

Syntax and Morphology in Sentence Parsing: A new look at German subject-object ambiguities¹

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1 Introduction

A prominent class of syntactic ambiguities in German are subject-object ambiguities. A simple example of such an ambiguity is given in (1). The wh-phrase *welches Mädchen* in (1) is ambiguous between nominative and accusative case. In consequence, the two sentences under (1) are locally ambiguous until the second NP is encountered which is unambiguously marked for accusative case in (1a) and for nominative case in (1b). From the unambiguous case-marking on the second NP it can be inferred that sentence (1a) exhibits the word-order subject-before-object whereas sentence (1b) exhibits the word-order object-before-subject.

- (1) a. [Welches Mädchen]_{nom/acc} hat [den Lehrer]_{acc} besucht?
which girl has the teacher visited
“Which girl has visited the teacher?”
- b. [Welches Mädchen]_{nom/acc} hat [der Lehrer]_{nom} besucht?
which girl has the teacher visited
“Which girl has the teacher visited”

Subject-object ambiguities have received a great deal of attention in the recent psycholinguistic literature (cf. Hemforth, 1993; Bader, 1994a,b and the references cited below). This work has shown that in most types of subject-object ambiguities the subject-before-object (SO) order is the preferred one. A further result has been that the garden-path effects which arise when sentences are disambiguated in favor of the unpreferred object-before-subject (OS) structure vary widely in strength, ranging from barely detectable effects to effects that are easily perceived consciously. In the first part of this paper, we will present the Case Preference Principles as an approach to first-pass parsing preferences that takes seriously the fact that subject-object ambiguities always involve some kind of morphological ambiguity, namely morphologically case-ambiguous NPs. The Case Preference Principles are motivated by experimental evidence on first-pass parsing preferences in subject-object ambiguities which cannot be explained with reference to phrase structural information alone but make it necessary to take morphological information about case into account.

We will then turn to the finding that garden-path effects observed in subject-object ambiguities vary in strength. We will propose a new theory of the strength of garden-path effects that stems from a generalization that we found in experiments on subject-object ambiguities using the method of speeded-grammaticality judgments. Assuming a serial model of the human sentence processing mechanism (HSPM) (cf. Frazier, 1978; Frazier & Rayner, 1982), the notion of ungrammaticality is intimately related to the notion of a garden-path sentence. During the processing of every garden-path sentence, a temporary ungrammaticality will arise at the point where the initial structure is contradicted by further input material. In several speeded grammaticality-judgment experiments, we found a correlation between garden-path strength and the processing of truly ungrammatical sentences: Sentences that cause strong garden-path effects contain a temporary ungrammaticality that is easily detected

¹ This paper is the written version of the talk we gave at the Conference on Architectures and Mechanisms for Language Processing, Torino, September 1996.

in corresponding ungrammatical sentences whereas sentences causing weak garden-path effects contain a temporary ungrammaticality that is difficult to detect in corresponding ungrammatical sentences. We have termed this relation between ungrammaticality detection and garden-path strength the Mismatch Effect, which is given in (2).

(2) The Mismatch Effect

The more salient a temporary ungrammaticality is, the stronger the resulting garden-path effect will be.

This correlation finds a simple explanation if it is assumed that the HSPM has two options after it has detected a temporary ungrammaticality. It can either try to reanalyze the sentence or it can judge it as ungrammatical immediately, without an attempt at reanalysis. Under this account, which ties garden-path strength to ungrammaticality detection, the most important question becomes why some ungrammaticalities are easier to detect than others. At this point, morphology will come into play again. We will show that a coherent explanation of garden-path effects in subject-object ambiguities is possible if the Mismatch Effect is combined with the assumptions about the interplay of syntactic and morphological information that were developed to account for first-pass parsing preferences. In particular, we will show that the ease of detecting an ungrammaticality is a function of the way syntactic features are expressed morphologically. In a manner to be made precise below, ungrammaticalities involving features that are usually encoded in an unambiguous way are easier to detect than ungrammaticalities that involve features that are ambiguously coded. As we will show, this holds across different kinds of syntactic features (case and agreement features) and across different kinds of subject-object ambiguities (subject-object ambiguities in main and embedded clauses, subject-object ambiguities involving a filler-gap ambiguity or not).

The organization of this paper is as follows. In section 2 we introduce the grammatical background that is needed to discuss subject-object ambiguities in German. In section 3 we will discuss first-pass parsing-preferences in different kinds of subject-object ambiguities and motivate the Case Preference Principles. Our approach to garden-path strength will be introduced in section 4 and applied to a range of subject-object ambiguities in section 5. Section 6 will contain a summary of the main results.

2 The Syntactic and Morphological Sources of Subject-Object Ambiguities

Subject-object ambiguities are the joint effect of two properties of the German language: First, the ordering of subject and object(s) is highly variable in German. This means that in many sentences the mapping from NPs to grammatical roles can only be determined by the case-markings on the NPs involved. Secondly, despite its importance in signaling syntactic functions, the case system of German contains many morphological ambiguities (case syncretisms). Hence, NPs are often ambiguous with respect to their case. In this section we will explain first how the variability in the ordering of subject and objects comes about and then discuss the German case system.

2.1 Derived Versus Basic Word Orders

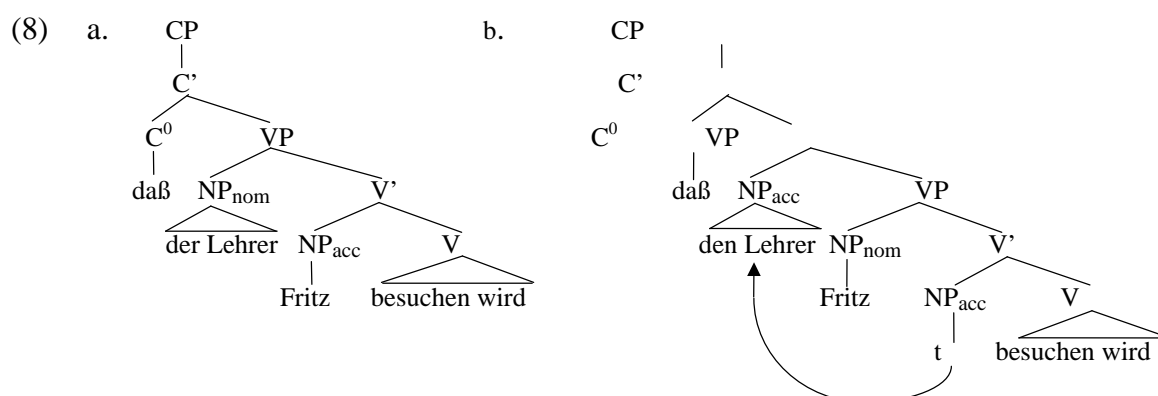
In contrast to the SVO-language English, German is an SOV-language (for surveys of German syntax, cf. Grewendorf, 1988; Stechow & Sternefeld, 1988; Haider, 1993). This can be seen in the embedded clause of (3a), where both main verb and auxiliary are located in clause-final position. Furthermore, German, as all other Germanic languages except English, exhibits the verb-second property, which means that the finite verb in main clauses is raised from its underlying clause-final position to the second position of the sentence and exactly

Movement to SpecCP is not only found in main clauses but also in embedded clauses, as shown in (6). The syntactic structures of the embedded clauses of (6a) and (6b) are identical to those in (5a) and (5b) except that the finite auxiliary stays in clause-final position in embedded clauses whereas it moves to C^0 in main clauses.

- (6) a. Ich will wissen, wer_i t_i Fritz besuchen wird. SO
I want know who Fritz visit will
“I want to know who will visit Fritz.”
- b. Ich will wissen, wen_i Fritz t_i besuchen wird. OS
I want know who Fritz visit will
“I want to know who Fritz will visit.”

OS-sentences where the object has moved to SpecCP are of course not peculiar to German. As can be seen from the translations to the German examples in (4) and (6), the same kind of OS-clauses also exist in English. More peculiar to German, and the main reason for calling German a language with a relatively free word-order, are the next two options of producing sentences with OS-word order. The sentences in (7) are similar to the ones in (4) and (6) insofar as the OS-sentence in (7b) involves the movement of the object in front of the subject. However, in this case movement is not to SpecCP but more local, namely to a position in the phrase-structure tree that is located below CP and above the subject. In adherence with the assumption that in German clauses VP is the sister to C^0 , the sentences in (7a) and (7b) will receive the phrase-structure representations in (8a) and (8b), respectively. In (8b), the object, which has moved to a position adjoined to VP, is coindexed with a trace in the underlying object position.

- (7) a. Ich weiß, daß der Lehrer Fritz besuchen wird. SO
I know that the teacher Fritz visit will
“I know that the teacher will visit Fritz.”
- b. Ich weiß, daß den Lehrer_i Fritz t_i besuchen wird. OS
I know, that the teacher Fritz visit will
“I know that Fritz will visit the teacher.”



According to (8), the SO-sentence (7a) receives a tree that is base-generated by the grammar whereas the OS-sentence in (7b) is derived from an underlying structure by an application of Move- α . One justification for ascribing such a syntactic difference to SO- and OS-sentences derives from the fact that the SO-order in sentences like (7a) is a “normal” or “unmarked” order whereas the OS-order in (7b) is a “marked” one. In this connection, the markedness of a given word order derives from its focus structure (cf. Höhle, 1982; von Stechow & Uhmman, 1986). A word-order of a clause is unmarked if it allows the whole clause to be in focus, i.e. if the clause can be used as an answer to a question like “What

happened?” and thus as an out-of-the-blue-utterance. This is possible for (7a) but not for (7b). If a word-order, in contrast, only allows narrow focus on one of its constituents, it is a marked word-order. A sentence with such a word-order cannot be used as out-of-the-blue utterance. Moving the object in front of the subject, as in (7b), has the consequence that the subject is narrowly focused. Therefore, such a sentence cannot answer a question like “What happened” but only the more specific question “Who visited the teacher?”.

The base-order of a sentence is dependent on the particular verb that the sentence contains. Whereas for the majority of verbs the SO-order is basic, certain subclasses of verbs have an OS-base-order. The order of arguments must therefore be specified in the argument-structure of a verb. For the verb *besuchen*, a simplified argument-structure might look as in (9), where the order of arguments within the verb’s argument structure determines the base-order of a clause containing the verb. From the argument structure in (9), it can be determined that the base-order is subject before accusative object. Note that this base-order is found both in (8a) and (8b). In (8a), the subject precedes the object; in (8b), the object precedes the subject but the subject still precedes the trace of the object.³

(9) /besuchen/: [Agent_{Nom}, Goal_{Acc}]

As just said, not all verbs have an argument structure that specifies the subject to precede the object. For certain verbs, the reversed word order is determined within their argument structures. Under the assumption that the base-order of a sentence directly reflects the order of arguments within the verb’s argument structure, the third and final way how an OS-word-order might arise is therefore by base-generating the object in front of the subject. To the class of verbs with an underlying OS-word order belong mainly ergative verbs and possibly certain psych-verbs (cf. Grewendorf, 1989). Furthermore, if a ditransitive verb is passivized, the resulting argument structure will exhibit OS-order. Since a large part of the experimental evidence to be considered later comes from an ambiguity involving active and passive clauses, we will illustrate the possibility of base-generating the object in front of the subject with passive sentences.

The argument structures of the ditransitive verb *schicken* (to send) and its passive participle *geschickt* (sent) are shown in (10a) and (10b), respectively. Sentences illustrating the active and passive use of *schicken* are given in (11).⁴

(10) a. /schicken/: [Agent_{Nom}, Recipient_{Dat}, Theme_{Acc}]

b. /geschickt/: [Recipient_{Dat}, Theme_{Nom}]

(11) a. (Fritz hat behauptet,) daß Uli_{NOM} dem_{DAT} Detektiv einen_{ACC} Brief geschickt hat.
Fritz has claimed that Uli the detective a letter sent has
 “Fritz claimed that Uli sent the detective a letter.”

b. (Fritz hat behauptet,) daß dem_{DAT} Detektiv ein_{NOM} Brief geschickt wurde.
Fritz has claimed that the detective a letter sent was
 “Fritz claimed that a letter was sent to the detective.”

³ For reasons of simplicity, we have collapsed information about thematic roles and information about case into a single argument structure. In a more detailed account of argument structures, these two aspects might well be separated (cf. e.g. Grimshaw, 1990; Jackendoff, 1990).

⁴ We have replaced the perfect auxiliary *hat* with the past tense form of the passive auxiliary *wurde* instead of the perfect form *worden ist*. The reason for this is that we will later present an ambiguity involving active and passive sentences where it is crucial that sentences are disambiguated by an equal number of words. Note that the distinction between past tense and perfect is not as clearcut in German as in English, and in most contexts the two forms are interchangeable.

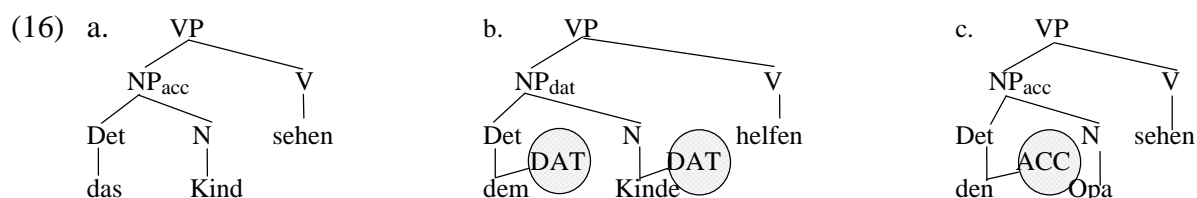
With respect to morphological case, we see the same pattern as the one found for abstract case: nominative and accusative case share certain properties whereas dative case is different. In particular, dative case is almost always unambiguously signaled whereas nominative and accusative case often coincide. Consider Table 1, which shows the complete inflection paradigm for the definite article. Besides the already discussed cases, German has also genitive case. Genitive is mainly used for NPs that modify nouns (cf. (14) above). Since genitive case is almost extinct for arguments of verbs, it will not be discussed further.

Table 1
The inflection paradigm for definite articles

		Singular		Plural
	Masculine	Feminine	Neuter	
Nominative	der	die	das	die
Accusative	den	die	das	die
Dative	dem	der	dem	den
Genitive	des	der	des	der

Table 1 shows two things. First, with the exception of masculine singular articles, nominative forms are not differentiated from accusative forms. Second, in each column, the dative form is distinct from both the nominative and accusative form. In short, nominative and accusative case often share forms with each other but never with dative case. What holds for definite articles also holds for most other kinds of determiners, like indefinite determiners (except that there are no plural indefinite determiners) and determiner-like elements (e.g., demonstrative pronouns and quantifiers), pronouns and *wh*-words. Together with the fact that case in German is mainly signaled on determiners, and to a lesser degree on adjectives and nouns, this means that there are many NPs that are two-way case ambiguous, namely between nominative and accusative case, whereas NPs that are three-way ambiguous are confined to determinerless NPs like proper names and bare NPs.

