4. The Processing of Scrambling

Introduction

Having reviewed the grammar of scrambling in the previous chapter, I discuss the psycholinguistics of scrambling in native processing in this chapter. The various interface dimensions that characterize the grammar of scrambling also inform the processing of scrambling. In processing, scrambling invokes distinctive reanalysis effects, i.e. processing effects of revising a preliminary parse, that are modulated by morphology, argument structure and information structure. The aim of this chapter is to identify the patterns of native processing of scrambling, since these patterns will present the background to the processing experiments with L2 (and native) speakers of German reported in this thesis. In this chapter, I review previous research on processing (non-)canonical word orders by native speakers in German, Dutch, Russian and English, and I discuss how the Garden-Path model accounts for the processing of scrambling and its interface dimensions.

This chapter is structured as follows: In Section 4.1, I outline the essentials of the Garden-Path model of sentence processing. Section 4.2 presents the morphosyntactic processing and reanalysis patterns found for subject-object ambiguities in cross-linguistic perspective. The following section, Section 4.3, relates these processing patterns to the Garden-Path model. In Section 4.4, I discuss effects of information structure on the processing of scrambling. Section 4.5 summarizes and concludes.

4.1. The Garden-Path model of language processing: Analysis and reanalysis

Psycholinguistic models of human sentence processing have conceived of the architecture of the sentence processor in different ways. Broadly speaking, two families of approaches can be distinguished (for overview, see Crocker, 1999; Pickering, Clifton & Crocker, 2000): (a) Syntax-first approaches, which claim that the processing of syntactic, thematic and discourse information takes places successively (e.g. Frazier & Clifton, 1996). (b) Interactive approaches, which claim that the processing of syntactic, thematic, discourse information, etc. takes place in parallel (e.g. Trueswell & Tanenhaus, 1994). It is not the aim of this thesis to test between these approaches. Not least because most of the research on syntactic ambiguity resolution in German, Dutch and Russian has been carried out within the syntax-first framework, I adopt the principles and constraints employed within this approach.

A variant of syntax-first models, the Garden-Path model of human sentence processing (e.g. Frazier, 1987; Frazier & Clifton, 1996; Frazier & Fodor, 1978) posits that language processing is serial, modular and proceeds by principles that are predominantly motivated by economy considerations. According to this model, parsing
proceeds in two stages: It is assumed that, initially, the parser incrementally analyses the input purely according to structure-driven syntactic strategies. At this stage, only the syntactic category information of lexical items informs the parser, which assembles the input according to a set of parsing principles (Frazier, 1989). This initial stage of parsing is commonly referred to as first-pass parsing. The incremental syntactic representation of the input thus constructed is subsequently fed to other modules, which check this provisional analysis for lexical-thematic, morphological, semantic or pragmatic consistency and potentially reject it. If a given analysis is rejected after first-pass parsing, syntactic reanalysis is initiated by revising the original structural analysis in order to obtain the correct grammatical structure. Such reanalysis is costly as it entails additional processing effort. This stage of parsing is labeled second-pass parsing.

In first-pass parsing, the serial parser employs parsing principles which govern the incremental construction of syntactic structure (e.g. DeVincenzi, 1991; Frazier & Fodor, 1978; Gibson, 1998; Gorrell, 1995; Schlesewsky, Bornkessel & Frisch, 2003; Sturt & Crocker, 1996). These are formulated as universal economy principles that dictate the parser to construct as parsimonious a phrase-structure as possible without violating principles of grammar. One example is the Minimal Chain Principle (1) by DeVincenzi (1991).

(1) Minimal Chain Principle (MCP) (DeVincenzi, 1991: 13)
Avoid postulating unnecessary chain members at S-structure, but do not delay required chain members.

The MCP identifies the main strategy of the parser in minimizing syntactic structure as expressed by the number of movement chains involved in a sentence, because each constituent introduced as a member of a chain forces the parser to relate it to its base position. In essence, then, the optimal parse has minimal phrase structure by containing as few chains as necessary for a grammatical representation of the input. At the same time, the second clause allows for the construction of chains, if they are grammatically required.

In second-pass parsing, or reanalysis, the parser makes use of strategies to correct a phrase-structural representation of the input arrived at by applying universal parsing principles in first-pass parsing. Depending on the gravity of the initial misparse, the parser either needs to abandon the initial representation and reparse the string thus far analysed, or uses reanalysis algorithms to repair individual elements of relations in the initial parse. Various such algorithms have been proposed (e.g. Bader & Bayer, 2006; Fodor & Inoue, 1994, 1998; Gorrell, 1995) and will be introduced in later sections. Both the MCP and reanalysis algorithms play a large role in accounting for the processing of scrambling, or, more generally, of subject-object ambiguities in German.
4.2. Subject-object ambiguities

Subject-object ambiguities arise when the parser cannot immediately decide whether an NP is to be assigned the role of grammatical subject or object of a clause. Typically, these ambiguities are temporary in that, at some point, morphological marking on nominal arguments (case) or the verb (e.g. number) disambiguates the syntactic function of NPs in a sentence.

The processing of subject-object ambiguities has been much studied across languages. In this section, I focus on subject-object ambiguities in German, but make reference to relevant studies on Dutch, Russian and English. Two morphosyntactic properties make German particularly interesting for the study of subject-object ambiguities:

(A) Due to morphological syncretism, case marking on determiners can be ambiguous. This is illustrated for definite determiners in Table 4.1 (repeated from Chapter 3). For instance, *die* can denote either feminine singular nominative or accusative case or plural nominative or accusative case.

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*Table 4.1. Definite determiners in German.*

Such syncretism in case marking can lead to NPs being fully ambiguous in terms of syntactic function. This is illustrated in (2), where case-marking on both NPs in the embedded clause is ambiguous. In (2), the sentence is ambiguous up to the point of the sentence-final auxiliary that disambiguates order by virtue of subject-verb agreement.

(2) Ich glaube, dass die Lehrerin die Mütter gesehen haben. (German)  
I think that the teacher the mothers seen have  
‘I think that the mothers saw the teacher.’

(B) Due to the different surface orders in main clauses, which induce verb second, and embedded clauses, which are SOV, the occurrence of verbal information in German is variable. Verb information in main clauses occurs very early, at least for thematic verbs in verb second position, so that its effects can be compared to verb information in embedded clauses that is delayed until the end of the sentence. The clause-final positioning of the verb in embedded clauses means (a) syntactic ambiguities can prevail
across the sentence until verbal disambiguation, e.g. by virtue of subject-verb agreement 
and (b) syntactic ambiguities can be studied without immediate effects of the lexical 
semantics of verbal information.

In the following, I will mainly be concerned with two aspects in the processing of 
subject-object ambiguities: (a) first-pass preferences for SO over OS orders and (b) 
second-pass parsing or syntactic reanalysis from SO to OS. In particular, the review 
focuses on presenting and assessing

- cross-linguistic evidence of a first-pass SO preference in processing (ambiguous) 
  sentences
- evidence of incremental reanalysis to OS orders once morphological information 
  disambiguating the order is encountered
- different strengths of reanalysis effects depending on morphosyntactic properties 
  (e.g. case, verbal agreement)
- specific processing reflexes of the interface nature of scrambling in reanalysis, 
  namely,
  o effects of argument structure on reanalysis of dative experiencer verbs
  o effects of information structure on reanalysis of scrambled orders in 
    context

First, I discuss the processing of OS orders derived by movement in declaratives and 
wh-questions to give a cross-linguistic overview of parsing preferences for SO over OS. 
Second, I review experiments on the processing of scrambling. Third, I consider the 
potential relevance of non-syntactic factors for the processing of scrambling, and, fourth, 
I give an account of the native processing of morphosyntax and of interface information.

