)
SRC	Singular	-1,772 (,727)					x	-1,026*** (,346)	-4,204*** (,580)	-4,204*** (,580)
	Plural	-2,797 (,733)						x	-3,178*** (,565)	-3,178*** (,565)
ORC	Singular	-5,975 (,893)							x	,000 (,728)

	Plural	-5,975 (,893)								x

Relations between the different sentence types and their predictive power on children's accuracy scores. Numbers shown are partial regression coefficients, numbers between brackets the standard error. Note: R^2 = ,304 (Cox & Snell); ,407 (Nagelkerke). Model $X^2(1)$ = 237,84; and p = ,000
*p < 0,1; **p < 0,05; ***p < 0,01

As age was a significant predictor of children's accuracy scores, the analysis in the above was repeated for the two age groups separately. As for the 5-year olds only two children did not obtain a score of 2 for the backwards word span task, only STM was included as variable, besides Sentence Type. Results are shown in Table 21. First of all, similar to the previous regression model, a significant difference was found in accuracy scores between the singular active sentences and the plural active, the singular passives, the plural SRCs and the singular and plural ORCs. In addition the difference between the singular actives and the plural passives was marginally significant. The partial regression coefficient was always negative, indicating that chances of being accurate increased in the singular active condition compared to the other sentence categories.

A second finding was that the plural actives only significantly differed from the singular SRC structure and both ORCs. The direction of the partial regression coefficient was positive in the first case, indicating that children's performance increased in the singular SRC condition compared to the plural actives. The effect between the plural actives and both ORCs was negative, which shows that children's chances of being accurate decreased in the ORC structures compared to the plural active condition. In contrast to the previous analysis no significant increase was found in chances of being accurate in the singular passive condition and the plural active condition.

Third, children's performance decreased on the singular passives compared to the plural passives and the singular SRCs. In addition, the chances of being accurate were higher for the singular passives than for both ORC structures. In contrast to the previous analysis no difference was found between the singular passives and the plural SRCs, which is indicative of the 5-year olds being rather inaccurate on the later category compared to the 7-year olds. As in the previous analysis, the plural passives were acted out more accurately than the singular and plural ORCs.

In addition, the previous findings that children were more accurate on the singular SRCs compared to the plural SRCs and the singular and plural ORCs and that the chances of being accurate increased in the plural SRC condition compared to the ORC conditions were repeated.

Finally, no significant difference was found between the two ORC conditions, and neither for the STM variable.

Table 21

			Active		**Passive**		**SRC**		**ORC**	
		Constant	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
Active	Singular	1,333* (,767)	x	-1,793*** (,523)	-2,353*** (,556)	-1,211** (,510)	-,528 (,518)	-1,793*** (,523)	-4,656*** (1,085)	-4,656*** (1,085)
	Plural	-,460 (,746)		x	-,560 (,582)	,582 (,486)	1,264** (,496)	,000 (,500)	-2,863*** (1,074)	-2,863*** (1,074)
Passive	Singular	-1,020 (,768)			x	1,142** (,522)	1,824*** (,530)	,560 (,535)	-2,303** (1,091)	-2,303** (1,091)
	Plural	,122 (,739)				x	,682 (,482)	-,582 (,486)	-3,445*** (1,068)	-3,445*** (1,068)
SRC	Singular	,804 (,747)					x	-1,264** (,496)	-4,127*** (1,072)	-4,127*** (1,072)
	Plural	-,460 (,746)						x	-2,863*** (1,074)	-2,863*** (1,074)

ORC	Singular	-3,323*** (1,206)							x	,000 (1,434)
	Plural	-3,323*** (1,206)								x

Relations between the different sentence types and their predictive power on 5-year old children's accuracy scores. Numbers shown are partial regression coefficients, numbers between brackets the standard error. Note: R^2 = ,263 (Cox & Snell); ,362 (Nagelkerke). Model $X^2(1)$ = 87,851; and p = ,000.
*p < 0,1; **p < 0,05; ***p < 0,01

Finally the analysis was repeated for the 7-year olds, with Sentence Type, STM and WM included in the logistic regression model. The results are shown in Table 22. First of all, the singular active sentences only significantly differ on accuracy scores for the 7-year olds from the singular passives and the singular and plural ORCs. The partial regression coefficient is negative for all these differences, indicating that chances of being accurate increased in the singular active condition compared to the other three sentence types. As the 7-year old group's accuracy increased on the plural actives, the plural passives and the plural SRCs compared to the 5-year old group, no longer was there a significance difference found between the singular actives and these categories.

Like the 5-year olds, the performance of the 7-year olds on the singular passive sentences remained rather poorly, which is reflected by the chances of being accurate increasing for the plural actives, the singular passives, and the singular and plural SRCs (and the singular actives as mentioned before). Similarly, the 7-year olds remained relatively inaccurate on the singular and plural ORCs compared to the other sentence categories: all differences between these two categories and the other sentence types remained significant. No significant difference was found for this age group either between the two ORC categories.

In addition, only a marginally significant difference remained between children's accuracy on the singular SRC structure and the plural SRC structure. Again, this finding is indicative of 7-year old children's increased performance on the plural sentence types compared to the 5-year olds.

Finally, no significant effects were found for either STM nor WM.

Table 22

			Active		**Passive**		**SRC**		**ORC**	
		Constant	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
Active	Singular	1,357 (,906)	x	-,316 (,460)	-1,266*** (,450)	-,110 (,469)	,517 (,514)	-,316 (,460)	-3,706*** (,685)	-3,706*** (,685)
	Plural	1,041 (,898)		x	-,950** (,435)	,206 (,454)	,833* (,096)	,000 (,445)	-3,390*** (,675)	-3,390*** (,675)
Passive	Singular	,091 (,888)			x	1,156*** (,444)	1,783*** (,491)	,950** (,435)	-2,440*** (,668)	-2,440*** (,668)
	Plural	1,247 (,903)				x	,627 (,509)	-,206 (,454)	-3,596*** (,681)	-3,596*** (,681)
SRC	Singular	1,874** (,928)					x	-,833* (,500)	-4,222*** (,713)	-4,222*** (,713)
	Plural	1,041 (,898)						x	-3,390*** (,675)	-3,390*** (,675)
ORC	Singular	-2,349** (1,025)							x	,000 (,845)
	Plural	-2,349** (1,025)								x

Relations between the different sentence types and their predictive power on 7-year old children's accuracy scores. Numbers shown are partial regression coefficients, numbers between brackets the standard error. Note: R^2 = ,309 (Cox & Snell); ,412 (Nagelkerke). Model $X^2(1)$ = 135,481; and p = ,000.

Summarizing, adults were highly accurate on the singular and plural actives and SRCs and were at ceiling in the plural passive condition. Their performance was slightly weaker on the singular passives. In addition, adults were significantly less accurate on the singular and plural ORC structures compared to the other sentence types. A similar pattern was found for the 7-year olds, although this group had overall lower accuracy scores in all categories. Still, their performance on the singular and plural actives and SRCs and the plural passives did not significantly differ, as was found for the adults. In addition their performance on the singular passives was significantly weaker compared to these sentence types. Similarly, the 7-year olds had the weakest performance on the singular and plural ORCs compared to the other sentence categories.

Finally, the 5-year olds deviated somewhat from this pattern. This was probably caused by their overall difficulties with the plural sentence types. Like for the adults and the 7-year olds they scored significantly better on the other sentence types than on the singular and plural ORCs. However, their accuracy scores were significantly lower in the plural active and SRC conditions compared to the singular active and SRC structures. In addition, the 5-year olds scored significantly better on the singular actives than on the plural passives. Which was, again, not found for the adults and the 7-year olds.

9.3.2 Error analysis

As explained in the previous chapter, the focus of the act out task is not so much on children's accuracy on the SRCs and the ORCs, but on their error pattern in each relative clause category. It has been previously argued (as discussed in chapter 5) that children tend to reverse the agent and the patient role in ORCs and, hence, interpret the ORC structure as a SRC structure. If children indeed interpret ORCs as SRCs, regardless of the differences in number on the embedded auxiliary, three predictions can be made. First of all, the "role-reversal error" should only occur in the ORC condition and not – or only rarely – occur in the SRC condition. Hence, it should be found that ORCs, are often interpreted as SRCs, but not in the reverse direction. So, the SRC in example (69) is predicted to be interpreted as in (71) and not, or only rarely, as in (72). The ORC in example (70) is also predicted to be interpreted as in (71) and only rarely as in (72). In order to test the first prediction, the number of role reversal errors will be compared between the different relative clause categories.

(69) De leeuw die de apen aan het borstelen is.
the lion-SG that the monkeys-PL brushing is-SG
"The lion that is brushing the monkeys."

(70) De leeuw die de apen aan het borstelen zijn.
the lion-SG that the monkeys-PL brushing are-PL
"The lion that the monkeys are brushing."

(71) Correct SRC response: 1 lion brushes 2 or 3 monkeys.

(72) Correct ORC response: 2 or 3 monkeys brush 1 lion.

Second, a similar amount of SRCs correctly acted-out to ORCs interpreted as SRCs should be found in the data. Hence, responses on SRCs are classified as "SRC" when an SRC such as in example (69), is correctly interpreted, such as in (71). Responses on ORCs are classified as "SRC" when they are interpreted as its SRC variant. This would mean for the ORC in (70), that it would be interpreted like the SRC in (69), hence such as in example (71). If all SRCs would be correctly acted out and all ORCs interpreted as their corresponding SRC sentence, all relative clauses tested should be categorized as "SRC".

And third, the type of the left-over errors – all error types except the "role-reversal error" – should be similar in amount for the ORCs as for the SRCs if children would no use different strategies to deal with the number agreement between their presupposed subject and the auxiliary. Except for the role reversal error, three other common error types were found in the data for the relative clasues – for the ORCs often in combination with the role reversal error – : (1) number errors, indicating that for one type of animal in a sentence children used the wrong amount of animals to act out the sentence; (2) number reversal errors,

indicating that children switched singular and plural number of the two animal types in a sentence; and (3) one-to-one matching, which means that a child used animal 1 of type x to do something to animal 1 of type y, and animal 2 of type x to do something to animal 2 of type y[13]. An example of the possible errors are given for sentence (73).

(73) De leeuw die de apen aan het borstelen is. the lion-SG that the monkeys-PL brushing is-SG "The lion that is brushing the monkeys."	
Correct interpretation	1 lion is brushing 2 or 3 monkeys
Number error	2 lions are brushing 2 or 3 monkeys / 1 lion is brushing 1 monkey
Number reversal	2 or 3 lions are brushing 2 or 3 monkeys
One-to-one matching	1 lion is brushing 1 monkey and another lion is brushing another monkey
Role reversal	2 or 3 monkeys are brushing 1 lion

Adults

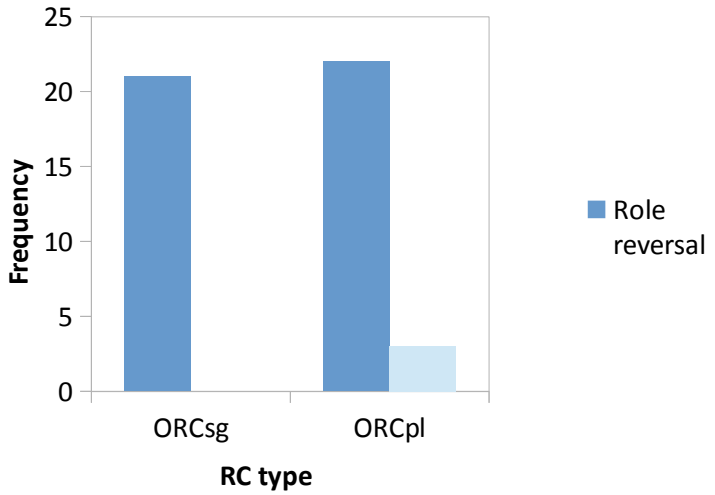
The amount of role reversal errors observed in the individual relative clause categories for the adults is reported in Table 23. Adults made no role reversal errors in the SRC conditions, whereas the majority of sentences in the ORC conditions (82,7%) were incorrectly acted out with the agent in the patient role and vice versa. These findings are further supported by the proportion of the different error categories in the ORC conditions: 87,8% of the errors were constituted by the role reversal category.

Table 23

	SRC		**ORC**	
	Singular	Plural	Singular	Plural
Amount of role reversal errors	-	-	21 (80,8%)	22 (84,6%)
Total	-		43 (82,7%)	

Amount and percentages of role reversal errors in the SRC and the ORC condition.

Figure 3



13 This error type could also be classified as a number error as the singular animal type in these sentences is interpreted as plural. However, as these errors show a specific strategy children use – namely repeating a certain action with different animals – this error is classified separately.

Amount of role reversals and other errors in the ORCsg and the ORCpl condition for the adults.

In Table 24 the number of "SRC" observations are given for each relative clause category. The ORCs acted out correctly were excluded from these data. This table clearly shows that there is no real difference in the relative amount of "SRC" responses between the relative clause pairs – between the SRC singular and the ORC singular and between the SRC plural and the ORC plural.

Table 24

	SRC		**ORC**	
	Singular	Plural	Singular	Plural
Adults	100	88	100	87

The amount of sentences marked "SRC" in each condition in percentages.

Finally, the different kinds of errors adults made was further looked into. Apart from the role reversal errors, adults made (1) number errors, and (2) number reversal errors. Only few errors other than role reversals were made by the adults in the act out task. The total amount of number and number reversal errors was 6, of which three were found in the plural SRC condition and three in the plural ORC condition – no errors other than role reversal errors were made in the singular SRC and ORC conditions. All errors were number reversal errors, except for one number error in the plural SRC condition. Hence, no real difference was found for the error types different than the role reversal error between conditions.

Children

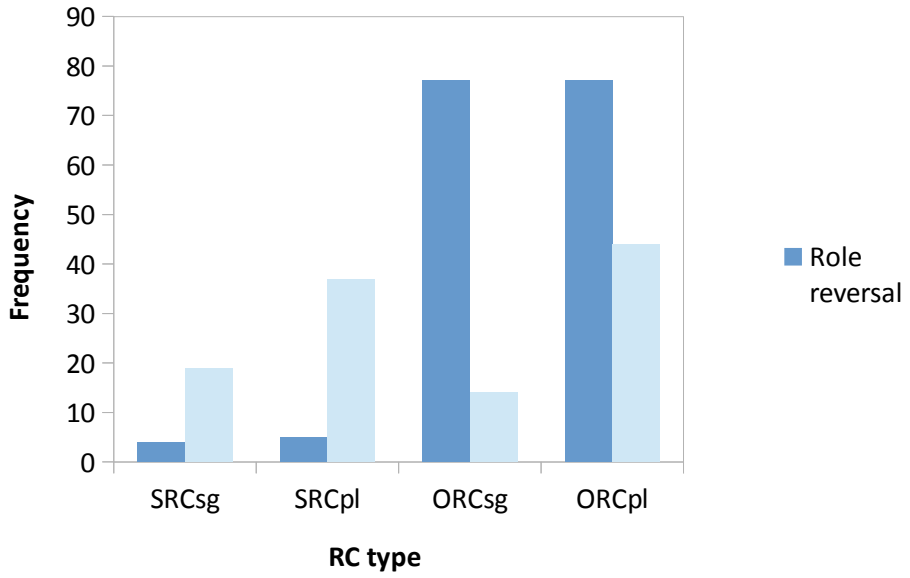
The number of role reversal errors children made are represented in Table 25. When looking at the distribution of role reversal errors it is immediately clear that this type of error is almost absent in the SRC conditions. Out of the 172 SRCs children were asked to act out, children incorrectly interpreted the agent to be the patient and vice versa 9 times (5,2%). For the same amount of ORCs children acted out, the incorrect agent-patient interpretation was found in 154 cases (89,5%). The rarity of the role reversal error in the SRC conditions is further illustrated in Figure 4, as the role reversal error only constitutes a small proportion of the total amount of errors. On the other hand, for the ORCs, the majority of errors children made are role reversal errors.

Table 25

	SRC		**ORC**	
	Singular	Plural	Singular	Plural
Amount of role reversal errors	4 (4,7%)	5 (5,8%)	77 (89,5%)	77 (89,5%)
Total	9 (5,2%)		154 (89,5%)	

Amount and percentages of role reversal errors in the SRC and the ORC condition.

Figure 4



Amount of role reversals and other errors in each relative clause condition for the children.

For the second prediction, the amount of SRC interpretations in the SRC and the ORC conditions are compared. In Table 26 the number of SRC interpretations for each relative clause category for each age group is given. Remember that the singular SRC condition forms a pair with the singular ORC condition, like the plural SRC and the plural ORC conditions as they only differ in terms of RC type as expressed on the embedded auxiliary. At first sight the same amount of sentences of both members of both SRC-ORC pairs seem to be interpreted as "SRC" by the children. This observation was confirmed by a logistic regression analysis as no significant difference was found between the singular SRC condition and the singular ORC condition and between the plural SRC condition and the plural ORC condition. The regression analysis was repeated for the separate age groups, but no significant differences were found between the SRC-ORC pairs.

Table 26

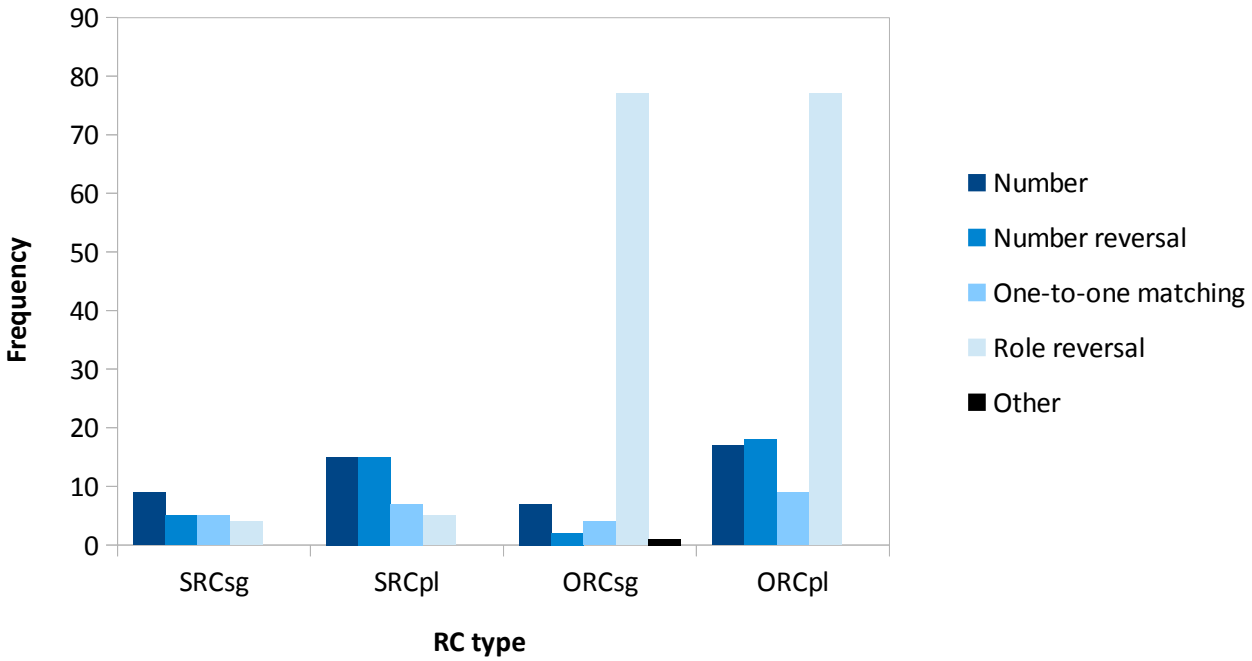
	SRC		**ORC**	
	Singular	Plural	Singular	Plural
5-years	66	32	76	34
7-years	83	67	85	52
Total	75	51	81	44

The amount of sentences marked "SRC" for each condition for each age group in percentages.