Following earlier proposals (cf. Bader, Bayer, Hopf, & Meng, 1996), we will represent the facts about case that we have just reviewed in the following way. First, the distinction between abstract and lexical case will be represented by using small letters for abstract case and capitals for morphological case. Second, we assume that a lexical item bearing abstract dative case always bears a morphological feature signaling morphological dative case. A lexical item bearing abstract structural case (nominative or accusative), in contrast, may be left unspecified for morphological case as long as it is compatible with both nominative and accusative case. This captures the fact that dative case is most of the time unambiguously signaled by morphological means, whereas nominative and accusative case are often not distinguished morphologically. Although these assumptions were originally proposed for psycholinguistic reasons, they meet with certain ideas found in current morphological theory (cf. e.g. Halle & Marantz, 1993; Wunderlich & Fabri, 1995). In particular, the systematic morphological ambiguity (syncretism) between nominative and accusative is captured by underspecification, and the marked status of dative is reflected in a marked feature structure. Sample representations illustrating our assumptions about abstract and morphological case are given in (16). (16a) shows an NP morphologically underspecified for case; (16b) shows an NP morphologically specified for dative case and (16c) an NP morphologically specified for accusative case.



As a final question with respect to the representation of case, we have to ask how three-way case-ambiguous words are to be represented. For example, what will be the lexical representation of a proper name like *Uli*? According to our assumptions about the morphological representation of case, the lexical system must deliver the following information to the parser. First, *Uli* can bear both abstract nominative and accusative case. This means that *Uli* might be unspecified for morphological case, as the word *Kind* in (16a). Secondly, *Uli* might bear abstract dative case. This must be signaled by a morphological dative feature as in (16b). We therefore assume that the lexical entry for a proper name provides two forms that can be inserted into the phrase-marker: a morphologically unspecified one for structural case (cf. (17a)) and a second one specified for dative case (cf. (17b)). By this assumption, proper names are taken to be exceptional in that their dative form has no overt morphological reflex.



3 Parsing Preferences in Subject-Object Ambiguities

In this section we will review some experimental findings on parsing preferences in subject-object ambiguities. Our discussion will center around the question of which kind of parsing strategy is needed to derive the first-pass parsing preferences found in German subject-object ambiguities. As we will argue, the grammatical assumptions outlined in the preceding section together with certain assumptions about the human sentence processing mechanism (HSPM) can explain these preferences if it is taken into account that the parser bases its decisions not only on phrase structural information but also on considerations concerning the syntactic and morphological status of case.

3.1 Preferences in Filler-Gap Ambiguities

The basic classification of subject-object ambiguities in German is between filler-gap ambiguities and base-generated ambiguities. A typical example of a filler-gap subject-object-ambiguity is provided by the sentence pair in (18), with (18a) exhibiting the SO-word order and (18b) exhibiting the reversed OS-order. Since the NPs in the embedded clauses of (18a) and (18b) are case-ambiguous, the question which NP is subject and which is object can only be determined by looking at the finite auxiliary. Hence, these sentences are locally ambiguous up to the clause final word where the ambiguity is resolved. Due to subject-verb agreement, the singular pronoun *sie* must be the subject in (18a) whereas the plural NP *die Eltern* must be the subject in (18b).

- (18) a. Maria hat gesagt, daß sie_{NOM-SG} die Eltern_{ACC-PL} angerufen **hat**_{SG}
Maria has said that she the parents phoned has
 “Maria said that she has phoned the parents”
- b. Maria hat gesagt, daß sie_{ACC-SG/i} die Eltern_{NOM-PL} (t_i) angerufen **haben**_{PL}
Maria has said, that her the parents phoned have

“Maria said that the parents have phoned her”

According to the assumptions outlined above, sentence (18b) is derived from an underlying SO-order by an application of move- α . Thereby, the object is moved to a position in front of the subject, leaving a trace behind. This is a doubtful trace (cf. Fodor, 1978) since the SO-order of sentence (18a) is directly generated by the grammar and does therefore not involve any trace. In short, SO-order and OS-order in sentences like those in (18) are distinguished in terms of the absence or existence of a filler-gap dependency.

The MINIMAL CHAIN PRINCIPLE proposed by deVincenci (1991) (cf. (19)) predicts that the SO-order should be the preferred one in sentences like (18). This follows from the fact that the OS-order contains an additional chain member, namely the trace, that is absent in the SO-order.

(19) Minimal Chain Principle (MCP)

Avoid postulating unnecessary chain members at S-structure, but do not delay required chain members.

The predictions of the MCP for sentences like (18) have been experimentally confirmed both with the method of self-paced reading (cf. Bader, 1994a) and with the method of speeded-grammaticality judgments (cf. Bader, 1996a). In an experiment using the latter method, ambiguous sentences like those in (18) were compared to their unambiguous counterparts. Unambiguous sentences were derived from ambiguous sentences by substituting masculine proper names and pronouns for feminine proper names and pronouns. In contrast to the ambiguous feminine pronoun *sie*, masculine pronouns are differentiated between nominative (*er/he*) and accusative (*ihn/him*). The experiment also contained matched ungrammatical sentences that will be discussed below. In the particular version of the speeded-grammaticality judgments task used in our experiments, words were presented in the middle of the screen for 224ms plus an additional 14ms for each character. At the end of each sentence, three red question-marks appeared, signaling to subjects that they now had to judge the sentence as either grammatical or ungrammatical. If no response occurred within 2000 ms, the words “Zu langsam” (too slow) appeared, and the trial was stopped. Results for this experiment are shown in Figure 1.

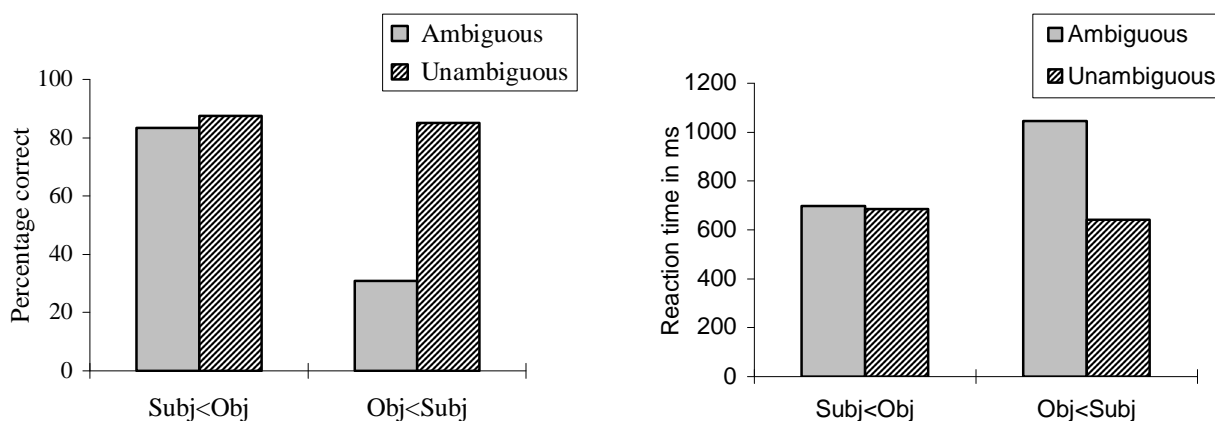


Figure 1: Percentages of correct responses (left side) and reaction times for correct responses (right side) for sentences like (18) and their unambiguous counterparts

A clear garden-path effect can be seen both in the percentages of sentences judged to be grammatical and in the reaction times. For unambiguous sentences, no difference emerged between sentences with SO- and sentences with OS-order. Ambiguous SO-sentences

patterned with unambiguous sentences. Ambiguous OS-sentences, in contrast, showed a sharp drop in the percentages of “grammatical” judgments and a corresponding increase in the reaction time data. This pattern of results, which confirms the predictions derived from the Minimal Chain Principle, has also been found for various other types of filler-gap ambiguities in German (cf. Friederici, Mecklinger, Steinhauer, & Meyer, 1996; Hemforth, 1993; Mecklinger, Schriefers, Steinhauer, & Friederici, 1995; Meng, in prep.; Schlesewsky, Fanselow, Kliegl, & Krems, 1996; Schriefers, Friederici, & Kühn, 1995)

3.2 Preferences in Base-Generated Ambiguities

In contrast to filler-gap ambiguities, base-generated ambiguities involve an SO- and an OS-structure both of which are base-generated, i.e. the OS-order is not derived from the SO-order. An example of such an ambiguity is given in (20). As before, the ambiguity is contained within the embedded clause. The embedded clause of (20a) is an active clause with *Uli* as subject and *ein Päckchen* as direct or accusative object. (20b) contains an embedded passive clause. Here *Uli* is an indirect or dative object and *ein Päckchen* is the subject. As with the sentences in (18), the sentences in (20) differ only in the clause final auxiliary. The SO-clause in (20a) ends in a perfect auxiliary, whereas the OS-clause ends in a passive auxiliary.

- (20) a. Fritz hat behauptet, daß Uli_{NOM} ein Päckchen_{ACC} geschickt **hat**
Fritz has claimed that Uli a parcel sent has
“Fritz claimed that Uli has sent a parcel.”
- b. Fritz hat behauptet, daß Uli_{DAT} ein Päckchen_{NOM} geschickt **wurde**
Fritz has claimed that Uli a parcel sent was
“Fritz claimed that a parcel was sent to Uli.”

According to the syntactic assumptions outlined above, the two sentences in (20) are phrase-structurally non-distinct. Nevertheless, passive sentences like (20b) with the word-order object-before subject are consistently associated with garden-path effects. In contrast to sentences like (18b), these are rather weak garden-path effects. In a selfpaced-reading experiment (cf. Bader, 1994a), ambiguous sentences like (20b) took longer to read than unambiguous control sentences but the difference did not reach significance. In an experiment using the same method of speeded-grammaticality judgments as described above (cf. Bader, 1996b), ambiguous active and passive sentences like those in (20) were compared to their unambiguous counterparts. Unambiguous sentences were derived from ambiguous sentences by replacing the ambiguous proper name with unambiguous pronouns.⁵ Results for this experiment are shown in Figure 2.

⁵ The experiment also included ungrammatical control sentences which will be discussed in detail in section 4.1 and 4.2.

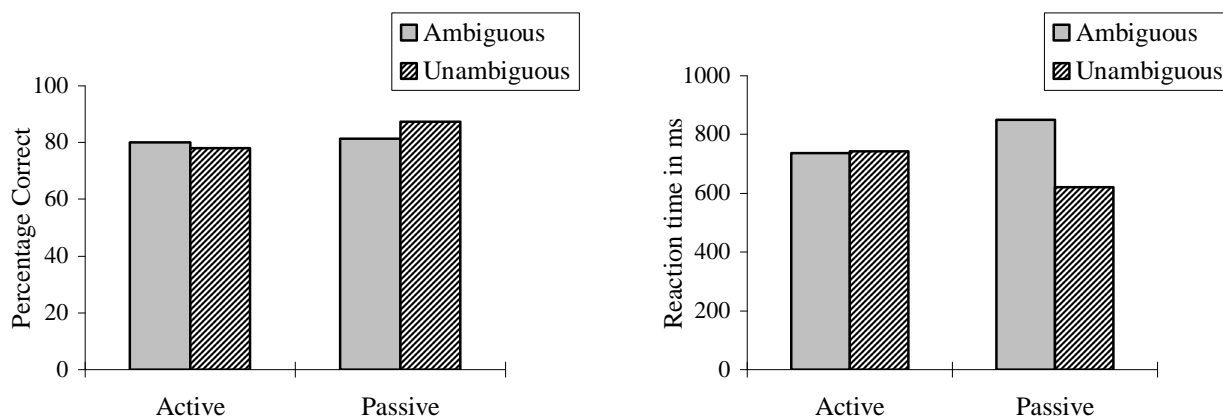


Figure 2: Percentages of correct responses (left side) and reaction times for correct responses (right side) for sentences like (20) and their unambiguous counterparts

A comparison of ambiguous sentences with unambiguous sentences shows two main things. First, there is only a slight and non-significant drop in percentages of sentences judged to be grammatical from ambiguous to unambiguous passive sentences. Second, there is a clear ambiguity effect in the reaction time data. Ambiguous passive clauses needed a significant 230ms more to be judged as grammatical than unambiguous passive clauses. From these results we can conclude that ambiguous passive sentences cause garden-path effects, albeit slight ones. This experimental finding, which has been replicated several times, closely matches intuitive judgments: Ambiguous passive clauses are almost never intuitively perceived as causing garden-path effects.

According to our syntactic assumptions, active and passive sentences do not differ phrase-structurally. Hence, a phrase-structure-based principle like the MCP does not apply to this type of subject-object ambiguity, and the preference for the SO-structure must be explained with reference to some other kind of syntactic knowledge. The distribution of case provides the principal distinction between active and passive clauses in German and we therefore assume that the SO-preference is due to preferences for certain case assignments. A preference for certain case-assignments has already been found for another type of syntactic ambiguity by Bader et al. (1996), who have proposed the Case Preference Principles in (21).

(21) Case Preference Principles

- a. Prefer structural Case to lexical Case.
- b. Prefer nominative Case to accusative Case.

The Case Preference Principles can be seen to directly reflect the basic properties of the German case system as they were presented in the preceding section. Clause (a) follows from the fact that structural cases are default cases whereas dative case is dependent on a lexical licenser. Clause (b) reflects the fact that the presence of an accusative object implies the presence of a subject but not vice versa. That is, sentences with a subject do not need to have an accusative object but sentences with an accusative object do need a subject.⁶ Due to these properties of the German case system, the Case Preference Principles are to be expected of a cautious parser, that is, a parser that prefers hypotheses that make minimal assumptions about the input.

⁶ There is a handful of verbs that violate this generalization, i.e. verbs that take an accusative object without having a subject. Besides the small number of such verbs, there is also a tendency to use these verbs with an expletive subject.

3.3 Inducing Object-Subject preferences

For simple pairs of active and passive sentences (cf. (11)), the SO-order is the preferred one. Conversely, the OS-order leads to a garden-path effect, albeit a rather weak one. We have explained this pattern in terms of preferences for particular case assignments. As we will show now, it is possible to reverse this pattern by certain morphological means. Consider the sentences in (22) and (23). These sentences are identical to the sentences in (11) besides containing a relative clause appositively related to the ambiguous proper name. In (22), the relative clause is headed by a relative pronoun bearing accusative case. The relative clause in (23) is headed by a relative pronoun bearing dative case. Otherwise, the sentences in (22) and (23) are completely parallel.