4.2.1. Derived OS orders in declaratives: Cross-linguistic incremental effects of 
reanalysis

In declarative sentences, objects can topicalize to SpecCP in main clauses or move to 
SpecCP in relative clauses constructions. In the German main clause (3), the first NP (die 
Tante, ‘the aunt’) is ambiguously case-marked, and the second NP displays unambiguous 
case marking, thus disambiguating the sentence towards an SO reading (3a) or an OS 
reading (3b). In all examples in this chapter, the disambiguating constituent will be 
marked in boldface, and the constituent showing a reanalysis effect (e.g. increased 
reading times) will be marked in italics. In many, though not all, cases this will be the 
same constituent.
Using the method of speeded grammaticality judgements, Hemforth (1993) finds that subject-object orders disambiguated on the second NP as in (3a) are judged more accurately and faster than the corresponding object-subject order (3b). In eye-tracking studies, Scheepers (1996; see also Scheepers et al., 2000) also finds that SO main clauses as in (3a) receive shorter reading times than OS sentences. On the region of disambiguation, i.e. the second NP, OS sentences evince significantly longer reading times (see also Weskott, 2003). These slowdowns are indicative of, first, a first-pass preference for SO orders, and, second, syntactic reanalysis to the OS order once case marking on the determiner of the second NP disambiguates the order of the string to OS.

ERP studies show that OS orders evince processing costs that can be linked to syntactic reanalysis. Using ERPs, Frisch, Schlesewsky, Saddy & Alpermann (2002) tested sentences that were either case-ambiguous on the first NP and then disambiguated on the second NP (4a) or disambiguated on the first NP (4b).

For (4a), OS orders elicit a positive-going deflection of the waveform compared to the SO order around 600ms after the onset of the second, disambiguating NP; this P600 effect has been argued to reflect the costs of syntactic reanalysis (see, e.g., Friederici, 2002). Since the effect occurs immediately at the point of disambiguation, syntactic reanalysis is incremental in processing. Note also that processing difficulty reflecting

1 In addition to the temporal resolution of neurophysiological effects, ERP studies also allow for (approximate) local inferences of where the effects are (most) measurable across the scalp. Since these issues are orthogonal to the concerns here, I will henceforth only indicate the temporal characteristics of the relevant effects measured in the ERP studies reported in order to enhance readability.

2 Comparing (4a) and (4b), the ambiguous first NP in (4a) equally gives rise to a P600 compared to the unambiguously case-marked NP in (4b), while there was no significant difference between nominative-marked and accusative-marked initial NPs. This suggests that syntactically ambiguous NPs cause additional processing cost in ways similar to NPs that signal reanalysis by disambiguating the structure to the dispreferred OS order. Hence, the P600 appears to be an ERP component that is elicited by various syntax-related phenomena, e.g syntactic violations, syntactic ambiguity, syntactic disambiguation and syntactic integration of information. For discussion, see Gouvea, Phillips, Kazanina & Poeppel (2007).
syntactic reanalysis to the OS orders is found before the lexical verb in (4). The SO preference has thus been characterized as a structural parsing preference that obtains independently of verb information.

OS orders are associated with increased processing cost in all four languages under review. For Dutch, Frazier & Flores d’Arcais (1989) investigated processing preferences in main clauses, in which number marking on the verb disambiguates order (5).

(5) a. De patient heeft de dokters bezocht.  
The patient hasSG the doctors visited  
‘The patient visited the doctors.’

b. De patient hebben de dokters bezocht.  
The patient havePL the doctors visited  
‘The doctors visited the patient.’

As in German, subject-object orders in Dutch are responded to faster and more accurately than OS orders in a speeded grammaticality judgement task. Employing the self-paced reading paradigm, Kaan (1997) finds for sentences similar to (5) that SO orders were read faster on the disambiguating verbal segment than OS orders. Overall, participants also made fewer comprehension errors for SO sentences than for OS sentences (for relative clauses, see Frazier, 1987). Finally, Lamers (2001) investigated Dutch main clauses which were disambiguated by case marking on the second pronominal NP (6) in an ERP experiment.

(6) De oude vrouw in de straat verzorgde hij/hem vrijwel elke dag.  
The old womanNOM/ACC in the street looked-after heNOM/himACC almost every day  
‘He looked after the old woman in the street almost every day./The old woman in the street looked after him almost every day.’

The results show a parsing disadvantage for OS orders versus SO orders as documented in several positive deviations from the ERP-waveforms of the SO orders at the disambiguating pronoun. Lamers (2001) relates some of these deviations to positivities reflecting the detection of morphosyntactic mismatches and subsequent reanalysis processes identified in the literature.

For Russian, Sekerina (1997; 2003) carried out a reading time experiment, in which participants were presented with fully ambiguous sentences as in (7), in which only the position of the verb varied.
Irrespective of the ambiguity, the order in (7b) requires (at least) one NP to have scrambled across the verb, seeing that SVO constitutes the base order in Russian. Participants read the sentences in (7) in full and answered comprehension questions that differentiated between the two readings. The analysis of the reading times shows that (7a) sentences are read significantly faster than the sentences corresponding to (7b). Moreover, the participants assign all sentences a subject-initial reading significantly more often than an object-initial reading, irrespective of the argument-verb ordering. These results indicate that deviations from the Russian SVO base order (though not necessarily OSV) are dispreferred and incur processing difficulty as reflected in the elevated reading times.

In a self-paced reading experiment on Russian relative clauses, Fedorenko & Gibson (2004) find that object relative pronouns (8b) evince longer reading times than subject relative pronouns (8a).

For English, the investigation of subject-object ambiguities has been largely limited to relative clauses. A large body of research employing different methods, such as on-line lexical decision, response accuracy, reading times, eye-tracking and neuroimaging techniques (e.g. Gibson, 1998; Gibson, Desmet, Grodner, Watson & Ko, 2005; Holmes, 1973; Holmes & O'Reagan, 1981) demonstrate that object-extracted relative clauses (9a) give rise to increased processing effort compared to subject-extracted relative clauses (9b), although there is no ambiguity.

Cross-linguistically, then, OS orders are dispreferred and incur increased processing cost on the regions of disambiguation. These costs index a universal preference for SO in first-
pass parsing. The incremental effects of processing difficulty signal that the parser makes immediate use of disambiguating information and reanalyses the assumed SO phrase-structure representation to an OS order.

4.2.2. Non-derived OS orders: Effects of argument structure

Recall from Chapter 3.5 that not all verbs in German, Dutch and Russian project an underlying subject-object order. Dative experiencer verbs, a special class of psych-verbs in which a dative-marked experiencer thematically outranks a nominative-marked theme, project a non-derived OS order in syntax (e.g. den Besten, 1989), as is illustrated in (10b) for the dative-experiencer verb *gefallen* (‘please/be appealing to’).

(10) a. … dass der Vater dem Onkel gefällt. (German)  
   … that the father NOM the uncle DAT pleases  
   b. … dass dem Onkel der Vater gefällt.

Several processing studies on German and Dutch investigated whether such thematic verb information projecting to syntax affects the parsing of subject-object ambiguities. In a speeded grammaticality judgement experiment, Schlesewsky & Bornkessel (2003) compared subject-object ambiguities of dative active and dative experiencer verbs that were disambiguated by verbal agreement (11). In contrast to dative experiencer verbs like *gefallen* (11b), dative active verbs like *applaudieren* (‘applaud’) project a canonical underlying SO order (11a). Note that the NPs, i.e. proper names and plural nouns, are three-way ambiguous between nominative, accusative and dative case in German.

