

Syntactic and Morphological Contributions
to Processing Subject-Object Ambiguities

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Running Head: Syntax and Morphology in Parsing

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Abstract

In three experiments using a speeded grammaticality judgement task the question was investigated of what role morphological ambiguity plays for syntactic ambiguity resolution. The stimuli were German verb-final clauses which are locally ambiguous between a subject-object and an object-subject reading and where the ambiguity is not caused by phrase-structural differences but by differing case-assignments. The first and the second experiment show that sentences of this kind exhibit a subject-object preference which must be explained by preferences for certain case-assignments to morphologically ambiguous NPs. The third experiment shows that this subject-before-object preferences turns into an object-before-subject preferences if a case-ambiguous noun is followed by a relative pronoun that is unambiguously marked for dative case. This reversal of the subject-before-object preference is explained by assuming that a case-ambiguous noun can attract a case-feature of an adjacent relative pronoun, a phenomenon similar to attraction-errors found in speech production (Bock & Miller, 1991).

Syntactic and Morphological Contributions to Processing Subject-Object Ambiguities

Introduction

In order to understand a sentence, the listener or reader must quickly compute representations on different levels, ranging from acoustic or visual representations of the input to models of the situation described by the sentence. On most, or perhaps all, levels of representation hearers or readers are faced with the problem of ambiguity: At the point where a piece of input is received, the information available does not suffice to determine a unique analysis. Despite lack of sufficient information, the human sentence comprehension system often seems to select one of the possible analyses immediately. If this analysis is not confirmed by later input, processing difficulties are encountered.

An area of research where ambiguity has played a particularly important role is the area of parsing, that is, the process of assigning syntactic structures to sentences. Models of the human parsing mechanism are typically defined with respect to the way they handle syntactic ambiguity resolution (for a recent review, cf. Mitchell, 1994). According to SERIAL MODELS of the human parsing mechanism (cf. Frazier & Fodor, 1978; Frazier, 1987), the input to the parser is structured into a single ongoing syntactic representation on a word-by-word basis. This initial assignment of a syntactic structure is called first-pass-parsing. In case of a syntactic ambiguity, where a word can be integrated into the ongoing representation in more than one way, one of the possible continuations is selected immediately. If this initial analysis is contradicted by later input material, it has to be reanalysed. Such a reanalysis, which is called second-pass parsing, often leads to garden-path effects, that is, increases in processing load at the point of disambiguation. A well-

known illustration of the garden-path phenomenon is the sentence pair in (1). The reduced-relative reading in (1a) leads to a garden-path effect at the disambiguating main verb (fell) whereas the main-verb reading in (1b) is processed smoothly.

- (1) a. The horse raced past the barn fell down.
b. The horse raced past the barn and fell down.

However, not all local syntactic ambiguities lead to processing difficulties as severe as those in (1a). An example of such an ambiguity is provided in (2). Although there seems to be an initial preference for analysing the ambiguous NP the answer as an object of knew, the reanalysis that becomes necessary if this initial analysis cannot be upheld is quite easy (cf. Frazier & Rayner, 1982; Fodor & Inoue, 1994; Gorrell, 1995).

- (2) a. Peter knew the answer was false.
b. Peter knew the answer immediately.

A central aim of research into syntactic ambiguity resolution has been to identify the particular contributions that various kinds of linguistic information make to first-pass parsing preferences and to reanalysis. In particular, it has been asked what types of information determine which structure is preferred at the point of ambiguity, and what types of information determine whether a reanalysis of the structure initially computed is difficult or not. Information sources proposed to control first-pass parsing decisions include phrase-structure rules (e.g. Frazier, 1987), thematic roles (e.g. Carlson & Tanenhaus, 1988; MacDonald, Pearlmutter, & Seidenberg, 1994), lexical-semantic knowledge (Stowe, 1989; Lipka, 1993) and semantic-pragmatic knowledge (e.g. Altmann, 1988). With respect to the fact that garden-path effects vary in strength, a range of theories has been proposed, both within the framework of serial parsing (cf. Frazier, 1987; Fodor

& Inoue, 1994) and within the competing frameworks of parallel (cf. Gibson, 1991) and minimal commitment parsing (cf. Weinberg, 1993). To account for differences in garden-path strength, most theories rely on syntactic knowledge, but alternatives have also been proposed (cf. Ferreira & Henderson, 1991; Bader, 1994).