Finally, the different type of errors children made is further looked into. The distribution of the different error types is illustrated by Figure 5. As mentioned earlier, the role reversal error is clearly the most frequent error in the ORC conditions. In this section I will focus on the other error types, regardless of role reversal errors. From a first observation it seems that little errors, besides the role reversal error, are made in the singular SRC and singular ORC conditions. In the plural SRCs and the plural ORCs the majority of errors, apart from the role reversal errors, seems to be caused by number reversals and number errors. The question remains whether there exists a significant difference between the amount of different error types between the relative clause pairs (the singular SRCs versus the singular ORCs and the plural SRCs versus the plural ORCs). In order to test this a Pearson's chi-square test was conducted as frequency of categories had to be compared. The results of the chi-square should be interpreted with caution as the two categories

number reversal and one-to-one matching in the singular ORC condition contained less than 5 occurrences. The outcome of the analysis was insignificant, indicating that the relative clause condition did not influence the amount of errors.

Figure 5



Amount of error types for each RC type.

As the small amounts of errors in the singular ORC condition might have influenced the outcome of the chi-square – one assumption of this test is that the frequency in each cell is at least 5 – the analysis was repeated for the plural SRCs and plural ORCs only, which, again, turned out to be insignificant. No further comparison was done between the singular SRC and singular ORC categories due to the small frequency of errors in the last category. However, it should be clear from observing the figures in Figure 2 and the numbers in Table 27 that there is little difference in the number of error types other than the role reversal error between the singular SRC and ORC condition.

Table 27

	SRC		**ORC**	
	Singular	Plural	Singular	Plural
Number	9	15	7	17
Number reversal	5	15	2	18
One-to-one matching	5	7	4	9

Amount of error types for each RC type.

In summary, although children made relatively more errors that were not role reversals, the patterning of the different error types on the SRCs and ORCs and participants' general behaviour on the act out task was similar for the children and the adults. First of all, the majority of errors made by both groups were role reversal errors. Second, in almost all ORC conditions acted out, role reversal errors were made by both adults and children. However, role reversal errors were (almost) absent in the SRC conditions.

Another finding for both groups was that relatively the same amount of SRCs was given the correct SRC interpretation as was found for the corresponding ORC sentences (although the SRC interpretation is not correct for these sentence types). Hence, regardless of the number information on the auxiliary, which is different between the SRCs and the ORCs that form a pair, children and adults interpreted the same amount of SRCs and ORCs similarly.

A final finding was that errors other than role reversals were equally scarce in the corresponding SRC and ORC conditions. As was mentioned before, there was a difference here between the children and the adults as in that 'other errors' were almost absent in the adult group, whereas some of the errors were still relatively frequently made by the children. However, the children still patterned similarly to the adults as no significant difference was found for the amount of errors in the different error categories between the singular SRC and the singular ORC, and the plural SRC and the plural ORC categories.

9.4 Self-paced listening task

9.4.1 Accuracy scores

Adults

Adults' mean accuracy scores on the active and passive sentences and the sentences containing a relative clause are presented in Table 28. It shows that adults performed highly accurate on the singular and plural active sentences as well as on the passive and SRC structures. Only their performance on the ORCs was below chance. This indicates that adults correctly interpreted the active, passive and SRC sentences, but not the ORC structure.

Table 28

Active		**Passive**		**SRC**		**ORC**	
Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
96	93	91	88	86	85	37	33

Adults' accuracy scores on the act out task for each sentence type in percentages.

In order to further analyze the results a logistic regression analysis was performed. Table …. shows the partial regression coefficients and their potential significance. First of all, a difference in performance was found between the comprehension questions belonging to the singular active sentences and the questions belonging to the plural passive sentences, the singular and plural SRCs and the singular and plural ORCs. The negative partial regression coefficients in the model with the singular active sentences as indicator indicate that the chances of being accurate decreased for other sentence types compared to the singular active condition.

In addition to these results, the chances of answering a sentence correctly were higher for each sentence type compared to the singular and plural ORC sentences, as indicated by the negative coefficients in Table 29. The odds of answering a comprehension question correctly belonging to a singular ORC were equal to answering an plural ORC question correctly. Furthermore, no differences in chances of answering the questions correctly were found between the other sentence types.

Table 29

			Active		**Passive**		**SRC**		**ORC**	
		Constant	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
Active	Singular	3,135*** (,457)	x	-,623 (,624)	-,791 (,536)	-1,190** (,534)	-1,320** (,540)	-1,401*** (,536)	-3,668*** (,502)	-3,859*** (,505)
	Plural	2,512***		x	-,168	-,566	-,697	-,778	-3,045***	-3,236***

		(,424)			(,508)	(,506)	(,513)	(,509)	(,472)	(,476)
Passive	Singular	2,345*** (,280)			x	-,399 (,393)	-,529 (,402)	-,610 (,396)	-2,877*** (,348)	-3,068*** (,353)
	Plural	1,946*** (,276)				x	-,131 (,399)	-,211 (,393)	-2,478*** (,345)	-2,670*** (,350)
SRC	Singular	1,815*** (,288)					x	-,081 (,402)	-2,348*** (,355)	-2,539*** (,360)
	Plural	1,735*** (,280)						x	-2,267*** (,348)	-2,459*** (,353)
ORC	Singular	-,532** (,207)							x	-,192 (,299)
	Plural	-,724*** (,215)								x

Relations between the different sentence types and their predictive power on adults' accuracy scores. Numbers shown are partial regression coefficients, numbers between brackets the standard error. Note: R^2 = ,245 (Cox & Snell); ,373 (Nagelkerke). Model $X^2(1)$ = 246,645 ; and p = ,000.
*p < 0,1; **p < 0,05; ***p < 0,01

Children

In Table 30 children's mean accuracy scores on the different sentence types are presented. It clearly shows that children in general did not perform at ceiling on the comprehension questions of any of the sentence types. Furthermore, children seem to perform slightly better on the singular active and passive sentences and the SRCs than on the other sentences. When looking at the 7-year olds, they seemed to perform better on the singular active sentences than the 5-year olds.

Table 30

	Active		**Passive**		**SRC**		**ORC**	
	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
5-years	58	45	63	45	55	59	43	46
7-years	70	51	56	46	57	52	41	50
Total	66	48	58	46	56	55	42	48

Children's accuracy scores on the act out task for each sentence type in percentages.

A logistic regression analysis was performed in order to look for differences between accuracy scores per sentence category. The variables Age, STM and WM were included as covariates. Table 31 shows the partial regression coefficients and their potential significance. First of all, children significantly performed better on comprehension questions belonging to the active sentences than to other sentence types, except for the singular passive sentences, in which the coefficient is only marginally significant. All the partial regression coefficients in the model with the singular active sentence type as indicator are negative, indicating that the chances of being accurate decreased for other sentence types compared to the singular active condition.

Second, the marginal positive partial regression coefficient found for the passive singular sentence type compared to the plural active sentences suggests that children performed better on the first sentence type than on the second. No difference in chances of answering the comprehension questions correctly were found between the plural active sentences and the remaining sentence types.

In addition to the odds of answering the questions correctly being in favor of the singular passive sentences compared to the plural active sentences, children's chances of being accurate were significantly lower for the plural passive sentences and the singular ORC sentences – and marginally significantly lower

for the plural ORC sentences – compared to the passive singular sentences. Furthermore, the chances of being accurate on the comprehension questions were marginally significantly lower for the plural passive sentences than for the singular and the plural SRCs. No differences in chances were found between the singular passives and the SRCs, or the plural passives and the ORCs.

Furthermore, a significant difference was found between the singular SRCs and the singular ORCs: the chances of being accurate increased in the SRC structure compared to the ORCs. In addition, a significant decrease in chances of answering accurately were found in the singular ORC condition compared to the plural SRC condition. No significant differences in odds were found between the SRC conditions and the SRC and ORC plural. In addition, chances of being accurate did not increase or decrease between the singular and plural ORC structures. Finally, neither Age, STM, nor WM turned out to be a significant predictor of children's performance on the comprehension questions belonging to any of the sentence types.

Table 31

			Active		**Passive**		**SRC**		**ORC**	
		Constant	Singular	Plural	Singular	Plural	Singular	Plural	Singular	Plural
Active	Singular	,445 (,411)	x	-,742*** (,217)	-,380* (,195)	-,798*** (,204)	-,444** (,206)	-,429** (,207)	-,972*** (,207)	-,751*** (,207)
	Plural	-,297 (,408)		x	,362* (,203)	-,056 (,212)	,298 (,213)	,313 (,214)	-,230 (,214)	-,009 (,214)
Passive	Singular	,065 (,409)			x	-,418** (,189)	-,064 (,192)	-,049 (,193)	-,592** (,192)	-,370* (,193)
	Plural	-,353 (,409)				x	,354* (,200)	,369* (,201)	-,174 (,201)	,047 (,201)
SRC	Singular	,001 (,998)					x	,015 (,203)	-,528** (,203)	-0,307 (,203)
	Plural	,016 (,403)						x	-,543** (,204)	-0,322 (,204)
ORC	Singular	-,306 (,404)							x	-,221 (,204)
	Plural	-,527 (,402)								x

Relations between the different sentence types and their predictive power on children's accuracy scores. Numbers shown are partial regression coefficients, numbers between brackets the standard error. Note: R^2 = ,021 (Cox & Snell); ,028 (Nagelkerke). Model $X^2(1)$ = 33,998 ; and p = ,000.
*p < 0,1; **p < 0,05; ***p < 0,01

In summary, adults were highly significant on the comprehension questions belonging to all sentence types in the self-paced listening task except for the questions belonging to the ORCs. Second, adults performed significantly better on the questions belonging to the singular actives than the questions belonging to the plural passives and the singular and plural SRC structures. This final pattern was more or less similar for the children, except that this last group also performed significantly better on the singular actives compared to the plural actives. In addition, children were less accurate on the singular ORC construction compared to the singular and plural SRCs and the singular passives (and the singular actives as mentioned earlier). Furthermore, children were significantly less accurate on comprehension questions belonging to the plural passives than to the singular passives. The same effect was marginally significant for the plural passives compared to the singular and plural SRCs. Finally, children were marginal significantly more accurate on the singular passives than on the plural ORC structure. Hence, the main difference between children and adults on the comprehension question in this task was that adults were highly accurate on all sentence types except the ORCs, whereas children were rather inaccurate overall and only

few significant differences were found between the ORCs and other sentence types.

9.4.2 RTs

As discussed in chapter 8, participants had to listen to sentences that were cut into segments. At the end of each segment they had to press a button in order to start the next segment. In this chapter the RTs on the different segments of the experimental sentences will be analyzed. Remember that these sentences were divided over 9 segments. In Table 32 an example is given of each relative clause condition. Briefly repeated, segment 1, segment 2, segment 4, segment 6 and segment 8 are similar in each condition. Segment 3, segment 5 and segment 9 vary between the singular and plural conditions. Finally, segment 7 varies between the SRC and the ORC conditions. Hence, sentences are similar between the SRCsg and the SRCpl, and the ORCsg and the ORCpl conditions except for the number feature on segment 3, segment 5 and segment 9, and they are similar between the SRCsg and the ORCsg, and the SRCpl and the ORCpl conditions except for the number feature on segment 7.

Table 32

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
SRCsg	Ik zag I saw	dat that	de leeuw the lion-SG	die that	de honden the dogs-PL	aan het wassen washing	is is-SG	door het bos through the forest	wandelde walked-SG
	I saw that the lion that is washing the dogs walked through the forest.								
SRCpl	Ik zag I saw	dat that	de leeuwen the lions-PL	die that	de hond the dog-SG	aan het wassen washing	zijn are-PL	door het bos through the forest	wandelden walked-PL
	I saw that the lions that are washing the dog walked through the forest.								
ORCsg	Ik zag I saw	that dat	de leeuw the lion-SG	die that	de honden the dogs-PL	aan het wassen washing	zijn are-PL	door het bos through the forest	wandelde walked-SG
	I saw that the lion that the dogs are washing walked through the forest.								
ORCpl	Ik zag I saw	dat that	de leeuwen the lions-PL	die that	de hond the dog-SG	aan het wassen washing	is is-SG	door het bos through the forest	wandelden walked-PL
	I saw that the lions that the dog is washing walked through the forest.								

Example of a quartet of sentences used in the self-paced listening task.

For the analysis of the RTs per segment a Mixed Linear Model (MLM) was conducted. There are a number of advantages of using a MLM over an ANOVA. Relevant for the present study is that MLM can deal with dependent data. This is important because the RT data collected contain repeated measures for the same subjects on the same sentences in different conditions and repeated measures on the same sentences in different conditions for different subjects. A normal Repeated Measures ANOVA would not be able to deal with these dependencies. Another advantage of the MLM is its ability to cope with missing values. Again this is important for this data set as part of the data is excluded as explained above (see Quené & van den Bergh (2014) for a detailed description of the advantages of using MLM with data from repeated measures designs).

Adults

After each participant finished the self-paced listening task, E-Prime provided the total RTs for each segment, including the duration of the sound files. In order to compare the RTs for different sentences, residuals were calculated by extracting the duration of each sound segment from the total RT. As the experiment would occasionally skip a segment after a participant pressed the button, every RT in the same sentence after a skip occurred was excluded. This resulted in the exclusion of less than 0,01% of all RTs for

the adults. Then, the resulting residual RTs were searched for extreme and negative values. Initially, the amount of 3000ms would be used as a cut-off point by excluding all RTs above this value. However, the segments from the critical segment 7 on often contained residuals above 3000ms not distributed evenly across conditions. Taken the three final segments together a value above 3000ms was found 24 times for SRC structures versus 46 times for ORC structures. As some of the adults explained after the testing session that they needed some time to figure out which animal did what, I assume that RTs from the critical segment above 3000ms should not just be regarded as extreme values as they actually seem to reflect the time (some of the) adults needed to process the sentences. Therefore the decision was made to regard RTs above 10.000ms in segment 7, 8 and 9 as extremes and to exclude these. From segment 1 to segment 6 3000ms was maintained as cut-off point.

In addition, RTs below -300ms were excluded from the data set. Negative values arise when participants press the button before the end of a segment. Hence, the duration of the sound is longer than the total RT, resulting in participants not listening to the entire sound segment. The decision not to exclude all negative data has to do with participants' behaviour in this experiment. 711 out of 3600 residual RTs were negative, which constitutes almost 20% of the data. Almost half of the negative values were found in the first two segments (312 negative RTs). This is not very surprising as the first two segments were similar for all the sentences in the task - “I saw” and “that” - and participants could already predict during these two segments what they were going to hear. Two other segments containing many negative values were the VP “being V-ing” (segment 6) and the PP (segment 8), which were relatively long in duration. Adults might have pressed early at these segments as these were not informative on the order of the actions performed in the relative clauses, which the participants needed to know in order to answer the comprehension question at the end of the sentence. Finally, a little over 20% of the negative values were found in segment 3 (DP1) and segment 5 (DP2). A first reason for this might be that in all sentences, including the fillers, the DPs were presented in these two segments and their presence was therefore more or less predictable. Second, many singular DPs ended on a fricative and all the plural ones on a schwa and -n. In the first case the fricative sound at the end of the animal name often persisted for a while before the sound segment ended. Participants might have pressed the button immediately or soon after the beginning of the fricative, resulting in negative RTs. In addition, in plural Dutch nouns ending on a schwa and -n the final -n is often dropped in spoken language. This also might explain some of the negative values on segment 3 and 5. Based on the distribution of the negative values over the segments and on the considerations discussed here the decision was made not to exclude all negative RTs: only those below -300ms.

Using the criteria described above less than 3% of the residual RTs were excluded. From the resulting RTs outliers were calculated. A value was considered an outlier when it was at least 2,5 times below or above the mean of the residual RTs for a particular segment and condition. As a result, an additional number of 167 RTs was excluded. In total less than 6% of all adult data was excluded from the analysis.

Analysis

In order to test whether adult's RTs were influenced by the condition of the sentences a MLM was conducted with RC type, Number and the interaction between RC type and number as fixed factors and Subject and Sentence as random subject variables. The model was build in three steps: (1) containing fixed effects only; (2) a random intercept with Subject as subject variable added; and (3) a random intercept with Sentence as subject variable added. For each model the (marginally) significant main effects and interactions will be reported.

In model (1) Number was found to be a significant predictor of adults' RTs on segment 5 (F = 2,568; and p = ,000). The direction of this effect was positive (b = 321,79; t = 3,679; and p = ,000), indicating that adult's responded faster on segment 5 to singular sentences compared to plural sentences. Second, a significant main effect was found for RC type on segment 7 (F = 4,251; and p = ,040). This effect had a positive slope (b = 701,18), indicating that adult's responded faster on segment 7 to SRCs than to ORCs. In addition Number was a marginal significant predictor of adult's RTs on this segment (F = 2,872; and p = , 091). The direction of this effect (b = 577,23; t = 1,695; and p = ,091) suggests that adult's responded faster

on segment 7 to singular sentences than to plural sentences. No other significant main effects or interactions were found for this model.

For model (2) a similar main effect was found on segment 5 for Number (F = 15,913; and p = ,000), which had again a positive slope (b = 326,79; t = 3,989; and p = ,000). The significant main effect for RC type on segment 7 was also repeated in this model (F = 9,758; and p = ,002). In addition, Number was found to be a highly significant predictor of adult's RTs on this segment (F = 8,003; and p = ,005). Both main effects had a positive slope (RC type: b = 828,23; t = 3,124; and p = ,002; and Number: b = 752,07; t = 2,829; and p = ,005), indicating that adults responded faster on segment 7 to singular sentences than to plural sentences and faster to SRCs than to ORCs. Furthermore, the interaction between RC type and Number turned out to be significant on the same segment (F = 5,961; and p = ,015). In addition, a marginal significant main effect of RC type was found on segment 8 (F = 3,015; and p = ,083). The slope of this effect was positive (b = 166,47; t = 1,736; and p = ,083), suggesting that adults responded faster on segment 8 to SRCs than to ORCs. No main effects or interactions were found in model (2) on the other segments. Finally, the slopes significantly varied across participants on each segment (see Table 33).

For model (3) Number continued to be a significant predictor of adult's RTs on segment 5 with a positive slope (F = 17,244; b = 321,23; t = 4,153; and p = ,000). Also similar results to model (2) were obtained for segment 7, with RC type (F = 9,988; and p = ,002) and Number (F = 7,974; and p = ,005) as highly significant main effects and a significant interaction between RC type and Number (F = 5,992; and p = ,015). As previous the direction of the effect of RC type (b = 821,71; t = 3,160; and p = ,002) and Number (b = 736,28; t = 2,824; and p = ,005) was positive. Furthermore, RC type remained a marginal significant predictor of adult's RTs on segment 8 (F = 3,201; and p = ,075) with a positive slope (F = 168,58; t = 1,789; and p = ,075). Finally, the slopes significantly varied across sentences on segment 2, segment 3, segment 5, segment 7 and segment 8 only (see Table 33).

Table 33

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	14597,78	159,63**	532,55	3,46
Segment 2	23162,29	179,78**	1022,69	5,97*
Segment 3	16411,58	95,06**	2111,99	10,92**
Segment 4	10448,24	106,56**	-	,00
Segment 5	10235,09	25,08**	7520,51	24,85**
Segment 6	9379,96	43,51**	104,88	,040
Segment 7	501531,82	138,37**	27503,76	5,41*
Segment 8	23207,43	49,49**	2914,32	4,22*
Segment 9	117141,84	87,51**	2893,36	,72

Estimates for Subject and Sentence as random subject effects for each segment.
*p < ,05; **p < ,01

In order to further investigate the interaction between RC type and Number on segment 7, the dataset was split up into singular and plural sentences and these were analyzed separately for this segment only. Again a mixed model was used to analyze the data with RC type as fixed effect and Subject and Sentence added as random subject effects. Model (1) contains only RC type as fixed effect, model (2) reports results with the inclusion of Subject as random subject effect and to model (3) Sentence is added as random subject effect. First the models will be discussed for the singular sentences, second the plural dataset will be analyzed.

For the singular sentences a significant main effect was found in model (1) on segment 7 for RC type

(F = 5,888; and p = ,016). Like previous, the slope of this effect was positive (b = 370,93; t = 2,427; and p = , 016), indicating that adults responded faster to SRCs than to ORCs in the singular condition on segment 7. This effect became stronger in model (2) (F = 10,937; and p = ,001) and remained positive (b = 407,95; t = 3,307; and p = ,001). The slopes significantly varied on segment 7 across participants in this model (Estimate = 418103,59; X^2 = 48,19; and p < ,01). Finally, these results did not change in model (3) as Sentence as random subject effect turned out to be redundant and the model remained similar to model (2).