(22) *Relative pronoun: structural case*

a. *Active*

Ich glaube, daß Maria, **die** ich vorhin getroffen habe, das Buch geliefert **hat**.
I believe that M. who I just met have the book delivered has
 “I believe that Maria, who I have just met, has delivered the book.”

b. *Passive*

Ich glaube, daß Maria, **die** ich vorhin getroffen habe, das Buch geliefert **wurde**.
I believe that M. who I just met have the book delivered was
 “I believe that the book was delivered to Maria, who I have just met.”

(23) *Relative pronoun: dative case*

a. *Active*

Ich glaube, daß Maria, **der** ich vorhin begegnet bin, das Buch geliefert **hat**.
I believe that M. who I just met am the book delivered has
 “I believe that Maria, who I have just met, has delivered the book.”

b. *Passive*

Ich glaube, daß Maria, **der** ich vorhin begegnet bin, das Buch geliefert **wurde**.
I believe that M. who I just met am the book delivered was
 “I believe that the book was delivered to Maria, who I have just met.”

Ambiguous active and passive sentences containing either no relative clause (cf. (20)), a relative clause headed by a relative pronoun with structural case (nominative or accusative) (cf. (22)), or a relative clause headed by relative pronoun bearing dative case (cf. (23)) were tested with the same speeded grammaticality judgment procedure as described above (cf. Bader (1996b) for details). The results are shown in Figure 3.

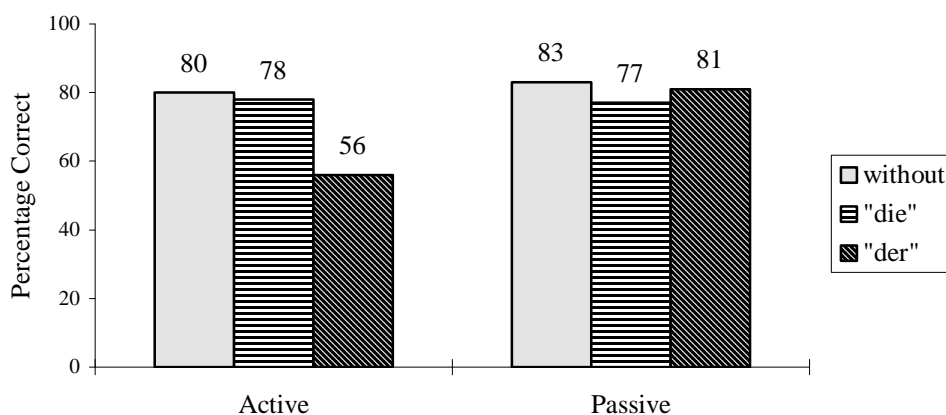


Figure 3: Percentages of correct responses (left side) for sentences like (22) and (23) and corresponding sentences without relative clause.

Figure 3 shows a surprising result. The SO-preference found in pairs of simple active and passive clauses (cf. (20)) reverses to an OS-preference in sentences where an ambiguous proper name is followed by a dative relative pronoun. This reversal of the usual preference is reflected in the sharp drop of correct judgments for active sentences containing a dative relative pronoun. In contrast to relative clauses headed by a dative marked relative pronoun, the introduction of a relative clause with structural case had almost no effect on the processing of the sentences under consideration. In addition to the reversal of the normal SO-preference to an OS-preference under the influence of a dative relative pronoun, Figure 3 also reveals that active sentences containing a dative relative pronoun produce a much stronger garden-path effect than passive sentences with either no or a structural relative clause. As can be seen in Figure 2 and Figure 3, the percentages of correct responses are much lower for active clauses containing a dative relative clause than for passive clauses (whether they contain a relative clause or not). We will postpone the question why this should be so to section 4, where the question of garden-path strength will be discussed at length, and confine the discussion at this point to the reversal of the SO-preference to an OS-preferences in sentences containing a dative relative clause. This reversal can be explained in analogy to certain results found in experiments on speech production.

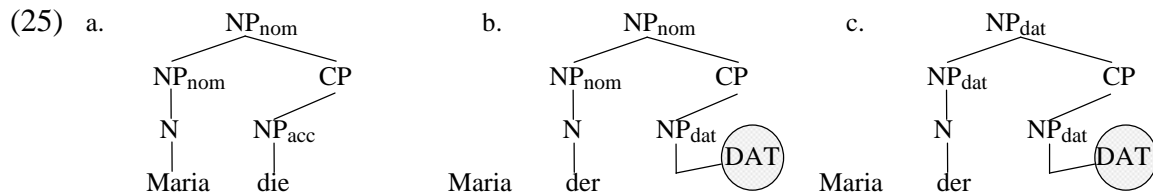
Consider the sentence in (24). This sentence is ungrammatical due to a lack of subject-verb agreement. In a certain sense, one might say that the verb in (24) does not agree with the singular noun *visit*, as it should, but illicitly with the plural noun *sisters*. Errors of the kind in (24) are called ATTRACTION ERRORS because the subject NP erroneously “attracts” the plural feature of an embedded noun.

(24) *The visit of my sisters were great fun.

In experiments that elicited attraction errors of the sort given in (24), an asymmetry has been found between singular and plural nouns (cf. Bock & Cutting, 1992; Bock & Miller, 1991). Whereas NPs of the form *the owner of the houses* elicited a certain amount of attraction errors, NPs of the form *the owners of the house* very seldom did. This means that a plural but not a singular feature might be erroneously attracted. This asymmetry between plural and singular in attraction errors has been traced back to an accompanying morphological asymmetry between singular and plural (cf. Eberhard 1993): singular is not morphologically marked but is simply the default number whereas plural needs a morphological exponent. If only features that are morphologically encoded can be attracted then it follows that *the owner of the houses* might lead to attraction errors but not *the owners of the house*.

The relation between structural and dative case in German parallels the relation between singular and plural in English. Dative case is morphologically marked whereas structural case

is not. The relevant parts of the syntactic and morphological representations of (22) and (23) are shown in (25a) and (25b), respectively. In accordance with the distribution of morphological case features on the relative pronouns, case attraction might occur for a proper name followed by a dative relative pronoun. Thereby, (25b) will be converted to (25c) and a preference for the OS-structure will arise. A relative pronoun with structural case (cf. (25a)), in contrast, will have no influence on the preceding proper name.



If it is possible to turn the preference for associating the first NP with the subject role into a preference to analyze this NP as a dative object by the mere presence of an unambiguously dative-marked relative pronoun, it follows that case must play an independent role during parsing. This finding supports the more general assumption that the parser's decisions, at least those concerning the on-line assignment of syntactic functions, are not only sensitive to phrase-structural configurations but also to considerations about case.

3.4 Preferences for Case versus Preferences for Minimal Chains

Before we can leave the topic of parsing preferences in subject-object ambiguities, we have to discuss the relation between the Minimal Chain Principle (MCP) and the Case Preference Principles (CPP). Under the syntactic assumptions that we have adopted in this paper, the MCP and the CPP are coextensional with regard to filler-gap ambiguities but not with regard to base-generated ambiguities. For filler-gap ambiguities, a SO-preference is predicted by both the MCP and the second clause of the CPP. For base-generated ambiguities, the MCP predicts no preference whereas the first clause of the CPP correctly predicts a SO-preference. There are at least three ways how the redundancy between the MCP and the CPP might be eliminated. First, the MCP is given up in favor of the CPP. Second, the CPP is reduced to a principle favoring structural to lexical case. Third, the syntactic assumptions are altered in such a way that the MCP makes the CPP superfluous. We believe that the last option is the least probable one. First of all, a preference for structural case to dative case is not only found for base-generated subject-object ambiguities but also for object-object ambiguities. An example for a local ambiguity between accusative object and dative object is provided in (26). In (26a), the clause-final verb *unterstützen* (*to support*) subcategorizes for an accusative object. The clause-final verb *helfen* (*to help*) in (26b), in contrast, subcategorizes for a dative object. Under the usual assumption that dative and accusative objects in sentences with a single object occupy the same phrase-structural position, the ambiguity in (26) is a further instance of a base-generated syntactic ambiguity.

- (26) a. Personen, die in Not sind, sollte man unterstützen.
persons who in distress are should one support
 "One should support persons who are in distress."
- b. Personen, die in Not sind, sollte man helfen.
persons who in distress are should one help
 "One should help persons who are in distress."

It has been shown by Bader et al. (1996) that sentences like (26b), where the initial case-ambiguous noun *Personen* (*persons*) receives dative case, elicit a garden-path effect at the case-assigning verb. This finding, which indicates that accusative case is preferred to dative

case in sentences like (26), was the initial reason to propose the CPP. This means, in particular, that the second clause of the CPP is supported by evidence that is independent from particular assumptions about the syntactic representation of base-generated subject-object ambiguities. We therefore think that at least this part of the CPP will be required even if it should turn out that our syntactic assumptions about base-generated subject-object are in need of revision.

This leaves us with the redundancy between MCP and CPP with respect to filler-gap ambiguities. At the moment, we do not know of any evidence which might decide between the MCP and the CPP as a better explanation for the SO-preference found in filler-gap ambiguities. Furthermore, it is not even clear that such a decision is necessary. It is at least a possibility that the human parsing mechanism contains a certain amount of redundancy. With regard to subject-object ambiguities, this might simply be a consequence of the fact that UG provides two ways to encode syntactic functions: in terms of phrase-structure positions and in terms of case. These two devices do not exclude each other, but one or the other might be dominant in a given language. For example, in English and Italian, subject and object are defined positionally whereas in German case is more important than particular positions. Therefore, it may be possible that subject-object ambiguities in a language like English or Italian are resolved on the basis of syntactic parsing strategies like the MCP, whereas in German, more prominence is given to preferences of Case assignment.

3.5 Summary

To conclude our discussion of parsing preferences in subject-object ambiguities, let us summarize the main points that emerge from the preceding sections: First, we have reviewed experimental evidence that subject-object ambiguities show a SO-preference which holds both for filler-gap and base-generated ambiguities. SO-preferences in the latter kind of ambiguity do not follow from structure-based principles like the MCP, at least not under the syntactic assumptions we have adopted here. They have instead to be explained with recourse to preferences for particular case assignments which are captured in the Case Preference Principles in (21).

Secondly, the SO-preference can be overridden under specific circumstances. In particular, if a proper name is followed by a relative clause headed by a dative-marked relative-pronoun, it “attracts” the dative feature from the relative pronoun and thus turns into a dative object. In the active-passive ambiguity discussed above, this case-attraction results in an OS-preference instead of the usual SO-preference. The phenomenon of case-attraction provides further evidence for the claim that first-pass parsing is influenced by case-features - evidence that is independent from any particular syntactic assumptions.

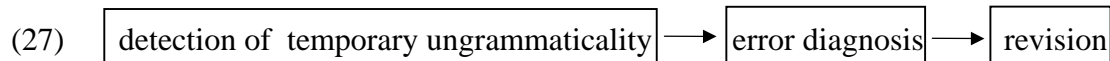
4 Deriving the Strength of Garden-Path Effects in Subject-Object Ambiguities

As the discussion in the preceding sections has already shown, the garden-path effects that are observed in subject-object-ambiguities when a preferred structure turns out to be inconsistent with further material vary widely in strength. First of all, disambiguation in favor of the unpreferred OS-structure causes a much more severe garden-path effect in the case of filler-gap ambiguities than in the case of base-generated ambiguities (cf. section 3.1 and 3.2). Second, there are not only differences between filler-gap and base-generated ambiguities but also differences within the class of base generated ambiguities (cf. section 3.3). Ambiguous passive clauses, either simple ones or those containing a structural relative clause, only lead to weak garden-path effects whereas active clauses containing a dative relative clause cause strong garden-path effects.

In this section, we will consider the questions of how garden-path effects come about in different types of subject-object ambiguities and why they may vary in strength both between and within construction types. Since current approaches to reanalysis do not offer a satisfactory solution, we will introduce a new theory of reanalysis that captures the empirical facts more adequately. For ease of exposition, we will concentrate in this section solely on garden-path effects in base-generated subject-object ambiguities and turn to filler-gap ambiguities afterwards.

4.1 What Happens in Garden-Path-Sentences?

Within a serial model of the human parsing mechanism, processing a garden-path sentence will proceed in the following steps. First, the parser encounters a local ambiguity in the input string. According to some preference principle (e.g. MCP, MA etc.), it selects one of the possible structures and pursues only this one further. At some later point, an input item is encountered that cannot be integrated into the ongoing syntactic representation in a grammatically licit way: the syntactic structure selected at the point of ambiguity has led to a temporary ungrammaticality. The crucial question now is what happens after such a temporary ungrammaticality has been detected. The usual answer within serial models of the HSPM is that a process of reanalysis is triggered that will convert the initial, ungrammatical structure to a new, grammatical one. This basic picture has recently been refined by Fodor and Inoue (1994) (F&I for short). According to the diagnosis model of F&I, two steps have to be taken after the detection of a temporary ungrammaticality. First, the parser must diagnose both the error that led to the mismatch and the actions that are needed to correct the initial structure. Second, the parser must carry out the revisions that will transform the incorrect to the correct structure. (27) summarizes the basic processing steps of the diagnosis model.



F&I hypothesize that diagnosis is the only source for the processing difficulties exhibited by garden-path sentences. When it is difficult for the parser to deduce what error it made on first-pass analysis and how this error can be corrected, a strong garden-path effect will be observed. Otherwise, the garden-path effect will be only weak. Revision processes, in contrast, are held to be associated with the same costs that they are associated with in first-pass parsing. Can the contrasts in garden-path strength found in subject-object ambiguities be explained with reference to diagnosis? Confining ourselves to base-generated ambiguities, the basic difference to explain is the one between sentences like (22b) and (23a), which are here repeated from above.

(22) b. Ich glaube, daß Maria (die ich vorhin gesehen habe), das Buch geliefert **wurde**.
I believe that M. who I just seen have the book delivered was
“I believe that the book was delivered to Maria (, who I have just seen).”

(23) a. Ich glaube, daß Maria, der ich vorhin begegnet bin, das Buch geliefert **hat**.
I believe that M. who I just met am the book delivered has
“I believe that Maria, who I have just met, has delivered the book.”

(22b) is an ambiguous passive clause that gives rise to a slight garden-path effect. The relative clause in (22b) is enclosed in brackets since a garden-path effect is observed whether this relative clause is present or not. (23a) is an ambiguous active clause that causes a strong garden-path effect. The relative clause in (23a) is essential since only under the influence of a dative relative pronoun does the normal SO-preference reverse to an OS-preference.

Diagnosis cannot be the decisive factor for explaining the difference between (22b) and (23a), because diagnosis is completely symmetrical for these two sentences. What has to be diagnosed is the source of the case mismatch. For (22b), the parser must recognize that the initial proper name has erroneously been assigned nominative case instead of dative case and the second NP accusative case instead of nominative case. For (23a), the parser must recognize that the initial proper name has erroneously been assigned dative case instead of nominative case and the second NP nominative case instead of accusative case. These seem to be very easy deductions, and therefore neither sentence should elicit a strong garden-path effect.