This paper will investigate a further piece of linguistic information, namely case, and its role in first- and second-pass parsing. Case has played only a minor role in theories of human parsing, mainly because of its impoverished role in English. Case might provide insights into the nature of the human parsing mechanism due to its double-sided nature. On the one hand, case is a syntactic notion: NPs bearing particular syntactic functions are assigned particular cases (e.g. nominative case for subject, accusative case for direct object). On the other hand, case is also a morphological notion: NPs bearing different cases might have different morphological shapes. In English, only pronouns are morphologically differentiated with respect to case (e.g. I versus me, he versus him, etc.), whereas all other kinds of NPs are undifferentiated. The language investigated in this paper, German, has a much more elaborated morphological case system than English but at the same time a great deal of case ambiguity. These case ambiguities often lead to syntactic ambiguities. A particular kind of syntactic ambiguity caused by case ambiguity are subject-object ambiguities, as exemplified in (3). Since proper names are not inflected for case and since German is a language with a relatively free word order, (3) is globally ambiguous between the reading “Maria loves Fritz” and the reading “Fritz loves Maria”.

(3) Maria liebt Fritz.

Maria loves Fritz

Either “Maria loves Fritz” or “Fritz loves Maria”

Research on subject-object ambiguities in German (cf. Hemforth, 1993, Bader, 1994, and the references given in the next section) has not paid attention to the question as to what role case might play in processing such ambiguities. Instead, subject-object ambiguities have been treated on a par with simple structural ambiguities, in particular filler-gap ambiguities of the kind known from research on English (cf. Fodor, 1989). The aim of this paper is to show that in order to account for the full range of subject-object ambiguities, the processing of case has to be explicitly integrated into models of the human sentence processing mechanism. Due to the two-sided nature of case, this integration has not only consequences for the parser proper, but also for the relation between parsing and lexical-morphological processing. The main aim of this paper is to show that certain garden-path phenomena found for subject-object ambiguities follow naturally from some simple and independently justified assumptions about how case is morphologically and syntactically represented and how these representations are put to use in comprehending sentences.

The main evidence for these claims on the processing of case comes from a series of three speeded grammaticality judgement experiments that investigated a particular subject-object ambiguity that is not amenable to a treatment in terms of filler-gap-processing. Before presenting these experiments, the next section will introduce this ambiguity together with relevant background information on German and the processing of subject-object ambiguities.

Case and the Processing of Subject-Object Ambiguities

In contrast to the SVO-language English, where syntactic functions like subject or object are determined positionally, German is a verb-end-language where syntactic functions are mainly signalled by morphological means. Consider the sentences in (4).¹

- (4) a. Peter hat gesagt, daß [NP-Nom er] [NP-Akk den Onkel] getroffen hat.

Peter has said that he the uncle met has

“Peter said that he met the uncle”

- b. Peter hat gesagt, daß [NP-Akk ihn] [NP-Nom der Onkel] getroffen hat.

Peter has said that him the uncle met has

“Peter said that the uncle met him”

In the embedded clause of (4a), the subject precedes the object, whereas in the embedded clause of (4b) the subject follows the object. This can be determined by looking at the case morphology of the two NPs involved. In (4a), the pronoun er is marked for nominative and den Onkel marked for accusative case. In (4b), ihn is marked for accusative and der Onkel marked for nominative case. Despite the importance of case morphology in signalling syntactic functions, case-ambiguous NPs abound in German. By replacing the masculine NPs in (4b) with feminine ones, the globally ambiguous sentence (5) results.

- (5) Maria hat gesagt, daß [NP-Nom/Akk sie] [NP-Nom/Akk die Tante] getroffen hat.

Maria has said that she/her the aunt met has.

“Maria said that she met the aunt” or “Maria said that the aunt met her”

Feminine NPs in German are not differentiated between nominative and accusative case. In consequence, the syntactic functions of the NPs in (5) are not unambiguously determined and the sentence admits both a reading with the subject preceding the object (Maria said that she met the aunt) and a reading with the object preceding the subject (Maria said that the aunt met her). The global ambiguity disappears if the two case-ambiguous NPs differ in number, as in (6).

- (6) a. Maria hat gesagt, daß [NP-Nom sie] [NP-Akk die Tanten] getroffen hat.

Maria has said that she/her the aunts met has.

“Maria said that she met the aunts”

- b. Maria hat gesagt, daß [NP-Acc sie] [NP-Nom die Tanten] getroffen haben.

Maria has said that she/her the aunts met have.

“Maria said that the aunts met her”

Due to subject-verb-agreement, the sentences in (6) are globally unambiguous.

Nevertheless, they are still locally ambiguous: the parser has no secure basis to decide which of the two NPs is subject and which object until it hits the clause-final finite auxiliary. Therefore, these sentences raise the usual questions for locally ambiguous sentences: is there a preference for one of the two structures, and if so, does disambiguation in favour of the non-preferred structure lead to a measurable garden-path effect?