In the plural condition, model (1) did not yield RC type as significant main effect on segment 7. This did not change in model (2), although slopes did significantly vary across participants (Estimate = 64,37; X^2 = 64,37; and p < ,01). RC type remained insignificant as a predictor in model (3). In addition slopes did not significantly vary across sentences in this model.

In the analysis above all experimental sentences were included, irrespective of participants' responses on the comprehension question after the sentence. Usually sentences in a self-paced listening task conducted by adults are only considered for analysis when their corresponding question is answered correctly. There are two reasons why all sentences are considered in the analysis above. First of all, because the overall accuracy data has shown that the adults did pay attention to the task, as their accuracy scores for all sentence types except the ORCs were (almost) at ceiling. They were in general rather inaccurate though on the ORC sentences. If only correctly answered sentences would have been considered, the majority of RTs from ORCs would have had to be discarded, even though there is no reason to assume that adults did not pay attention to these sentences in particular. Second, the child data, as will be discussed below, will be considered in total as well, regardless of children's performance on the comprehension questions. In order to keep all things equal to compare adults' and children's RTs, the same strategy was used for the adult data.

However, in order to check whether similar results would be obtained as in the earlier analysis, an additional analysis has been conducted with RTs of sentences of which the corresponding comprehension question was answered correctly. Like in the previous models for the whole dataset Number was found to be a significant predictor of adults RTs on segment 5 (F = 5,073; and p = ,025). The slope of this effect was positive (b = 222,46; t = 2,252; and p = ,025), indicating that adults were predicted to respond faster on segment 5 to singular sentences than to plural sentences. In addition, a significant main effect was again obtained for RC type on segment 7 (F = 4,315; and p = ,039). The direction of this effect was again positive (b = 994,56; t = 2,077; and p = ,039), indicating that adults responded faster on segment 7 to SRCs than to ORCs. No other significant main effects or interactions were found for model (1).

In model (2), the main effect of Number on segment 5 was maintained (F = 6,408; and p = ,012). The slope of the effect remained positive (b = 231,30; t = 2,531; and p = ,012). On segment 7 a main effect was found for RC type (F = 9,738; and p = ,002) and Number (F = 8,991; and p = ,003). Both effects had positive slopes (RC type: b = 1085,95; t = 3,121; and p = ,002; and Number: b = 910,75; t = 2,999; and p = ,003), indicating that adults responded faster on segment 7 to SRCs than to ORCs and to singular sentences than to plural sentences. In addition a significant interaction was found between RC type and Number (F = 5,901; and p = ,016). No other significant main effects or interactions were found in this model. In model (2) slopes varied significantly across participants as shown in Table (34).

Finally, in model (3) Number remained a significant main effect on segment 5 (F = 7,488; and p = , 007) with a positive slope (b = 239,90; t = 2,736; and p = ,007). The results obtained in model (2) on segment 7 were also repeated in this model, with RC type (F = 9,161; and p = ,003) and Number (F = 8,035; and p = ,005) as significant predictors of adult's RTs on segment 7 in a positive direction (RC type: b = 1033,32; t = 3,027; and p = ,003; and Number: b = 844,67; t = 2,835; and p = ,005) and complicated by a significant interaction between RC type and Number (F = 5,365; and p = ,022). The slopes varied significantly across sentences on segment 5, segment 7 and segment 8 (see Table 34). No main effects or interactions were found for model (3) on other segments.

Table 34

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**

Segment 1	15988,20	109,20**	740,15	3,26
Segment 2	23978,28	122,31**	654,32	1,84
Segment 3	21765,52	61,70**	614,97	,54
Segment 4	9722,90	50,90**	-	,00
Segment 5	10821,09	17,37**	5170,86	8,88**
Segment 6	6840,55	11,25**	-	,00
Segment 7	554422,94	107,38**	32246,60	3,92*
Segment 8	17953,32	38,31**	3845,69	5,45*
Segment 9	102915,56	44,81**	2138,00	,15

Estimates for Subject and Sentence as random subject effects for each segment.
*p < ,05; **p < ,01

Children

As described above, residual RTs were calculated by extracting the duration of the sound files from the total RTs. In addition, skipped segments and segments following these 'skips' were excluded from the data. This resulted in the exclusion of 1,2% of the data of the children. Again, the resulting dataset was searched for negative and extremes values. Similar criteria for negative and extreme values as for the adult data set were used for the children. RTs were excluded when they were below -300ms or above 3000ms. As there were relatively few RTs above 3000ms on the final segments, these were excluded as well, unlike for the adults. This resulted in the exclusion of less than 6% of the remaining data. Again, outliers were calculated based on 2,5 times the standard deviation below or above the average RT per segment per condition. These values were removed from the dataset as well. Following these criteria less than 8,5% of the data was excluded.

Like for the adults a MLM analysis was used to analyze the data. First, the analysis of the whole data set, including the data from all children, will be presented. Then, the data will be split up based on the age, STM and WM of the children. Only (marginally) significant effects and interactions will be reported in more detail. Before STM and WM were added to the model, children were divided into groups based on their memory scores to facilitate further analyses. Children were divided into three STM groups: the low STM group contained the children who scored 2,5 or 3 on the forward word span task; the medium STM group contained all children who had a score of 3,5; and the the high STM group consisted of children who had a forward word span of 4 or higher. Children who were not able to participate in the forward word span task or scored below 2,5 were not included in these groups (2 children). As the majority of the children had a similar score on the backward word span task, children were divided over only two WM groups: a low WM group with children who had a backward word span of 2; and a high WM group with children who obtained a score of 2,5 or 3 on the backward word span task. By doing so, 5 children, who either were not able to do the task, or who failed to successfully finish the first block were excluded from further analysis.

Table 35

	Low STM *2,5 - 3*		**Medium STM** *3,5*		**High STM** *> 3,5*	
	5-years	7-years	5-years	7-years	5-years	7-years
N	10	8	3	7	3	8
Total	18		10		11	

Amount of 5-year old and 7-year old children in each STM group.

Table 36

	Low WM *2*		High WM *2,5 - 3*	
	5-years	7-years	5-years	7-years
N	14	9	1	13
Total	23		14	

Amount of 5-year old and 7-year old children in each WM group.

For the total data set the outcomes of 8 different stages of the model will be described for each segment. Stage (1) only contains the two conditions RC type and Number as main effects and the interaction between RC type and Number. In model (2) and (3) Subject and Sentence are included as random Subject effects. In model (4), (5) and (6) either Age, STM or WM respectively are added to stage (3) as a main effect and with all possible interactions included. In model (7) and (8) model (4) is expanded with STM and WM respectively as main effect including all possible interactions. It should be noted that some of the interactions result in comparisons between relatively small groups (for example including the 5-year old medium/high STM or 5-year old high WM group). Therefore findings for the whole data set described below should be interpreted with caution.

Finally, no model with RC type type, Number, Age, WM and STM was constructed. This has to do with the fact that Age, STM and WM are correlated (see Table 37). The correlations between Age and STM and Age and WM are found to be weak and the correlation between Age and WM is moderate. In addition, the resulting interactions if all three variables would be included would led to the comparison of relatively small groups. As all correlations between Age, WM and STM were found to be significant and the comparison of small groups would not be beneficial no model was build containing all variables.

Table 37

	Age	**STM**	**WM**
Age		,213*	,524*
STM			,297*
WM			

Pearson's correlations between children's Age, STM and WM.
*p < ,01

In model (1) a significant main effect for Number was found on segment 5 (F = 9,432; and p = ,002). As the direction of the effect was positive (b = 220,36; t = 3,071; and p = ,002), children were predicted to respond faster to singular sentences on segment 5 when slopes are assumed to be equal between subjects and sentences. On segment 9 condition 3 was found to be a marginally significant predictor of children's RTs (F = 3,112; and p = ,078). The direction of this effect was negative (b = 104,88; t = -1,764; and p = ,078) suggesting that children responded faster to segment 9 when a sentence was in the plural condition compared to singular sentences when slopes are assumed to be equal between subjects and sentences. No significant effects were found on other segments in model (1).

The inclusion of Subject as random subject effect in model (2) again yielded a significant, and slightly stronger, main effect on segment 5 for the number condition (F = 12,207; and p = ,001). In this model the slopes significantly varied across participants (Estimate = 29416,28; X^2 = 144,85; and p < ,01). The direction of the effect was positive again (b = 216,95; t = 3,494; and p = ,001) indicating that participants were predicted to react faster on segment 5 when the sentences were singular than when they were plural. Number on segment 9 remained marginally significant in model (2) (F = 3,161; and p = ,076) and the direction of the effect remained negative (b = -93,74; t = -1,778; and p = ,076). This suggested again that participants were predicted to respond faster on segment 9 when the sentence was plural than when the sentence was singular. The slopes on this segment significantly varied across participants (Estimate = 16252,67; X^2 = 116,78; and p < ,01). For the other segments, no significant main effects or interactions were

found, although all models significantly improved with the addition of Subject as random subject effect, indicating that slopes significantly varied across participants on all segments (see table 38).

In model (3) the effect of Number on segment 5 became more strongly significant (F = 12,775; and p = ,000) and remained positive (b = 213,30; t = 3,574; and p = ,000). Slopes significantly varied across sentences on this segment (Estimate = 6273,86; X^2 = 39,54; and p < ,01). In addition, the main effect of Number on segment 9 became almost significant in model (3) (F = 3,769; and p = ,053). The slope remained negative (b = -99,046878; t = -1,941; and p = ,053), indicating that children were predicted to respond faster on segment 9 to sentences in the plural condition than sentences in the singular condition. No main effects or interactions were found for the other segments. In addition to segment 5 and 9, the slopes significantly varied across sentences on segment 3, segment 6 and segment 8 (see Table 38).

Table 38

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	43667,61	203,45*	1123,56	2,84
Segment 2	26577,94	167,82*	382,47	,69
Segment 3	29360,48	173,39*	1645,70	7,59**
Segment 4	20348,66	152,21*	-	,00
Segment 5	29416,28	144,85*	6273,86	39,54**
Segment 6	31761,11	160,50*	1522,59	6,58*
Segment 7	25907,62	135,06*	227,74	,26
Segment 8	21582,48	131,38*	4369,47	34,07**
Segment 9	16252,67	116,78*	3786,11	32,79**

Estimates for Subject and Sentence as random subject effects for each segment.
*p < ,05; **p < ,01

In stage (4), Age was added to model (3), as well as all possible interactions between Age, RC type and Number. Results show that Age was a significant predictor on segment 6 (F = 5,432; and p = ,020). The direction of the effect was positive (b = -201,16; t = -2,331; and p = ,020). Hence, 7-year old children were predicted to respond faster to segment 6 than the 5-year olds. A similar effect was found on segment 8, with Age being a significant predictor of RTs (F = 4,998; and p = ,026). As the direction of the effect was negative again (b = -196,73; t = -2,236; and p = ,026) 7-year olds were predicted to respond faster than the 5-year olds on segment 8 as well. No other significant main effects or interactions were found for model (4).

Model (5) is similar to model (4), except that Age is replaced by STM. Like in model (1), (2) and (3) a significant main effect was found on segment 5: Number was a significant predictor of RTs (F = 8,647; and p = ,003). Like for the previous results on segment 5, the effect was found to be positive (b = 435,34; t = 2,941; and p = ,003), indicating that the singular sentences are predicted to be responded to faster than the plural sentences on segment 5. In addition all main effects and interactions on segment 6 were found to be (marginally) significant. The corresponding F-values and significance levels are shown in Table 39. Number was found to be a significant predictor of children RTs on segment 6. Furthermore, the interactions between RC type and STM, and Number and STM were also found to be significant. The interactions found on segment 6 will be further investigated below by separately analyzing the STM groups.

Table 39

	F
RC type	3,605*

Number	4,788**
STM	3,112*
RC type x Number	3,175*
RC type x STM	4,494**
Number x STM	5,063**
RC type x Number x STM	3,231*

Overview of main effects and interactions and their significance for segment 6.
* p < ,1; * p < ,05

The analysis of segment 7 revealed that RC type significantly predicted children's RTs at this segment (F = 4,408; and p = ,036). The positive slope of the effect (b = 309,07; t = 2,099; and p = ,036) indicated that children responded faster to SRCs than to ORCs on segment 7. In addition, the interaction between RC type and STM approached significance (F = 3,224; and p = ,073). Like for segment 6, this interaction will be looked at in more detail later in this chapter. For the other segments, no main effects or interactions were found.

In model (6) STM was replaced by WM. The only significant effect found was for RC type on segment 7 (F = 3,951; and p = ,047). On this segment the assumption that the slopes varied across sentences was left out of the model as this turned out to be redundant. The slope of the effect found was again positive (b = 377,37; t = 1,988; and p = ,047) indicating that children responded faster on segment 7 in the SRC condition than in the ORC condition. Also a marginally significant interaction between RC type and WM was found (F = 3,226; and p = ,073), which will be further investigated below. In addition, WM turned out to be a marginally significant predictor of children's RTs on segment 8 (F = 2,886; and p = ,090). As its slope is negative (b = -332,28; t = -1,699; and p = ,090) children in the high WM group were predicted to respond faster on segment 8 than children in the low WM group.

Model (7), containing RC type, Number, Age and STM as fixed effects and all possible interactions between them, yielded (marginally) significant results at segments 1, 4 and 6. At segment 1 a marginally significant interaction was found between Number and STM (F = 2,733; and p = ,099). At segment 4 almost all main effects and interactions were found to be significant, as shown in Table 40. In addition a number of (marginally) significant effects and interactions were found on segment 6 (Table 41). Like in the previous models, the effects and interactions found will be looked at in more detail later in this chapter.

Table 40

	F
RC type	3,964**
Number	4,639**
Age	1,441
STM	4,779**
Age x STM	4,531**
RC type x Number	5,131**
RC type x Age	3,712*
Number x Age	4,464**
RC type x Number x Age	5,404**
RC type x STM	6,164**
Number x STM	6,819***

RC type x Number x STM	6,848***
RC type x Age x STM	5,967**
Number x Age x STM	6,940***
RC type x Number x Age x STM	7,280***

Overview of main effects and interactions and their significance for segment 4.
*p < ,1; ** p < ,05; *** p < ,01

Table 41

	F
RC type	2,397
Number	3,560*
Age	,134
STM	2,529
Age x STM	1,574
RC type x Number	4,480**
RC type x Age	1,501
Number x Age	2,271
RC type x Number x Age	3,369*
RC type x STM	3,994**
Number x STM	4,898**
RC type x Number x STM	4,855**
RC type x Age x STM	2,805*
Number x Age x STM	3,504*
RC type x Number x Age x STM	3,868*

Overview of main effects and interactions and their significance for segment 6.
*p < ,1; ** p < ,05

Finally, the same steps were repeated for model (8) with STM being replaced for WM. No significant main effects or interactions were found in this model.

In order to further investigate the data, the dataset was split up in groups, based on Age (5- and 7-year olds), STM (low, medium and high) and WM (low and high). First, results for each age group will be described. Then the results based on each STM and WM group will be presented. Similar to the larger data set the different stages of the model will be described: first the model with only RC type and Number as fixed effects and the interaction between RC type and Number; then model (2) and (3) with Subject and Sentence as random subject variables respectively; and finally, in the analyses for the age groups, first model (4) with STM and all possible interactions added will be described and then a similar model (5) in which STM is replaced with WM.

As the majority of the younger children were categorized in the low STM group (N = 10) the 5-year olds were reclassified into STM groups. Two groups were created: a low STM group containing children who scored either 2,5 or 3 at the forward word span task; and a high STM group containing the children who had a forward word span above 3. As especially the highest group is small in number of participants (N = 6) results of the analysis should be interpreted with caution. As 14 out of the 15 5-year olds that were able to

successfully conduct the backwards word span task had the same score, for this group no further analysis was done with WM as variable.

Table 42

	Low STM *2,5 - 3*	**High STM** *> 3*
N	10	6

Amount of 5-year old children in the Low and High STM groups.

For the 5-year olds a significant main effect of Number was found on segment 5 in model (1) (F = 4,109; and p = ,043). The slope of the effect was positive (b = 234,83; t = 2,027; and p = ,043) indicating that sentences in the singular condition were responded to faster than sentences in the plural condition on segment 5. No other effects were found in model (1). A similar, but stronger effect was found in model (2) on segment 5 (F = 5,625; and p = ,018) in the same direction (b = 243,57; t = 2,372; and p = ,018). Slopes varied significantly across participants on segment 5 and all other segments (see Table 43). Again, no main effects or interactions were found on the other segments. The main effect of Number on segment 5 persisted in model (3) (F = 5,823; b = 240,82; t = 2,413; and p = ,016). Slopes varied across sentences on segment 5, segment 8 and segment 9 only (see Table 43). No other main effects or interactions were found for model (3).

Table 43

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	45474,61	82,418**	-	,00
Segment 2	20648,05	52,74**	465,21	,20
Segment 3	25436,26	53,94**	-	,00
Segment 4	10113,94	30,92**	-	,00
Segment 5	30856,77	50,62**	5584,13	8,37*
Segment 6	39819,66	57,35**	2693,52	2,70
Segment 7	22119,18	36,48**	-	,00
Segment 8	21085,11	40,28**	4448,96	8,24*
Segment 9	13190,68	29,67**	5413,46	12,76*

Estimates for Subject and Sentence as random subject effects for each segment in model (2) en (3).
*p < ,05; **p < ,01

Finally, in model (4) STM was added to stage (3). This model yielded significant results on segment 4, with Number (F = 3,972; and p = ,047) and STM (F = 4,430; and p = ,036) being significant predictors of children's RTs. In addition, the interactions between Number and STM (F = 4,444; and p = ,036) and RC type and STM (F = 4,784; and p = ,030) were found to be significant. Furthermore, the main effect of RC type was found to be marginally significant (F = 3,421; and p = ,065), as were the interactions between RC type and Number (F = 2,845; p = ,093) and RC type x Number x STM (F = 3,759; and p = ,054). To further investigate these interactions on segment 4, the data set was further split up into a low and a high STM group of 5-year olds. A model was created for each data set with RC type and Number and the interaction between RC type and Number as fixed effects. Subject and Sentence were included as random subject effects. No significant main effects or interactions were found for either group on segment 4. Only for the high STM group RC type (F = 3,331; and p = ,071), Number (F = 3,106; and p = ,081) and RC type x Number (F = 2,898; and p = ,092)

were marginally significant.

Other significant effects for model (4) were found on segment 6. RC type (F = 4,010; and p = ,046), Number (F = 4,938; and p = ,027) and the interactions between RC type and Number (F = 5,415; and p = , 021), RC type x STM (F = 4,671; and p = ,032), Number x STM (F = 5,012; and p = ,026) and RC type x Number x STM (F = 5,122; and p = ,024) were found to be significant predictors of children's RTs. In addition a marginally significant effect was found for STM (F = 2,994; and p = ,085). Like for segment 4, the interactions were looked at into more detail by repeating the analysis with RC type and Number and the interaction between RC type and Number with Subject and Sentence as random subject effects for each STM group. Again, no significant effects were found for the analysis with the individual STM groups on segment 6. In the low STM group the interaction between RC type and Number was only found to be marginally significant (F = 3,054; and p = ,082) and in the high STM group a marginal significant main effect was found for RC type (F = 2,979; and p = ,087). No other significant main effects or interactions were found in model (4) for the 5-year olds.

The analysis described above was repeated for the 7-year olds. A similar distribution for the STM groups as for the whole data set was used for the older children. This resulted into three STM groups more or less similar in size: low STM (N = 8); medium STM (N = 7); and high STM (N = 8). In addition three groups were created based on children's performance on the backwards word span task. The low WM group contained children that had a backward word span of 2 (N = 9), the medium WM group consisted of data belonging to children that scored 2.5 (N = 6), and finally the high WM group contained the children that had a score of 3 on the task (N = 7).

Table 44

	Low STM *2,5 - 3*	**Medium STM** *3,5*	**High STM** *> 3,5*
N	8	7	8
	Low WM *2*	**Medium WM** *2,5*	**High WM** *3*
N	9	6	7

Amount of 7-year old children in the different STM and WM groups.

For model (1), only containing RC type and Number and the interaction between the two conditions as fixed effect, Number was found to be a significant predictor of children's RTs on segment 5 (F = 5,459; and p = ,020). The direction of the effect was found to be positive (b = 200,35; t = 2,336; and p = ,020), which indicated that children respond faster on segment 5 when the sentences were singular compared to the plural sentences. In addition, Number was also found to be an almost significant predictor of children's RTs on segment 9 (F = 3,708; and p = ,055). In contrast to the effect found on segment 5, the slope of the Number effect on segment 9 was found to be negative (b = -133,30; t = -1,926; and p = ,055), which indicated that the 7-year olds responded faster on segment 9 when the sentences were in the plural condition than when they were singular. No other significant main effects or interactions were found in model (1).