The same conclusion emerges if one considers the criteria that F&I have identified to distinguish informative from uninformative symptoms. The first criterion is whether an error - that is, the selection of the false structure at the point of ambiguity - is signaled by an overt or by a covert symptom. On first-pass parsing, the underlined PP in the sentences (28) and (29) is erroneously attached to the relative clause instead of being attached as the second object of the matrix verb *put*. In (28), this error is not overtly signaled by some element but must be figured out from the fact that the sentence comes to an end without providing a directional object for the verb *put*. In (29), in contrast, there is an overt symptom, namely the directional preposition *into* which overtly signals that the PPs conjoined by *or* cannot belong into the relative clause but must be an object of *put*. According to F&I, reanalysis is easier in (28) than in (29) because the symptom is covert in (28) but overt in (29).

(28) Did Susan put the book that she'd been reading all afternoon in the library?

(29) Did Susan put the book that she'd been reading all afternoon in the library or INTO her bag?

According to the second criterion, an overt symptom only leads to an easy revision in case it creates a productive mismatch, as in (29). In (30), in contrast, the verb *bothered* is an overt symptom but it does not create an overt mismatch. When encountering *bothered* the parser will realize that the verb *put* is illicitly missing a PP-object, but *bothered* does not give any cue as to where to find this object. The symptom *bothered* is thus no more helpful than the complete lack of an overt symptom as in (28).

(30) The fact that Susan put the book that she'd been reading all afternoon in the library BOTHERED her parents.

A final criterion is whether the error is signaled by a formal, syntactic mismatch or by a semantic/pragmatic symptom. In both (31) and (32) the clause starting with *that* is initially analyzed as object of the main verb *told*. The fact that this clause is not a complement clause but rather a relative clause is signaled in (31) by the semantic implausibility that arises when the NP *the story* is attached as object of *met*. In (32), in contrast, the error is signaled in a formal way, namely by the fact that *to* cannot start the object of *met*. The garden-path effect caused by (31) is claimed to be stronger than the one caused by (32), which according to F&I shows that formal symptoms are more helpful than semantic symptoms.

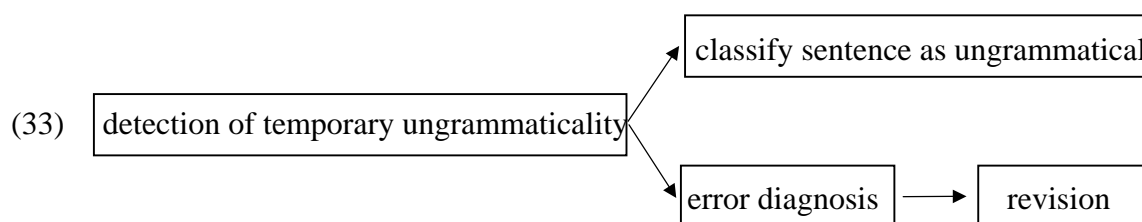
(31) They told the boy that the girl met the STORY.

(32) They told the boy that the girl met not TO go home.

In our two sentences (22b) and (23a), the symptom, i.e. the respective clause final auxiliary, is overt, formal, and it creates a productive mismatch. Hence, a garden-path effect of the mildest sort is predicted by the diagnosis model. This prediction is borne out for sentence (22b) but not for (23a). We therefore conclude that diagnosis cannot explain the difference between (22b) and (23a).

If diagnosis is not the decisive factor, what about the inherent revision costs associated with computing the correct structure? According to F&I, correcting the initial phrase-marker is no more costly than the corresponding first-pass parsing operations. However, this is not necessarily so. There are many proposals to the effect that certain revision operations are more difficult than others (cf. Ferreira & Henderson, 1991; Gorrell, 1995). Therefore, let us ask whether the difference between (22b) and (23a) can be explained with reference to inherent revision costs. In both (23a) and (22b), the same syntactic revision operations are called for. For both sentences, an initial incorrect case assignment must be replaced by a new, corrected one. There seems to be no reason for assuming that the ease with which a case feature can be replaced by another one is dependent on the particular case features involved.

If the desired explanation does neither reside in error diagnosis nor in revision, we must take a step back and consider again what might happen after the parser has detected a temporary ungrammaticality in the input string. According to current models of garden-path effects, the parser will start a process of reanalysis after detecting a temporary ungrammaticality. This reanalysis may be easy or not. However, there is a further option the parser may take. Instead of searching for an alternative structure that is grammatically licit, the parser may simply classify the current input string as ungrammatical, without even considering the possibility that there might be an alternative, wellformed structure. That is, the parser might treat the input string on a par with unambiguously ungrammatical sentences, and assume that the temporary ungrammaticality is a permanent one. This proposal leads to an expansion of the model in (27) which is shown (33).



According to (33), there are two principal actions the parser may take after it has detected a temporary ungrammaticality. It may classify the sentence as ungrammatical, or it may start a process of reanalysis. This latter process, which can be broken down into diagnosis and revision, may be easy or difficult. If an ambiguous sentence is judged as ungrammatical, this can have two sources in a model like (33). It is judged as ungrammatical immediately by taking the upper path, or it is judged as ungrammatical because reanalysis failed to find a correct solution. This latter possibility corresponds to the lower path in (33). Since we have already concluded that sentences like (22b) and (23a) do not differ with respect to either diagnosis or revision, the difference between these two sentences must reside in the prior branching that leads either to perceived ungrammaticality without any intervening reanalysis or to reanalysis (which will consist in both diagnosis and revision processes).

Which of these two branches is taken must be a function of the temporary ungrammaticality that lies at the beginning of the processes leading to a garden-path effect. This leads directly to a further hypothesis besides the introduction of a path leading directly to the judgment of ungrammaticality. According to this hypothesis, the more salient a temporary ungrammaticality is the higher is the probability that an ambiguous sentence is judged as ungrammatical without an attempt at reanalysis. Such a sentence will therefore lead to a large decrease in the percentages of correct judgments in a speeded grammaticality judgment task, indicating strong garden-path effect. We have termed the hypothesis that the salience of a particular temporary ungrammaticality is positively correlated with the strength of the resulting garden-path effect the Mismatch Effect which is given in (34).

(34) The Mismatch Effect

The more salient a temporary ungrammaticality is, the stronger the resulting garden-path effect will be.

In a nutshell, the Mismatch Effect says that if the temporary ungrammaticality springs to mind, the parser will not bother looking for alternative structures but will give up immediately. Applied to the difference between (22b) and (23a), this amounts to the claim that (23a) elicits a stronger garden-path effect than (22b) because the temporary ungrammaticality that is produced when the clause final auxiliary is processed is more salient in (23a) than in (22b).

Empirical evidence for this claim comes from results that we found for truly ungrammatical sentences in experiments that used the version of the speeded grammaticality judgment task described above. Ungrammatical sentences for the active-passive ambiguity are shown in (35). (35a) and (35b) have been derived from the unambiguous (11a) and (11b), respectively, by switching around the unambiguous pronouns. The active verb in (35a) needs an animate subject and an accusative object, but the only animate NP, the pronoun *ihr*, is unambiguously marked for dative case. (35b), in contrast, is ungrammatical because the passivized verb *geschickt wurde* calls for an inanimate subject and an animate dative object, but the only animate NP, the pronoun *sie*, is incompatible with dative case. In short, nominative case is assigned to a pronoun marked for dative case in (35a), and dative case is assigned to a pronoun bearing structural case in (35b).⁷

(35) Pronoun Sentences

- a. *... daß ihr_{dat} letzte Woche ein Päckchen geschickt hat. $V_{\text{nom}} \rightarrow$
 N_{dat}
that her last week a parcel sent has
- b. *... daß $sie_{\text{nom/acc}}$ letzte Woche ein Päckchen geschickt wurde. $V_{\text{dat}} \rightarrow$
 $N_{\text{nom/acc}}$
that she last week a parcel sent was

The same pattern of ungrammaticality is found in (36), but with a definite NP in place of the pronoun. In (36a), the unambiguously dative-marked NP *der Frau* receives nominative case whereas in (36a) dative case is assigned to the NP *die Frau*, which is ambiguous between nominative and accusative case but incompatible with dative case.

(36) Definite NP Sentences

- a. *... daß $der\ Frau_{\text{dat}}$ letzte Woche ein Päckchen geschickt hat. $V_{\text{nom}} \rightarrow$
 N_{dat}
that the woman last week a parcel sent has
- b. *... daß $die\ Frau_{\text{nom/acc}}$ letzte Woche ein Päckchen geschickt wurde. $V_{\text{dat}} \rightarrow$
 $N_{\text{nom/acc}}$
that the woman last week a parcel sent was

Sentences like (35) were part of the experiment on the passive-active ambiguity already described in section 3.2; sentences like (36) stem from an unpublished experiment. Figure 4 shows the percentages of correct responses found for these sentences.

⁷ For (35b), an alternative description exists. Since *geschickt hat* has an optional dative object, one might perceive (35b) as missing a subject instead of taking the dative marked pronoun *ihr* as bearing an illicit case. We are currently investigating this possibility.

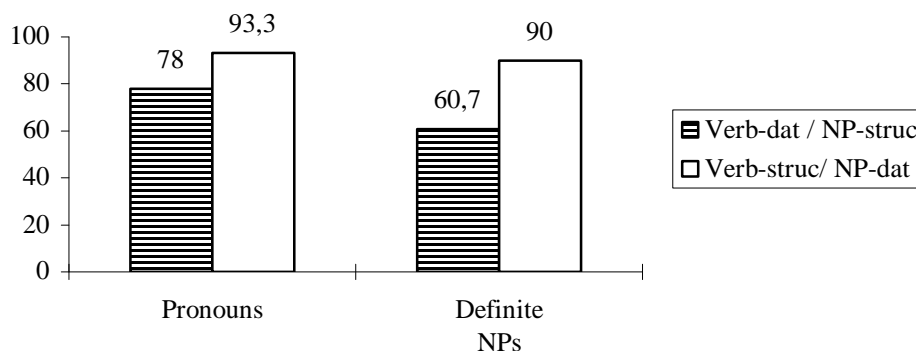


Figure 4: Percentages of correct responses to ungrammatical sentences like (35a) and (35b) (pronoun sentences) and (36a) and (36b) (definite NP sentences)

While pronoun and definite NP-sentences differ with respect to overall error rate, the same pattern emerges in both cases: Sentences where a NP only compatible with structural case is assigned dative case elicit significantly less correct responses than sentences where an unambiguous dative NP is assigned structural case. This asymmetry between the two types of case mismatch seems to be a very general phenomenon: It has not only been found in the two experiments cited, but also in several unpublished experiments. How this asymmetry can be explained within a serial model of the HSPM will be shown in the next section. At this point, it is important to note the empirical relationship between processing ambiguous and ungrammatical sentences. This relationship is depicted in Table 2.

Table 2

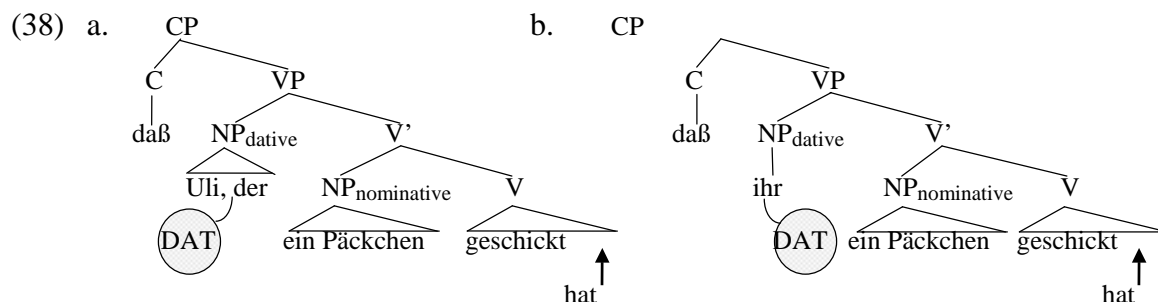
Relation between ungrammaticality detection and strength of garden-path effect

Syntactic configuration	Ungrammaticality	Garden-Path effect
a. $\text{NP}_{\text{structural case}} \xrightarrow{\text{dative case}} \dots \text{V}$	(35a) & (36a)	(11b) & (22b)
b. $\text{NP}_{\text{dative case}} \xrightarrow{\text{structural case}} \dots \text{V}$	less salient (35b) & (36b)	weak (23a)
	very salient	strong

The empirical generalization that emerges from Table 2 is the Mismatch Effect: A less salient ungrammaticality corresponds to a weak garden-path effect and a salient ungrammaticality to a strong garden-path effect. It is this pattern of experimental results that supports the assumption that garden-path strength in sentences like (20b), (22b) and (23a) is to a large extent determined by the particular temporary ungrammaticality that arises at the point of disambiguation. However, our account is not yet complete. First of all, we have not yet given a grammatical definition of the salience of an ungrammaticality but have used this term in an operational way. An ungrammaticality is salient if it is detected with high reliability; it is less salient if it is detected with only low reliability. Furthermore, we have not yet specified the mechanisms that tie together the two phenomena of ungrammaticality detection and garden-path strength. In the next subsection we will sketch a partial model of the HSPM that explicates the notion of salience of ungrammaticality and at the same time relates this notion to garden-path effects.

sentences of this kind will be judged as ungrammatical. However, these judgments are slowed by the additional reaccess process. Due to the time pressure induced by the experimental task, this can have the consequence that subjects will sometimes respond before reaccess is finished and instead simply guess. Since guessing will be incorrect to a certain amount, the error rate increases for ungrammatical passive clauses.

Now consider what will happen during the processing of ambiguous and ungrammatical active sentences. The phrase-structure trees are shown in (38).



In (38a) and (38b), the active verb *geschickt hat* seeks a nominative NP but finds a dative NP (*Uli* in (38a) *ihr* in (38b)). Hence, a case mismatch arises. For ambiguous and ungrammatical passive clauses, we have proposed that the detection of a case mismatch triggers a process of lexical reaccess. Might it be the case that lexical reaccess also occurs for (38a) and (38b) and that lexical reaccess is so difficult for these sentences that it can explain the strong garden-path effect observed for (38a) and the salient ungrammaticality in (38b)? The answer has to be clearly no. It is rather implausible that retrieving information about structural case is more difficult than retrieving information about dative case. Indeed, if anything, the opposite should hold because proper names are more often used with structural case than with dative case which should make structural case more accessible than dative case. We therefore propose that no lexical reaccess is triggered for active clauses. As we will show immediately, this proposal does not need to be stipulated since it follows directly from the asymmetry between structural and dative case within the case system of German. Due to this asymmetry, the conclusions that the parser can draw from a NP marked for structural case differ strongly from the conclusions that can be drawn from a dative-marked NP.