(11) a. Gestern wurde berichtet, dass Stefan Autoren *applaudieren*. (German)  
   Yesterday was reported that Stefan NOM/ACC/DAT authors NOM/ACC/DAT applaud  
   ‘Yesterday, it was reported that authors applauded Stefan.’  
   b. Gestern wurde berichtet, dass Stefan Autoren *gefallen*.  
   Yesterday was reported that Stefan NOM/ACC/DAT authors NOM/ACC/DAT appeal-to  
   ‘Yesterday, it was reported that Stefan appealed to authors.’

OS orders with dative active verbs lead to decreased judgement accuracy and increased response times compared to SO orders, in line with the results on canonical transitive verbs. In contrast, OS orders of dative experiencers are judged more accurately and faster than SO orders.

In a series of self-paced reading tasks on Dutch dative experiencers, Lamers (2001) finds that SO orders are preferred and read faster than OS orders. However, in offline ratings, OS orders with experiencer verbs were judged to be more comprehensible
than OS orders with other verb types, and the on-line processing costs of OS orders with experiencer verbs were marginally lower compared to OS orders for other verb types.\(^3\)

In a series of ERP experiments on German, Schlesewsky & Bornkessel (2004) employed similar stimuli as in (11) and sentences disambiguated by overt case marking (see also Bornkessel, Schlesewsky & Friederici, 2002a; 2003b). For sentences in which verb information disambiguates order (11), OS orders in dative experiencers are judged more accurately than OS orders with canonical transitive verbs. In addition, the OS dative experiencers elicit a different neurophysiological response compared to OS transitive verbs. As noted in Section 4.3.1, OS orders with transitive verbs (11a) give rise to a P600 on the verb signaling syntactic reanalysis. In contrast, OS orders with dative experiencers bear no evidence of a P600, suggesting that reanalysis does not occur; rather, OS dative experiencers (11b) give rise to a negativity around 400ms post onset of the verb (N400). Bornkessel et al. (2004)) interpret this N400 as signaling case revision.\(^4\) Case revision is argued to occur, since the parser needs to revise its original syntactic function assignment to the case-ambiguous NPs, namely, nominative-accusative, to the dative-nominative order upon encountering a dative experiencer verb. Once case assignment has been revised, no further syntactic reanalysis is necessary, since the OS order is available via the thematic properties of the verb.

Interestingly, a lack of syntactic reanalysis effects (P600) and the occurrence of a (somewhat less pronounced) case revision reflex (N400) was also found for OS orders with dative active verbs (e.g. *vertrauen*, ‘trust’).\(^5\) Bornkessel et al. (2004) argue that the N400 indexing case revision is a carry-over effect from dative-marked experiencers.

In sum, studies using different methods report that argument structure alternations incur qualitatively different processing reflexes. OS order of dative experiencer verbs in German show no processing disadvantages or even a processing advantage compared to SO orders of the same verb class. No effects indicating syntactic reanalysis are observable. These results have been related to the thematic properties of dative experiencers which project an underlying OS order to syntax (Lamers, 2001; Scheepers (1996) and Scheepers et al. (2000) study the processing of subject-object ambiguities with experiencer verbs in which an accusative-marked experiencer is argued to thematically outrank a nominative-marked theme (e.g. *ängstigen*, ‘frighten’). Specifically, stative psych verbs projecting a canonical SO order (e.g. *fürchten*, ‘fear’) were compared to causative psych verbs (like *ängstigen*) that were argued to project an OS order. In off-line rating studies and an eye-tracking experiment, OS orders with causative psych verbs fail to show processing advantages compared to SO orders (for Dutch, see Lamers, 2001). Scheepers et al. (2000) suggest that the possibility of assigning the nominative-marked argument of causative psych verbs an agentive reading might lead to a canonical SO ordering of the arguments (as in *The boy frightened the cat*).

\(^3\) Scheepers (1996) and Scheepers et al. (2000) study the processing of subject-object ambiguities with experiencer verbs in which an accusative-marked experiencer is argued to thematically outrank a nominative-marked theme (e.g. *ängstigen*, ‘frighten’). Specifically, stative psych verbs projecting a canonical SO order (e.g. *fürchten*, ‘fear’) were compared to causative psych verbs (like *ängstigen*) that were argued to project an OS order. In off-line rating studies and an eye-tracking experiment, OS orders with causative psych verbs fail to show processing advantages compared to SO orders (for Dutch, see Lamers, 2001). Scheepers et al. (2000) suggest that the possibility of assigning the nominative-marked argument of causative psych verbs an agentive reading might lead to a canonical SO ordering of the arguments (as in *The boy frightened the cat*).

\(^4\) Note that taking the N400 to reflect case revision represents a non-canonical interpretation of the N400 effect. For further argumentation, see Bornkessel et al. (2004; 2003b).

\(^5\) This effect could not be replicated in Schlesewsky & Bornkessel (2006) with similar materials. In this study, dative-active verbs were associated with a biphasic N400 and P600 pattern.
In the four languages studied in this thesis, \textit{wh}-questions are formed by raising the \textit{wh}-phrase to SpecCP. For ambiguous \textit{wh}-questions in German (12), Meng (1995), Meng & Bader (2000) and Schlesewsky, Fanselow, Kliegl & Krems (2000) found that OS questions elicit significantly longer reading times on the disambiguating auxiliary in self-paced reading (for Dutch, see Frazier & Flores d'Arcais, 1989; Kaan, 1997). These effects demonstrate that the SO preference and subsequent syntactic reanalysis equally holds for \textit{wh}-movement.

(12) a. Welche Tante \textbf{hat} die Jungen gestern besucht? \hspace{1cm} (German)

Which aunt \textit{has} the boys yesterday visited

‘Which aunt visited the boys yesterday?’

b. Welche Tante \textbf{haben} die Jungen gestern besucht?

Which aunt \textit{have} the boys yesterday visited

‘Which aunt did the boys visit yesterday?’

Further, research on \textit{wh}-movement in German shows that reanalysis differs in strength depending on the morphosyntactic feature of disambiguation (case versus verbal agreement). Several studies found differences in the processing of ambiguous embedded \textit{wh}-questions such as (13) and (14) using self-paced reading and speeded grammaticality judgements (Bader & Meng, 1999; Fanselow, Kliegl & Schlesewsky, 1999; Meng, 1998; Meng & Bader, 2000).

(13) Alle waren neugierig zu erfahren, welche Politiker\textit{in} die Minister kritisiert \textbf{hat/haben}.

All were curious to know which politician\textit{NOM/ACC} the ministers\textit{NOM/ACC} criticized

has/have

(14) ... zu erfahren, \textbf{welcher/welchen} Politiker \textit{die} Minister kritisiert \textbf{hat/haben}.

… to know which politician\textit{NOM} / which politician\textit{ACC} the minister criticized

has/have

For OS orders disambiguated by verbal agreement in (13), reading times were longer on the disambiguating auxiliary in self-paced reading; in speeded judgements, reaction times to OS orders were longer and judgement accuracy was lower than for SO orders. By contrast, for embedded \textit{wh}-questions disambiguated by case-marking on the fronted \textit{wh}-
The Processing of Scrambling

phrase (14) or the second NP, there were no significant differences between SO and OS orders on any segment; only the total reading times differed, with OS orders taking longer to read than SO orders (Fanselow et al., 1999; Meng, 1998). Likewise, OS orders disambiguated by case marking led to only weak reanalysis costs in speeded judgements (Meng & Bader, 2000).