The ambiguity illustrated in (5) is a filler-gap ambiguity (cf. Fodor, 1978, 1989). In formal accounts of German syntax (cf. Stechow & Sternefeld, 1988; Haider, 1993), it is assumed that for simple transitive verbs like treffen (to meet), the basic word order is subject in front of object. This is the order found in (6a). The reversed word order in (6b), in contrast, is not a basic one, but must be derived by an application of “Move α ”: The object must be moved to a position in front of the subject, leaving a trace behind. This gives rise to a filler-gap ambiguity as shown in (7). Here, the gap t_i is a doubtful gap (Fodor, 1978) because it only appears in the reading with sie as object but not in the reading with sie as subject.

- (7) ... daß sie_(i) die Tante (t_i) getroffen hat.

According to the Minimal Chain Principle proposed by de Vincenci (1991) (cf. (8)), the parser will analyse the ambiguous pronoun sie in (7) as subject, because with this analysis it is not necessary to postulate a trace, whereas a trace would be necessary if sie is analysed as object. If the sentence then ends in the plural auxiliary haben, the initial structure has to be revised by creating the chain shown in (7). This revision should show up in processing difficulties for sentences disambiguated by haben.

(8) Minimal Chain Principle (MCP)

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

This prediction has been confirmed both in a self-paced reading study (Bader, 1994) and in a study using the method of speeded grammaticality judgements (Bader, 1996b). The former study found prolonged reading times for the disambiguating clause-final auxiliary in sentences like (6b). In the latter study, ambiguous object-subject sentences like (6b) were judged as grammatical at only 31%, whereas unambiguous object-subject sentences like (4b) were judged as grammatical at 83%, which is not different from either ambiguous (cf. (6a)) or unambiguous subject-object sentences (cf. (4a)). This is clear evidence of a preference for taking the initial NP as subject and the second NP as object. If this preferred structure is contradicted by the sentence-final auxiliary haben in (6b), reanalysis becomes necessary, resulting in a strong garden-path effect. Similar results have been found for other kinds of filler-gap ambiguities in German (e.g. Bader & Meng, 1996; Hemforth, 1993; Mecklinger, Schriefers, Steinhauer, & Friederici, 1995; Schriefers, Friederici, & Kühn, 1995)

By explaining the subject-before-object preference exhibited by sentences like (6) in terms of a principle like the MCP, one gives no role to the fact that a sentence pair like (6)

exhibits not only a filler-gap ambiguity but at the same time a case-ambiguity. While case ambiguity per se might not be crucial to the processing of filler-gap ambiguities, there is a further class of subject-object ambiguities for which case might be more important. This kind of subject-object ambiguity is illustrated in (9). In the active clause (9a), the NP Uli is the subject and the NP eine Postkarte the accusative object. In the corresponding passive clause (9b), Uli is the dative object whereas eine Postkarte is the subject.

(9) a. Jemand hat behauptet, daß Uli eine Postkarte geschickt hat.

Someone has claimed that Uli a postcard sent has

“Someone claimed that Uli sent a postcard”

b. Jemand hat behauptet, daß Uli eine Postkarte geschickt wurde.

Someone has claimed that Uli a postcard sent was

“Someone claimed that a postcard was sent to Uli”

The local ambiguity of the two sentences in (9) is caused by the fact that the two NPs involved, namely Uli and eine Postkarte, are morphologically ambiguous with respect to their case. By using unambiguously case-marked NPs instead, unambiguous sentences can be created. This is shown in (10).

(10) a. Uli hat behauptet, daß sie einen Brief geschickt hat.

Uli has claimed that she a letter sent has

“Uli claimed that he sent a letter.”

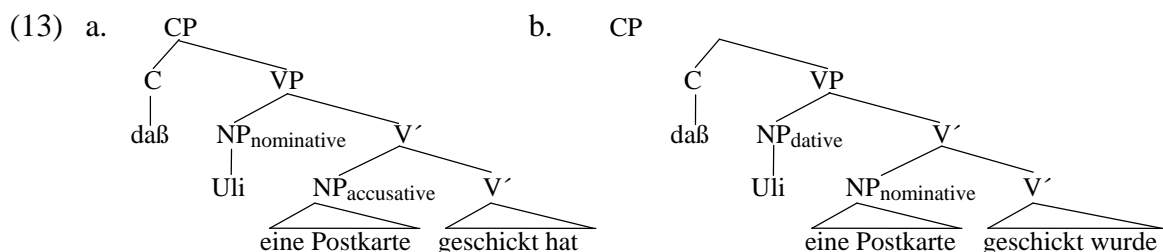
b. Uli hat behauptet, daß ihr ein Brief geschickt wurde.