A nominative feature on an NP can have two sources. First, it might be due to a lexical item that is unambiguously marked for nominative case. Second, the NP can be morphologically ambiguous and the nominative feature has been assigned via the Case Preference Principles in (21). Due to the second source, a nominative feature on an NP always leaves open the possibility that this NP might also be compatible with another case assignment, and in particular with dative case. Dative case, in contrast, can only be assigned to a case ambiguous NP by the Case Preference Principles in the special circumstance where both nominative and accusative case have already been assigned, i.e. in sentences with three case ambiguous NPs. Otherwise, dative case can only come about by an unambiguous morphological specification. Therefore, dative case on an NP signals with high probability that this NP is morphologically unambiguous. Note that for the parser, *Uli* in (23a)/(38a) is unambiguously dative marked. This is of course not true in the grammar of German. However, as soon as *Uli* has attracted the dative feature from the adjacent relative pronoun, it will act like the truly unambiguously dative marked pronoun *ihr*.

The upshot of the preceding discussion is that the parser will reaccess the lexicon only for nominative marked NPs but not for dative marked NPs. In consequence, both (38a) and (38b) will be classified as ungrammatical immediately after detecting the case mismatch without the additional step of lexical reaccess. For the ambiguous (38a) this means that a high proportion of sentences will be judged as ungrammatical. For the truly ungrammatical (38b) this means that response times will be shorter than response times to ungrammatical passive sentences,

and furthermore that less errors will occur, because the information that an ungrammaticality has occurred will be delivered to higher-level decision processes quickly enough to make an informed decision within the time span set up by the speeded grammaticality judgment procedure.

The explanation of the experimental findings on the active-passive ambiguity is summarized by the flowchart model shown in Figure 5. This model is a particular instantiation of the general model in (33). Since it is intended to apply to the processing of ambiguous, (unambiguous) grammatical and (unambiguous) ungrammatical sentences, the output of the model is indicated by the two labels “grammatical” and “ungrammatical”. The status of ambiguous sentences depends on whether they lead to the response “grammatical” or “ungrammatical” and how either of these responses comes about.

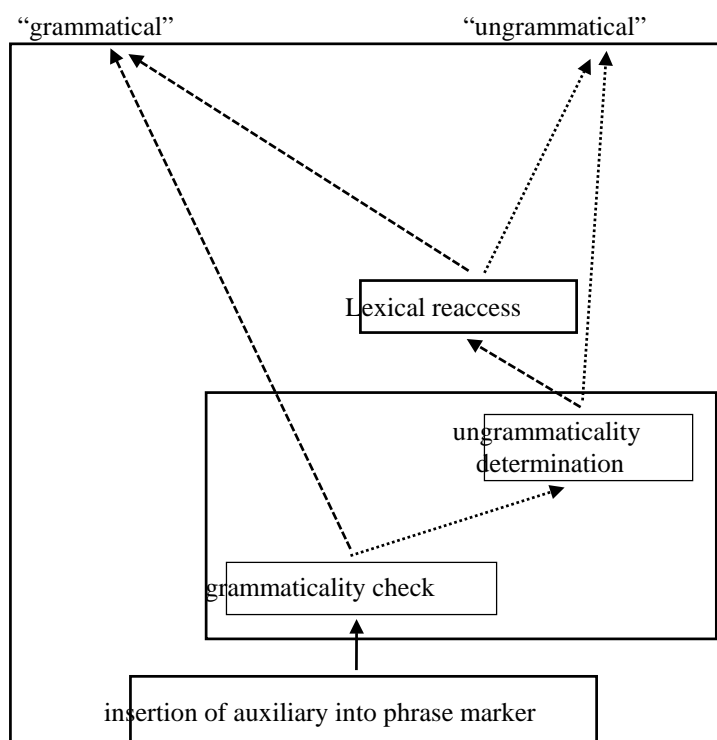


Figure 5: A flowchart of the actions taken by the parser after encountering the clause final auxiliary in ambiguous active and passive clauses like (20), (22) and (23)

In order to summarize this section, we will describe in turn how grammatical, ungrammatical and ambiguous sentences are processed according to the flowchart in Figure 5. Common to all three kinds of sentences is that the first step consists in the insertion of the clause final auxiliary into the phrase-marker that has been computed before (cf. (37) and (38)). After the auxiliary has been inserted, the grammaticality of the resulting syntactic-representation is checked. What happens next depends on whether the grammaticality check leads to a positive or negative outcome.

(i) **GRAMMATICAL SENTENCES.** For grammatical sentences, the grammaticality check will lead to a positive result. Therefore, grammatical sentences can be judged as grammatical without delay.

(ii) **UNGRAMMATICAL SENTENCES.** For ungrammatical sentences, the grammaticality check delivers a negative result. Since at this early point of processing the parser cannot know whether it is dealing with a permanent or a temporary ungrammaticality, the sentence is not judged as ungrammatical immediately. Instead, the next step consists in determining the type of ungrammaticality. For ungrammatical active sentences of the type shown in (35a), the parser will conclude that there is no way in which the structure might be improved. This is

due to the fact that the initial pronoun *ihr* is morphology marked for dative case and the parser has no reason to assume that this pronoun might be compatible with nominative case (cf. the above discussion). Therefore, the sentence will be judged as ungrammatical as soon as the type of the ungrammaticality has been determined. For ungrammatical passive sentences like (35b), determining the type of the ungrammaticality will show that a morphologically unspecified pronoun is bearing nominative case instead of dative case. Since this leaves open the possibility that the pronoun might also be compatible with dative case, the sentence is not yet judged as ungrammatical. Instead, the lexical system is entered again in order to check the case possibilities for the pronoun *sie*. This lexical reaccess will lead to a negative result because *sie* cannot bear dative case. Therefore, the sentence will be judged as ungrammatical after lexical reaccess is completed.

In sum, ungrammatical passive sentences will trigger an extra step of lexical reaccess whereas ungrammatical active sentences will not. This extra step will take some additional time. Since subjects are under time-pressure in the speeded grammaticality judgment task, they will therefore make more errors for ungrammatical passive clauses because the extra time needed for lexical reaccess will not always leave enough time for an informed response but will lead to a certain amount of guessing.⁸

(iii) AMBIGUOUS SENTENCES. If an ambiguous sentence is disambiguated according to its preferred structure, it will be processed exactly like an unambiguous grammatical sentence. If the preferred structure is contradicted by the clause final auxiliary, the grammaticality check will lead to a negative result. As with ungrammatical sentences, the further course of processing is determined by the type of ungrammaticality which will be determined at the stage called ungrammaticality determination in Figure 5. Ambiguous active clauses will be processed in the same way as corresponding ungrammatical sentences. No lexical reaccess will be triggered and the sentences will be judged as ungrammatical without further delay. Since ambiguous active clauses are in fact judged as grammatical more often than ungrammatical active clauses, we must assume that the dative feature of the relative pronoun is attracted only in a certain percentage of cases. If it is attracted, the sentence will be processed like an unambiguous ungrammatical sentence; if not, the sentence will be processed like an unambiguous grammatical sentence. Ambiguous passive clauses will trigger lexical reaccess. They share this property with their ungrammatical counterparts. However, for a proper name lexical reaccess will succeed because a proper name is indeed compatible with dative case. Therefore, ambiguous passive clauses will be ultimately judged as grammatical. Compared to unambiguous and grammatical passive clauses, the processing of ambiguous passive clauses will take more time because of the extra step of lexical reaccess that is not needed in unambiguous passive clauses.

5 Garden-Path-Strength in Filler-Gap-Ambiguities

In the following sections, we will demonstrate that the model of reanalysis we have outlined above helps to shed light on a variety of reanalysis phenomena within the domain of filler-gap ambiguities. Section 5.1 discusses differences in garden-path strength within the class of filler-gap ambiguities which are shown to be dependent on two possible types of disambiguating information: case and number agreement. Again, variation in garden-path strength within one and the same type of ambiguity poses problems for current models of reanalysis, but as we will show, the facts follow naturally from our model without additional assumptions. In Section 5.2, we will come back to the comparison of garden-path phenomena

⁸ This interpretation is strengthened by the fact that reaction times for ungrammatical passive sentences (cf. (35b) and (36b)) have been found to be slower than reaction times to ungrammatical active sentences (cf. (35a) and (36a)).

between base-generated and filler-gap ambiguities. Section 5.3 takes up the issue of why the so-called filled-gap effect is absent at the subject position in English. Finally, section 5.4 puts our theory of reanalysis into a broader perspective, specifically addressing the scope of this theory.

5.1 Filler-Gap-Ambiguities and Mode of Disambiguation

Local filler-gap ambiguities remarkably differ with respect to the strength of the garden-path effects that they elicit. In particular, garden-path strength seems to depend on the means by which the filler-gap ambiguity is disambiguated. Consider first the globally ambiguous sentence (39). This sentence has either a SO- or an OS-reading, depending on the position of the trace of the wh-phrase *welche Studentin*.

- (39) Welche Studentin_i **hat** (t_i) die Frau (t_i) besucht?
Which student has the women visited

“Which student has visited the woman?” or “Which student has the woman visited?”.

If the trace precedes the second NP *die Frau*, the wh-phrase is the subject and the sentence exhibits the word-order subject before object. If the trace follows the second NP, the wh-phrase is the object and the sentence exhibits the word-order object before subject. This is completely parallel to the filler-gap ambiguity found in sentence pairs like (18) above.

There are two possibilities to derive sentences that are only locally ambiguous from a globally ambiguous sentence like (39). The first possibility is shown in (40). Here, the feminine noun *Frau* has been replaced by the masculine noun *Mann*. In contrast to feminine NPs, masculine NPs are not ambiguous between nominative and accusative case (cf. Table 1). Therefore, the sentences in (40) are disambiguated at the second NP. The NP *den Mann* in (40a) is unambiguously an accusative NP and the whole sentence exhibits SO-order. The NP *der Mann* in (40b) is a nominative NP, and consequently, the whole sentence must exhibit OS-order.

- (40) a. Welche Studentin hat **den Mann** besucht?
Which student has the man visited
 “Which student has visited the man?”
 b. Welche Studentin hat **der Mann** besucht?
Which student has the man visited
 “Which student has the man visited?”

The second possibility to turn a globally ambiguous sentence like (39) into locally ambiguous sentences is provided in (41). The sentences in (41) contain a singular NP followed by a plural NP. Due to subject-verb agreement, these sentences are disambiguated at the position of the clause-final auxiliary. (41a) contains a singular auxiliary and therefore the first NP must be the subject. In (41b), the auxiliary is a plural auxiliary and the second NP must be the subject.

- (41) a. Welche Studentin **hat** die Männer besucht?
Which student has the men visited
 “Which student has visited the men?”
 b. Welche Studentin **haben** die Männer besucht?
Which student have the men visited
 “Which student have the men visited?”

In the following, we will accordingly distinguish two different modes of disambiguation: disambiguation by case, i.e. via the morphological case marking of a second NP, and disambiguation by agreement, i.e. via the number features of the finite verb.

As was already noted in section 3.1, there is evidence from several sources which demonstrates that the SO-order is preferred in processing ambiguous wh-questions (cf. e.g. Meng, in prep.; Schlesewsky et al., 1996). Consequently, a garden-path effect arises in case sentences are disambiguated towards the OS-reading. What we are primarily concerned with is the fact that the strength of the garden-path effect in the unpreferred OS-order differs, depending on which of the two ways of disambiguation introduced above is used. In a series of experiments, we found that locally ambiguous wh-questions which are disambiguated by number features of the finite verb as in (41) lead to a fairly strong garden-path effect. In contrast, garden-path effects in sentences like (40), in which the overt case marking of a second NP provides the disambiguating information, are rather weak. Important in the present context is the additional observation that this difference in garden-path strength is again accompanied by a marked difference with respect to performance on truly ungrammatical sentences: the ungrammatical counterparts of garden-path sentences disambiguated by number agreement are detected much more reliably than ungrammatical counterparts of garden-path sentences which are disambiguated by the morphological case features of the second NP.

To illustrate this point, we will present results of two speeded-grammaticality judgment experiments which independently investigated locally ambiguous wh-questions differing with respect to the mode of disambiguation. The first experiment used sentences as in (42), which all contain an embedded question. Due to the morphological ambiguity of the initial wh-phrase, the embedded question in (42a) remains ambiguous until the auxiliary in sentence final position is reached. The number features of the finite verb resolve the local ambiguity towards the OS-reading. Assuming that the ambiguous embedded question will be preferably assigned an SO-structure, a garden-path effect is expected to arise. In contrast, the wh-phrase in the grammatical counterpart (42b) is unambiguously marked for accusative. Therefore, no ambiguity arises, and the wh-phrase will be assigned to a gap in object position immediately. Finally, (42c) serves as the ungrammatical counterpart of (42a). Since its initial wh-phrase is overtly marked as nominative, the embedded question must be assigned a SO-structure. However, the finite verb does not agree with the nominative NP, rendering the sentence ungrammatical. Notice that the ambiguous sentence in (42a) and the ungrammatical sentence in (42c) will be assigned the same phrase structural representation and consequently the same type of ungrammaticality will arise as soon as the finite verb is received. The only difference is that the ungrammaticality is permanent in (42c), whereas it is only temporary in (42a).

- (42) a. Jemand fragte, welche Studentin die Männer besucht **haben**. (ambiguous)
Someone asked, which student the men visited have
 “Someone asked which student the men visited.”
- b. Jemand fragte, welchen Studenten die Männer besucht **haben**.
 (unambiguous)
Someone asked, which student the men visited have
 “Someone asked which student the men visited.”
- c. *Jemand fragte, welcher Student die Männer besucht **haben**. (ungrammatical)
Someone asked, which student the men visited have

A second experiment used sentences as in (43) in which a wh-phrase has been extracted out of a sentential complement. (43a) is again locally ambiguous. The wh-phrase could function as the subject or the object of the embedded clause but according to the strategies for

parsing filler-gap dependencies, the *wh*-phrase will be initially assigned to the subject position. This time, however, it is not a finite verb that provides the disambiguating information, but rather the morphological case marking on the NP in sentence final position. Since this NP *der Mann* is overtly marked as nominative in (43a), the *wh*-phrase cannot be associated with the subject position. Instead, its correct gap site turns out to be the direct object position of the embedded clause. (43b) is the unambiguous grammatical counterpart of (43a). Being marked for accusative, the *wh*-phrase can be recognized as a direct object immediately, and so it will not be erroneously assigned to the subject position first. Finally, (43c) is the corresponding ungrammatical sentence. As in (43a), its *wh*-phrase will be analyzed as a subject, an assignment that leads to an error when the nominative NP *der Mann* is received, since this NP must fill the subject position. Contrary to (43a), there is no way to correct this error in (43c), thus leading to a permanent ungrammaticality.