At first glance, it might seem that this difference follows from the different linear positions of disambiguating case and verbal agreement information; for instance, in the embedded OS sentences in (15), case information (15a) becomes available sooner than verbal agreement (15b). The earlier occurrence of disambiguating information in (15a) compared to (15b) might lead to reduced reanalysis cost because the portion of the sentence that is ambiguous is shorter in (15a) than in (15b).

(15) a. … dass den Jungen die Tante gesehen hat. (German)
   … that the boy ACC the aunt NOM/ACC seen has
b. … dass die Tante die Mädchen gesehen haben. … that the aunt NOM/ACC the girls NOM/ACC seen have

Yet, using speeded grammaticality judgements, Meng & Bader (2000) and Schlesewsky et al. (2000) report, for matrix wh-questions (16), that OS orders disambiguated by verbal agreement also elicit higher costs than OS orders disambiguated by case marking.

(16) a. Welche Frau sah der Mann am Freitag? (German)
   Which woman NOM/ACC saw the man NOM on Friday
b. Welche Frau sahen die Männer am Freitag?
   Which woman NOM/ACC saw PL the men NOM/ACC on Friday

In (16), the linear position of case and verbal agreement disambiguation are the reverse of (15); yet, the same pattern of processing difficulty obtains, suggesting that the linear point of disambiguation does not account for the differential processing of case and verbal agreement information.

In speeded grammaticality judgements, Meng & Bader (2000) and Schlesewsky et al. (2000) also found that case and verbal agreement information elicit differential processing difficulty in ungrammatical sentences by comparing ungrammatical sentences in which both verbal arguments are marked with the same case (17a) and ungrammatical sentences in which the verb bears number marking different from the number marking of all NPs (17b).

(17) a. *Welcher Politiker aus der Opposition attackierte der Minister? (German)
   Which politician NOM of the opposition attacked the minister NOM
b. *Welcher Politiker aus der Opposition attackierten der Minister?  
Which politician\textsubscript{SG} of the opposition attacked\textsubscript{PL} the minister\textsubscript{SG}

For ungrammatical sentences, the inverse relation in processing difficulty between case and verbal agreement holds compared to grammatical sentences: Ungrammatical case marking is harder to detect than ungrammatical verbal agreement marking in that erroneous case marking evinced significantly more false positive judgements than incorrect verbal agreement marking did (see also Schlesewsky, Fanselow & Frisch, 2003).

In sum, processing difficulty of case versus verbal agreement interact with sentence type: In grammatical sentences, verbal agreement elicits greater processing inaccuracy than case; in ungrammatical sentences, case violations elicit greater processing inaccuracy than verbal agreement violations. This interaction suggests that case and verbal agreement have a different status in reanalysis (see Section 4.3.2).

4.2.4. Scrambling: Additional reanalysis costs

Using eye-tracking, Scheepers, Hemforth & Konieczny (2000) studied the processing of scrambling in the context of causative psych-verbs in sentences disambiguated by case marking on the second NP (18). In line with derived OS orders in declaratives and wh-questions, scrambled OS orders evince significantly elevated reading times on the disambiguating case-marked second NP and the clause-final verb.

(18) a. Daß die strenge Lehrerin \textit{den stillen Schüler} ein wenig ängstigte...  
That the strict teacher\textsubscript{NOM/ACC} the quiet pupil\textsubscript{ACC} a little scared  
‘That the strict teacher scared the quiet pupil a little …’

b. Daß die strenge Lehrerin \textit{der stillen Schüler} ein wenig ängstigte...  
That the strict teacher\textsubscript{NOM/ACC} the quiet pupil\textsubscript{NOM} a little scared  
‘That the quiet pupil scared the strict teacher a little …’

Compared to OS orders derived by movement to SpecCP, however, OS orders derived by scrambling in the Mittelfeld evince additional reanalysis costs. For scrambled sentences disambiguated by number marking as in (19a), Bader & Meng (1999) compared OS orders derived by scrambling (19a) to OS orders in relative clauses (19b) or OS orders derived by pronoun fronting and \textit{wh}-movement in embedded clauses. Scrambling leads to significantly stronger garden-paths than OS orders of the other movement types, which were found not to differ among each other in judgement accuracy and latency for OS orders.
The director has said that the new teacher\textsubscript{NOM/ACC} and some of the colleagues called have

‘The director said that some of the colleagues called the new teacher.’

b. Die Direktorin hat von der neuen Lehrerin erzählt, die
The director has of the new teacher\textsubscript{NOM/ACC} said that

‘The director talked of the new teacher that some of the colleagues called.’

In an ERP study in which scrambled OS orders (as in (19a)) and object-extracted relative clauses (as in (19b)) disambiguated by number marking on the auxiliary were tested, Friederici & Mecklinger (1996) document that OS orders give rise to a positive-going waveform (P600) after the onset of the auxiliary (see also Bornkessel, McElree et al., 2004; Friederici, Schlesewsky & Fiebach, 2003). For scrambled OS orders, the amplitude of this effect was more pronounced than for relative clauses – a finding that is in line with the behavioural evidence for differential processing effort between relative clauses and scrambling reported in Bader & Meng (1999).

An even stronger effect holds for scrambled sentences disambiguated by case marking. For scrambled sentences disambiguated by case marking on the first NP (20), Bornkessel, Schlesewky & Friederici (2002a; 2002b; 2003a) report that OS orders, compared to SO orders, elicit a P600 following the onset of the first accusative-case-marked NP. In addition, OS orders give rise to a negative-going deflection of the ERP waveform approximately 400ms after the onset of the accusative-marked NP (for three-place predicates, see also Rösler, Pechmann, Streb, Röder & Henninghausen, 1998; Schlesewsky, Bornkessel et al., 2003). Bornkessel et al. interpret these effects as reflecting two different processes: The negativity in the 400ms time window is argued to reflect the revision of focus structure (from the object to the subject) associated with scrambling: The later positivity is argued to follow from phrase-structural revision necessary for OS orders (see Section 4.3.5 for further discussion). Bornkessel et al. term the negativity evinced specifically by OS orders derived by scrambling the ‘scrambling negativity’.

(20) a. Er hörte, dass \textbf{der Gärtner} den Lehrer \textsubscript{NOM} besucht hat. (German)
He heard that the gardener\textsubscript{NOM} the teacher\textsubscript{ACC} visited has

‘He heard that the gardener visited the teacher.’
b. Er hörte, dass den Gärtner der Lehrer besucht hat.
   He heard that the gardener, the teacher visited has
   ‘He heard that the teacher visited the gardener.’

Summarizing, several studies cohere in attesting that both incremental and global processing costs for OS orders derived by scrambling are higher than for other OS constructions and that scrambled OS orders evince neurophysiological components not attested for other OS orders (the ‘scrambling negativity’). An account of the elevated processing cost in reanalysis specific to scrambling will be given in Section 4.4.

4.2.5. Subject-object ambiguities and non-syntactic factors

Several studies investigated the extent to which the structural parsing preference for SO orders is susceptible to non-syntactic factors. For instance, research has considered whether animacy or verb information affects the SO preference. For German wh-questions, Schlesewsky et al. (2000) varied the animacy of the first and second noun phrases of sentences such as (21) in a self-paced reading study. They report that the subject-first preference remained unaffected by animacy, since reanalysis effects in sentences as (21) with inanimate NPs did not differ from sentences containing animate NPs.

(21) a. Welches System unterstützt die Programme auf dem Computer? (German)
   Which system supports the programs on the computer
   ‘Which system supports the programs on the computer?’

b. Welches System unterstützen die Programme auf dem Computer?
   Which system support the programs on the computer
   ‘Which system do the programs support on the computer?’