Uli has claimed that her a letter sent was

“Uli claimed that a letter was sent to him”

same position as the object of the corresponding active clause. This means that active and passive clauses differ in the serialisation of case but not in the serialisation of thematic roles. Whereas the position of the nominative marked NP changes in active and passive clauses, the position of the theme does not change. It is the final argument both in active and in passive clauses.

The syntactic representations for the two sentences in (9) are shown in (13). These representations, which are taken from Haider (1993) (cf. Reuland & Kosmeijer (1993) for a related proposal), do not contain an Inflectional Phrase (IP) and thereby do not provide a privileged position for the subject. Instead, the Complementizer Phrase (CP) directly dominates the Verb Phrase (VP) which contains both the subject and the object. One reason for this kind of representation lies in the fact just outlined, namely that in passive sentences the subject normally follows the object and is not moved to a clause-initial position as in English, indicating that there is no single subject-position.



As can be seen by comparing (13a) to (13b), the ambiguity of the sentences in (9) does not involve a filler-gap ambiguity, and, indeed, no phrase-structural ambiguity whatsoever. The only difference between (13a) and (13b) lies in the distribution of case features. From this it follows that a structure-based principle like the MCP does not apply to sentences like (9a) or (9b). That is, if the resolution of syntactic ambiguities were completely determined by phrase-structural differences between alternative syntactic structures, neither of the two readings possible for the ambiguous regions of the sentences in (9) should be preferred to the other. Accordingly, neither disambiguation should lead to

a garden-path effect. However, if syntactic ambiguity resolution is not only driven by phrase-structural information but also by information about case, a parsing difference between (9a) and (9b) could be expected. The experiments reported later address these predictions.

A theory of syntactic ambiguity resolution that integrates the processing of case information into a serial model of the human parsing mechanism has been proposed by Bader, Bayer, Hopf and Meng (1996). The empirical evidence for this theory comes from the fact that not only subject-object ambiguities can lead to garden-path effects in German but also object-object ambiguities. Consider a sentence pair like that in (14).

(14) a. Menschen, die in Not sind, sollte man unterstützen.

persons who in distress are should one support

“One should support persons who are in distress.”

b. Menschen, die in Not sind, sollte man helfen.

persons who in distress are should one help

“One should help persons who are in distress.”

(14) displays a local ambiguity between accusative and dative object. In (14a), the initial NP Menschen, die in Not sind (persons who are in distress) is an accusative object, whereas it is a dative object in (14b). This difference, which cannot be observed directly in (14), because the noun Menschen is morphologically ambiguous between accusative and dative case, will show up if a determiner is inserted in front of Menschen. For (14a), the determiner die would be appropriate, whereas den would be the correct form for (14b). It is an idiosyncratic property of verbs that have only a single object whether they assign accusative or dative case to their objects. Both with a sentence rating study and an experiment measuring event related brain potentials (ERPs), Bader et al. (1996) could

show that a garden-path effect is elicited at the clause-final verb in (14b), where the initial case-ambiguous NP receives dative case. This indicates that the human parsing mechanism prefers to assign accusative case to an ambiguous object, and that it causes some difficulty to change this decision on encountering a verb assigning dative case to its object instead of accusative case.

The preference for accusative to dative case during first-pass parsing and the concomitant difficulty of withdrawing the preferred case-assignment can be explained by certain properties of the German case system. Both syntactically and morphologically, nominative and accusative case pattern together while dative is distinguished. Syntactically, nominative and accusative case are so-called STRUCTURAL cases whereas dative case is a LEXICAL case. The basis for this classification lies in the fact that argument-alternations like the active-passive alternation affects nominative and accusative NPs but not dative NPs. This is illustrated in (15). (15a) shows that an accusative object becomes a subject and thus nominative-marked under passivization. In contrast, if a verb with a dative object is passivized, as in (15b), the grammatical status of the dative object does not change. There, the resulting passive clause still has a dative object and no subject at all, as is clear by the fact that the dative-marked NP does not agree with the passive verb.

- (15) a. Sie_{nom} unterstützt viele_{acc}. Viele_{nom} werden von ihr unterstützt.
 She supports many Many are by her supported
 “She supports many people.” “Many people are supported by her.”
- b. Sie_{nom} hilft vielen_{dat} Vielen_{dat} wird von ihr geholfen.
 She helps many Many is by her helped.
 “She helps many people.” “Many people are helped by her.”

Morphologically, the two structural cases nominative and accusative often share the same form, whereas dative is signalled unambiguously in most cases. Table 1 shows the inflection paradigm for the definite determiner in German. German has four cases: nominative, accusative, dative, and genitive case. Since genitive case is mainly used for modifiers and arguments of nouns and plays only a marginal role as a case for verbal arguments, it will not be considered any further.