In model (2) Subject was added as random subject effect. Again a significant, but stronger, main effect was found for Number on segment 5 (F = 6,414; and p = ,012). The slope of the effect was again positive (b = 193,42; t = 2,533; and p = ,012). Furthermore, Number remained marginally significant at segment 9 (F = 3,824; and p = ,051). The slope of the effect was negative again (b = -123,93; t = -1,956; and p = ,051). In addition, slopes significantly varied across participants on all segments (see Table 45). No further main effects or interactions were found on the other segments.

Table 45

	Subject	**Sentence**

	Estimate	X^2	Estimate	X^2
Segment 1	23064,90	66,01**	2942,98	5,72*
Segment 2	19542,10	66,23**	-	,00
Segment 3	21098,77	78,94**	4118,31	15,34**
Segment 4	19913,84	75,35**	-	,00
Segment 5	17840,38	62,26**	6264,72	23,63**
Segment 6	16219,02	75,23**	330,07	,32
Segment 7	13285,97	46,32**	714,99	,93
Segment 8	14121,49	63,86**	3810,63	18,08**
Segment 9	9183,58	44,94**	2591,91	12,1**

Estimates for Subject and Sentence as random subject effects for each segment in model (2) and (3).
*p < ,05; **p < ,01

In model (3) Sentence was added as random subject effect. In this model Number turned out to be an even stronger predictor of children's RTs on segment 5 (F = 7,072; and p = ,008). The direction of this effect was in the same direction as in the previous models (b = 193,62; t = 2,659; and p = ,008), indicating that the 7-year olds responded faster on segment 5 when the sentences were in the singular condition compared to the sentences in the plural condition. With the introduction of Sentence as random subject effect, Number became a significant predictor of children's RTs on segment 9 (F = 4,164; and p = ,042). The direction of this effect continued to be negative (b = -125,75; t = -2,041; and p = ,042), again indicating that 7-year olds respond faster to plural sentences than to singular sentences on segment 9. Slopes significantly varied across sentences only on segment 1, segment 3, segment 5, segment 8 and segment 9.

After adding STM and all possible interactions as mixed effects, model (4) was analyzed. On segment 4 the interactions between RC type and Number (F = 2,832; and p = ,093) and the interaction between RC type, Number and STM (F = 3,493; and p = ,062) became marginally significant. The interactions were studied into more detail by analyzing the STM groups separately for the 7-year olds. Again a mixed model was build with RC type and Number and the interaction between RC type and Number as fixed effects and Subject and Sentence as random subject effects. For none of the STM groups significant effects or interactions were found on segment 4. In addition, no main effects or interactions were found for the other segments in model (4).

For model (5), in which STM was replaced by WM, marginal significant effects and interactions were found on segment 1 and 5. For segment 1 the interaction between Number and WM became marginally significant (F = 2,879; and p = ,091). In order to further investigate this interaction the WM groups were analyzed separately using the same mixed model leaving out WM as fixed effect and all possible interactions with WM. No significant main effects or interactions were found within the WM group on segment 1. In addition, for segment 5 Number was a marginal significant predictor of children's RTs (F = 2,969; and p = , 086). The direction of this effect was again positive (b = 325,25, t = 1,723; and p = ,086) indicating that children responded faster to sentences in the singular condition than in the plural condition on segment 5. No other main effects or interactions were found for model (5).

The lack of significant results in model (4) and (5) might be caused by the relatively small STM and WM group. Therefore, the analysis was repeated for both models with children being recategorized into two groups for both variables. The low STM group remained the same and contained the children that scored either 2,5 or 3 on the forwards word span task (N = 8) and the high STM group consisted of the children that had a higher forward word span than 3 on the task (N = 15). The low WM group also remained the same, containing the children that had a score of 2 on the backward word span task (N = 9). The high WM group consisted of the children that had a backward word span above 2 (N = 13). Model (6) contains the new high STM group and all possible interactions in addition to stage (3) and model (7) contains the new high WM groups and all possible interactions in addition to stage (3).

Table 46

	Low STM *2,5 - 3*	**High STM** *> 3*
N	8	15
	Low WM *2*	**High WM** *> 2*
N	9	13

Amount of children in the Low and High STM and WM groups.

For model (6) marginal significant interactions were found between RC type and Number (F = 3,101; and p = ,079), between Number and STM (F = 2,973; and p = ,085) and between RC type, Number and STM (F = 3,513; and p = ,062) on segment 4. In order to further investigate these interactions, the data from the low and the high STM groups were analyzed separately. The same mixed model was used except that STM and all its interactions were excluded from the analysis. For neither of the data sets significant results were obtained. In addition, in model (6) Number was found to be an almost significant predictor of children's RTs on segment 5 (F = 3,426; and p = ,065). As previous the slope of this effect was positive (b = 483,68; t = 1,851; and p = ,065), indicating that singular sentences were responded faster to by the 7-year olds than plural sentences on segment 5. Furthermore, a significant main effect was found for RC type on segment 7 (F = 4,076; and p = ,044), a marginal main effect for STM (F = 2,737; and p = ,099) and an almost significant interaction between RC type and STM (F = 3,764; and p = ,053). The slope of RC type as main effect was positive (b = 546,45; t = 2,019; and p = ,044), indicating that 7-year olds were predicted to respond faster to SRCs than to ORCs on segment 7. The marginal significant effect of STM had a positive direction as well (b = 419,25; t = 1,654; and p = ,099), which suggested that the 7-year olds in the low STM group responded faster on segment 7 than the children in the high STM group. Like for segment 4, the interaction was further investigated by separately analyzing the STM groups. The mixed model yielded an almost significant main effect of RC type in the low STM group (F = 3,612; and p = ,059) with a positive slope (b = 242,98; t = 1,901; and p = ,059). No significant main effects or interactions were found on the other segments for model (6).

For model (7) the analysis yielded a marginal significant main effect for RC type (F = 3,162; and p = , 076) and a marginal significant interaction between RC type and WM (F = 3,211; and p = ,074) for segment 7. The direction of the main effect was positive (b = 469,72; t = 1,778; and p = ,076), indicating that children responded faster on segment 7 when the sentence was a SRC than when the sentence was an ORC. In order to further investigate the interaction on segment 7, the mixed model without WM was repeated for the separate WM groups. In the low STM group a marginal significant interaction was found between RC type and Number (F = 2,762; and p = ,098) on segment 7. This interaction was also studied in more detail by splitting up the data set into singular and plural sentences. This did not yield any (marginal) significant results. In addition no other significant main effects or interactions were found in model (7).

In the remainder of this section results will be given of the separate analyses of each STM and WM group, regardless of children's age. The same categories as used in the analysis of the whole data set were used for this purpose. The categories and the number of participant in each group are repeated in Table 47. Like for the other analyses first the bare model will be described with only RC type and Number and the interaction between the two variables as fixed effects. In model (2) Subject and in model (3) Sentence are added as random subject effects.

Table 47

	Low STM *2,5 - 3*		**Medium STM** *3,5*		**High STM** *> 3,5*	
	5-years	7-years	5-years	7-years	5-years	7-years

N	10	8	3	7	3	8
Total	18		10		11	

Amount of 5-year old and 7-year old children in the Low, Medium and High STM groups.

Table 48

	Low WM *2*		**High WM** *2,5 - 3*	
	5-years	7-years	5-years	7-years
N	14	9	1	13
Total	23		14	

Amount of 5-year old and 7-year old children in the Low and High WM groups.

For model (1) of the low STM group, Number was found to be a significant predictor of children's RTs on segment 5 (F = 6,707; and p = ,010). The slope of this effect was positive (b = 115,42; t = 1,022; and p = ,010), indicating that children in the low STM group responded faster on segment 5 to sentences in the singular condition compared to sentences in the plural condition. In addition, a significant main effect of RC type was found on segment 7 (F = 4,760; and p = ,030). The slope of this effect was also positive (b = 239,07; t = 2,182; and p = ,030), indicating that children in the low STM group responded faster on segment 7 to SRCs than to ORCs. Furthermore, the interaction between RC type and Number was approaching significance for segment 7 as well (F = 2,820; and p = ,094). No other significant main effects or interactions were found for this model.

For model (2) segment 5 yielded a significant main effect of Number (F = 12,906; and p = ,000), with again a positive slope (b = 324,93; t = 3,593; and p = ,000). Second, RC type remained a significant predictor of children's RTs on segment 7 (F = 5,094; and p = ,025) with a positive slope (b = 211,56; t = 2,257; and p = , 025). In addition Number became marginally significant as main effect on segment 7 for this model (F = 2,817; and p = ,094) as well as the interaction between Number and RC type (F = 2,855; and p = ,092). The slopes significantly varied across subjects for each segment (see Table 49). No other significant main effects or interactions were found.

Model (3) yielded similar results to the previous two models: Number was a significant predictor of children's RTs on segment 5 (F = 13,135; and p = ,000) and the positive slope was maintained (b = 324,84; t = 3,624; and p = ,000). Second, results found in model (2) on segment 7 were exactly similar to the ones obtained in model (3) as the addition of sentence as random subject effect did not make changes to the model. Furthermore, slopes did only significantly vary across sentences on segment 8 and segment 9.

Table 49

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	47411,34	89,64**	1343,10	,863
Segment 2	29213,04	85,22**	-	,00
Segment 3	31165,66	80,53**	-	,00
Segment 4	20599,24	76,51**	-	,00
Segment 5	44448,66	100,21**	1555,32	1,67
Segment 6	46366,41	90,01**	2077,36	2,64
Segment 7	34158,76	66,21**	-	,00
Segment 8	28729,90	68,64**	3541,77	7,34**

Segment 9	22432,85	63,68**	4096,45	9,793**

Estimates for Subject and Sentence as random subject effects for each segment in model (2) and (3).
*p < ,05; **p < ,01

Model (1) for the medium STM group did not yield any significant main effects or interactions. The same was true for model (2) and (3). For model (2) slopes significantly varied across participants for each segment. For model (3) slopes only significantly varied across sentences on segment 5 (see Table 50).

Table 50

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	11018,93	11,06**	-	,00
Segment 2	7938,57	8,31**	-	,00
Segment 3	9009,87	12,76**	3018,79	2,616
Segment 4	19753,46	31,84**	347,64	,05
Segment 5	11500,98	12,98**	6392,68	5,84*
Segment 6	12041,62	18,08**	-	,00
Segment 7	12502,59	18,10**	1911,22	1,18
Segment 8	14606,72	23,29**	1640,53	,97
Segment 9	11009,55	18,59**	2572,38	2,51

Estimates for Subject and Sentence as random subject effects for each segment in model (2) and (3).
*p < ,05; **p < ,01

Similar to the analysis for the medium STM group, no significant main effects or interactions were found in model (1) of the analysis of the high STM group. For model (2) only a marginal significant main effect was found on segment 6 for RC type (F = 2,753; and p = ,099). The direction of the effect was negative (b = -181,40; t = -1,659; and p = ,099), suggesting that children responded faster on segment 6 to ORCs than to SRCs. The slopes varied across participants for each segment (see Table 51). The same marginal significant effect found for segment 6 in model (2) was found in model (3) as the addition of Sentence as random subject effect did not change the model. Only on segment 5, 8 and 9 slopes significantly varied across sentences (see Table 51).

Table 51

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	35495,38	45,166**	2632,75	1,18
Segment 2	27235,03	39,77**	-	,00
Segment 3	31563,48	45,82**	-	,00
Segment 4	20613,44	29,30**	-	,00
Segment 5	22769,56	26,38**	13987,02	18,23**
Segment 6	22594,09	37,40**	-	,00
Segment 7	19005,44	26,23**	-	,00
Segment 8	17135,02	36,23**	4289,57	6,51*

Segment 9	4749,20	7,57**	3785,56	6,39*

Estimates for Subject and Sentence as random subject effects for each segment in model (2) and (3).
*p < ,05; **p < ,01

The absence of significant results for the medium and high STM groups might be caused by the small group sizes. Therefore, the medium and high group were grouped together (N = 21) and the analysis was repeated for the larger group. In model (1) a marginal significant main effect of Number was found on segment 5 (F = 3,595; and p = ,059). The direction of this effect was positive (b = 184,17; t = 1,896; and p = , 059), indicating that children responded faster on segment 5 to sentences in the singular condition than to sentences in the plural condition. In addition a similar marginal effect was found on segment 9 (F = 3,125; and p = ,078), although in the opposite direction (b = -132,89; t = -1,768; and p = ,078). This suggested that children responded faster on segment 9 to plural sentences than to singular sentences.

In model (2) Number was again a marginal significant predictor for children's RTs on segment 5 (F = 3,573; and p = ,060) and on segment 9 (F = 3,101; and p = ,079). The direction of the effect on segment 5 remained positive (b = 168,25; t = 1,890; and p = ,060) and the direction on segment 9 remained negative (b = -124,26; t = -1,761; and p = ,079). Slopes varied significantly across participants on all segments (see Table 52). Finally, in model (3) the marginal significant main effect of Number on segment 5 was found again (F = 3,293; and p = ,070). The slope of the effect was positive (b = 152,69; t = 1,815; and p = ,070). The marginal significant main effect of Number on segment 9 became stronger in this model (F = 3,550; and p = ,060). The direction of the effect remained negative (b = -128,43; t = -1,884; and p= ,060). For model (3) the slopes varied significantly across sentences on segment 3, segment 5, segment 8 and segment 9 (see Table 52).

Table 52

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	22635,19	57,73**	250,67	,06
Segment 2	16639,37	45,20**	-	,00
Segment 3	19904,20	61,11**	2361,45	5,01*
Segment 4	19193,19	60,69**	-	,00
Segment 5	16469,48	38,92**	9400,19	26,35**
Segment 6	18412,84	60,78**	200,92	,07
Segment 7	15305,76	44,69**	-	,00
Segment 8	5932,34	56,54**	3463,59	11,6**
Segment 9	7338,22	25,62**	3605,69	14,48**

Estimates for Subject and Sentence as random subject effects for each segment in model (2) and (3).
*p < ,05; **p < ,01

For the low WM group, model (1) yielded a significant main effect of Number on segment 5 (F = 7,263; and p = ,007). The direction of this effect was positive (b = 249,54; t = 2,695; and p = ,007), indicating that children in the low WM group responded faster on segment 5 to singular sentences than to plural sentences. In addition, RC type was found to be a marginal significant predictor of children's RTs on segment 7 (F = 3,328; and p = ,069). The slope of this effect was positive (b = 170,78; t = 1,824; and p = ,069), suggesting that children responded faster on segment 7 to SRCs than to ORCs.

In model (2) Number remained a significant predictor of children's RTs on segment 5 (F = 7,800; and p = ,005). The effect had the same direction as in model (1) (b = 239,07; t = 2,793; and p = ,005). RC type was again marginally significant as a main effect on segment 7 (F = 3,184; and p = ,075) and the direction of the effect remained positive (b = 147,59; t = 1,784; and p = ,075). Finally, in model (3) Number was again

found to be a significant main effect on segment 5 (F = 8,088; and p = ,005) with a positive slope (b = 238,36; t = 2,844; and p = ,005). The marginal significant main effect found on segment 7 in model (2) did not change in model (3) as Sentence as random subject effect turned out to be redundant for this segment and therefore the addition of it did not change the model on this segment. Furthermore, the slopes did vary significantly across sentences on segment 5, segment 6, segment 8 and segment 9 in model (3).

Table 53

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	23229,09	52,79**	1305,54	1,24
Segment 2	17632,00	63,99**	493,16	,43
Segment 3	17981,86	58,80**	453,30	,32
Segment 4	9077,39	33,84**	-	,00
Segment 5	15247,57	36,06**	4090,65	9,04**
Segment 6	15521,68	38,30**	2235,19	4,18*
Segment 7	25951,22	61,72**	-	,00
Segment 8	25201,24	88,49**	3013,98	9,50**
Segment 9	17786,87	77,02**	3172,47	12,29**

Estimates for Subject and Sentence as random subject effects for each segment in model (2) and (3).
*p < ,05; **p < ,01

Finally the same models were build for the high WM group. In model (1) Number was found to be a significant predictor of children's RTs on segment 5 (F = 5,651; and p = ,018). The direction of this effect was positive (b = 271,05; t = 2,377; and p = ,018), indicating that children in this group also responded faster on segment 5 to singular sentences than to plural sentences. No other significant main effects or interactions were found for model (1). Similarly, in model (2) Number was found to be a significant main effect on segment 5 (F = 6,048; and p = ,015). The direction of the effect was again positive (b = 252,00; t = 2,459; and p = ,015). In addition, the slopes varied across participants on each segment (see Table 54). Finally, in model (3) similar results on segment 5 were found: Number was again a significant predictor of children's RTs (F = 5,710; and p = ,018) and the slope of the effect remained positive (b = 234,88; t = 2,390; and p = ,018). Slopes varied significantly across sentences on segment 5, segment 8 and segment 9. No other significant main effects or interactions were found in model (2) and (3).

Table 54

	Subject		**Sentence**	
	Estimate	**X^2**	**Estimate**	**X^2**
Segment 1	27797,27	59,68**	124,22	,011
Segment 2	21832,20	38,84**	-	,00
Segment 3	24841,31	58,64**	1819,12	2,19
Segment 4	11122,31	61,99**	-	,00
Segment 5	18686,43	33,87**	6327,28	10,88**
Segment 6	19984,41	53,78**	1230,90	1,18
Segment 7	17098,10	34,60**	-	,00

Segment 8	12892,42	26,48**	4742,36	9,97**
Segment 9	5476,69	10,58**	3077,87	5,76*

Estimates for Subject and Sentence as random subject effects for each segment in model (2) and model (3).
*p < ,05; **p < ,01

Summarizing, a number of mixed models were constructed to analyze the RTs of different groups of adults and children. For the adults a significant main effect was found for Number on segment 5. The direction of the effect indicated that adults responded faster on segment 5 to singular sentences than to plural sentences. In addition, significant main effects were found for RC type and Number on segment 7. The direction of these effects indicated that adults responded faster on segment 7 when they were listening to SRCs compared to when they were listening to ORCs, and they responded faster whey they were listening to singular sentences compared to plural sentences. These effects were complicated by a significant interaction between RC type and Number on the same segment. The interaction was the result of singular SRCs being responded to faster on segment 7 by the adults than singular ORCs. Finally, a marginally significant main effect of RC type was found on segment 8, which indicated that adults responded faster on segment 8 to SRCs than to ORCs. These results, except for the marginal significant effect on segment 8 were repeated in the analysis in which only sentences where included of which the comprehension questions were answered accurately.

For the dataset including all children, significant results were found on segment 4, 5, 6, 7 and 8. On segment 4 a number of main effects and interactions were found for the complex model that included RC type, Number, Age and STM and all possible interactions. More or less the same results were found again for the 5-year olds and seem to be caused by the 5-year olds (N = 6) who were classified into the high STM group. In addition, some interactions on segment 4 turned out to be significant for the 7-year olds as well, again influenced by STM. When for both age groups the participants were further split up into STM groups to investigate the interactions, no significant effects could be found.

Second, children's RTs on segment 5 were found to be predicted by Number for the whole dataset: children responded faster on segment 5 when the sentence was singular than when the sentence was plural. This result was highly persistent throughout the analyses: it was maintained during different stages of the mixed models and for different groups of participants.

Third, the results found on segment 6 for the whole dataset are rather similar to those on segment 4. In the model in which RC type, Number and STM are included and the most complex model with RC type, Number, STM and Age (most of) the main effects and interactions on this segment were found to be significant. These effects seem to be caused by the RTs of the 5-year olds: in the separate age group analyses most main effects and interactions on segment 6 turn out to be significant again for the 5-year olds in the model that includes RC type, Number and STM. When the data is further split up into STM groups, the significant effects disappear on this segment. In addition, an age effect was found for the whole dataset on segment 6 in the model including RC type, Number and Age, indicating that the 5-year olds responded slower on segment 6 than the 7-year olds.