However, Mak, Vonk & Schriefers (2002) find that the SO preference disappears for Dutch wh-questions if the subject is inanimate and the object is animate. Reanalysing their earlier finding, Mak, Vonk & Schriefers (2006) argue, though, that animacy effects actually reduce to an information-structural effect of topichood. The influence of information structure on the SO preference will be explored in Section 4.4.

Other studies probe the effects of plausibility of verb information on processing preferences. Schriefers, Friederici & Kühn (1995) manipulated the plausibility of syntactic order in a study on ambiguous relative pronouns, e.g. by replacing the neutral verb gesehen (‘seen’) in (22) by the semantically biased verb entlassen (‘fired’), which renders one reading pragmatically highly implausible.
Plausibility was balanced across orders, so that both SO and OS orders were neutral, positively biased and negatively biased equally often. For neutral and semantically biased verbs, the same SO preference obtained, irrespective of plausibility differences, which suggests that semantic information of the verb does not override the structural SO preference. In an ERP study with similar materials, Mecklinger, Schriefers, Steinhauer & Friederici (1995) find that, at least for subjects with fast response times to the stimuli, SO orders elicit less processing effort at the disambiguating verb than OS orders do (see also Friederici & Mecklinger, 1996); again, semantically biasing the verb did not alleviate reanalysis costs for OS orders.

4.2.6. Summary

The preceding review of studies on native-language processing of subject-object ambiguities documents a robust subject-first preference which holds across sentence types across the languages under review and has been established using different methodologies. The further findings can be summarized as follows:

- The subject-first preference is a structural preference of the human sentence processor which is established independently of lexical-semantic information because it is already measurable on clause-initial case-marked NPs before verb information becomes available (e.g. Hemforth, 1993; Schlesewsky et al., 2000).
- The SO preference remains unaffected by the semantic plausibility of verb information (e.g. Mecklinger et al., 1995; Schriefers et al., 1995).
- Additional processing effort surfaces at the points of morphological disambiguation to the OS order (and sometimes later), indicating that the parser uses morphological information incrementally for revising the default SO order to the OS order (syntactic reanalysis).
- Reanalysis is modulated by thematic properties of the verb. Non-derived OS orders with dative experiencer verbs do not give rise to syntactic reanalysis effects
- Across sentence types, OS orders disambiguated by number marking on the verb evince greater reanalysis cost than OS orders disambiguated by case marking.
- For scrambled OS orders, elevated reanalysis cost have been observed compared to other OS constructions. In addition, reanalysis for scrambling is associated with additional ERP components (the ‘scrambling negativity’).
In the following I sketch how these processing patterns of subject-object ambiguities can be analysed in a serial model of sentence processing, the model of Linking and Checking proposed by Bader & Bayer (2006). Finally, I discuss the effects of context on scrambling by outlining the interaction of reanalysis and information structure (Section 4.4).

4.3. Subject-object ambiguities and the Garden-Path model: Linking and checking

Within the framework of serial Garden-Path approaches of sentence processing, the model of the human sentence processor developed in Bader & Bayer (2006) provides an account of the processing of verbal arguments and the relations between them (for other models, see, e.g., Bornkessel & Schlesewsky, 2006a; Fodor & Inoue, 1998).\(^6\) In the following I present a somewhat simplified sketch of the model, restricting my attention to the aspects relevant in the context of the present thesis.\(^7\)

Following Mitchell (1994), Bader & Bayer (2006) distinguish between three processes relevant in syntactic processing (23):

\begin{itemize}
  \item \textbf{STRUCTURE ASSEMBLY}
  Processes that compute phrase-structure trees
  \item \textbf{LINKING}
  Processes that associate phrases within the phrase-structure tree with argument structure positions
  \item \textbf{CHECKING}
  Processes that check the proper distribution of Case features and the agreement between a verb and its subject
\end{itemize}

(from: Bader & Bayer, 2006: 2)

Arguing for the sequential application of these processes, Bader & Bayer (2006) propose a three-stage model of the computation of syntactic structure in parsing (Figure 4.1).

\(^6\) In this thesis, I do not subscribe to Bader & Bayer’s model as the only model of sentence processing. Rather, this model presents an explicit formulation of the processing of verbs and their arguments in a serial framework that captures the relevant experimental findings reported above. Other models could arguably equally be recruited for analysing the data. However, Bader & Bayer’s (2006) model constitutes the best worked-out model for the processing of (German) word orders relevant in this thesis and will thus be used for analysing the data.

\(^7\) Bader & Bayer (2006)’s analysis encompasses the effects of animacy as well as relying on a somewhat different analysis of dative case than the one given here. These differences are inconsequential for the purposes of this thesis.
For structure assembly, Bader and Bayer assume that universal parsing principles, like the Minimal Chain Principle (1), determine basic phrase structure construction. The subsequent processes of argument linking and feature checking are specified in the Linking-Based Checking Algorithm (LBCA) as given in Figure 4.2.

1. Argument Linking
   Link each NP within the CPPM (Current Partial Phrase Marker; H.H.) to a position within the verb’s argument structure.

2. Feature Handling
   A. Feature Checking
      Check the relevant features (Case for subject and objects, number and person for subject).
   B. Feature Repair
      For each resulting feature mismatch, where a feature mismatch has the form “Feature value α assigned to XP instead of feature value β”, determine if the lexical material of XP would be compatible with the assignment of β.
      If so, replace α with β and – if necessary – adjust the phrase-marker accordingly.

The first part of the LBCA complements structure-assembly processes in first-pass parsing by integrating incoming NPs into the phrase structure. Note that the use of argument structure in Figure 4.4 does not refer to specific thematic roles (such as Agent, Patient, etc.); rather, it refers to the number of argument slots available. The second part of the LBCA (inspired by the Diagnosis Model of Fodor & Inoue, 1994; 2000) deals with second-pass parsing in that it covers the processes for reanalysis. Let us consider first-pass and second-pass parsing in turn.

4.3.1. First-pass parsing: Subject-object ambiguities and the Minimal Chain Principle

At the initial processing stages, structure assembly and linking, arguments are incrementally linked into an evolving phrase structure representation. The Minimal Chain
Principle forces the parser to assign the incoming input the most parsimonious structural representation in terms of movement chains involved ((24), repeated from (1)).

(24) Minimal Chain Principle (MCP) (DeVincenzi, 1991: 13)
Avoid postulating unnecessary chain members at S-structure, but do not delay required chain members.

A chain is defined as in (25).

(25) Chain
A set of co-indexed elements, bearing one and only one theta-role and one and only one case, where each element in the chain c-commands the next. (Clifton & De Vicenzi, 1990: 276)

The MCP imposes two requirements on the parser for creating filler-gap dependencies. The first clause of the MCP presses the parser to avoid creating a filler-gap dependency at all. Hence, SO orders which reflect the underlying canonical word order are preferred over derived OS orders which necessitate the creation of a chain between the displaced filler and its gap. For scrambling sentences involving transitive active verbs, the relevant chains are illustrated in Figures 4.3 and 4.4. Compared to the SO base order in Figure 4.3, the scrambled order in Figure 4.4 contains an additional chain, namely, the filler-gap dependency between the scrambled object and its base position.

![Figure 4.3. Phrase structure of SO orders in embedded clauses.](image-url)
The second clause of the MCP deals with the search for a gap when a filler was identified forcing the parser to identify a gap as soon as possible. This part accounts for the preference for subject-object orders in \textit{wh}-questions and relative clauses, where relating a filler to a gap in subject position entails a more immediate completion of a filler-gap dependency than relating the filler to a gap in object position.