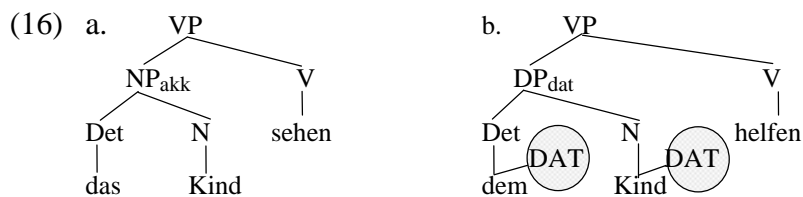
Insert Table 1 about here

As can be seen from Table 1, nominative and accusative case are only distinguished for masculine singular determiners. For feminine and neuter singular and for plural determiners, the nominative form is identical to the accusative form. Dative determiners, on the other hand, are always distinguished from both nominative and accusative determiners, and indeed have a unique morphological shape with the exception of the feminine der which is either dative or genitive. What holds for definite determiners also holds for most other kinds of determiners, like indefinite determiners, quantifiers and interrogative determiners. From this it follows that ambiguities involving dative case can only arise from determinerless NPs, like proper names or bare NPs as in (14).

The case pattern of German, as illustrated in Table 1, may be summarised as follows: First, structural case (nominative and accusative) is the default case for determiners. Second, a determiner can express dative case only if it is explicitly marked for dative case by morphological means. This generalisation can be represented by assuming that there are distinct features for abstract and morphological case and that every lexical item realising abstract dative case must bear a morphological dative feature, whereas abstract structural case can be realised by lexical items unmarked for morphological case. These

assumptions will give rise to representations like those in (16). (Abstract case is indicated by small letters, morphological case by capitalisation and additionally by circling.)

Although these representations were first proposed on psycholinguistic grounds (cf. Bader et al., 1996), they meet with certain ideas in current morphological theory, namely that systematic morphological ambiguity (syncretism) should be captured by the notion of underspecification (e.g. Halle & Marantz, 1993; Wunderlich & Fabri, 1995).



The assumptions that have been made so far about the syntactic and morphological representation of case must be supplemented by assumptions about the lexical and syntactic processing of case. The assumptions about the lexical processing of case directly derive from the syntactic-morphological representation just introduced. According to this representation, for a case-ambiguous noun like Uli, lexical access must make available the information that this noun can be either underspecified for morphological case, thereby realising structural case, or morphologically specified for dative case. I therefore assume that the lexical entry for a proper name provides two morphological forms that can be inserted into the phrase-marker: a morphologically underspecified one for structural case and a second one specified for dative case. According to this assumption, proper names are regular insofar as they distinguish a form for structural case from a form for dative case but exceptional in that their dative form has no overt morphological reflex.

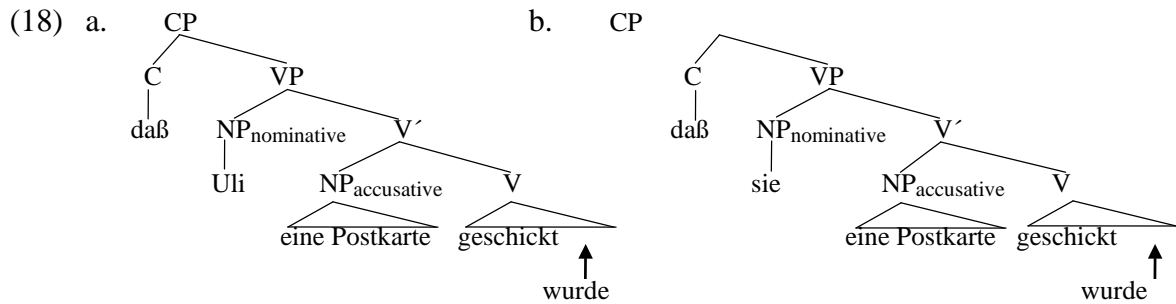
With respect to how the human parsing mechanism copes with case ambiguous NPs, Bader et al. (1996) propose that the parser is guided by the case preference principles in (17).