- (43) a. *Welche Studentin glaubst du, besuchte **der Mann**?* (ambiguous)
Which student believe you visited the man
“Which student do you believe the man visited?”
- b. *Welchen Studenten glaubst du, besuchte **der Mann**?* (unambiguous)
Which student believe you visited the man
“Which student do you believe the man visited?”
- c. **Welcher Student glaubst du, besuchte **der Mann**?* (ungrammatical)
Which student believe you visited the man

In two end-of-sentence speeded grammaticality judgment experiments, the processing of sentences with agreement disambiguation as in (42) and sentences with case-disambiguation as in (43) was independently investigated. The results are summarized in Figure 6 (cf. Meng, in prep. for a detailed description).

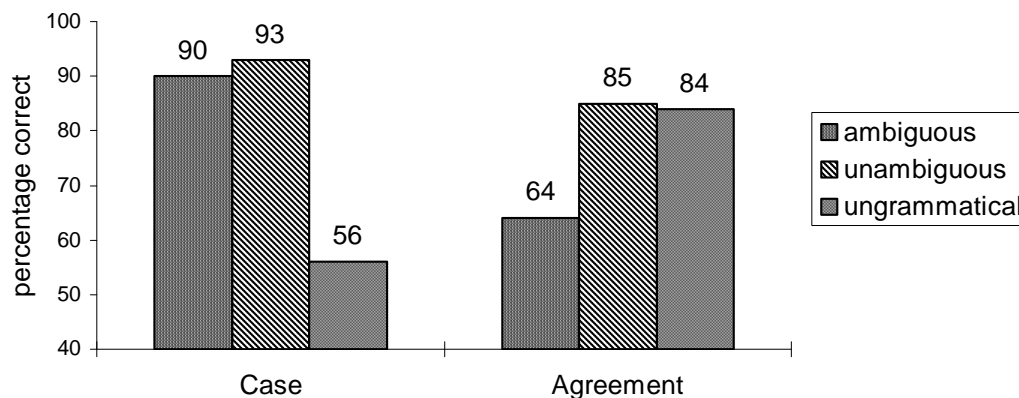


Figure 6: Percentages of correct answers for sentences disambiguated by Case (cf. (43)) or by agreement (cf. (42))

Comparing the experimental results for the sentences of type (42) and (43), there are striking differences in the performance patterns. Most obviously, the two sentence types differ with respect to the strength of the garden-path effects which their ambiguous versions elicit. Ambiguous sentences which are disambiguated by the number features of the finite verb lead to a garden-path effect of considerable size. The accuracy of grammaticality judgments for ambiguous sentences with OS-order drops to 64% correct, which is significantly lower than for unambiguous grammatical OS-structures. The picture is quite different for the sentences in (43) which are disambiguated by case. Concerning ambiguous sentences, there was no

indication for a garden-path effect in the accuracy of judgments. The difference between ambiguous and unambiguous grammatical sentences was only a non-significant 3%. However, there was evidence for a garden-path in the reaction time data (not depicted here): Judgments for OS-sentences were considerably slowed. Therefore, the first generalization that we can derive seems to be as follows: Ambiguous questions that are disambiguated by number agreement elicit a stronger garden-path effect compared to ambiguous questions disambiguated by case.

For current theories of reanalysis, such a difference in garden-path strength appears to be problematic. Consider again the relevant garden-path sentences in (42b) and (43b), repeated below.

- (42) b. Jemand fragte, welche Studentin die Männer besucht **haben**. (64% correct, strong GP)
Someone asked which student the men visited have
 “Someone asked which student the men visited”
- (43) b. Welche Studentin glaubst du, besuchte **der Mann**? (90% correct, weak GP)
Which student believe you visited the man
 “Which student do you believe the man visited?”

As we have outlined in section 3, both the Minimal Chain Principle in (19) and the Case Preference Principles in (21) would predict that a wh-phrase which is ambiguous between a subject and a direct object interpretation will be preferably associated with a subject position. This preferred analysis is contradicted by the disambiguating item *haben* in (42b) and *der Mann* in (43b), indicating that the wh-phrase must be associated with the direct object position instead. Obviously, the revision operations that become necessary when the disambiguating element is received are identical: A dependency between the filler and the subject position must be replaced by a dependency between the filler and the direct object position. Therefore, the revision process itself is unlikely to be responsible for the observed differences in garden-path strength. However, it is equally unlikely that diagnosis, i.e. the ease with which the necessary revision can be spotted, is the relevant factor. Both the disagreeing finite verb in (42b) and the nominative NP *der Mann* in (43b) unambiguously signal that the wh-phrase cannot be the subject. But in both cases, the only alternative left is to relate the wh-phrase to the direct object position. Thus, the reasoning which is initiated by the temporary ungrammaticality to determine which steps the parser should take cannot be very complex. There is only one way out, which should not be difficult to find, even for a short-sighted parser. Moreover, the temporary ungrammaticalities that arise in (42b) and (43b) are both due to overt and formal errors in the sense of Fodor and Inoue (1994). Taken together, this does not only suggest that the garden-path effects in (42b) and (43b) should be of identical strength but also that they should be weak in both cases. This leaves us with the question why disambiguation by a case-conflict is easy whereas disambiguation by the number features of the finite verb is difficult.⁹

Let us therefore turn back to the experimental results in Figure 6. Evidently, performance on ungrammatical sentences also shows a striking difference. For ungrammatical sentences

⁹ The particular constructions discussed here differ in various respects, e.g. clause-internal wh-movement in (42) but long wh-movement crossing a clause boundary in (43). Such construction specific differences could in principle be held responsible for the observed differences in garden-path strength, and our generalization concerning the mode of disambiguation may thus appear somewhat premature. However, more recent experimental evidence on filler-gap ambiguities clearly shows that the same difference shows up if the two modes of disambiguation are directly compared (cf. Bader & Meng, in prep. as well as Meng, in prep).

with agreement disambiguation (cf. (42c)), subjects had no difficulty in detecting truly ungrammatical sentences. The accuracy of judgments was fairly high (84%), and no different from the level of accuracy for unambiguous grammatical sentences. For sentences with case disambiguation (cf. (43c)), performance on the corresponding ungrammatical structures was considerably worse. The accuracy of judgments dropped to 56% which is much below the level of accuracy that unambiguous grammatical sentences reached. Recall that the ungrammatical sentences in (42c) and (43c) give rise to the same local error that indicates the temporary ungrammaticality in the corresponding ambiguous sentences. In (42a) and (42c), an agreement mismatch arises when the finite verb is reached. Similarly, a case mismatch arises both in (43a) and (43c) because the parser expects an accusative NP but receives a nominative NP. The only difference between ambiguous and ungrammatical sentences is that the ungrammatical sentences do not allow for a correction of the error, because they do not allow for an alternative structural assignment.

Consequently, a further conclusion that we can draw from the two experiments seems to be that ungrammaticalities due to an agreement mismatch are easier to detect than ungrammaticalities due to a case mismatch. In sum, the overall pattern of results obviously parallels the pattern that we found for the base generated ambiguities discussed in the preceding sections. The data behave as predicted by the Mismatch Effect: strong garden-path effects correlate with good performance on ungrammatical sentences, weak garden-path effects correlate with poor performance on ungrammatical sentences. Therefore, we propose that the difference in garden-path strength between questions disambiguated by case and sentences disambiguated by agreement must be essentially due to a difference in the salience of the temporary ungrammaticality which the disambiguating elements give rise to. The crucial question then becomes why an agreement mismatch is more salient than a case mismatch.

As with the difference between ungrammatical active and passive sentences discussed in connection with base-generated subject-object ambiguities, we will propose that the particular syntactic features involved in agreement and case mismatches are the main determinants of the salience of these two types of mismatches. We will start with the sentences in (42a) and (42c) which elicit an agreement mismatch. To see why an agreement mismatch leads to a salient error, a few preliminary remarks are in order concerning the syntactic status and the morphological representation of number information. Morphologically, number information is expressed on the finite verb as well as on the noun phrase. On the verb, number is encoded together with person information within a single affix attached to the stem (which may be zero). Table 1 illustrates the regular inflection paradigm for German strong and weak third-person verbs in the present tense.

Table 3

	strong verbs		weak verbs + haben	
	singular	plural	singular	plural
third-person	komm- t	komm- en	lach- t/ha-t	lach- en/hab-en

Within the noun phrase, number information is signaled on the noun, on the determiner and on pronominal modifiers. Morphological marking on the noun or on the determiner alone may sometimes not uniquely specify singular or plural. Combined, however, the marking on the noun and on the determiner leads to an unambiguous expression of number for the whole noun phrase.

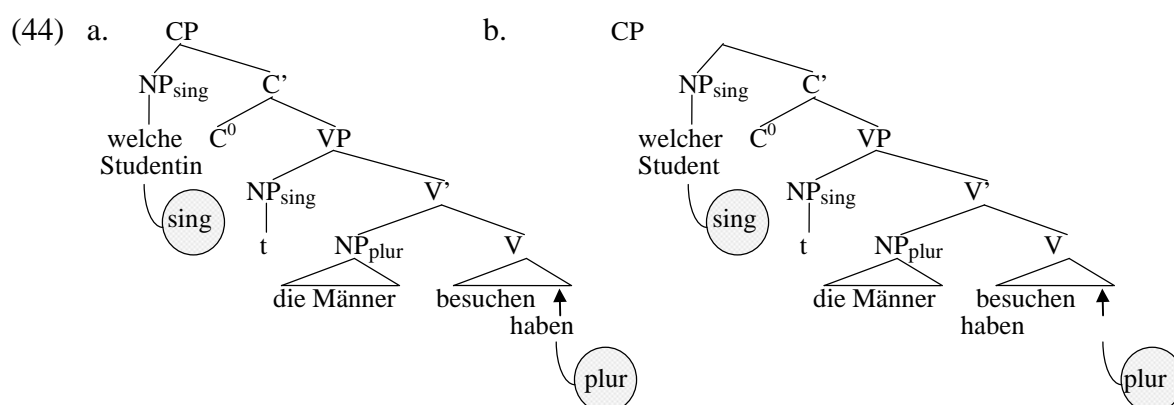
Table 4

	Singular	Plural
Type 1: article only	das Muster	die Muster
Type 2: suffix only	die Frau	die Frauen
Type 3: article + suffix	das Auto	die Autos
Type 4: article + Umlaut	der Apfel	die Äpfel
Type 5: article + Umlaut + suffix	der Wald	die Wälder

In sum, we see that number information is unambiguously signaled on both the noun phrase and the finite verb which participate in the agreement relation. Singular and plural are distinctly marked, and never coincide. The only exceptions to this generalization can be found in the pronominal system. The 3rd person pronoun *sie* can be either singular or plural. Furthermore, the personal pronoun *ihr* can function as a 3rd person singular with dative case, or as a 2nd person plural with nominative case. In this respect, number information is unlike structural case, where we find a considerable amount of overlap among nominative and accusative forms. It rather parallels the morphological expression of dative case which, as described above, is also most of the time unambiguous.

The parallelism between dative case and number marking is further strengthened by the fact that both directly affect the semantic interpretation of a sentence. As far as number is concerned, it is obvious that specification for singular or plural has distinct semantic effects. Concerning case, NPs that are assigned structural cases can be associated with a broad range of semantic roles, whereas the set of semantic roles that a dative NP can be associated with is much more restricted (cf. Wegener, 1985). Dative NPs are usually confined to the expression of the goal or the beneficent/ maleficent of an action or event.¹⁰ Having semantic content, number features (as well as the dative feature) are not confined to specific syntactic positions and are therefore never changed in the course of a syntactic transformation, unlike e.g. nominative or accusative case features.

We are now in a position to explain how sentences like (42a) and (42c) that contain a temporary or a permanent number agreement mismatch are processed. The phrase structural representations of the embedded clause that the parser has computed immediately prior to the attachment of the finite auxiliary are depicted below.

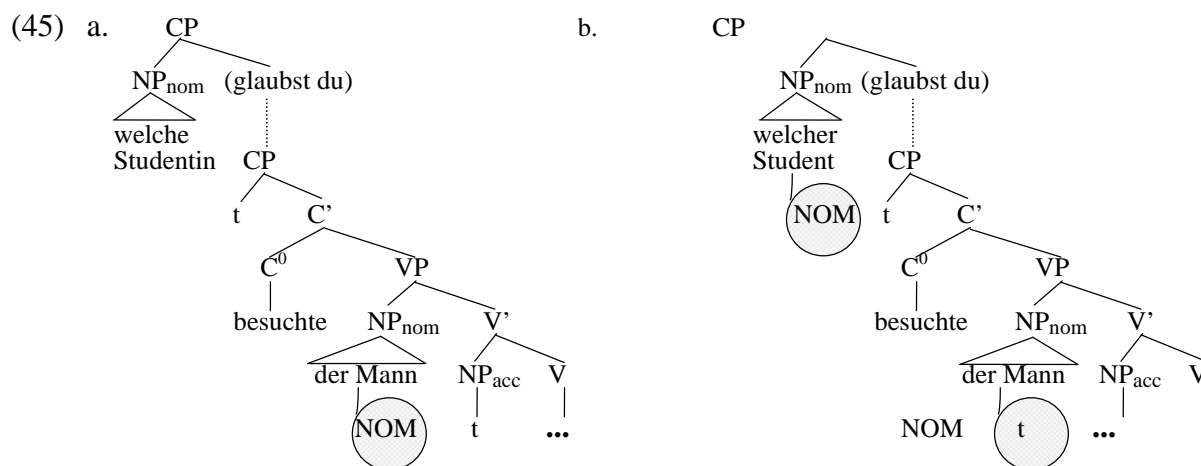


In both cases, the finite verb will first be attached to the V^0 -position, the only legitimate attachment site. The parser then has to check whether the finite verb and the subject NP agree, i.e., share the same features for number and person. Since the finite verb is marked for plural, but the wh-phrase, which is associated with the subject position via the trace, is marked for singular, a number mismatch arises. This error is fairly salient and will therefore block

¹⁰ In recent syntactic theory, dative case and number information therefore both belong to the class of “interpretable” features, whereas structural case features are “uninterpretable” (cf. Chomsky, 1995).

attempts at reanalysis. Why is it salient? As we have seen, the syntactic specification of number always has a distinct morphological correlate, i.e. there is always unambiguous morphological evidence that forces the specification of a number feature in the syntax. Consequently, the parser must conclude that the sentence is ungrammatical, and it tends to stop further processing without starting reanalysis. This explains why an ungrammatical sentence involving a number mismatch as (42c) is detected easily. This also explains why a locally ambiguous sentence involving a temporary number mismatch as in (42a) elicits a strong garden-path effect. Since the agreement error seems to obviously render the sentence ungrammatical, no attempt is made to find alternative structural assignments that would lead to a successful parse. Consequently, locally ambiguous sentences of this type are judged as ungrammatical in a large number of cases.