Hence, parsing principles based on parsimony in structure building can account for processing differences between SO and OS orders by assuming that only structural, i.e. syntactic information, is involved initially in incremental sentence comprehension. As per the Argument Linking part of the LBCA, NPs are successively linked to the positions made available in phrase-structure building. These assumptions are in line with the experimental results on subject-object ambiguities that the first NP is structurally linked to the subject position and that this analysis is maintained even in the face of semantically implausible verb information.

### 4.3.2. Second-pass parsing: Linking and checking in the processing of word order

As the empirical results show, the structural subject-first preference in parsing, as expressed in the Minimal Chain Principle, is modulated by (a) the thematic order of arguments projecting syntactic structure (active verbs vs dative experiencers), and (b) the informativity of morphosyntactic features for reanalysis (case vs verbal agreement). According to the assumptions of the Garden-Path model, these modulations occur in
second-pass parsing, or reanalysis. These processes are specified in the second part of the Linking-Based Checking Algorithm (LBCA), Feature Handling.

Let us briefly see how the LBCA, or specifically, Feature Handling, deals with the processing of canonical and non-canonical orders. For canonical SO orders with unambiguous case marking, the first incoming nominative-marked NP is linked to the phrase-structure marker as the subject according to the Minimal Chain Principle and the first part of the LBCA; hence it is treated as bearing nominative case. Subsequently, feature checking of nominative case and NP-verb agreement confirms the first-pass linking. Feature checking requires access to the inflectional lexicon to match morphosyntactic features (e.g. [NOM]) and morphophonological forms (e.g. *der*). For case-ambiguous NPs, verbal agreement will confirm the parse.

For derived, e.g. scrambled OS orders, the first NP is assigned the external, i.e. subject, argument position and default nominative case in first-pass parsing. At the stage of Feature Checking, non-nominative case on the first NP, however, signals the erroneous parse and repair is initiated; as per Feature Repair, the parser can replace the erroneous nominative subject-marking (α) with accusative case (β) and expand the phrase structure to accommodate a fronted object. The additional effort engendered by repair and the local reconstruction of the phrase marker is measurable in increased processing costs for scrambled OS orders.

In the case of OS orders disambiguated by verbal agreement, the first ambiguously case-marked NP is linked to subject position; at the level of Feature Checking, a clash in subject-verb agreement (number) will be noted. In this constellation, however, Feature Repair cannot effect automatic repair. Assume the first NP is, say, singular (α) and the verb is plural (β): Reassigning the plural number feature of the verb to the first NP fails since the latter is inherently singular-marked. As a consequence, the parse needs to be corrected outside the mechanisms provided by the LBCA, i.e. a reparsing of the structure is necessary (see Fodor & Inoue, 1998; 2000), which incurs greater effort than local Feature Repair.

These different consequences of Feature Repair also account for why case violations are harder to detect than verbal agreement violations in ungrammatical sentences. Judging a sentence to be ungrammatical means that no grammatical parse could have been constructed. Crucially, this means that processes of linking and checking sketched above apply for ungrammatical sentences, too, since the parser must attempt reanalysis before concluding that a sentence is ungrammatical. Consider the double nominative violations in (17a), where both the first and second NPs are nominative marked. When the parser encounters the case mismatch on the second NP such as in (17a), Feature Repair initially signals a potential reanalysis of the sentence to the parser, namely, to interpret the second NP as the nominative subject. Since Feature Repair is thus initiated, the parser attempts to reanalyse the structure to an OS order. It is only when the
The Processing of Scrambling 167

parser rechecks the (nominative) case feature of the first NP that it can conclude that such reanalysis is untenable and declare the parse as unsuccessful.

In contrast, verbal agreement violations, where, e.g., a singular subject and a plural verb combine (17b), are readily detected as ungrammatical. Encountering a verbal agreement violation in number marking on the verb (17b) flags a misparse, yet it does not initiate Feature Repair. This is because reassigning the plural verb a singular feature is not compatible with the plural marking on the lexical verb. For judgements under time pressure, the reanalysis option that is automatically initiated by case marking leads to false positive judgements, while the negative verbal agreement symptom ensures more reliable ungrammaticality detection.

Finally, base OS orders in the context of dative experiencer verbs can be accommodated within the phrase marker constructed in first-pass parsing: An incoming initial dative-marked NP is assigned the subject position and nominative case by default; once the verb is encountered, a clash arises in terms of case features since the argument structure of dative experiencers maps dative case to the highest argument. However, as per Feature Repair, substitution of nominative case on the assumed subject by dative case remedies the feature mismatch and leads to the correct linking of arguments.

Table 4.2 (overleaf) summarizes the various stages and processes involved in the processing of subject-object ambiguities (for further details, see Bader & Bayer, 2006).

In sum, the model of Linking and Checking advanced in Bader & Bayer (2006) captures the complex patterns of subject-object ambiguities in first-pass and second-pass parsing in terms of argument linking and feature checking. First-pass parsing involves the linking of arguments into a minimal phrase structure marker as defined by the Minimal Chain Principle (DeVincenzi, 1991). Second-pass parsing is initiated by feature checking, with Feature Repair as the strategy for reanalysis. At present, however, Bader & Bayer's (2006) model is limited to the integration of morphosyntactic information in parsing and does not incorporate, e.g., contextual information. The following section discusses how the effects of context on the processing of scrambling can be accounted for in language processing.
<table>
<thead>
<tr>
<th>Type of input</th>
<th>Linking</th>
<th>Checking</th>
<th>Repair Processes</th>
<th>Repair difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO</td>
<td></td>
<td>Ok</td>
<td>n/a</td>
<td>none</td>
</tr>
<tr>
<td>OS – disambiguation by case</td>
<td></td>
<td>Clash</td>
<td>yes</td>
<td>reversal of case features</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- creation of additional phrase structure</td>
</tr>
<tr>
<td>OS – disambiguation by verbal agreement</td>
<td>First NP \rightarrow Subject\text{NOM}</td>
<td>Clash</td>
<td>no</td>
<td>- reparse</td>
</tr>
<tr>
<td>OS – dative experiencer verbs (disambiguation by case)</td>
<td>Clash</td>
<td>yes</td>
<td></td>
<td>reversal of case features</td>
</tr>
<tr>
<td>OS – dative experiencer verbs (disambiguation by case)</td>
<td>Clash</td>
<td>yes</td>
<td></td>
<td>- creation of additional phrase structure</td>
</tr>
<tr>
<td>OS – dative active verbs (disambiguation by case)</td>
<td>Clash</td>
<td>yes</td>
<td></td>
<td>reversal of case features</td>
</tr>
</tbody>
</table>

Table 4.2. The LBCA and subject-object ambiguities.

4.4. Scrambling and information structure in processing

The grammatical interaction of scrambling with information structure was discussed in Chapter 3.6.1, where it was argued that scrambling of NPs is subject to information-structural licensing. Several psycholinguistic studies report that information structure facilitates the processing of non-canonical orders by attenuating reanalysis costs. In these studies, the effects of information structure on the resolution of syntactic ambiguities are commonly studied by embedding the target sentences in short discourse contexts that manipulate the informational status of the constituents and hence modulate the focus structure of the target sentence.