(17) Case Preference Principles

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

For a serial parser that computes fully specified syntactic structures, these principles are to be expected under the natural assumption that the parser's decisions are guided by the desire to entertain hypotheses that presuppose as few as possible. (17a) can be seen as a consequence of the fact that dative case needs a specific lexical licenser whereas the two structural cases are default cases. (17b) follows from the generalisation that a sentence containing an accusative object also contains a subject, which bears nominative case, but not vice versa. Therefore, it is safer to assign nominative case to a case-ambiguous NP than to assign dative case.²

Taking together the grammatical assumptions about the representation of case and the assumptions about the processing of case, the processing of locally ambiguous sentences like those in (9) will proceed as follows. The lexical system will make available to the parser two lexical entries for the word Uli, an underspecified one for structural case and a further one for dative case. Since this is the first NP of its clause, it will be assigned nominative case in accordance with the case preference principles in (17). This means that the lexical entry for Uli that is underspecified for morphological case will be inserted into the ongoing phrase-marker. After having processed the second NP and the following participle, the parser will have computed the structure in (18a). Since only one NP within a sentence can bear nominative case, the second NP in (18a) has been assigned abstract accusative case.



The corresponding sentence with the pronoun sie, which, in contrast to the proper name Uli, cannot bear dative case, is shown in (18b). Note that (18a) and (18b) are identical up to the lexical content of the subject NP. When processing the clause final auxiliary, this has an important consequence: The insertion of the passive auxiliary wurde leads to ill-formed structures both in (18a) and in (18b). The fact that this ill-formedness can be remedied for (18a) but not for (18b) cannot be directly read off of the corresponding phrase-markers. The phrase-markers in (18) only contain the information that the respective subjects are compatible with structural case. The information that Uli, but not sie, can also realise dative case is not to be found in these phrase-markers. Instead, in order to obtain this piece of information it is necessary to go back to the lexicon and check whether these words have a lexical entry specified for dative case. Since a proper name like Uli is case-ambiguous between structural case and dative case, lexical rechecking will succeed for Uli and retrieve the dative entry for this name. Hence, the case-features in the phrase-marker (18a) can be replaced by the correct ones, namely dative followed by nominative case, leading to a successful parse. Since reaccessing the mental lexicon will be associated with some costs, ambiguous passive sentences are predicted to be more difficult to comprehend than unambiguous passive sentences like (10b). (cf. Duffy, Morris and Rayner (1988) and Frazier and Rayner (1990) for evidence for processing difficulties caused by lexical ambiguity). In contrast to the proper name Uli, the pronoun sie in (18b) cannot bear dative case. Therefore, no lexical entry for dative

is available and the completion of the phrase-marker (18b) by the auxiliary wurde will lead to an ungrammatical sentence.

A precursor to our assumption that what makes processing of ambiguous passive clauses hard is the need to reaccess the mental lexicon can be found in Ferreira and Henderson (1991). Their proposal is based on the finding that for garden-path sentences of the kind shown in (19) the strength of the garden-path effect increases with increasing distance between the verb of the fronted while-clause (reading) and the head noun of the following ambiguous NP (book).

(19) While Mary was reading the book (that was long and boring) was stolen.

Ferreira and Henderson explain this finding by assuming first that the lexical system makes available to the parser all possible thematic frames for a verb. For the verb to read in (19), there would be at least two thematic frames, one with an agent role and a theme role and a second one with an agent role only. For the preferred reading of (19), the two-argument frame is needed. According to a second assumption of Ferreira and Henderson, an argument frame which is not initially selected will decay with time. This concerns the one-argument frame of to read. On disambiguation, the one-argument frame will have to be reactivated. Since this will be the more expensive the longer the decay has lasted, a late disambiguation will be more difficult to process than an immediate one. This explanation is basically the same as the one proposed for the processing of ambiguous passive clauses, with two exceptions. First, the lexical ambiguity that plays a crucial role in the two explanations concerns the thematic frames of a verb in (19) whereas it concerns the case features of a noun in our passive clauses. Second, Ferreira and Henderson invoke the concept of lexical reactivation whereas we have spoken of lexical reaccess. However, these two notions seem to be two related ways of implementing the same idea, namely that

certain features of an ambiguous lexical item are not integrated within the ongoing syntactic representation and are therefore not available cost-free at the point of disambiguation.

The predictions derived from the theory of Bader et al. (1996) can be contrasted to the theory of Babyonyshev and Gibson (1995), which is one of the rare theories that makes explicit claims about the processing of case in general and dative case in particular. Babyonyshev and Gibson (1995) incorporate the notion of case into the parallel parsing model proposed by Gibson (1991). According to Gibson (1991), the parser computes all possible analyses when it encounters a syntactic ambiguity in the input string. These analyses are pursued in parallel as long as they do not differ in processing load or do differ in processing load only by a small amount. When the processing costs of two parallel structures exceed a certain amount, the more expensive structure is discarded from further consideration and only the cheaper one is pursued further. The main determinant for processing load derives from the Theta Criterion of the Principles- and Parameters-Theory, which, simplifying somewhat, says that every argument in a sentence must carry a thematic role and that all thematic roles of a verb must be assigned to an argument (cf. Riemsdijk & Williams, 1986). In the theory of Gibson (1991), an NP that has been created by the parser but that does not yet have been assigned a thematic role increases the processing load of the structure that contains this NP by one processing load unit (PLU). The threshold at which one of two parallel structures is removed from consideration is assumed to be two PLUs.