The final question in our explanation of garden-path effects in filler-gap ambiguities is how a temporary or a permanent case mismatch is processed. What happens if the parser receives an NP that is overtly marked as nominative, as in (43a) and (43c)? The first question is where this nominative NP is attached. Since a nominative NP must function as a subject, the only legitimate attachment site will be the subject position of the embedded clause. This attachment leaves the *wh*-phrase without a gap site. The only alternative gap site for the *wh*-phrase is the direct object position of the embedded clause. If the *wh*-phrase is coindexed with a gap in direct object position, however, it cannot carry abstract nominative case anymore, but has to be assigned abstract accusative case. Thus, a case mismatch arises. The resulting phrase structural configuration - somewhat simplified - is shown in (45a) for the garden-path sentence (43a), and in (45b) for the corresponding ungrammatical sentence (43c).



The crucial question we have to answer concerns the salience of the error that arises in (45). As shown by the data in Figure 6, this kind of error is not salient, leading to many incorrect responses. Why should this be so? At first glance, the high proportion of incorrect responses that truly ungrammatical structures like (45b) elicit may seem surprising. After all, the initial *wh*-phrase is morphologically specified for nominative case and therefore, it should become clear immediately that assignment of accusative case is impossible. However, if the distinction between abstract and morphological case is taken into account, a solution to this puzzle might take the following form.

In terms of abstract case, the two *wh*-NPs in (45) do not differ. Both carry an abstract nominative feature. The only difference between (45a) and (45b) pertains to the strategies that were used to assign abstract nominative. According to our syntactic assumptions, abstract nominative may have two sources: It may be assigned by default rules or, as in the case of dative, on the basis of morphological features that the NP carries. Default assignment is seen in (45a) whereas assignment on the basis of morphological information takes place in (45b). If the parser encounters the second NP *der Mann*, it will only look at the abstract nominative

feature on the first NP node, but the abstract case feature on NP1 doesn't signal whether its assignment was due to a default rule or due to some morphological feature. Therefore, neither in (45a) nor in (45b) can the parser immediately conclude that the structure it has computed is ungrammatical, since the assignment of abstract nominative case could have been triggered by default. Given this possibility, the parser may simply conclude that the nominative feature on NP1 must be withdrawn, and accusative case be assigned to the wh-phrase instead.

To be sure, the parser would have to check whether the lexical items that make up the wh-phrase are compatible with the assignment of accusative case. In the case of ambiguous sentences (45a), no problems arise. The derivation converges and the sentences will therefore be correctly judged as grammatical. In (45b), on the other hand, problems do arise, because the interrogative pronoun *welcher* is explicitly marked as nominative and definitely incompatible with accusative case. However, given the time pressure of the experimental task, responses may often be initiated before the parser has completed the checking procedure. Consequently, ungrammatical sentences are judged incorrectly in a large number of cases. Note, that lexical reaccess is not necessary to carry out this checking procedure since the relevant information is already in the lexical items that the parser has. According to our morphological assumptions, the NP *welche Studentin* is underspecified with respect to morphological case and therefore compatible with structural case in general, that is, with both nominative and accusative case. The NP *welcher Student*, instead, is morphologically specified for nominative case.¹¹

5.2 Filler-Gap Ambiguities and Base-Generated Ambiguities Reconsidered

In this section, we come back to a contrast in garden-path strength that was already pointed out when we introduced the two types of subject-object ambiguities in section 3 (cf. (46a) and (46b), repeated from above). Whereas base-generated OS-sentences like (46a) only elicit a weak garden-path effect, filler-gap OS-sentences in (46b) cause a rather strong one.

- (46) a. Fritz hat behauptet, daß Uli_{DAT} ein Päckchen_{NOM} geschickt wurde **weak GP**
Fritz has claimed that Uli a parcel sent was
“Fritz claimed that a parcel was sent to Uli.”
- b. Maria hat gesagt, daß sie_{ACC-SG/i} die Eltern_{NOM-PL} (t_i) angerufen **haben**_{PL} **strong GP**
Maria has said, that her the parents phoned have
“Maria said that the parents have phoned her.”

The various subject-object ambiguities that were already surveyed have made clear that there are severe differences with respect to garden-path strength both within base-generated ambiguities and within filler-gap ambiguities. Ambiguities of either type may elicit strong or weak garden-path effects alike, depending on various factors that we have discussed. The difference between (46a) and (46b) does therefore not represent a general difference between base-generated and filler-gap ambiguities but only a difference between particular instantiation of these two types of subject-object ambiguities. It is thus rather improbable that the difference in garden-path strength between (46a) and (46b) can be reduced to (46a) being a base-generated ambiguity and (46b) a filler-gap ambiguity, as claimed in Bader (1994a,b).

¹¹ A further factor contributing to the low performance on sentences like *Welcher Student besucht der Mann?* might have to do with the nature of the NPs involved, especially the complex make-up of the wh-phrase. For example, replacing this wh-phrase by the nominative pronoun *er* (he) results in an ungrammaticality that is intuitively detected easily. Since investigating the possible influence of the structure of the NPs involved has only recently started, we will not go further into this topic.

The main reason for comparing (46a) and (46b) lies in the fact that that these two sentences are closely matched instances of base-generated and filler-gap ambiguities, respectively. In both sentences, the ambiguity is contained within an embedded clause composed out of the same constituents (complementizer followed by two NPs followed by main and auxiliary verb) and the disambiguation is provided by the clause-final auxiliary. It is therefore of some interest to see how well our theory of garden-path strength fares with this type of contrast.

According to the theory presented in this paper, the strength of a garden-path effect is to a large degree dependent on how salient the respective ungrammaticality is. Truly ungrammatical counterparts to (46a) and (46b) are given in (47a) (repeated from above) and (47b). These ungrammatical sentences lead to the same type of mismatch as the garden-path sentences in (46a) and (46b), respectively. In (47a), the proper name has been replaced with the definite NP *die Tante*, which is compatible with structural case but not with dative case. In (47b), the ambiguous feminine pronoun *sie* has been replaced with the masculine pronoun *er*, which is unambiguously marked for nominative case.

- (47) a. *Fritz hat behauptet, daß die Tante ein Päckchen geschickt wurde
Fritz has claimed that the aunt a parcel sent was
- b. *Fritz hat gesagt, daß er die Eltern angerufen haben
Fritz has said, that he the parents phoned have

Results for ambiguous, unambiguous and ungrammatical OS-sentences, for both base-generated and filler-gap ambiguities, are summarized in Figure 7.

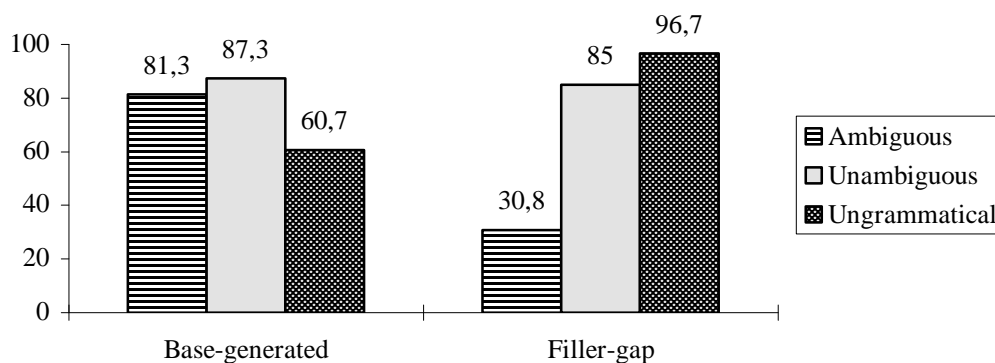


Figure 7: Performance on object-subject structures for base-generated and filler-gap ambiguities

The experimental data in Figure 7 pattern precisely as predicted by the Mismatch Effect. The weak garden-path effect for base generated ambiguities correlates with rather poor performance on truly ungrammatical sentences, whereas the strong garden-path effect for filler-gap ambiguities correlates with good accuracy in the judgments on ungrammatical sentences. From this we conclude that the model of reanalysis that we have developed in the previous sections successfully covers contrasts in garden-path strength not only within construction types but also across construction types.

5.3 Filler-Gap Ambiguities in English

In this section we will show how our theory of garden-path strength might account for a recalcitrant garden-path phenomenon from the domain of filler-gap processing in English. This phenomenon is the surprising absence of the filled-gap effect at the subject position. The filled-gap effect was an early demonstration that filler-gap ambiguities are not only processed

on-line but may also give rise to true garden-path effects (cf. Crain & Fodor, 1985 for the original observation). Consider the examples in (48) which are taken from Stowe (1986).

- (48) a. My brother wanted to know if Ruth will bring us home to Mom at Christmas
b. My brother wanted to know who Ruth will bring us home to (e) at Christmas

The sentence in (48b) contains an embedded question initiated by the wh-phrase *who*. The syntactic function of this wh-phrase remains temporarily ambiguous. Since English has lost its case morphology almost entirely, *who* may function as subject, direct or oblique object. As has been shown in Stowe (1986) and since then replicated in numerous other experiments, processing difficulties can be observed if the position of the direct object of a verb like *bring* is occupied by a lexical NP in (48b), relative to (48a) (cf. Boland, Tanenhaus, Garnsey, & Carlson, 1995; Kurtzman, Crawford, & Nychis-Florence, 1991; Stowe, Tanenhaus, & Carlson, 1991; Traxler & Pickering, 1996). The standard interpretation of this phenomenon starts from the assumption that the parser follows an on-line first-resort strategy in filler-gap assignment. Therefore, the parser postulates a gap for the filler in direct object position without first checking whether the upcoming input string contains a NP that would have to fill this position. If such a constituent is indeed encountered, as the NP *us* in (48b), and the putative gap site turns out to be filled, the provisional filler-gap assignment has to be reanalyzed, thus giving rise to the observed processing effects.

As has also been observed by Stowe (1986), no comparable filled-gap effect can be observed at the subject position. No processing difficulty arises if the subject position turns out to be filled by a lexical NP, e.g. *Ruth* in (48b). If the standard filled-gap effect at the direct object position is taken to indicate a first-resort strategy in filler-gap assignment, the absence of a likewise difficulty at the subject position is in need of an explanation.

In the literature, two different strategies have been employed to explain the filled-gap effect asymmetry. According to the first strategy, there is a general preference for the SO-order in English, but additional factors disguise the reanalysis effect that we would expect at the subject position and that we in fact see at direct object positions. Stowe herself hypothesized that postulating a gap in object position has more semantic consequences since it completes a proposition. The need to revise a semantically interpreted structure gives rise to the 'standard' filled-gap effect. Since no proposition is completed when a filler is assigned to the subject position, no likewise effect is observed if the subject position turns out to be filled. A similar line of reasoning underlies the COMPLETENESS CONSTRAINT ON BINDING (cf. Goodluck & Finney, 1993) which states that filler-gap assignment only takes place if the putative gap-site marks a potential end-of-sentence. Clifton and Frazier (1989) suggest that the subject NP may simply arrive too early, i.e. before a filler-gap assignment to the subject position has even been formed. More recently, Gibson, Hickok, & Schütze (1994) formulate a theory within the framework of parallel parsing according to which subject-object preferences do not develop until the theta-role assigning verb has been processed. Since in English, the subject position always precedes the verb, a gap site may or may not be postulated there. Accordingly, there is no preference for postulating a gap or attaching a lexical NP when the subject position is reached.

One common thread of all these theories is that they construct a principled difference between associating a filler to the subject position and associating a filler to the object position: revising a gap in subject-position is always easy and does not lead to difficulties whereas revising a gap in object-position is always difficult and therefore leads to difficulties. But there is ample processing evidence from German and Dutch which shows that postulating a gap at the subject position can also lead to processing difficulties very early in the sentence, as in examples like (49).

- (49) Welche Frau haben die Männer besucht? **strong GP**
Which woman have the men visited
 “Which woman have the men visited”

In (49), the finite verb *haben* disambiguates the structure towards an OS-order. In a self-paced reading study, processing difficulties were found right at the finite verb, showing that filler assignment to the subject position had already taken place (Meng, 1995, see Schlesewsky et al., 1996, for similar results, and Kaan, 1994, for on-line evidence from Dutch).

The second strategy to explain the absence of the filled-gap effect at subject positions does not focus on processes of reanalysis but rather on the direction of the preference itself. According to Phillips (1995), different preferences hold in German and Dutch on the one hand and English on the other hand. For German and Dutch, Phillips postulates an SO-preference, but for English an OS-preference. This cross-linguistic difference directly follows from Phillips’ principle of GENERALIZED RIGHT ASSOCIATION, which predicts that object-gap assignment will be preferred in SVO languages like English, while subject-gap assignment is preferred in SOV languages like German and Dutch. This not only explains the absence of the subject filled-gap effect in English but also handles the processing facts in (49).

Nevertheless, there are conceptual as well as empirical arguments which raise serious problems for Phillips’ theory. Conceptually, the problem simply is that there is so far no positive evidence for the claim that English follows an object-first strategy. The only evidence is indirect, drawn from the observation that an effect was absent that would be predicted to occur under standard assumptions. Empirically, already the data in Stowe (1986) are problematic to handle for Phillips’ theory. As shown in Stowe (1986), processing difficulties at the object position do not occur in case the *wh*-phrase must function as the subject, as e.g. in (50). This is quite unexpected if the filler is preferably assigned to the object position and we again would have to explain a surprising absence of a filled-gap effect.

- (50) My brother wanted to know who brought us home to Mom at Christmas

There is even more direct evidence that speaks in favor of a subject preference in filler-gap processing in English. Consider the locally ambiguous sentences in (51) and (52) which were brought to our attention by Paul Gorrell (p.c.).

- (51) a. Which doctor are the patients angry about?
 b. Which doctor is angry about the patients?
- (52) a. Which doctors is the patient angry about?
 b. Which doctors are angry about the patient?

As in the German examples above, sentences are disambiguated by the number features of the finite auxiliary. The versions in (a) are disambiguated towards the OS-reading, the versions in (b) towards the SO-reading. According to native speaker intuitions, there is a clear asymmetry between the (a) and (b) versions. Disambiguation towards the OS-structure seems to lead to slight processing difficulties, with the perceived garden-path effect being somewhat stronger in (52a). This suggests that what is actually preferred is a filler assignment to the subject position. If such intuitions can be confirmed experimentally, these sentences not only provide clear counterevidence to Phillips’ theory of filler-gap processing, they also demonstrate that even in English, revision of a filler assignment to the subject position is not always easy.¹²

¹² Note that Phillips’ theory also wrongly predicts a preference for object gaps in ambiguous *wh*-questions in Italian, an SVO language.