8 There are other ways of varying information structure: For instance, Bader (1996; 1998; 2000) and Stolterfoht & Bader (2004) manipulate the focus structure of German scrambling sentences by inserting focus particles such as nur (‘only’) in front of NPs which induce a narrow focus reading of these NPs. Alternatively, personal pronouns instead of full NPs can be used to affect information structure, since pronouns denote given information by default (for German, see, e.g., Bader & Meng. 1999; for Dutch, see Kaan, 1997; Schlesewsky, Fanselow et al., 2003). However, since narrow focus on scrambled constituents entails a different focus assignment (focus scrambling) than the canonical focus structure associated with scrambling discussed in Section 3.6.1 and since pronoun movement is subject to different syntactic conditions than scrambling of full NPs, I will not discuss these approaches at present.
In the first study of contextual effects on the resolution of subject-object ambiguities in German, Bayer & Marslen-Wilson (1992; reported in Kaan, 1997; Weskott, 2003) tested case-marked matrix clauses in SO or (topicalized) OS order (26) in a self-paced reading task.

(26)  a. Der Hausmeister hat den Mann gerettet.  
      The janitor\textsubscript{NOM} has the man\textsubscript{ACC} saved

   b. Den Mann hat der Hausmeister gerettet.  
      The man\textsubscript{ACC} has the janitor\textsubscript{NOM} saved

These sentences were preceded by discourse contexts that were either neutral or biased with regard to information structure. The biased contexts were designed so that the subject NP of the target sentence would receive contrastive focus as well as being new information, while the object NP was contextually given or inferable information and would thus be defocused (27).

(27) Neulich gab es einen Brand in der Innenstadt. In der Zeitung stand, dass ein Mann von Feuerwehrmännern aus seiner brennenden Wohnung befreit wurde. Später stellte sich aber das Folgende heraus:

   ‘Recently, there was a fire in the town centre. The newspaper said that a man had been rescued from his burning flat by firemen. However, the following later emerged:’

By contrast, the neutral contexts mentioned both NPs and did thus not lead to contrastive focus on the subject of the target sentence. The results show that there are no statistically significant differences in processing SO or OS orders depending on context. However, several methodological problems in this study, e.g. plausibility differences between the critical NPs, should lead to a cautious interpretation of the finding that context does not affect processing patterns (for discussion, see Weskott, 2003).

In a series of self-paced reading experiments, Weskott (2003) manipulated the contextual support for topicalized OS orders by varying (a) the inferability of the object NP from previous discourse (as in Bayer & Marslen-Wilson, 1992), (b) parallel structure of two conjoined sentences (i.e. OS-OS (see (28)) versus SO-SO), and (c) the previous mention of the object NP in preceding discourse (i.e. givenness). (28) illustrates the materials of Weskott (2003, Experiment 3) in which parallel structure and previous mention were combined.
Ein Saboteur hatte sich in den kleinen Zirkus eingeschlichen. Als die schlechte Nachricht zum Direktor und zum Dompteur durchgesickert war, wurden alle sehr misstrauisch.

‘A saboteur had crept into the small circus. When the bad news had leaked to the director and the tamer, everybody got very suspicious.’

Den Direktor beschattete der Akrobat, und den Dompteur belauerte der Clown. The director ACC eyed the acrobat NOM, and the tamer ACC shadowed the clown NOM argwöhnisch, distrustfully.

In (28), the object NPs of the target sentence are mentioned in the preceding context, and the target sentence consisting of two conjoined clauses bears parallel structure in that the first conjoint is in OS order as well as the critical second conjoint. It was only in this condition that OS orders in the second conjoint were found to be read as quickly and accurately as SO orders. Manipulating the inferability of an object NP alone or providing parallel structure in the target sentence alone did not alleviate the processing disadvantage of OS orders. Weskott (2003) argues that only strong contextual factors, e.g. the combination of parallel structure and previous mention, lead to information-structural licensing of OS structures and can thus overturn the structural SO preference.

It is worth noting, though, that in the two studies above, the focus structure in the target sentences is solely established by coherence relations with the previous discourse — e.g. by the inferability of referents or the contextual givenness of referents — that have to be interpreted as changing the canonical focus structure of the target sentence. Based on a number of experiments, Altmann, van Nice, Garnham & Henstra (1998) argue that such contexts are not sufficient to induce contextual predictions; by contrast, question contexts such as *Who visited the grandmother?* create strong contextual predictions in that the answer must minimally include a target for the wh-pronoun. Moreover, in a wh-question context, the wh-pronoun forces focus on the corresponding wh-target in the answer. Hence, wh-question contexts give rise to unambiguous expectations as to the content and focus structure of an answer, suggesting that wh-contexts are the preferred choice in investigating contextual influences on processing.

Using wh-question contexts such as in (29) that were either neutral (29a) or biased in favour of an OS order (29b), Meng, Bader & Bayer (1999) conducted a self-paced reading task on SO and scrambled OS orders. After reading the sentence, participants had to indicate whether the response constituted an acceptable answer to the preceding question.
Sentences were either disambiguated by verbal agreement (as in (29c)) or disambiguated by case on both NPs. For sentences disambiguated by case, Meng, Bader & Bayer (1999) report that the biasing context neutralizes the slowdown for OS orders on the sentence-final auxiliary compared to the SO order. In terms of acceptability ratings, scores for the OS order are higher in the biasing context than in the neutral context and are at the same level as for SO orders. These findings suggest that context indeed modulates the structural subject-first preference in parsing. However, there is no effect of context for sentences disambiguated by verbal agreement. Unfortunately, Meng, Bader & Bayer (1999) report reading times only on the final segment, so that no conclusions can be drawn about the time course of contextual influences on processing scrambled OS orders. It is therefore not clear whether contextual effects occur incrementally in sentence comprehension or only at the end of sentences in a later stage of processing.

In an ERP experiment, Bornkessel, Schlesewsky & Friederici (2003a) address the question at which point in time contextual information is used in processing object-subject orders. The visually presented materials of their study encompassed SO and OS answers and four different wh-contexts for each order. The context-answer pairings for the OS conditions that are relevant for the present discussion are shown in (30). All questions in (30a-c) were paired with the same answer in (30d). (30a) was a neutral control context that was supposed to not induce specific expectations in the answer. (30b), labeled OS-topic (OS-TOP), designated the subject NP as the focus exponent in the answer which is a felicitous focus structure for scrambling. In contrast, (30c) imposes contrastive focus on the fronted object NP.

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9 In addition to the contexts in (30), Bornkessel, Schlesewsky & Friederici included contexts inducing case and lexical mismatches between context questions and answers. Since these tap contextual influences different from those induced by information structure, they are not discussed here.
Measuring effects on the first embedded NP in the answer (i.e. *den Gärtner*, ‘the gardener’), Bornkessel, Schlesewsky & Friederici (2003a) report that OS orders elicit a negativity around 400ms post onset of the first embedded NP (the ‘scrambling negativity’; see also Section 4.2.4). Compared to OS orders paired with the neutral context, OS orders paired with the (felicitous) OS-TOP context elicited a negativity with a shorter latency. Hence, although somewhat abated, the processing costs of OS orders signaled by the negativity emerge also in the felicitous OS context. This is taken as an indication that a favourable context can mitigate the processing costs for OS orders, yet it cannot override them. Somewhat surprisingly, there were no differences between SO and OS orders in the OS-FOC context that induced contrastive focus on the (fronted) object NP. Both the OS and the SO answer evinced a parietal positivity (280-450ms). Since there are no ERP differences between SO and OS, a contrastive focus context appears to license OS orders. Bornkessel, Schlesewsky & Friederici (2003a) conclude that context can influence the early stages of sentence processing when an element (e.g. the first object NP) serves to meet a contextual prediction, namely, providing a target for the *wh*-pronoun of (30c). A similar ERP study by Bornkessel & Schlesewsky (2006b) testing a larger range of conditions, finds that OS orders are also indistinguishable from SO orders in contexts expressing corrective focus. These are sentences in which the critical NP corrects an explicit assumption made in the context and thus receives focus (e.g. (30d) paired with a context like *Klaus asks himself who the gardener visited*). Bornkessel & Schlesewsky (2006b) suggest that contrastive and corrective focus can override syntactic processing preferences due to their extreme communicative salience.