Babyonyshev and Gibson (1995) (B&G henceforth) refine the theory of Gibson (1991) by taking case into account for defining processing load. The empirical motivation for B&G comes from an investigation of processing overload caused by centre-embedding in English and Japanese. For processing overload phenomena, the same definitions for

processing load units apply as for the processing of ambiguous sentences (cf. Gibson, 1991). The particular proposal B&G make is that NPs bearing structural case contribute to processing load but NPs bearing lexical case do not. Applying this refinement of the parallel theory of Gibson (1991) to the ambiguity considered in this paper gives the following result. For an ambiguous sentence beginning like daß Uli eine Postkarte (that Uli a postcard), two structures will be computed in parallel, one with Uli bearing nominative and eine Postkarte bearing accusative case and a second one with Uli bearing dative and eine Postkarte bearing nominative case.³ In the first structure, there will be two structurally cased NPs without a theta role and the associated processing load will therefore be two PLUs. In the second structure there will also be two NPs without thematic role but one of these NPs bears dative case and therefore does not contribute to processing load. The net result is that the active, SO-structure will be associated with two PLUs whereas the passive structure will only have a processing load of one PLU. This gives an advantage of one PLU in favour of the passive structure. A difference of one PLU is below the threshold for dropping the more expensive structure but it will have the effect that the more expensive structure should be ranked lower than the less expensive one. This ranking should result in an experimentally detectable processing difficulty in case the sentence is disambiguated in favour of the more expensive structure (cf. Gibson, Hickok, and Schütze, 1994). Since the active structure is the more expensive structure of the two structures considered here, disambiguation by an active verb should lead to processing difficulties whereas disambiguation by a passive auxiliary should not.

To summarise the discussion so far, according to the assumptions about the representation and processing of case taken over from Bader et al. (1996), ambiguous sentences of the kind shown in (9) are predicted to exhibit a preference in favour of the subject-before-object structure. This preference should have two consequences. First,

there should be no processing differences between ambiguous and unambiguous active clauses of type (9a) and (10a), respectively. Second, ambiguous passive clauses of type (9b) should elicit a garden-path effect because of the extra costs associated with checking whether the case-ambiguous proper name can realise dative case. This garden-path effect should manifest itself in a poorer performance on ambiguous passive sentences like (9b) compared to unambiguous passive sentences like (10b). The theory of Babyonyshev and Gibson (1995) leads to opposite predictions. Since dative-marked NPs do not contribute to processing load in this theory, the object-before-subject structure should be preferred to the subject-before-object structure for ambiguous sentences like (9). This in turn should result in a garden-path effect for ambiguous active sentences like (9a). Experiment 1 tested the competing predictions of Bader et al. (1996) and Babyonyshev and Gibson (1995).

Experiment 1

Experiment 1 used the method of speeded grammaticality judgements in order to test the predictions derived for locally ambiguous sentences like those in (9) from the theories proposed in Bader et al. (1996) and Babyonyshev and Gibson (1995).

Method

Subjects. A group of 30 students of the University of Jena participated in Experiment 1. Subjects received either course credit or 5 DM for participating. All subjects were native speakers of German and naive with respect to the purpose of the experiment.

Materials. 30 sentences were constructed. Each sentence appeared in six versions, according to the experimental variables sentence type (active versus passive) and ambiguity (ambiguous versus unambiguous versus ungrammatical). Table 2 shows a

complete sample item.⁴ The first two versions of each set were ambiguous sentences like those shown in (9). Each sentence consisted of a main clause followed by an embedded verb-final clause. The ambiguity of interest was contained in the embedded clause. Each embedded clause contained a proper name followed by an NP that was always inanimate except in one sentence and ended in a ditransitive verb either followed by the perfect auxiliary hat (active sentences) or the passive auxiliary wurde (passive sentences). In addition, an appropriate adverbial phrase was inserted into each embedded clause, either between the two NPs or between the last NP and the main verb. This adverbial served two purposes. First, to make the sentences sound more natural, and second, to lengthen the region of ambiguity in order to increase the chance of detecting a slight garden-path effect. The main clauses that preceded the ambiguous embedded clauses were constructed to be semantically neutral with respect to the active or passive variant of each sentence. This was achieved by mainly using verbs of saying or believing within the main clauses.