Furthermore, in both the model including RC type, Number and STM as the model including RC type, Number and WM for the whole dataset RC type was found to be a significant predictor of children's RTs on segment 7. For both models the slope of this effect was positive, indicating that children are predicted to respond faster on segment 7 to SRCs than to ORCs. This effect appeared again for the 7-year olds, in the second model including STM and was marginally significant for the same group in the second model containing WM. In addition this effect turned out to be significant in all the models for the low STM group and the low WM group.

A last significant effect found in the analysis of the whole dataset was on segment 8. Age significantly predicted children's performance on segment 8 in the model containing RC type, Number and Age: younger children were found to respond faster on this segment than the older children. No other significant results were found on segment 8 in the other analyses.

In addition to the effects found on the segments described above, a main effect of Number was found on segment 9 for the 7-year olds in the model containing RC type and Number as fixed effects and

Subject and Sentence as random subject effects. The direction of the effect indicated that children are predicted to respond faster on segment 9 to plural sentences than to singular sentences. This effect appeared more often for different datasets, although only marginally significant: in model (1), (2) and (3) of the whole dataset; in model (1) and (2) of the 7-year olds; and in all the models of the medium and high STM groups combined.

Finally, for all datasets the slopes varied significantly across participants for each segment. In addition, slopes also varied across sentences on some of the segments for some of the datasets.

10. Discussion

In this final chapter the results found will be discussed: first the results of the act-out task, and second for the self-paced listening task. First the results for the adults will be reviewed as these set the baseline to compare the outcomes for the children with. Then the results found for the children will be discussed.

10.1 Act-out task

The main goal of the act-out task was to stimulate participants to give their interpretation of the relative clause structures tested. In contrast to other recent studies with relatives clauses disambiguated by number marking on the relative clause verb/auxiliary, no set number of possible answers were presented in the present study: participants were free to act out any possible sequence of actions that they thought corresponded to the sentences tested.

Accuracy scores showed that the adults performed (almost) at ceiling on all sentence categories in the act-out task, except on the singular and plural ORC structures. This could be indicative that the comprehension of Dutch ORCs remains problematic into adulthood, or that the set-up of the act-out task did not optimally stimulate participants to get to the correct ORC interpretation. I would like to argue that the poor performance of the adults on the ORC structure is a combination of both. First of all, the correct responses on the ORCs in the act-out task belong to two participants that “got it”. The other 11 participants incorrectly acted out these sentences. The fact that two participants did get it right, indicates that the task did at least not completely prevent participants from deriving at the right interpretation.

Although the adults were highly inaccurate in acting out the ORCs, they did seem to notice the difference between the ORC structure and the SRC structure. During the act-out task and the self-paced listening task, some of the adults complained that the ORCs were ungrammatical. Hence, the mismatch in number between the first DP and the relative clause verb did not go unnoticed. However, regardless of this, most of the adults clearly failed to get to the correct interpretation of these sentences. Furthermore, after the test sessions the actual meaning of the ORCs was explained. Even then many adults would at first reject this sentence type as it still seemed ungrammatical to them. These two observations suggest that Dutch ORCs have a strong garden-path effect, even for adults. Adult's responses clearly indicate that ORCs – at least those with two lexical animate DPs – are not easy to interpret in general. Hence, in this task offline scores already reflect adults' difficulties with the ORC construction.

Although it is tempting to base adults' poor performance on the ORC structure on their difficulties to correctly interpret ORCs, another cause might be the method used. Before participants were asked to act out a structure, two potential interpretations were acted out in the introduction of the structure. In fact, what the participants was asked to do was to pay attention to the introduction and then repeat one of the two actions. Participants might therefore have been more focused on what actually happened – trying to remember the order of sequences – than on the sentence that they were asked to act out. They might have gotten away with this strategy on the active, passive and SRC sentences, but not in the ORC condition as this structure – as argued previously – might place higher demands on memory capacity to interpret. As part of this, memory capacity might already been spend on remembering the acts in the introduction, not enough capacity might be left over to succesfully reanalyze the ORCs.

The suggestion that adults' poor performance on the ORCs in this study is task related, is supported by a study by Metz, Van Hout & Van der Lely (2012), that investigated adults' and 5-year old children's comprehension of Dutch who- and which-questions. Like for relative clauses, subject and object who- and which questions are similar in word order and the subject or object interpretation of these question types in Dutch is based on the number marking on the verb in the sentences. An example of the questions used by Metz et al. is given below in Table 55. In order to measure children's comprehension of these sentence types, children were given a picture selection task with four pictures to choose from. One picture would be the target, one picture would be similar to the target, except that a different verb was acted out, a third picture reflected a role reversal error and a fourth and final picture reflected a number error.

Table 55

	Who	**Which**
Subject	Wie voert de elfjes? who-SG/PL feeds-SG the fairies-PL “Who is feeding the fairies?”	Welke vrouw kietelt de oma's? which woman-SG tickels-Sg the grannies-PL “Which woman is tickling the grannies?”
Object	Wie wassen de koninginnen?[14] who-SG/PL wash-PL the queens? “Who are the queens washing?”	Welke prinses duwen de danseressen? which princess-SG push-PL the dancers-PL “Which princess are the dancers pushing?”

Example of the type of sentences used in the Metz et al. (2012) study.

Metz et al. found that the adults performed at ceiling on all sentence types, including the object questions. In contrast to the present study, adults did not have to remember previously acted out sequences, and instead of a statement, they would hear a question, which might have facilitated the object interpretation in addition to the subject interpretation. As these question types have different structures than the relative clause structure no direct comparison can be made between the Metz et al. study and the present study. However, the results for the adults in the Metz et al. study do show that Dutch adults are able to correctly interpret object constructions other than the ORC.

Regardless of participant's accuracy, the main issue of interest investigated by the act-out task was the type of errrors particpants would make in the relative clause conditions and whether they were different between relative clause pairs – between the SRC singular and the ORC singular conditions and the SRC plural and the ORC plural conditions. The type of errors made by the adults was rather straightforward. The majority of errors were made in the ORC condition and virtually none were found when the SRCs were acted out. The most common error made was the role reversal error – the agent of the sentence was interpreted as the patient and vice versa. This error was only found for the ORCs and absent for the SRC structure. Hence, adults strongly tended to ignore the number marking on the embedded verb and interpret the ORC sentences as its corresponding SRC.

When looking at the accuracy scores on the act-out task for the 5- and 7-year olds some observations can be made. First of all, some parallels can be drawn with the adult results: the 7-year olds were relatively accurate – although not yet at ceiling – on the singular actives, singular SRCs and the plural passives. In addition, their performance on the plural actives and plural SRCs was above chance. Just like the adults the 7-year olds were highly inaccurate on the ORCs compared to their performance on the other sentence categories. Hence, although the 7-year olds were overall not yet at ceiling on any category, their accuracy scores patterned more or less like those of the adults. Similarly, the 5-year olds were relatively accurate – above chance level – on the singular actives and the singular SRCs, but had a very poor performance on the ORCs, again showing similarities to the adult group.

Second, in contrast to the adults and the older age group, the youngest children clearly struggled in correctly acting out the plural conditions, as accuracy was below chance for each plural sentence category. There are two obvious explanations for this: (1) children at this age have difficulties interpreting the number feature on nouns and verbs, or just prefer a singular DP to be the agent of a sentence; and/or (2) children prefer to act out the stories using only one animal as actor. Hence, the first explanation seems to be competence based, whereas the second is a task artifact. The fact that children seem to prefer a singular agent in a sentence is supported by the relatively large number of number and number reversal errors in the plural SRC and ORC conditions – such that a singular animal was the agent of the action –, compared to the singular conditions. This is further supported by children being more accurate on the plural passives than the singular passives: in the latter condition a singular animal is the agent of the sentence and in the first condition the action is performed by multiple animals. Both the 5-year olds as the 7-year olds performed better on the plural passives.

14 Note that this type of sentence is ambiguous between a subject or an object reading as “who” in Dutch can either be singular or plural. Therefore it could be the subject or the object of this question.

Third, the fact that children did not correctly interpret the ORC structure in this study is in line with other studies that looked at relative clause comprehension based on number features by children in other languages by Adani (2011), Arosio et al. (2009; 2011; and 2012) and Guasti et al. (2012). In these studies, as discussed above, children were relatively inaccurate in comprehending ORCs compared to SRCs. However, accuracy scores were never as low in these studies as found for the children in this study, not even for the 3-year olds Adani tested on the highly marked Italian postverbal ORCs. In addition, the 7-year old German and Italian children in the studies discussed earlier at least scored at chance level on the (postverbal) ORCs.

Although the results on the ORC structure seem to be even less accurate in the present study compared with the Italian, German and Greek studies above, similarities were found with the Metz et al. (2000) study. The children tested in this study were highly inaccurate on the object questions (18% correct on the object who-questions and 11% correct on the object which-questions). In addition, their performance on the subject questions was neither at ceiling (69% on the subject who-questions and 63% on the subject which-questions). Hence, the data of the Metz et al. study and the present study seem to suggest that object structures in who- and which-questions and relative clauses are highly problematic for (at least 5-year old) Dutch children to interpret. Even more so than for children from other language backgrounds. However, the design used by Metz et al. to test their sentence types might not have been entirely felicitous – as probably neither was the design of the current study for investigating accuracy scores, as even the adults performed below chance on the ORCs – which might have caused children's poor performance in the object conditions.

However, as mentioned earlier, the main goal of the act-out task was not to measure children's accuracy on relative clauses, but to investigate children's repair strategies when encountering the mismatch in number between the head DP and the relative clause auxiliary in the ORC condition. Arosio et al. (2009) and Arosio et al. (2012) suggested that the garden-path effect could be too strong for children in ORCs to recover from, resulting in them opting for a "cheaper" repair strategy: repairing the number on the embedded verb/auxiliary so that it would match the number with the head DP. This prediction was supported by other studies that have shown that children interpret ORCs as being SRCs – what would be the result if they would change the number on the verb –, hence, resulting in role reversal errors. However, these studies gave children only limited possibilities for ginvig their own interpretation. Therefore, this study compared children's behaviour on SRCs to children's behaviour on ORCs on a task which encouraged children to give their own interpretation of the structures. Three predictions were made based on the assumption that children would only use the repair strategy mentioned to deal with ORCs.

According to the first prediction, the role reversal error should be limited in use to ORCs only. This type of error should be absent – or at most rarely present – in the SRC condition. This prediction was supported by the analysis of the data. Only a little over 5% of the acted out SRCs contained role reversal errors, which is in contrast to the large amount of role reversal errors that were found for the ORCs (in almost 90% of the sentences). In addition, the role reversal error was the largest error type for the ORC structure, whereas it only constituted a small amount of the errors in the SRC condition. This was again similar to the results from the Metz et al. (2012) study, who found that less than 10% of the children's answers on the subject questions were role reversal errors, whereas around 70% of the children's picture choices for the object questions were role reversal errors.

According to the second prediction the number repair strategy on the embedded auxiliary should lead to a similar amount of incorrect SRC interpretations for the ORC sentences as the amount of correct SRC interpretations of the SRC sentences. Hence, the relative clause pair in (74) and (75) should both be acted out as in (76), which would be the correct interpretation of the SRC in (74) and the incorrect interpretation of the ORC in (75), if SRCs would always be acted out correctly and the number on the auxiliary in ORCs would always be repaired in order to match the number on the head DP.

(74) De leeuw die de apen aan het borstelen is.
the lion-SG that the monkeys-PL brushing is-SG
"The lion that is brushing the monkeys."

(75) De leeuw die de apen aan het borstelen zijn.
the lion-SG that the monkeys-PL brushing are-PL

"The lion that the monkeys are brushing."

(76) Correct SRC response: 1 lion brushes 2 or 3 monkeys.
(77) Correct ORC response: 2 or 3 monkeys brush 1 lion.

This prediction was also supported by the data: there was no difference in the amount of SRCs and ORCs that were acted out as SRC by the children. Similarly, Metz et al. (2012) argue that object questions were often interpreted as subject questions. More or less the same amount of subject questions were correctly interpreted in their study.

According to the third prediction, other error types should be similar in amount for the SRC and the ORC conditions. If children would use other strategies to deal with ORCs than the repair strategy mentioned, other error types than the role reversal error should be more frequent in the ORC condition than in the SRC condition. For example, if another strategy would be that children would repair the number on the head DP, instead of changing the number on the auxiliary, in order to match number features, number errors should be frequently found for the ORCs, but less so for the SRCs. The results of the act-out task showed that children made the same amount of "other" error types in the ORC condition as in the SRC condition. This is evidence that the third prediction is true.

Combining the findings of the error type analysis, no evidence was found suggesting children use other strategies than the number repair strategy on the embedded auxiliary to deal with the garden path effect in ORCs – as neither was found for the adults. This supports findings in earlier studies that the most common error in ORC comprehension is the role reversal error. Hence, if children are indeed sensitive to number agreement violations in ORCs, their strategy seems to be to repair the number on the embedded auxiliary in order to make it match the number on the head DP, as suggested by the Arosio and colleagues (2009; and 2012). Another explanation could be that children's preference for a SRC interpretation is simply too strong for them to notice the mismatch in number between the head DP and the embedded auxiliary. This is what was investigated by the self-paced listening task and is discussed in the next section. As the data did not suggest children were using other repair strategies for ORCs, no additional analyses were done with memory as a predictor.

Some independent evidence in the form of spontanous utterances by some of the children who participated in the act-out task, suggest that children, first of all, initially interpret ORCs as SRCs and, like most of the adults, stick to this interpetation after detecting the mismatch in number between the first DP and the relative clause auxiliary. In Table 56 three examples are shown. The first child repeated the utterance of the experimenter, but (unconsciously) changed the number on the auxiliary to make it match the number on the first DP. In the second example the child rejected the number on the auxiliary as in the introduction only one chicken is pushing other animals. This clearly shows she did notice the plural number marking on the auxiliary, but sticks to her initial subject interpretation. Finally in example 3 the child corrected the experimenter by telling the number on the verb should be singular (in order to match the number on the first DP), which is similar to some of the responses of the adults. Hence, even though this child did detect a number mismatch between the first DP and the relative clause verb, she was unable to recover from a subject interpretation.

Table 56

Example 1	Experimenter: Laat zien, de giraffen-PL die de **dinosaurus-SG** aan het likken **is-SG**. "Act out, the giraffes that the dinosaur is licking." Child [repeats]: De **giraffen-PL** die de dinosaurus-SG aan het likken **zijn-PL**. "The giraffes that are licking the dinosaur."
Example 2	Experimenter: Laat zien, de kip-SG die de **geiten-PL** aan het duwen **zijn-PL**. "Act out, the chicken that the goats are pushing."

	Child: Dat hebben ze niet gedaan! Er heeft maar één kip geduwd. They didn't do that! Only one chicken pushed.
Example 3 (from pilot study)	Experimenter: Laat zien, de kip-SG die de **geiten-PL duwen-PL**. "Act out, the chicken that the goats push." Child [correcting the experimenter]: Je bedoelt de **kip-SG** die de geiten-PL **dúwt-SG**. "You mean the chicken that pushes the goats."

Finally, in the analysis of the accuracy scores for the children, no effect was found for children's scores on the forward and backward word recall tasks in this study. This is contradictory to previous findings by Arosio et al (2009; and 2012). In the first study a significant correlation was found between 9- and 11-year old children's performance on the ORCs disambiguated by number agreement and their scores on a backwards word recall task. In the second study it was shown that 7-year old children's performance increased in the ORC condition – disambiguated by number agreement – when their d-span, as measured by a digit recall task, increased. The absence of any memory effects on the ORC accuracy scores in this task is first of all caused by all children being almost always inaccurate on this sentence type. Furthermore, insufficient memory resources could not be (solely) responsible for children's performance on the ORC structure in the act-out task as even the adults were highly inaccurate on this sentence type.

10.2 Self-paced listening task

In the self-paced listening task sentences containing center-embedded relative clauses were cut into 9 segments and participants' RTs were measured for each segment. Each experimental sentence was followed by a comprehension question on which the participants had to decide whether it was true or false, based on the structure of the relative clause they listened to. In this way, participants' understanding of the relative clauses could be measured.

Results showed that adults were highly accurate on all sentence types, except for the ORC structures. In contrast to the act-out task, 5 adults performed above chance on the singular and plural ORC sentences, reflected by a higher percentage of correct answers on the comprehension questions belonging to the ORCs in the self-paced listening task, compared to the amount of correct responses in the act-out task. Again, adults were (almost) at ceiling on all other sentence types. In contrast to the act-out task, adults significantly performed better on the singular active sentences in this experiment than on the singular and plural SRCs. This might be caused by the high demands the self-paced listening task placed on memory resources in the experimental conditions: relative clauses were center-embedded, causing an interruption of the main clause; the order of actions had to be remembered for the different kind of animals and compared to the direction of the actions in the comprehension questions; and finally this has to be done while listening to interrupted speech. In contrast, the relative clauses in the act-out task were right-branching, without a main verb; and the speech was fluid. Still, performance of adults on the SRCs in the self-paced listening task was relatively accurate.

The high accuracy found for the adults, on the other hand, was in clear contrast to the children's performance on the comprehension questions. The children scored around chance level on most sentence types. They only seemed relatively accurate on the singular active sentences, although the average performance of the children was still far from being at ceiling. At first sight little difference seems to exist between children's accuracy scores on the comprehension questions belonging to the SRC structures and to the ORC structures, however, a significant difference was found in their offline performance on the singular and plural SRC structures and the singular ORC structure: children were less accurate on the latter. No difference was found between the SRC structures and the plural ORC sentences.

The fact that the children were at chance level for most of the sentence types indicates that children – even the 7-year olds – struggled in this task to give the right answer to the questions. A number of reasons for this were observed during testing: (1) some children found it very difficult to remain focused

during the task, resulting in them staring out of the window or trying to make a conversation during the task and not really paying attention to the sentences; (2) some children were not interested in the questions and just pressed a button as soon as possible; and (3) some children simply did not get the purpose of the questions and would always answer either “yes” or “no” or judge the questions to be true or false based on the plausibility of a certain action performed by an animal. These problems with the task were mainly observed for the 5-year olds, even though they were given a shorter task to avoid them getting tired and loosing interest. Furthermore, the finding that children performed at chance level on the ORC structures – which is a better result than found for the adults – indicates that children were actually guessing the answers on these structures.

The offline findings for the children in this study are in sharp contrast to the offline results in the Arosio et al. (2011) study. They found that that children performed at ceiling on the SRCs. In the present study, children were at chance level on this structure. In addition, children's digit span predicted their accuracy on the ORCs: children with a digit span of 4 were less accurate on the questions belonging to the ORCs than children with a higher digit span. They did not find an effect of listening span on children's accuracy. Similarly no effect of WM was found on the performance of the children participating in the current study. Furthermore, however, neither an effect was found for STM. This difference might potentially be caused by the use of word span as a measurement of STM in the present study, whereas Arosio et al. used digit span instead.

Like for the act-out task, the focus of the self-paced listening task was not so much on children's accuracy on the various sentence types, though. The main goal of this task was to find out whether Dutch children are sensitive to number agreement as disambiguating cue in relative clauses. In order to establish a baseline, the adult group served as a control group. The prediction was that adults would respond faster to SRCs on the disambiguating segment 7 – containing the embedded auxiliary with the crucial number marking – than to ORCs. For children a similar effect was expected if they would pay attention to the number marking on the embedded auxiliary. In addtion, children might potentially show a delayed effect of this on segment 8 as this was found by Arosio et al. (2010).

The prediction for the adults was found to be partially true: a significant effect of RC type was found on segment 7, indicating that the adults indeed responded faster to the SRCs than to the ORCs on this segment. In addition, adults also responded faster on this segment to singular sentences than to plural sentences. These effects were complicated, however, by a significant interaction between RC type and Number. The interaction was caused by the adults pressing the button significantly faster on segment 7 in the SRC condition compared to the ORC condition when the sentences had a singular DP1. If the first animal of the experimental sentences was plural, no effect was found for RC type. In addition, a potential spill-over effect was found on segment 8, which was marginal significant: adults were faster on this segment in the SRC conditions than in the ORC conditions.