In sum, the psycholinguistic evidence of the effects of contextual, or, more specifically, information-structural information on the processing of subject-object ambiguities in German suggests that at least strong contextual information, namely, the combination of several types of discourse information (Weskott, 2003) and, in particular, *wh*-questions (Meng et al., 1999) may affect phrase-structural preferences in parsing. As the studies by Bornkessel, Schlesewsky & Friederici (2003a) and Bornkessel & Schlesewsky (2006b)
show, such influences of information structure expressed in focus occur early and incrementally in processing by attenuating reanalysis costs associated with scrambling.

### 4.4.1. Syntactic reanalysis and information-structural reanalysis

Processing research in the visual modality has hitherto considered focus predominantly in its prosodic expression as accent in inner speech in silent reading (implicit prosody). Several studies investigated how prosodic effects in silent reading affect, e.g., the resolution of relative clause attachment ambiguities (e.g. Fodor, 1998; Steinhauer & Friederici, 2001; for overview, see Stolterfoht, 2005, Chapter 6). To account for the effects of implicit prosody on ambiguity resolution, Fodor (2002) proposes the *Implicit Prosody Hypothesis* (31).

(31) **The Implicit Prosody Hypothesis (IPH)**  
In silent reading, a default prosodic contour is projected onto the stimulus, and it may influence syntactic ambiguity resolution. Other things being equal, the parser favors the syntactic analysis associated with the most natural (default) prosodic contour for the construction. (Fodor, 2002)

Taking his cue from Fodor (1998) and translating the IPH to reanalysis in the processing of subject-object ambiguities in German, Bader (1998) proposes the *Prosodic Constraint on Reanalysis* (32).

(32) **The Prosodic Constraint on Reanalysis**  
Revising a syntactic structure is difficult if it necessitates a concomitant reanalysis of the associated prosodic structure. (Bader, 1998)

Using the speeded judgement paradigm, Bader (1998) studied how the insertion of focus particles (see also Stolterfoht & Bader, 2004) affects reanalysis in the processing of subject-object ambiguities in German. In (33), the pronoun *ihr* (‘their/they’) is ambiguous in that it can either be the indirect object of a ditransitive verb such as *anvertraut* (‘entrusted’) or the possessive pronoun embedded within an accusative object of a transitive verb such as *beschlagnahmt* (‘confiscated’).

(33) … dass man (sogar) ihr Geld anvertraut/beschlagnahmt hat. (German)  
… that one (even) her money entrusted/confiscated has  
‘… that someone entrusted money to her/confiscated her money.’

The insertion of a focus particle such as *sogar* (‘even’) was found to affect processing: when no focus particle was inserted, reading times were statistically indistinguishable
between the sentences with the different verbs. The addition of a focus particle, however, incurred elevated reading times for the verb disambiguating the pronoun to the direct object (*anvertraut*). Bader (1998) argues that this difference is due to additional revision of prosodic structure necessitated by the focus particle. However, as Stolterfoht et al. (2006) note, the presence of a focus particle also alters the focus structure of the sentence, such that the observed effect could also be due to focus structural differences.

Scrambled OS orders differ from SO orders in focus structure. In Chapter 3, scrambling was characterized as a syntactic operation that changes focus structure in order to preserve canonical prosodic contours at the level of PF. Both SO and OS orders realize prosodic prominence on the second, preverbal NP. Hence, scrambling changes focus structure, yet not prosody, such that the question arises whether processing is sensitive to focus structure in ways similar to prosody.

In a comparison of subject-object ambiguities across different constructions, such as *wh*-movement, pronoun-movement, relative clauses and scrambling, Bader & Meng (1999) report that OS orders derived by scrambling give rise to the strongest garden-path effects in a speeded judgement task. Scrambling differs from, e.g., pronoun movement or *wh*-movement in that only scrambling has information-structural differences between the SO order and the OS order affecting focus. Accordingly, the authors relate the severity of reanalysis difficulty associated with scrambling to the dual reanalysis task unique to scrambling, namely, (a) syntactic reanalysis of the default SO order to the scrambled OS order, and (b) information structure reanalysis of the default wide focus reading with focus on the object to narrow focus on the subject (see Sections 3.8.2-3.8.4).

It has also been suggested that the early right-central negativity that Bornkessel & Schlesewsky term the ‘scrambling negativity’ is in fact an ERP signature of information-structural revision (Stolterfoht, 2005; Stolterfoht et al., 2006). As the ERP studies on scrambling by Bornkessel et al. (2003a) and Bornkessel & Schlesewsky (2006b) show, embedding scrambling in a felicitous focus context mitigates the amplitude of the ‘scrambling negativity’. Other studies find that OS orders that do not incur information-structural reanalysis equally do not give rise to a scrambling negativity. For instance, OS orders with pronouns yield no scrambling negativity (Stolterfoht, 2005, Experiment 1); in addition, for sentences in which a focus particle marks narrow focus on the subject, regardless of syntactic order, scrambled OS orders do not evince a scrambling negativity compared to SO orders (Stolterfoht & Bader, 2004). Neurophysiological evidence thus supports the hypothesis that scrambling invokes information-structural reanalysis in addition to syntactic reanalysis.

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10 The term ‘information structure reanalysis’ used by Bader & Meng (1999) and the term ‘focus structure reanalysis’ refer to the same process of revising focus structure. I will henceforth adopt Bader & Meng’s term ‘information structure reanalysis’.
4.5. Summary

This chapter discussed how the range of experimental findings on the processing of subject-object ambiguities can be accounted for in a serial processing model. Bader & Bayer’s (2006) model of Linking and Checking was outlined in order to explain how syntactic, morphological and thematic information interact in the processing of word order. Further, it was shown how information structure affects the processing of word order variation in that revisions of focus structure induce additional reanalysis on top of syntactic reanalysis. The two types of reanalysis are summarized in (34).

(34) a. SYNTACTIC REANALYSIS of phrase structure
    modulated by: - morphological feature type
                - thematic properties of the verb

b. INFORMATION-STRUCTURE REANALYSIS of focus structure
    modulated by: - context

In the experiments in this thesis, I investigate whether non-natives show an SO preference in parsing subject-object ambiguities in German, and whether non-natives demonstrate reanalysis effects according to the different types of (interface) information in (34). Table 4.3 gives a preview of the processing experiments with L2 speakers in the subsequent chapters and how they relate to the phenomena reported in the above review.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Phenomenon</th>
<th>Experiment number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax - Morphology</td>
<td>SO preference</td>
<td>2, 3</td>
</tr>
<tr>
<td></td>
<td>Reanalysis: Incremental reanalysis according to</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>morphological cues</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reanalysis: morphological feature types (case vs</td>
<td>2, 3</td>
</tr>
<tr>
<td></td>
<td>agreement)</td>
<td></td>
</tr>
<tr>
<td>Syntax - Information Structure</td>
<td>Reanalysis: Context effects</td>
<td>6</td>
</tr>
<tr>
<td>Syntax - Lexicon</td>
<td>Reanalysis: Dative experiencers</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.3. Preview of processing experiments in this thesis.

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11 This section did not discuss other potentially relevant factors in processing scrambling, such as animacy, adverbs, effects of pronominalization, etc. because they fall outside the scope of interest of the thesis.
Before presenting the experiments probing these factors in Chapters 6 to 8, the following chapter discusses the L2 acquisition of scrambling and outlines the learnability tasks facing L1 English, L1 Dutch and L1 Russian learners of German.