Given the theory developed in this paper, a unified explanation becomes possible for the early processing effects in German and Dutch and in the English examples (51) and (52) on the one hand, and the absence of the filled-gap effect that we started with in this section. What again seems to matter here is the mode of disambiguation that is used in these sentences and with it, the nature of the temporary ungrammaticality that arises during processing. Let us first turn to the question of why no processing effect was observed in sentences like (48). Due to the strict SVO order of English, the NP *Ruth*, which immediately follows the wh-phrase, unambiguously signals that the wh-phrase is not the subject. To integrate the NP *Ruth*, the provisional filler-gap assignment to the subject position has to be withdrawn and the parser must look for an alternative gap site. The alternative that the parser appears to choose is the position of the direct object. However, if the wh-phrase is to function as the direct object, the abstract case feature it is associated with must be changed. The wh-phrase can no longer be associated with abstract nominative case but must carry abstract accusative case instead. Since in English, there are hardly any morphological constraints on the case that a given noun can bear, the case feature can be altered immediately. Consequently, no processing difficulty is expected to occur.

In contrast, the sentences e.g. in (51) and (52) are disambiguated by number features of the finite auxiliary: the finite verb and the putative subject, the wh-phrase, do not agree with respect to number. Unlike case, number features are semantically interpretable. Furthermore, number features find a distinct morphological expression even in a language like English, although to a lesser extent. On the noun, number is marked using the affix *-s*, apart from some irregular forms, to distinguish the plural from the singular. On the finite verb, number is distinctly marked in present tense 3rd person forms, and in the 1st person for the auxiliary *be*. Since number information is always drawn from the lexicon and tied to specific morphological information, the mismatch in number that arises when receiving the finite auxiliary will lead to a salient error. Therefore, processing difficulties are predicted to occur, since the salient ungrammaticality will block attempts at finding an alternative structural assignment, and reanalysis cannot be performed effectively.

5.4 On the Scope of the Mismatch Effect

The final question we want to discuss concerns the scope of the theory of garden-path effects that we have proposed in this paper. Does all variation in garden-path strength that we find in the domain of subject-object ambiguities reduce to the Mismatch Effect? Are there other factors beyond the salience of an ungrammaticality that contribute to the strength of the garden-path? To begin with, let us point out a further finding about subject-object ambiguities which strongly suggests that the Mismatch Effect is only part of a more comprehensive theory of garden-path effects. In an experiment comparing different kinds of filler-gap ambiguities (cf. Bader & Meng, 1996), we have found that ambiguous OS-sentences like (53a) cause stronger garden-path effects than ambiguous OS-sentences like (54a) (the b-sentences are the corresponding ungrammatical sentences).

(53) a. Maria hat gesagt, daß die Lehrerin_{i, nom/acc, sing} die Eltern_{nom/acc, plural} t_i angerufen **haben**_{plural}
Maria has said , that the teacher the parents phoned have
 “*Maria said that the parents have phoned the teacher*”

b. *Maria hat gesagt, daß der Lehrer_{nom, sing} die Eltern_{nom/acc, plural} angerufen **haben**_{plural}
Maria has said , that the teacher the parents phoned have
 “**Maria said that the teacher have phoned the parents*”

(54) a. Maria hat gesagt, daß sie_{i, nom/acc, sing} die Eltern_{nom/acc, plural} t_i angerufen **haben**_{plural}

Maria has said , that her the parents phoned have
 “*Maria said that the parents have phoned her*”

- b.* *Peter hat gesagt, daß er_{nom, sing} die Eltern_{nom/acc, plural} angerufen haben_{plural}*
Peter has said , that he the parents phoned have
 “**Peter said that he have phoned the parents.*”

Grammatically, there are two differences between (53a) and (54a). The first and obvious one is that the first NP in the embedded clause of (53a) is a definite NP whereas the first NP in the embedded clause of (54a) is a pronoun. The second and not so obvious difference is an effect of the first one. Moving a definite NP-object in front of the subject as in (53a) leads to a marked focus-structure whereas moving an object pronoun in front of the subject as in (54a) does not (cf. the discussion in section 2.1). Therefore, (53a) has a marked focus structure whereas (54a) has an unmarked one. With respect to the processing of sentences like (53a) and (54a) we have found that sentences like (53a) elicit stronger garden-path effects than sentences like (54a) (cf. Bader & Meng, 1996). We have interpreted this difference as reflecting the distinction between marked and unmarked focus structure. However, given the Mismatch Effect, there might be an alternative explanation for (53a) eliciting a stronger garden-path effect than (54a), namely an explanation in terms of the temporary ungrammaticalities ensuing during the processing of these sentences.

There is both an empirical and a theoretical reason why the difference between (54a) and (53a) can probably not be explained with reference to the Mismatch Effect. The empirical reason is evident from a look at Figure 7: Percentages of correct judgments for ungrammatical sentences like (54b) are already at such a high level (96.7%) that we cannot expect an improvement for ungrammatical sentences like (53b), or at least not an improvement that is great enough to explain the difference in garden-path strength. A theoretical reason to expect that ungrammatical sentences like (53b) are judged with the same degree of reliability as ungrammatical sentences like (54b) derives from the fact that, due to the unambiguous nominative marking on the first NP, these are ungrammatical sentences with SO-order. As already pointed out, SO-sentences containing a subject pronoun do not differ from SO-sentences containing a definite NP as subject apart from the lexical content of the subject. In particular, they do not differ with respect to their focus structures. Such a difference only shows up for OS-sentences, but this should not have any influence on the processing of SO-sentences. Therefore, there should be no difference between judging ungrammatical SO-sentences like (54b) and (53b) as ungrammatical.

Although this has not yet been tested experimentally, we tentatively conclude that the Mismatch Effect can explain why both (54b) and (53b) elicit relatively strong garden-path effects - both contain the same salient ungrammaticality -, but that it cannot explain why the garden-path effect elicited by (53a) is even stronger than the one elicited by (54a). Given the model shown in (33), the difference between (54a) and (53a) can only reside in differences in the ease of reanalysis, because reanalysis is the only further source of garden-path strength in this model apart from detecting a temporary ungrammaticality. We will therefore uphold our earlier proposal (cf. Bader & Meng, 1996) that (53a) is more difficult to reanalyze than (54a) because (54a) only involves a revision of the syntactic structure whereas (53a), in addition to the same syntactic revision, also involves a revision of the associated focus structure. This clearly shows that the salience of an ungrammaticality is only one factor contributing to the strength of a garden-path effect.

6 Summary

In this paper we have proposed that syntactic ambiguity resolution is not only sensitive to phrase-structure information but also to information about syntactic features and their

morphological spell-out. Evidence for this claim comes from experiments that have investigated the processing of subject-object ambiguities in German. With respect to first-pass parsing, we have shown that there is a general preference for assigning an SO-structure to locally ambiguous sentences. We have explained this preference with resort to the Case Preference Principles proposed by Bader et al. (1996). These principles capture the SO-preference found for base-generated subject-object ambiguities which are problematic for purely phrase-structural accounts. Independent support for the assumption that the parser's decisions are sensitive to information about case derives from the finding of case-attraction phenomena: under the influence of an adjacent dative-marked relative pronoun, a case-ambiguous proper name is preferentially understood as a dative object.

With respect to second-pass parsing, our claim that morphological information contributes to the strength of garden-path effects is based on a new account of garden-path strength in subject-object ambiguities. This account derives from the observation that the strength of garden-path effects in ambiguous sentences is directly related to performance on corresponding ungrammatical sentences: ungrammatical sentences corresponding to difficult garden-path sentences are correctly judged as ungrammatical with higher reliability than ungrammatical sentences corresponding to easy garden-path sentences. This empirical generalization is easily explained by three assumptions. First, the human parsing mechanism is a serial device. This assumption provides a natural link between garden-path phenomena and ungrammaticality detection because it is one of the basic tenets of serial models that an ungrammaticality occurs during the processing of a garden-path sentences, albeit a temporary one.

Our second assumption is an extension of the standard serial model. According to the standard view, the parser will try to reanalyze the current structure in order to find a correct one after it has detected a temporary ungrammaticality. As we have argued above, this view cannot explain the complicated pattern of garden-path strength seen in subject-object ambiguities, even if we acknowledge the division of reanalysis into diagnosis and revision processes as suggested by Fodor and Inoue (1994). We have therefore proposed that a second option apart from reanalysis has to be taken into account: instead of trying to reanalyze the incorrect structure, the parser might simply take this structure at face value and conclude that the sentence is ungrammatical. A sentence for which this option is taken often will result in a strong garden-path effect.

The third assumption has been that the choice between reanalysis and ungrammaticality judgment is a function of the salience of the ungrammaticality that signals that the initial structure is no longer compatible with the input: For salient ungrammaticalities, the option of judging a garden-path sentence as ungrammatical wins over the option of reanalysis whereas it is the reverse for less salient ungrammaticalities. Salient ungrammaticalities will therefore lead to strong garden-path effects whereas less salient ungrammaticalities will only lead to weak garden-path effects, as stated in the Mismatch Effect. This brings us back to the initial finding of a relation between the processing of garden-path sentences and ungrammatical sentences. If the salience of an ungrammaticality is reflected in how good it is detected, then it follows that strong garden-path effects correspond to ungrammatical sentences that are easily perceived whereas weak garden-path sentences correspond to ungrammatical sentences that are difficult to classify as ungrammatical.

Under this account of garden-strength, an important question becomes what determines the salience of an ungrammaticality. For the subject-object ambiguities discussed in this paper, this answer cannot be answered in syntactic terms alone. Instead, a crucial factor seems to be how syntactic features are spelled out in the morphology: ungrammaticalities involving syntactic features that are usually unambiguously signaled by morphological means are more salient than ungrammaticalities involving features that often have an ambiguous morphological realization. A further factor contributing to the salience of an

ungrammaticality is possibly whether the features have semantic content or not. Features with semantic content (e.g. dative case, number features) increase the salience of an ungrammaticality whereas features without semantic content don't.

The evidence for the Mismatch Effect presented in this paper stems from a survey of experiments that investigated subject-object ambiguities with the method of speeded-grammaticality judgments. This raises two questions. First, since the experiments were not designed as a direct test of the claim embodied in the Mismatch Effect, some of the crucial comparisons with respect to ungrammaticality detection and garden-path strength had to be made across different experiments. Given that performance may vary from experiment to experiment - in particular with respect to the magnitude of effects -, comparing percentages of correct answers across different experiments might lead to false conclusions. To remedy this situation, we are currently conducting a new series of experiments where ambiguous sentences exhibiting weak and strong garden-path effects are directly compared to their corresponding ungrammatical sentences (cf. Bader & Meng, in prep). The second question with regard to our empirical evidence concerns the fact that our theory of garden-path strength is based on experiments using the method of speeded grammaticality judgments. Since our theory is not intended to be a theory of speeded-grammaticality judgments but a general theory of garden-path strength, we have to make sure that garden-path strength as measured by the speeded grammaticality judgment task is not an artifact of this particular method. For ambiguities that have been investigated both with the method of speeded grammaticality judgments and with reading times methods, the same pattern of weak and strong garden-path effects has emerged. For example, in two self-paced reading experiments that investigated the base-generated subject-object ambiguity in (20) and the filler-gap subject ambiguity in (18), respectively, filler-gap OS-sentences elicited stronger garden-path effects than base-generated OS-sentences as measured by the reading times differences between ambiguous and unambiguous OS-sentences (cf. Bader, 1994). Similar results have been found for differences within filler-gap ambiguities (cf. Meng, in prep). We therefore conclude that speeded grammaticality judgments and reading times reflect basically the same phenomenon, namely the strength of garden-path effects, and that the Mismatch Effect is a general theory of garden-path strength.¹³

Let us finally point out that the particular relation between garden-path strength and ungrammaticality detection found for subject-object ambiguities favors serial models of the human parsing mechanism over competing models like parallel models (cf. Gibson, 1991) or minimal commitment models (cf. Weinberg, 1993). The reason for this is the natural link between ungrammaticality detection and garden-phenomena provided by serial models. Since serial models assume that a single fully specified analysis is pursued in case of an ambiguity, the processes that lead to a garden-path effect are always triggered by a mismatch between the current syntactic structure and some input item. Hence, the notion of detecting a mismatch - or temporary ungrammaticality - is one of the defining characteristics of serial models of the human parsing mechanism. This is not so for minimal commitment or parallel parsing models. In minimal commitment models, for example, temporary ungrammaticalities only arise during the processing of difficult garden-path sentences, in the same way as in serial models.¹⁴

¹³ This does not necessarily mean that there are no differences between speeded grammaticality judgment experiments and experiments using reading time measures. For example, it has been our experience that for subject-object ambiguities disambiguated at the clause-final verb, finer-grained distinctions in garden-path strength are obtained with speeded-grammaticality judgments than with self-paced reading.

¹⁴ Note that minimal commitment and parallel models often make the assumption that garden-path effects fall into two categories, namely weak and strong garden-path effects, with strong but not weak garden-path effects leading to conscious difficulties. We do not share this assumption but will discuss minimal commitment and parallel models in terms of the binary classification into weak and strong garden-path effects for reasons of simplicity (cf. Bader & Meng, 1996, for discussion).

During the processing of easy garden-path sentences, in contrast, temporary ungrammaticalities do not play any role because underspecified syntactic representations are computed for such sentences. Therefore, at the point of disambiguation no mismatch can arise between the already computed structure but only the need to convert an underspecified representation into a fully specified one. A correlation between easy garden-path sentences and less salient ungrammaticalities is therefore not to be expected.

A parallel model like the one of Gibson (1991) yields a more complicated picture because temporary ungrammaticalities occur both in easy and difficult garden-path sentences. Nevertheless, a correlation between garden-path strength and the salience of ungrammaticalities is not to be expected. In Gibson's model, the basic mechanism to explain differences in garden-path strength is provided by the assumption that alternative syntactic structures are pursued in parallel in the case of easy garden-path sentences but only a single preferred structure is pursued in the case of difficult garden-path sentences. Since both the preferred and the unpreferred structure are computed in parallel for easy garden-path sentences, with the preferred structure ranked higher than the unpreferred one, the unpreferred structure will be available should the preferred one lead to a mismatch with further input material, independent from the particular mismatch that causes the preferred structure to be pruned. For difficult garden-path sentences, only the preferred structure is pursued. If this structure is contradicted, the unpreferred structure must be computed from scratch. Again, the type of mismatch should not matter since the unpreferred structure will be unavailable for any kind of mismatch. This does not mean that there is no way to make a parallel model compatible with the results reported in this paper. However, this would lead to a model of considerable complexity, and it would undermine a central claim of a parallel model like the one in Gibson (1991), namely that the strength of a garden-path effect directly depends on whether alternative structures are computed in parallel or not.

7 References

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