The absence of an effect of RC type in the plural sentences on segment 7 is remarkable. It at least suggests that there exists a difference in the processing of relative clauses modifying a singular DP and relative clauses modifying a plural DP in Dutch. The slow down in RTs in the ORC condition in singular sentences on segment 7 indicates that the integration of the auxiliary in the existing sentence structure takes more time in the ORC condition. This suggests that adults are garden-pathed in the ORC sentences and have to revise the structure at the disambiguating segment, or at least in the singular condition. This revision process seems to persist into the next segment, again reflected by longer RTs in the ORC condition. In the case of the plural sentences, RTs seem to reflect that the reanalysis process does not start for these sentences at segment 7, but rather at segment 8.

That there exists a difference in integration cost in adult sentence processing between sentences with a singular and a plural DP is supported by the finding that adults responded faster on segment 5 – the segment containing the DP2 – in the singular condition than in the plural condition. Hence in the sentences with a plural DP1 and a singular DP2, adults were relatively slow on the segment containing the singular DP2. This slow down might reflect some additional integration costs at the point were the singular DP2 has to be integrated into the sentence compared to the integration of a plural DP2. This also suggests that sentences in the plural condition are generally harder to process than sentences in the singular condition in this experiment.

Potentially this additional processing load might also be at influence at segment 7 as at this point the embedded auxiliary had to be integrated in the relative clause structure and be linked to its subject and object. If integration of a singular embedded DP is indeed harder than the integration of a plural DP in these sentences, linking the embedded VP with this constituent might be more demanding in the plural condition than in the singular condition. As a result, any additional difficulties associated with the ORC condition might either disappear at segment 7 – as integration costs are already relatively high – or be delayed – as resources might already be spent at integrating the auxiliary into the more demanding structure. Both explanations are supported by the finding of a (marginal significant) effect at segment 8 for RC type found in both the singular as the plural conditions.

Some similar results were obtained by Mak, Vonk & Schriefers (2002) who studied adults' online processing of Dutch relative clauses with two animate DPs and one animate and one inanimate DP. They conducted two experiments: a self-paced reading task; and an eye-tracking experiment. In the first task Mak et al. did not find an effect of RC type on the disambiguating segment containing the embedded auxiliary. However, they did find a difference in RTs at the segment following the auxiliary for the “animate” relative clauses. Like in the present study at segment 8, adults responded faster at this segment in the SRC condition compared to the ORC condition. Mak et al. suggested that this effect resulted from adults trying to reanalyze the ORC sentences. In addition they conducted the second experiment to investigate whether this effect actually came from the disambiguating number cues on the auxiliary. In this experiment they found a direct effect of RC type on the auxiliary: first-pass reading times were longer at this segment for the adults for the ORCs.

The fact that Mak et al. did not find an effect of RC type in the self-paced reading task at the disambiguating segment seems to be in contrast to the finding in the present study that adults responded faster at the embedded auxiliary on the SRCs than on the ORCs in the singular condition. However, the different type of sentences used by Mak et al. might explain this difference. In (78) and (79) below examples are given of clauses containing a SRC and an ORC used in their first experiment. In the SRC in (78) the first DP “de inbrekers”, which is both the subject of the main clause and of the relative clause, is plural, whereas the second DP “de bewoner” is singular. In the ORC in (79) the first DP “de bewoner”, which is the subject of the main clause and the object of the relative clause, is singular and the second DP “de inbrekers” is plural. Hence, the use of number features on the DPs is similar to the plural condition used in the present study for Mak et al.'s SRCs, and to the singular condition for Mak et al.'s ORCs. The results of the present study show that there was no significant difference between the singular ORCs and the plural SRCs at the critical segment containing the auxiliary. This finding is supported by the absence of a RC effect between similar sentence types Mak et al. used in their study. Furthermore, Mak et al.'s finding of a relative clasuse effect at the embedded auxiliary in the eye-tracking experiment supports the idea that the effect for RC type found in this study at segment 8 stems – at least partially[15] – from the number agreement violation in the ORC condition at the auxiliary.

(78) Vanwege het onderzoek moeten de inbrekers, die de bewoner beroofd hebben,
because of the investigation must the burglars-PL who the occupant-SG robbed have-PL
nog een tijdje op het politiebureau blijven.
some time at the police station stay-PL
“Because of the investigation, the burglars, who robbed the occupant, had to stay at the police station for some time.”

(79) Vanwege het onderzoek moet de bewoner, die de inbrekers beroofd hebben,
because of the investigation must the occupant-SG who the burglars-PL robbed have-PL
nog een tijdje op het politiebureau blijven.

15 In the eye-tracking experiment, Mak et al. (2002) added a PP in the relative clause following the auxiliary to test whether the reanalysis process started at the auxiliary in the ORC condition would affect sentences wrap-up processes. Again, they found that adults' reading times were slower at this segment for the ORCs compared to the SRCs.

some time at the police station stay-PL
"Because of the investigation, the occupant, who the burglars robbed, had to stay at the police station for some time."

The results found for the children in the self-paced listening task were less straightforward than for the adults. However, with one exception: in general children also responded faster in the singular condition on segment 5 than in the plural condition. This effect was found for all the analysis of the whole child group and in the separate analyses based on age, STM and WM. Although the effect occasionally disappeared in certain models, I would like to argue that it was still a consistent finding throughout the analyses and that the effect holds for the entire group of children. Especially because the effect only disappeared when relatively small groups were compared in the model. The presence of a similar effect on segment 5 as found for the adults is an indication that the children that were tested were able to conduct the self-paced listening task and that their RTs could be interpreted.

In addition to the effect found on segment 5, another similarity was found between the adult data and the child RTs: a significant effect of RC type was found on segment 7. This effect was found for different groups of children and had always a similar direction, indicating that children responded faster on segment 7 in the SRC condition than in the ORC condition. This effect was, first of all, found for the entire dataset when either STM or WM was included in the model. However, this effect could probably not be ascribed to the entire group of children as the effect was (marginally significantly) modified by the interaction between STM and RC type and WM and RC type. Similarly, the effect also turned up in the analyses of the data of the 7-year olds, but only in the models containing either STM or WM scores. When the effect was looked at into more detail for each STM and WM group, it was only found for the children in the lowest groups. Hence, the finding that SRCs were responded to faster than ORCs on segment 7 was only found for the 7-year olds and not the 5-year olds in the separate analyses and only the data of the children classified into the lowest STM and WM groups showed this effect.

One of the reasons why the RC effect on segment 7 was not found for the 5-year olds, but only for the 7-year olds, could be because the 5-year olds generally had more difficulties in focusing on the task. As explained before, some of them were not able to pay attention during the (entire) test session or were not motivated to conduct the task. It could be that especially these children, who seemed to lack concentration and have a shorter attention span and than the other children that participated, might have had difficulties in remembering the number feature on the first DP or might have failed to notice it on the the first DP or the auxiliary. Another reason for their performance could be that they did not notice the mismatch in number between the auxiliary and the head DP. However, it is difficult to disentangle these two possibilities. Similarly, Booth et al. (2000) found in their self-paced listening experiment with 8-year to 11-year old children that the younger children listened at the same rate to English center-embedded SRCs (80) and ORCs (81), whereas the oldest age group listened overall faster to the SRCs than to the ORCs. According to them, this suggested that the older children were more sensitive to the differences between these sentence types. Similarly, the older age group in the present study seemed to be more sensitive to the number agreement cues on the auxiliary than the youngest age group.

(80) The principle that tripped the janitor used the phone to call home.
(81) The man that the captain invited built the stage for the band.

(Booth et al., 2000)

The presence of the RC type effect on segment 7 in the low STM and low WM groups only and not in the higher memory groups is more difficult to explain and was different from the other two self-paced listening experiments discussed. First of all, Arosio et al. (2011) did not find a significant effect of word span or digit span on either of the segments used in their experiment. However, they did not repeat the analysis for the different memory groups, but only included memory scores as covariates in the model used for the entire group of children. On the other hand, Booth et al. (2000) did find an effect of digit span at the transition between the relative clause and the main clause, with children with a high digit span slowing down at the transition more than children with a low digit span. However, in contrast to the present study,

Booth et al. did not find this effect at the disambiguating segment – which would be the segment immediately following the relative pronoun – as found in the present study, but only later in the sentence[16]. Furthermore, the effect of d-span was found at the transition between the two clauses regardless of the relative clause type. In addition, Booth et al. did not find an effect WM on children's performance on the self-paced listening task. It remains unclear whether an effect of RC type was absent in the higher memory groups in the present study.

The reason for the finding of the present study that only the children in the lower memory groups showed an effect of RC type at segment 7 remains unclear. If memory was predicted to have an effect on children's RTs at this segment, it would logically have to be predicted the other way around: children with a higher memory capacity could be argued to be more similar to adults and therefore be more likely to behave adultlike. As the adults showed sensitivity to the number mismatch between the first DP of the ORC and the relative clause auxiliary, children with a higher memory capacity are predicted to show this as well, whereas children with lower memory capacity might not show a difference in RTs between the SRC and the ORC condition. Possibly, the lack of an effect in the higher memory groups might be caused by the limited number of participants. The effect might appear when more children would have been tested.

One difference in the results of children's and adults' analyses needs further explanation. We saw that adults' RTs only significantly differed at segment 7 between the singular SRCs and ORCs and not between the plural sentences. For children the effect of RC type at this segment was found regardless of Number. For adults the effect of RC type in the plural conditions seems to be delayed to the segment following the critical segment. Hence, it seems that children did not distinguish between SRCs and ORCs in the singular and the plural condition when encountering the disambiguating cue, whereas adults seemingly were delayed in reanalyzing the plural ORCs. This difference is difficult to explain. Possibly a significant interaction would appear at segment 7 between RC type and Number when more children would have been tested. This is supported by the findings for the low STM group – which is relatively large – for which, in addition to a significant main effect of RC type, a marginal significant main effect on Number and a marginal significant interaction between RC type and Number were found.

In the remainder of this section some additional effects and interactions on other segments than segment 5 and 7 found for the child data will be discussed, that were not found for the adults. First of all, in some of the – more complex – models, a number of (marginally) significant results were found on segment 4, including interactions between RC type and other fixed effects. Remember that segment 4 contains the relative pronoun. No effect of RC type is expected here, as the singular SRC and ORC structures and the plural ones are still similar at this point. Similarly, Arosio et al. (2011) also found an effect of RC type at the relative pronoun in their study. They account for this by suggesting it is caused by a spill-over effect from the previous segment. This spill-over effect would be the result of the use of different nouns in the SRC and the ORC conditions at the previous segment. For the present study, this cannot be the entire explanation for the effects found at segment 4 as the DPs at the previous segment only differed in number.

More importantly, the main effects and interactions on segment 4 only appear in this study when relatively small groups of children are used in the mixed model analysis – when age groups and STM groups are combined. As mentioned earlier, the outcomes of the models containing relatively many variables and interactions should be interpreted with caution. For example, the effects on segment 4 seem to be mainly caused by the 5-year olds in the high STM group. This group consists of data from three children only for the analysis of the whole dataset and by 6 children only in the analysis for the 5-year olds. Hence, the results found on segment 4 are largely based on a very small number of children, making their validity rather questionable. In addition, when the interactions were further split up and investigated, the effects disappeared. Together this suggests that the significant effects and interactions found at segment 4, first of all, might be partially caused by the difference in number on the noun in segment 3 and by the relatively

16 Actually, a difference in RTs between the SRC and the ORC structure in English on the segment following the relative pronoun would be rather difficult to interpret, as word order is different between these two structures. Hence, RTs on a verb in the SRC condition and on a DP in the ORC condition would have to be compared. In addition, in the Booth et al. (2000) study, the researcher did not compare individual words or constituents at this point in the sentences but compared a combination of the head DP and the first three words over the relative clause structure.

small groups of children that were compared.

Similar to the results found on segment 4, (marginally) significant main effects and interactions were found on segment 6 in some of the models. Again, this mainly happened when relatively small groups were compared in the analyses – based on Age and STM – resulting in the data of a small number of children highly influencing the outcome of the analyses. In addition, these (marginally) significant results again disappeared when the interactions were split up and further investigated, suggesting that the groups these findings were based on, were to small to give reliable results on this segment. In addition, expending the reasoning Arosio et al. (2011) use for the RC type effect found on the relative pronoun, the effects and interaction might be a result of a spill-over effect from segment 5, as the nouns at this segment again differ in number.

Thirdly, an effect of Age was found at segment 6 and segment 8, indicating that the 7-year olds responded faster than the 5-year olds on these segments. Segment 6 contains the infinitive and segment 8 contains the PP and constitutes the transition from the relative clause to the main clause. The finding that the older children were actually faster at the transition from the relative clause to the main clause than the younger children is in contrast to findings by Booth et al. (2000), which was discussed above, as they found that at the transition between the clauses the older children actually slowed down compared to the younger ones. As Booth et al. studied older children than the ones that participated in this study, differences in outcomes do not have to be unexpected and can not be directly compared for this scenario.

In contrast to the adult data, a significant slowdown was found at segment 9 for the 7-year olds in the plural condition compared to the singular condition. Hence, the 7-year old children responded faster when the main verb was in the plural condition than when the main verb was in the singular condition. This effect was only marginally significant in some of the models for the whole dataset and for the medium and high STM groups combined. The final finding was probably caused by a relatively high number of 7-year olds that were classified into the medium and high STM group, compared to the 5-year olds. It is unclear, though, why this effect was found at the final segment. Especially because children seemed to struggle more with sentences with a plural DP1 compared to sentences with a singular DP1, as indicated by the accuracy scores for the act-out task and by the accuracy scores on the singular actives compared to the other sentence types – especially for the 7-year olds – in the self-paced listening task. If the sentences with a plural DP1 – and, hence, plural number marking on the main verb – would be indeed more problematic, higher processing costs reflected by longer RTs would be expected at the main verb in the plural condition. As the focus of this study is not on the differences in processing of singular and plural sentences, I will leave this question open.

Finally, a side note should be made for the finding that plural DPs at segment 5 are faster responded to than singular DPs at this segment by both adults and children, and for the finding that main verbs with plural marking are responded to faster by the children – or at least the 7-year olds – than the main verbs with singular marking. An alternative explanation for these findings could be that adults and children respond evenly fast at segment 5 and 9 in the singular and the plural conditions. However, with the extraction of the shorter singular DPs and Vs and the longer plural DPs and Vs, this would automatically results in longer residual RTs in the singular conditions. Hence, if adults and children would not really pay attention to the number marking at these segments, this would lead to a similar response pattern as obtained in this study. Still, this does not seem to be the case here: if participants would indeed not pay attention to number marking at all, but just press the button after a certain amount of time, similar results as found at segment 5 and 9 should have been obtained at segment 3, as at this segment a DP is used that varies on singular and plural number features as well. No significant effect was found at segment 3 though, indicating that children and adults were paying attention to the number marking on segment 5 and the 7-year olds to the number marking on segment 9.

Hence, the results of the self-paced listening task suggest that both Dutch adults as well as children are sensitive to number agreement violations at the embedded auxiliary in ORCs. For the children this is shown by their increase in the duration of their RTs at segment 7 for the object structures compared to the corresponding SRCs. Whether this finding also holds for the 5-year olds is debatable, however the findings suggest that at least children as young as 7 years old did detect the number agreement mismatch between the head DP and the auxiliary in the ORCs. For the adults a similar effect was found at this segment,

although it was modified by the interaction between RC type and Number. This interaction indicated that at this segment adults only responded faster to the SRCs in the singular condition compared to the ORCs in the singular condition. For them a spill-over effect was found at the segment following the disambiguating segment. This spill-over effect was found for the singular and plural conditions together and showed that adults responded slower at this segment in the ORC condition compared to the SRC condition.

The online findings, hence, show that regardless of participants poor performance on the offline comprehension tasks in the ORC condition, participants did notice a difference between the SRC and the ORC structures during sentence processing. The finding that participants were slower in the ORC condition reflects their difficulties of integrating the embedded auxiliary in this structure. As RTs were lower in the SRC condition at the critical segment 7 for the children and partially for the adults, and at the next segment for the adults, it could be argued that integration of the auxiliary for these sentences was relatively unproblematic, which is in line with the AFS (Frazier & Flores D'Arcais, 1989); the MCP (De Vincenzi, 1991), Gibson's DLT (1998; and 2000), and Van Dyke's and colleagues' SBIA (Van Dyke & Lewis, 2003; and Van Dyke, 2007). In the ORC condition, however, children and adults are garden-pathed and initially assign a SRC interpretation to this structure type. This interpretation leads to a temporal ungrammaticality at the embedded auxiliary reflected in the current study by the higher RTs at this segment and the next. I would like to argue that the higher RTs found at the critical segment(s) reflect, first of all, participants' noticing of a number agreement violation in the ORCs between the auxiliary and the head DP, which was their presupposed subject. Second, the increased RTs in the ORCs also reflect the reanalysis process that is initialized after the number mismatch has been detected. For most of the adults, this reanalysis clearly fails as their accuracy on the question types belonging to the ORCs was very poor compared to their performance on the SRC questions. For the children it is more difficult to tell whether or not they were able to assign a correct interpretation to the ORCs after reanalyzing the sentences as the results for the offline comprehension accuracy in the self-paced listening task probably do not correctly reflect their comprehension of the various sentence types used. However, when comparing their online performance on the self-paced listening task and their offline comprehension of the relative clauses in the act-out task I would like to argue that, like most of the adults, children fail to reanalyze the ORC structures and opt for the cheaper repair strategy, by changing the number on the auxiliary, such that it matches the number on the head DP.

Interestingly, the results obtained in both experiments together with adults' and children's spontanous responses support Fodor & Inoue's (2000) theory about number as disambiguating cue. First of all, as they mentioned, a number mismatch is a very strong indicator of an ungrammaticality and is easily perceived, which is reflected in the present study by 7-year olds' and adults' slow down in RTs in the ORC condition in the self-paced listening task and the comments of the adults about the ORCs used being ungrammatical. Secondly, according to Fodor & Inoue, number is a weak cue for recovering from a garden-path effect: it does signal an ungrammaticality, but is a negative symptom as it does not offer direct cues to rebuild the structure. Many of the adults in this study spoke of a mismatch in number between the first DP – their presupposed subject of the relative clause – and the relative clause verb/auxiliary –, and both adults and the 7-year olds seemed to notice it during sentence processing, but failed to use this information to get to the correct interpretation of the ORC. The adults rather accepted it as a flaw in the study and sticked to their original SRC interpretation. In addition, children also showed a strong preference for their initial relative clause interpretation and like the adults seemed to ignore the mismatch in number between the first DP and the relative clause auxiliary by repairing the number on the auxiliary.

What is difficult to explain, is the effect of STM and WM on children's slow down at segment 7 in the ORC condition. When children were divided into memory groups and these groups were analyzed separately, the effect at segment 7 was only present in the low STM group and was marginally significant in the low WM group. This is in contrast to earlier findings by Booth et al. (2000) and Arosio et al. (2011). Booth et al. did not find any effects of WM on children's performance on the self-paced listening task in their study. They did find an effect of STM, as measured by digit span, however this effect was not found for RC type, but was a general effect at the segment that contained the transition from the relative clause to the main clause. Furthermore, Arosio et al. did not find an effect of digit span or word span for their online findings at the critical segments. It is unclear why the effect was found in the analyses of the separate

memory groups for the low STM and WM groups only. If an effect of memory would have been found, this would have been predicted to be in the opposite direction: the higher memory groups should perform more like the adult group as their memory capacity is bigger and therefore more adult-like. Possibly the difference between the memory groups was caused by the relatively low amount of participants in each separate memory group. Another explanation could be that a different factor – possibly related to memory – was causing the differences found between the groups of children. For example children's ability to deal with number (agreement). Hence, if children have difficulties interpreting number features on the DPs and the auxiliary in general, they are automatically more likely to fail to notice the number agreement violation in the ORC structure during initial parsing. Further research with more participants in each memory group and with more variables measured is necessary to further investigate the role of memory in the online processing of relative clauses. Like in Arosio et al. (2011) and (2012) a grammatical judgment task could be used to measure Dutch children's sensitivity to number agreement violations, to see whether this ability is a predictor of their online performance on ORCs.

Finally, this study suggests that the number on the DPs involved in the relative clause structure and on the embedded auxiliary matter in (Dutch) relative clause processing. First of all, results showed that plural DP2's were responded to faster in general than singular ones. Furthermore, number on the DPs and the auxiliary influenced the initializing of a reanalysis process for the adults – or at least the reflection of it in the RT data. In the recent relative clause studies involving number agreement as disambiguating cue discussed in chapter 6 only sentences were studied involving a singular DP1 and a plural DP2 – with the exception of the Adani et al. (2010) study. It is therefore unclear how children would perform on similar tasks when number would be reversed for the DPs. In addition, to my knowledge, little attention has been paid to adults' (online) performance on Dutch relative clauses that differed in number. Hence, further research including singular and plural sentences is necessary to explain the role number plays in relative clause processing and perhaps sentence processing and comprehension in general.

11. Conclusion

In this study children's and adults' offline and online comprehension of subject-extracted and object-extracted relative clauses (SRCs and ORCs respectively) involving two animate DPs were investigated. The current study had three main goals: (1) to see whether children's error patterns during offline comprehension of relative clauses would reflect them being sensitive to number as disambiguating cue; (2) to see whether Dutch 5- and 7-year old children would show sensitivity to number marking in relative clause processing as was found by Arosio et al. (2011) for 9-year old Italian children; and (3) to investigate the role of short-term memory (STM) as measured by forward digit span and working memory (WM) as measured by backward digit span in childen's offline and online behaviour during relative clause processing. In order to do so, children and adults were tested by using an act-out task and a self-paced listening task. The experiments used had a number of advantages over previous tasks used to measure children's relative clause comprehension. First of all, in other recent (offline) studies a picture- or referent-selection design was often used. Although these tasks have a number of advantages over the act-out task, they limit their participants in their choices of showing their interpretation of a certain sentence. The act-out task used in the current study, on the other hand, encouraged participants to give their own interpretation of the structures given. Second, due to the order of Dutch embedded clauses, potential spill-over effects found by Arosio et al. could be further investigated. Finally, animal pairs in the experimental sentences in the self-paced listening task were tested on reversibility, such that preference for one animal performing a certain action would no longer be a confounding factor.

Results from the act-out task showed that both adults and children clearly struggled with the ORC structures. The majority of ORCs were interpreted and acted-out as SRCs by changing the thematic roles of the DPs. Whereas adults mainly made role reversal errors, many children also made number and number reversal errors, suggesting general difficulties with number interpretation. Another explanation could be that many children tested had a preference for acting out sentences using only one animal. Results found in this study suggest, first of all, that children and adults initially parsed the ORCs in this task as SRCs and, if they noticed a mismatch in number between the first DP and the embedded auxiliary, they failed to reanalyze the ORCs. Instead, they seemed to have opted for a cheaper solution of matching the number feature on the auxiliary to the number feature on the first DP. The preference for this solution was supported for both children and adults by the finding that if they made other errors than number reversal errors, they did equally so for the corresponding SRC and ORC constructions. Hence, they did not adjust the number on other constituents than the embedded auxiliary more in the ORC condition than in the SRC condition, ruling other strategies out to deal with the temporal incongruity during ORC processing.

In order to test whether adults and children actually noticed the mismatch in number between the first DP and the relative clause auxiliary, a self-paced listening task was conducted in which main clauses containing center-embedded relative clauses were segmented such that RTs could be measured after single words or cluster of words. Adults, first of all, did slow down at the second DP in the plural sentences compared to the singular sentences. Second, they showed sensitivity to the relative clause type of the sentences at the critical segment containing the auxiliary that disambiguated between a SRC and an ORC interpretation. This was reflected by longer RTs in the ORC condition compared to the SRC condition. In addition, adults slowed down more at this segment in the plural condition than in the singular condition. These effect were further complicated by an interaction between number and relative clause type, that was caused by adults slowing down at the auxiliary in the ORC condition on singular sentences only: the effect disappeared for the plural sentences. Possibly, the absence of an effect of relative clause type in the plural condition is caused by an increased processing demand of the plural sentences in general, resulting in a delayed effect of relative clause type. This is supported by a marginal significant effect of relative clause type, with again SRCs being responded to faster than ORCs, on the next segment.

For the children, some similarities were found with the adult data. First of all, the effect of number was present on the segment containing the second DP as well in most of the analyses conducted: children, like adults, responded faster to this segment when it belonged to a singular sentence, than when it

belonged to a plural sentence. More importantly, at least the 7 year old children responded faster to the segment containing the disambiguating auxiliary in the SRC condition than in the ORC condition. In the analyses based on memory groups, this effect was only found for the low STM and WM groups. Another effect seemed to be relevant for the 7-year olds: their RTs were lower on the final segment in the plural condition compared to the singular condition.

The findings for the adults and the children in the self-paced listening task suggest that both the adults as the 7-year olds are sensitive to number marking as disambiguating cue during relative clause processing. This, and participants' poor performance on the offline tasks supports Fodor & Inoue's (2000) theory about number marking being a negative symptom in garden-path reanalysis. Spontaneous utterances of children and adults and their online behaviour on the self-paced listening task indicates that they, first of all, initially interpret a relative clause containing to animate DPs as a SRC, and, second, do notice that this leads to an ungrammaticality as the first DP and the embedded auxiliary of the ORCs do not match in number. Hence, for them the number marking on the auxiliary clearly signals a garden-path. On the other hand, as argued by Fodor & Inoue, the number marking on the auxiliary seems not to be sufficient to revise the structure: children and most adults failed to reanalyze these structures as object-extracted and sticked to their initial SRC interpretation. In line with Arosio et al. (2009) and (2012), Dutch adults and children tend to opt for the cheaper strategy of changing the number marking on the embedded auxiliary such that it matches the number feature on the first DP and their initial interpretation becomes grammatical.

In contrast to the Booth et al. (2000) and Arosio et al. (2011; and 2012) studies, no connection was found between STM and WM and offline measures of children's comprehension of relative clauses. One of the reasons for this could be that instead of digit span, word span was measured as indicator of children's STM capacity. Furthermore, Arosio et al. (2011) and (2012) found that memory capacity was a predictor of children's accuracy on ORCs. However, in the present study children were highly inaccurate on this sentence type, potentially making memory effects on accuracy invisible. Furthermore, STM and WM seemed to be predictors of children's RTs at the critical segment during relative clause processing, with the effect of relative clause type being absent for the higher memory capacity groups. It remains unclear why this is so. Possibly some other mechanism – potentially correlating with memory capacity – such as sensitivity to number mismatch in general is a better explanator of children's online behaviour. An other possibility could be that the groups of children categorised into memory groups were to small to get significant results.

Finally, number seems to play an important role during relative clause processing as indicated by adults potentially being delayed in reanalyzing ORC structures in the plural condition. Furthermore, RTs suggested that both children and adults were slower in integrating the second DP when the sentence was in the plural condition. Finally, 7-year olds had higher RTs after the final segment for singular sentences than for plural sentences. These results suggest that number features influence processing and integration speed, at least when Dutch sentences are processed containing a relative clause. This is an important finding as many studies looking into number marking as disambiguating cue in relative clause processing always use a singular DP in the first position and a plural DP in the second position. It could be that children simply prefer a singular agent – as supported by children's behaviour on the act-out task – and therefore show additional difficulty with ORCs as these often have a plural subject in comprehension experiments. Hence, children (and potentially adults as well) might be not only biased for a SRC structure when processing a relative clause but also for a singular subject interpretation, adding additional processing load to ORCs containing a plural DP in the subject position.

Summarizing, this study has shown that not only Dutch adults but also Dutch children as young as 7-years old are sensitive to number marking as disambiguating cue during relative clause processing. This is not reflected in their offline scores, but is reflected by a slow down in the ORC condition at the disambiguating segment when listening to sentences containing relative clauses. Future research with more participants – and possibly more experimental items – is necessary to investigate whether this effect is present for Dutch 7-year olds in general or only for children with a certain memory capacity. Futhermore, other variables than memory span should be measured to see whether they correspond with children's online behaviour. Finally, much research on offline and online relative clause comprehension disambiguated by number marking on the embedded verb has focussed on relative clauses with a singular DP in the first

position and a plural DP in the second position. It is important that the order of number marking should also be studied in the reversed order, such that number should not place an additional burden to children's ORC comprehension.

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Appendix A – Introduction act-out task

Ernie houdt heel erg van verhaaltjes, dus ik ga een aantal verhaaltjes vertellen die ik uitbeeldt met de dieren. Ernie is alleen een beetje vergeetachtig en kan altijd maar de helft van het verhaaltje onthouden. Als ik het verhaaltje verteld heb, zegt Ernie wel stukje van het verhaal hij opnieuw wil zien. Dan kan jij hem helpen door het voor hem uit te beelden. Ernie is wel een beetje verlegen, dus hij durft het alleen tegen mij te zeggen. En hij zegt het ook net op een andere manier. Daarom vertel ik wat Ernie heeft gezegd en mag jij het uitbeelden.

“Ernie loves stories, so I'm going to tell you a couple of stories that I will act out using the animals. However, Ernie is a little forgetfull and can always only remember half of the story. When I've told you the story, Ernie will tell which part of the story he would like to see again. Then you can help him by acting it out. Ernie is a little shy, though, so he will only tell me. And he will say it in a slightly different manner. That's why I'll tell you what Ernie told me and then you can act it out.”

Ik zal het eerst even voordoen.
“I will show you first how it works.”

Practice item 1

Intro Op de boerderij zijn ganzen en biggetjes. Zij kussen elkaar vaak.
On the farm are geese and pigglets. They often kiss each other.

Act Dan kust een van de ganzen een paar biggetjes. En een paar biggetjes kussen een andere gans.
Then one of the geese kisses a couple of pigglets. And some pigglets kiss another goose.

(Experimenter acts out:) De gans kust de biggetjes.
the goose kisses the pigglets

Nu mag jij, luister en kijk maar goed.
“Now it is your turn, listen and watch closely.”

Practice item 2

Intro Op de boerderij zijn ook ooievaars en konijnen. Zij bijten elkaar soms.
On the farm are also storks and rabbits. They sometimes bite each other.

Act Dan bijt een van de konijnen een paar ooievaars. En een paar ooievaars bijten een ander konijn.
Then one of the rabbits bites a couple of storks. And some storks bite another rabbit.

Act out: De ooievaars bijten het konijn.
the storks bite the rabbit

Practice item 3

Intro Op de boerderij zijn ook veulentjes en varkens. Zij aaien elkaar af en toe.
On the farm are also foals and pigs. They pet each other now and then.

Act Dan aaien een paar varkens een van de veulentjes. En een ander veulentje aait een paar varkens.
Then a couple of pigs pet one of the foals. And another foal pets some pigs.

Act out: De varkens worden door het veulentje geaaid.
the pigs are by the foal petted
The pigs are petted by the foal.

Practice item 4 (optional)

Intro Op de boerderij waren ook biggetjes en ganzen hè? Zij bijten elkaar ook weleens.
On the farm were pigglets and geese, remember? They sometimes bite each other as well.

Act Dan bijten een paar ganzen een van de biggetjes. En een ander biggetje bijt een paar ganzen.
Then a couple of geese bite one of the pigglets. And another pigglet bites some geese.

Act out: Het biggetje wordt door de ganzen gebeten.
the pigglet is by the geese bitten
The pigglet is bitten by the geese.

Goed gedaan! Nu gaan we acht verhaaltjes uitbeelden.
"Well done! Now we are going to act out 8 stories."

Appendix B – Experimental items act-out task

Item 1

Intro 1	Op de boerderij zijn ook kippen en geiten. Zij duwen elkaar soms. On the farm are chickens and goats as well. They push each other sometimes.
Intro 2	Op de boerderij zijn ook geiten en kippen. Zij duwen elkaar soms. On the farm are goats and chickens as well. They push each other sometimes.
Act 1A	Dan duwt één van de kippen een paar geiten. En een paar geiten duwen een andere kip. Then one of the chickens pushes a couple of goats. And some goat push another chicken.
Act 1B	Dan duwen een paar geiten één van de kippen. En een andere kip duwt een paar geiten. Then a couple of goats push one of the chickens. And another chickens pushes some goats.
Act 2A	Dan duwen een paar kippen één van de geiten. En een andere geit duwt een paar kippen. Then a couple of chickens push one of the goats. And another goat pushes some chickens.
Act 2B	Dan duwt één van de geiten een paar kippen. En een paar kippen duwen een andere geit. Then one of the goats pushes a couple of chickens. And some chickens push another goat.
SRC singular	De kip die de geiten aan het duwen is. the chicken-SG that the goats-PL pushing is-SG The chicken that is pushing the goat.
SRC singular (reversed)	De geit die de kippen aan het duwen is. the goat-SG that the chickens-PL pushing is-SG The goat that is pushing the chickens
SRC plural	De kippen die de geit aan het duwen zijn. the chickens-PL that the goat-SG pushing are-PL The chickens that are pushing the goat.
SRC plural (reversed)	De geiten die de kip aan het duwen zijn. the goats-PL that the chicken-SG pushing are-PL The goats that are pushing the chicken.
ORC singular	De kip die de geiten aan het duwen zijn. the chicken-SG that the goats-PL pushing are-PL The chicken that the the goats are pushing.
ORC singular (reversed)	De geit die de kippen aan het duwen zijn. the goat-SG that the chickens-PL pushing are-PL The goat the the chickens are pushing.
ORC plural	De kippen die de geit aan het duwen is. the chickens-PL that the goat-SG pushing is-SG The chickens that the goat is pushing.
ORC plural (reversed)	De geiten die de kip aan het duwen is. the goats-PL that the chicken-SG pushing is-SG The goats that the chicken is pushing.

Item 2

DP1	Op de boerderij zijn ook dinosaurussen en giraffen. Zij likken elkaar weleens. On the farm are dinosaurs and giraffes as well. They lick each other sometimes.
DP2	Op de boerderij zijn ook giraffen en dinosaurussen. Zij likken elkaar weleens. On the farm are giraffes and dinosaurs as well. They lick each other sometimes.
Act 1A	Dan likt één van de dinosaurussen een paar giraffen. En een paar giraffen likken een andere dinosaurus. Then one of the dinosaurs licks a couple of giraffes. And some giraffes lick another dinosaur.
Act 1B	Dan likken een paar giraffen één van de dinosaurussen. En een andere dinosaurus likt een paar giraffen. Then a couple of giraffes lick one of the dinosaurs. And another dinosaur licks some giraffes.
Act 2A	Dan likken een paar dinosaurussen één van de giraffen. En een andere giraffe likt een paar dinosaurussen. Then a couple of dinosaurs lick one of the giraffes. And another giraffe licks some dinosaurs.
Act 2B	Dan likt één van de giraffen een paar dinosaurussen. En een paar dinosaurussen likken een andere giraffe. Then one of the giraffes licks a couple of dinosaurs. And some dinosaurs lick another giraffe.
SRC singular	De dinosaurus die de giraffen aan het likken is. the dinosaur-SG that the giraffes-PL licking is-SG The dinosaur that is licking the giraffes.
SRC singular (reversed)	De giraffe die de dinosaurussen aan het likken is. the giraffe-SG that the dinosaurs-PL licking is-SG The giraffe that is licking the dinosaurs.
SRC plural	De dinosaurussen die de giraffe aan het likken zijn. the dinosaurs-PL that the giraffe-SG licking are-PL The dinosaurs that are licking the giraffe.
SRC plural (reversed)	De giraffen die de dinosaurus aan het likken zijn. the giraffes-PL that the dinosaur-SG licking are-PL The giraffes that are licking the dinosaur.
ORC singular	De dinosaurus die de giraffen aan het likken zijn. the dinosaur-SG that the giraffes-PL licking are-PL The dinosaur that the giraffes are licking.
ORC singular (reversed)	De giraffe die de dinosaurussen aan het likken zijn. the giraffe-SG that the dinosaurs-PL licking are-PL The giraffe that the dinosaurs are licking.
ORC plural	De dinosaurussen die de giraffe aan het likken is. the dinosaurs-PL that the giraffe-SG licking is-SG The dinosaurs that the giraffe is licking.
ORC plural (reversed)	De giraffen die de dinosaurus aan het likken is. the giraffes-PL that the dinosaur-SG licking is-SG The giraffes that the dinosaur is licking.

Item 3

Intro 1	Op de boerderij zijn ook apen en leeuwen. Zij borstelen elkaar soms. On the farm are monkeys and lions as well. They brush each other sometimes.
Intro 2	Op de boerderij zijn ook leeuwen en apen. Zij borstelen elkaar soms. On the farm are lions and monkeys as well. They brush each other sometimes.
Act 1A	Dan borstelt één van de apen een paar leeuwen. En een paar leeuwen borstelen een andere aap. Then one of the monkeys brushes a couple of lions. And some lions brush another monkey.
Act 1B	Dan borstelen een paar leeuwen één van de apen. En een andere aap borstelt een paar leeuwen. Then a couple of lions brush one of the monkeys. And another monkey brushes some lions.
Act 2A	Dan borstelen een paar apen één van de leeuwen. En een andere leeuw borstelt een paar apen. Then a couple of monkeys brush one of the lions. And another lion brushes some monkeys.
Act 2B	Dan borstelt één van de leeuwen een paar apen. En een paar apen borstelt een andere leeuw. Then one of the lions brushes a couple of monkeys. And some monkeys brush another lion.
SRC singular	De aap die de leeuwen aan het borstelen is. the monkey-SG that the lions-PL brushing is-SG The monkey that is brusing the lions.
SRC singular (reversed)	De leeuw die de apen aan het borstelen is. the lion-SG that the monkeys-PL brushing is-SG The lion that is brushing the monkeys.
SRC plural	De apen die de leeuw aan het borstelen zijn. the monkeys-PL that the lion-SG brushing are-PL The monkeys that are brushing the lion.
SRC plural (reversed)	De leeuwen die de aap aan het borstelen zijn. the lions-PL that the monkey-SG brushing are-PL The lions that are brushing the monkey.
ORC singular	De aap die de leeuwen aan het borstelen zijn. the monkey-SG that the lions-PL brushing are-PL The monkey that the lions are brushing.
ORC singular (reversed)	De leeuw die de apen aan het borstelen zijn. the lion-SG that the monkeys-PL brushing are-PL The lion that the monkeys are brushing.
ORC plural	De apen die de leeuw aan het borstelen is. the monkeys-PL that the lion-SG brushing is-SG The monkeys that the lion is brushing.
ORC plural (reversed)	De leeuwen die de aap aan het borstelen is. the lions-PL that the monkey-SG brushing is-SG The lions that the monkey is brushing.

Item 4

Intro 1	Op de boerderij zijn ook olifanten en koeien. Zij schoppen elkaar weleens. On the farm are elephants and cows as well. They kick each other sometimes.
Intro 2	Op de boerderij zijn ook koeien en olifanten. Zij schoppen elkaar soms. On the farm are cows and elephants as well. They kick each other sometimes.
Act 1A	Dan schopt één van de olifanten een paar koeien. En een paar koeien schoppen een andere olifant. Then one of the elephants kicks a couple of cows. And some cows kick another elephant.
Act 1B	Dan schoppen een paar koeien één van de olifanten. En een andere olifant schopt een paar koeien. Then a couple of cows kick one of the elephants. And another elephant kicks some cows.
Act 2A	Dan schoppen een paar olifanten één van de koeien. En een andere koe borstelt een paar olifanten. Then a couple of elephants kick one of the cows. And another cow kicks some elephants.
Act 2B	Dan schopt één van de koeien een paar olifanten. En een paar olifanten schoppen een andere koe. Then one of the cows kicks a couple of elephants. And some elephants kick another cow.
SRC singular	De olifant die de koeien aan het schoppen is. the elephant-SG that the cows-PL kicking is-SG The elephant that is kicking the cows.
SRC singular (reversed)	De koe die de olifanten aan het schoppen is. the cow-SG that the elephants-PL kicking is-SG The cow that is kicking the elephants.
SRC plural	De olifanten die de koe aan het schoppen zijn. the elephants-PL that the cow-SG kicking are-PL The elephants that are kicking the cow.
SRC plural (reversed)	De koeien die de olifant aan het schoppen zijn. the cows-PL that the elephant-SG kicking are-PL The cows that are kicking the elephant.
ORC singular	De olifant die de koeien aan het schoppen zijn. the elephant-SG that the cows-PL kicking are-PL The elephant that the cows are kicking.
ORC singular (reversed)	De koe die de olifanten aan het schoppen zijn. the cow-SG that the elephants-PL kicking are-PL The cow that the elephants are kicking.
ORC plural	De olifanten die de koe aan het schoppen is. the elephants-PL that the cow-SG kicking is-SG The elephants that the cow is kicking.
ORC plural (reversed)	De koeien die de olifant aan het schoppen is. the cows-PL that the elephant-SG kicking is-SG The cows that the elephant is kicking.

Appendix C – Filler items act-out task

Active singular

Intro	Op de boerderij zijn ook nijlpaarden en kalfjes. Zij likken elkaar vaak. On the farm are hippos and calves as well. They lick each other often.
Act	Dan likken een paar nijlpaarden één van de kalfjes. En een ander kalfje likt een paar nijlpaarden. Then a couple of hippos lick one of the calves. And another calve licks some hippos.
	Het kalfje likt de nijlpaarden. The calf-SG licks-SG the hippos-PL

Active plural

Intro	Op de boerderij zijn ook paarden en schapen. Zij schoppen elkaar vaak. On the farm are horses and sheep as well. They kick each other often.
Act	Dan schopt een van de paarden een paar schapen. En een paar schapen schoppen een ander paard. Then one of the horses kicks a couple of sheep. And a couple of sheep kick another horse.
	De schapen schoppen het paard. the sheep-PL kick-PL the horse The sheep kick the horse.

Passive singular

Intro	Op de boerderij zijn ook bevers en herten. Zij borstelen elkaar af en toe. On the farm are beavers and dears as well. They brush each other now and then.
Act	Dan borstelen een paar herten één van de bevers. En een andere bever borstelt een paar herten. Then a couple of dears brush one of the beavers. And another beaver brushes some dears.
	De bever wordt door de herten geborsteld. the beaver-SG is-SG by the dears-PL brushed The beaver is being brushed by the dears.

Passive plural

Intro	Op de boerderij zijn ook pony's en varkens. Zij duwen elkaar af en toe. On the farm are ponies and pigs as well. They push each other now and then.
Act	Dan duwt een van de varkens een paar pony's. En een paar pony's duwen een ander varken. Then one of the pigs pushes a couple of ponies. And some ponies push another pig.
	De pony's worden door het varken geduwd. the ponies-PL are-PL by the pig-SG pushed The ponies are being pushed by the pig.

Appendix D – Introduction, break and finish self paced listening task

Introduction – part 1

1.	Hoi ik ben Merel.	Hi, I'm Merel
2.	Ik werk op de boerderij.	I work at a farm.
3.	Op de boerderij zijn allerlei dieren.	At the farm live all kinds of animals.
4.	Gisteren deden de dieren van alles: ze wandelden, zwommen, hinkelden en deden nog véél meer.	Yesterday, the animals did all kinds of different things: they walked, swam, hopped, and did much more.
5.	Vandaag spelen de dieren met elkáár.	Today, the animals are playing with each other.
6.	Ik ga jou zo meteen een aantal verhaaltjes vertellen over wat ik de dieren gisteren allemaal heb zien doen.	I will tell you a couple of stories in a little while about what I saw the animals do yesterday.
7.	Iedere keer hoor je een stukje van het verhaal.	Every time you hear a little piece of the story.
8.	Om het hele verhaal te horen, moet je op DEZE knop drukken.	In order to hear the entire story, you have to press THIS [picture of a button] button.
9.	Soms krijg je een vraag over het verhaaltje.	Sometimes you'll be asked a question about the story.
10.	Dan druk je op JA of op NEE.	Then you have to press YES [picture of the "YES-button"] or NO [picture of the "NO-button"].
11.	We gaan dit eerst even oefenen.	Let's practice first.

Practice items

1.	Ik zag / dat / het konijn / over / de varkens / sprong. I saw that the rabbit over the pigs jumped I saw the rabbit jump over the pigs. Question: Was het konijn over de varkens gesprongen? Did the rabbit jump over the pigs?
2.	Ik zag / dat / de kikker / en / de vissen / elkaar / nat / spetterden. I saw that the frog and the fish each other wet splashed I saw the frog and the fish splashing each other wet.
3.	Ik zag / dat / de pinguïns / langs / de struisvogel / renden. I saw that the penguins past the ostrich ran I saw the penguins ran past the ostrich. Question: Renden de pinguïns langs de struisvogel? Did the penguins run past the ostrich?
4.	Ik zag / dat / de zeehond / in de tuin / lag / te slapen.

	I saw that the seal in the garden lay sleeping I saw the seal was sleeping in the garden. Question: Was de zeehond aan het hinkelen? Did the seal hop?
5.	Ik zag / dat / de panda's / en / de kikker / door het veulentje / geaaid / werden. I saw that the pandas and the frog by the foal petted were. I saw that the pandas and the frog were being pet by the foal.
6.	Ik zag / dat / de mussen / en / de pinguïns / door de uil / gepikt / werden. I saw that the sparrows and the penguins by the owl pecked were I saw that the sparrows and the penguins were being pecked by the owl.

Introduction – part 2

1.	Nu ga ik je vertellen wat ik de dieren gisteren allemaal zag doen.	Now I will tell you about what I've seen the animals do yesterday.
2.	De volgende verhaaltjes gaan over KOEIEN, GEITEN, KIPPEN, STIEREN, EEN PAARD, etc.	The following stories are about COWS, GOATS, CHICKENS, BULLS, A HORSE, etc. [pictures of the animals that are present in the stories].
3.	Luister maar goed naar de verhaaltjes om uit te vinden wat de dieren gedaan hebben.	Listen carefully to the stories to find out what the animals did.
4.	Ben je er klaar voor?	Are you ready?

Break

1.	TIJD VOOR PAUZE!	TIME FOR A BREAK! [picture & text]
2.	De volgende verhaaltjes gaan over KOEIEN, GEITEN, KIPPEN, STIEREN, EEN PAARD, etc.	The following stories are about COWS, GOATS, CHICKENS, BULLS, A HORSE, etc. [pictures of the animals that are present in the stories].
3.	Luister maar goed naar de verhaaltjes om uit te vinden wat de dieren gedaan hebben.	Listen carefully to the stories to find out what the animals did.
4.	Ben je er klaar voor?	Are you ready?

Finish

1.	BEDANKT!	THANKS! [picture & text]

Appendix E – Quartets experimental items self-paced listening task

	Type	Sentence
1.	SRCsg	Ik zag dat de muis die de ratten aan het aaien is in de wei speelde. I saw that the mouse-SG that the rats-PL petting is-SG in the maddow played-SG I saw that the mouse that is petting the rats played in the maddow.
	SRCpl	Ik zag dat de muizen die de rat aan het aaien zijn in de wei speelden. I saw that the mice-PL that the rat-SG petting are-PL in the maddow played-PL I saw that the mice that are petting the rat played in the maddow.
	ORCsg	Ik zag dat de muis die de ratten aan het aaien zijn in de wei speelde. I saw that the mouse-SG that the rats-PL petting are-PL in the maddow played-SG I saw that the mouse that the rats are petting played in the maddow.
	ORCpl	Ik zag dat de muizen die de rat aan het aaien is in de wei speelden. I saw that the mice-PL that the rat-SG petting is-SG in the maddow played-PL I saw that the mice that the rat is petting played in the maddow.
2.	SRCsg	Ik zag dat de gans die de eenden aan het poetsen is door de tuin rende. I saw that the goose-SG that the ducks-PL brushing is-SG through the garden ran-SG I saw that the goose that is brushing the ducks ran through the garden.
	SRCpl	Ik zag dat de ganzen die de eend aan het poetsen zijn door de tuin renden. I saw that the geese-PL that the duck-SG brushing are-PL through the garden ran-PL I saw that the geese that are brushing the duck ran through the garden.
	ORCsg	Ik zag dat de gans die de eenden aan het poetsen zijn door de tuin rende. I saw that the goose-SG that the ducks-PL brushing are-PL through the garden ran-SG I saw that the goose that the ducks are brushing ran through the garden.
	ORCpl	Ik zag dat de ganzen die de eend aan het poetsen is door de tuin renden. I saw that the geese-PL that the duck-SG brushing is-SG through the garden ran-PL I saw that the geese that the duck is brushing ran through the garden.
3.	SRCsg	Ik zag dat de giraffe die de apen aan het duwen is onder de boom lag. I saw that the giraffe-SG that the monkeys-PL pushing is-SG under the tree lay-SG I saw that the giraffe that is pushing the monkeys lay under the tree.
	SRCpl	Ik zag dat de giraffen die de aap aan het duwen zijn onder de boom lagen. I saw that the giraffes-PL that the monkey-SG pushing are-PL under the tree lay-PL I saw that the giraffes that are pushing the monkey lay under the tree.
	ORCsg	Ik zag dat de giraffe die de apen aan het duwen zijn onder de boom lag. I saw that the giraffe-SG that the monkeys-PL pushing are-PL under the tree lay-SG I saw that the giraffe that the monkeys are pushing lay under the tree.
	ORCpl	Ik zag dat de giraffen die de aap aan het duwen is onder de boom lagen.

		I saw that the giraffes-PL that the monkey-SG pushing is-SG under the tree lay-PL I saw that the giraffes that the monkey is pushing lay under the tree.
4.	SRCsg	Ik zag dat de kat die de vossen aan het borstelen is door het bos liep. I saw that the cat-SG that the foxes-PL brushing is-SG through the forest walked-SG I saw that the cat that is brushing the foxes walked through the forest.
	SRCpl	Ik zag dat de katten die de vos aan het borstelen zijn door het bos liepen. I saw that the cats-PL that the fox-SG brushing are-PL through the forest walked-PL I saw that the cats that are brushing the foxes walked through the forest.
	ORCsg	Ik zag dat de kat die de vossen aan het borstelen zijn door het bos liep. I saw that the cat-SG that the foxes-PL brushing are-PL through the forest walked-SG I saw that the cat that the foxes are brushing walked through the forest.
	ORCpl	Ik zag dat de katten die de vos aan het borstelen is door het bos liepen. I saw that the cats-PL that the fox-SG brushing is-SG through the forest walked-PL I saw that the cats that the fox is brushing walked throug the forest.
5.	SRCsg	Ik zag dat de kameel die de koeien aan het likken is over het hek klom. I saw that the camel-SG that the cows-PL licking is-SG over the fence climbed-SG I saw that the camel that is licking the cows climbed over the fence.
	SRCpl	Ik zag dat de kamelen die de koe aan het likken zijn over het hek klommen. I saw that the camels-PL that the cow-SG licking are-PL over the fence climbed-PL I saw that the camels that are licking the cow climbed over the fence.
	ORCsg	Ik zag dat de kameel die de koeien aan het likken zijn over het hek klom. I saw that the camel-SG that the cows-PL licking are-PL over the fence climbed-SG I saw that the camel that the cows are licking climbed over the fence.
	ORCpl	Ik zag dat de kamelen die de koe aan het likken is over het hek klommen. I saw that the camels-PL that the cow-SG licking is-SG over the fence climbed-PL I saw that the camels that the cow is licking climbed over the fence.
6.	SRCsg	Ik zag dat de draak die de olifanten aan het plagen is in de vijver zwom. I saw that the dragon-SG that the elephants-PL teasing is-SG in the pond swam-SG I saw that the dragon that is teasing the elephants swam in the pond.
	SRCpl	Ik zag dat de draken die de olifant aan het plagen zijn in de vijver zwommen. I saw that the dragons-PL that the elephant-SG teasing are in the pond swam-PL I saw that the dragons that are teasing the elephant swam in the pond.
	ORCsg	Ik zag dat de draak die de olifanten aan het plagen zijn in de vijver zwom. I saw that the dragon-SG that the elephants-PL teasing are-PL in the pond swam-SG I saw that the dragon that the elephants are teasing swam in the pond.
	ORCpl	Ik zag dat de draken die de olifant aan het plagen is in de vijver zwommen. I saw that the dragons-PL that the elephant-SG teasing is-SG in the pond swam-PL

		I saw that the dragons that the elephant is teasing swam in the pond.
7.	SRCsg	Ik zag dat de duif die de kippen aan het knuffelen is door het park wandelde. I saw that the pigeon-SG that the chickens-PL hugging is-SG through the park walked-SG I saw that the pigeon that is hugging the chickens walked through the park.
	SRCpl	Ik zag dat de duiven die de kip aan het knuffelen zijn door het park wandelden. I saw that the pigeons-PL that the chicken-SG hugging are-PL through the park walked-PL I saw that the pigeons that are hugging the chicken walked through the park.
	ORCsg	Ik zag dat de duif die de kippen aan het knuffelen zijn door het park wandelde. I saw that the pigeon-SG that the chickens-PL hugging are-PL through the park walked-SG I saw that the pigeon that the chickens are hugging walked through the park.
	ORCpl	Ik zag dat de duiven die de kip aan het knuffelen is door het park wandelden. I saw that the pigeons-PL that the chicken-SG hugging is-SG through the park walked-PL I saw that the pigeon that the chicken is hugging walked through the park.
8.	SRCsg	Ik zag dat de beer die de wolven aan het krabben is over de weg hinkelde. I saw that the bear-SG that the wolves-PL scratching is-SG on the road hopped-SG I saw that the bear that is scratching the wolves hopped on the road.
	SRCpl	Ik zag dat de beren die de wolf aan het krabben zijn over de weg hinkelden. I saw that the bears-PL that the wolf-SG scratching are-PL on the road hopped-PL I saw that the bears that are scratching the wolf hopped on the road.
	ORCsg	Ik zag dat de beer die de wolven aan het krabben zijn over de weg hinkelde. I saw that the bear-SG that the wolves-PL scratching are-PL on the road hopped-SG I saw that the bear that the wolves are scratching hopped on the road.
	ORCpl	Ik zag dat de beren die de wolf aan het krabben is over de weg hinkelden. I saw that the bears-PL that the wolf-SG scratching is-SG on the road hopped-PL I saw that the bears that the wolf is scratching hopped on the road.
9.	SRCsg	Ik zag dat de leeuw die de honden aan het wassen is over de stenen sprong. I saw that the lion-SG that the dogs-PL washing is-SG over the rocks jumped-SG I saw that the lion that is washing the dogs jumped over the rocks.
	SRCpl	Ik zag dat de leeuwen die de hond aan het wassen zijn over de stenen sprongen. I saw that the lions-PL that the dog-SG washing are-PL over the rocks jumped-PL I saw that the lions that are washing the dog jumped over the rocks.
	ORCsg	Ik zag dat de leeuw die de honden aan het wassen zijn over de stenen sprong. I saw that the lion-SG that the dogs-PL washing are-PL over the rocks jumped-SG I saw that the lion that the dogs are washing jumped over the rocks.
	ORCpl	Ik zag dat de leeuwen die de hond aan het wassen is over de stenen sprongen. I saw that the lions-PL that the dog-SG washing is-SG over the rocks jumped-PL I saw that the lions that the dog is washing jumped over the rocks.

10.	SRCsg	Ik zag dat de poes die de schildpadden aan het kussen is door de struiken kroop. I saw that the cat-SG that the turtles-PL kissing is-SG through the bushes crawled-SG I saw that the cat that is kissing the turtles crawled through the bushes.
	SRCpl	Ik zag dat de poezen die de schildpad aan het kussen zijn door de struiken kropen. I saw that the cats-PL that the turtle-SG kissing are-PL through the bushes crawled-PL I saw that the cats that are kissing the turtle crawled through the bushes.
	ORCsg	Ik zag dat de poes die de schildpadden aan het kussen zijn door de struiken kroop. I saw that the cat-SG that the turtles-PL kissing are-PL through the bushes crawled-SG I saw that the cat that the turtles are kissing crawled through the bushes.
	ORCpl	Ik zag dat de poezen die de schildpad aan het kussen is door de struiken kropen. I saw that the cats-PL that the turtle-SG kissing is-SG through the bushes crawled-PL I saw that the cats that the turtle is kissing crawled through the buses.

Appendix F – Filler items self-paced listening task

The items below appear to the full lists used for the 7-year olds. Underscored sentence numbers appear in the short lists as well.

Actives singular	
1.	Ik zag dat de pony de herten heel zachtjes schopte. I saw that the pony the dears very gently kicked I saw that the pony very gently kicked the dears. Question: Heeft de pony de herten geschopt? Did the pony kick the dears?
2.	Ik zag dat de eekhoorn de konijnen voor de grap borstelde. I saw that the squirrel the rabbits for fun brushed I saw that the squirrel brushed the rabbits for fun. Question: Hebben de konijnen de eekhoorn geborsteld? Did the rabbits brush the squirrels?
3.	Ik zag dat de stier de varkens heel hard duwde. I saw that the bull the pigs very hard pushed I saw that the bull pushed the pigs very hard. Question: –
<u>4.</u>	Ik zag dat het veulentje de lammetjes snel poetste. I saw that the foal the lambs quickly brushed I saw that the foal quickly brushed the lambs. Question: Heeft het veulentje de lammetjes langzaam gepoetst? Did the foal slowly brush the lambs?
<u>5.</u>	Ik zag dat de tijger de gorilla's voorzichtig aaide. I saw that the tiger the gorillas carefully petted I saw that the tiger carefully petted the gorillas. Question: Heeft de tijger de gorilla's geaaid? Did the tiger pet the gorillas?
Actives plural	
<u>1.</u>	Ik zag dat de hanen de kalkoen opeens pikten. I saw that the roosters the turkey suddenly pecked I saw the roosters suddenly peck the turkey.

	Question: –
2.	Ik zag dat de panda's de krokodil stiekem krabden. I saw that the pandas the crocodile secretly scratched I saw the pandas secretly scratch the crocodile. Question: Hebben de panda's de krokodil gekrabd? Did the pandas scratch the crocodile?
3.	Ik zag dat de kalfjes de ezel keer op keer likten. I saw that the calves the donkey again and again licked I saw the calves lick the donkey again and again. Question: Heeft de ezel de kalfjes gelikt? Did the donkey lick the calves?
4.	Ik zag dat de egels de kalkoen met veel plezier wasten. I saw that the hedgehogs the turkey with pleasure washed I saw the hedgehogs wash the turkey with pleasure. Question: -
5.	Ik zag dat de neushoorns het paard per ongeluk beten. I saw that the rhinos the horse accidentally bit. I saw the rhinos accidentally bit the horse. Question: –
Passives singular	
1.	Ik zag dat de tijger voorzichtig door de lammetjes geaaid werd. I saw that the tiger carefully by the lambs petted was I saw the tiger was carefully petted by the lambs. Question: Hebben de lammetjes de tijger geaaid? Did the lambs pet the tiger?
2.	Ik zag dat de puppy snel door de konijnen gepoetst werd. I saw that the puppy quickly by the rabbits brushed was I saw the puppy was quickly brushed by the rabbits. Question: –
3.	Ik zag dat het veulentje heel zachtjes door de panda's geaaid werd. I saw that the foal very gently by the pandas petted was I saw the foal was very gently petted by the pandas. Question: Hebben de panda's het veulentje heel zachtjes geaaid? Did the pandas very gently pet the foal?

4.	Ik zag dat het paard voor de grap door de varkens geschopt werd. I saw that the horse for fun by the pigs kicked was I saw the horse was kicked by the pigs for fun. Question: Heeft het paard de varkens geschopt? Did the horse kick the pigs?
5.	Ik zag dat de ezel heel hard door de kalfjes geduwd werd. I saw that the donkey very hard by the calves pushed was I saw the donkey was pushed very hard by the calves. Question: Hebben de kalfjes de ezel geduwd? Did the calves push the donkey?

Passives plural

1.	Ik zag dat de herten met veel plezier door de stier gelikt werden. I saw that the dears with pleasure by the bull licked were I saw the dears were licked by the bull with pleasure. Question: Hebben de herten de stier gelikt? Did the dears lick the bull?
2.	Ik zag dat de gorilla's per ongeluk door de eekhoorn gekrabd werden. I saw that the gorillas accidentally by the squirrel scratched were I saw the gorillas were accidentally scratched by the squirrel. Question: –
3.	Ik zag dat de egels op eens door de pony gebeten werden. I saw that the hedgehogs suddenly by the pony bitten were I saw the hedgehogs were suddenly bitten by the pony. Question: Hebben de egels de pony gebeten? Did the hedgehogs bit the pony?
4.	Ik zag dat de mussen keer op keer door de uil gepikt werden. I saw that the sparrows again and again by the owl pecked were I saw the sparrows were pecked over and over again by the owl. Question: –
5.	Ik zag dat de neushoorns stiekem door de krokodil gewassen werden. I saw that the rhinos secretly by the crocodile washed were I saw the rhinos were secretly washed by the crocodile. Question: Heeft de krokodil de neushoorns gewassen? Did the crocodile wash the rhinos?