Insert Table 2 about here

The next four versions of each sentence were derived from the two ambiguous versions in the following way. First, unambiguous grammatical sentences were created by replacing the proper name in the embedded clause with a personal pronoun and by inserting the proper name into the main clause, with appropriate changes to the main clause (e.g. changing Someone told that Maria... to Maria told that she...). Feminine proper names were replaced by sie for active sentences and by ihr for passive sentences. Masculine proper names were replaced by er for active sentences and by ihm for passive sentences. Note that the feminine pronoun sie is not completely unambiguous. It cannot realise dative case but is compatible with both nominative and accusative case. When

constructing the sentences for Experiment 1 this remaining ambiguity was not eliminated because of the strong evidence that an initial pronoun that is ambiguous between nominative and accusative case is preferentially analysed as a subject (cf. Bader, 1994, 1996b). Therefore, a sentence starting with daß sie will be processed in the same way as a sentence starting with daß er, and the ambiguity of sie should not affect the present experiment. Whether this assumption is justified will be discussed further after the presentation of the results for Experiment 1.

The last two versions of each sentence were unambiguous ungrammatical sentences that were derived from unambiguous grammatical sentences simply by switching the pronoun. The result of this procedure was that active sentences contained an illicit dative pronoun (ihr or ihm), and the passive sentences an illicit nominative pronoun (sie or er).

The experimental sentences were divided into six lists so that each list contained an equal number of sentences in each condition but no more than one version of any sentence appeared in a list. Each list of experimental sentences was embedded in a list of 92 filler sentences. These filler sentences were of a variety of sentence types. Some of the filler sentences came from experiments unrelated to the present experiment. The order of presentation of experimental sentences was randomised individually for each subject.

Procedure. The current experiment as well as the following two experiments were run using the DMASTR software developed at Monash University and at the University of Arizona by K.I.Forster and J.C.Forster. A trial began with the presentation of the words “Leerzeichentaste für nächsten Satz” (“Spacebar for next sentence”). After pressing the space-bar, a fixation point appeared in the centre of the screen for 1050 ms. Thereafter, the words of a sentence were presented one after the other in the centre of the screen. The presentation time for each word was 224 ms plus an additional 14ms for each character of

the word. There was no interstimulus interval between words. Immediately after the last word, three question marks appeared on the screen, indicating to subjects that they now had to judge the grammaticality of the sentence. Subjects had to press the left shift key if they judged a sentence to be ungrammatical and the right shift key if they judged a sentence to be grammatical. Decisions and decision times were automatically recorded. If a subject did not make a response within 2000 ms, the words “zu langsam” (“too slow”) appeared on the screen and the trial was finished. This served to encourage subjects to respond quickly. The notion of grammaticality was explained to subjects by examples. Each subject received between 10 and 20 practice items before the experimental session started.

Results

Figure 1 shows the percentages of correct responses. In this and all following experiments, percentages of correct responses were analysed with both subjects (F1) and items (F2) as random effects.⁵

Insert Figure 1 about here

The factor sentence type was not significant (both F 's < 1), nor was the factor ambiguity ($F1(2,58) < 1$; $F2(2,58) = 1.61$, $p > .02$). However, the interaction between sentence type and ambiguity was significant by subjects and by items ($F1(2,58) = 7.26$, $p < .01$; $F2(2,58) = 5.61$, $p < .01$). Planned comparisons⁶ were conducted to test the hypothesis that ambiguous OS-sentences but not ambiguous active sentences elicit a garden-path effect. The difference between ambiguous and unambiguous active sentences (80% vs. 78%) was not significant (both t 's < 1), nor was the difference between ambiguous and unambiguous OS-sentences (81,3% vs. 87,3%) ($t1(58) = 1.09$, $t2(58) < 1$).

The percentages of correct responses also showed two unanticipated results that were tested by post-hoc Scheffé tests. First, unambiguous active sentences received less grammatical responses than unambiguous OS-sentences (78% vs. 87.3%). However, this difference did not reach significance. Second, ungrammatical active sentences received more correct responses than ungrammatical passive sentences (93.3% vs. 78%). This difference was significant by subjects and by items ($t_1(29) = 2.97, p < .05, t_2(29) = 2.38, p < .05$).

Before analysis of response times, all response times more than 2.5 standard deviations (SD) away from an individual subject's mean were replaced with the cut-off value for the subject (the value equal to 2.5 SD above or below the mean). Less than 5% of the response times were replaced by this criterion. Figure 2 shows the response times for correct responses. Response times were analysed with both subjects (F_1) and items (F_2) as random effects.

Insert Figure 2 about here

The factor sentence type was neither significant by subjects ($F_1(1,29) = 1.04, p > .3$) nor by items ($F_2(1,29) < 1$). The factor ambiguity was significant in both analyses ($F_1(2,58) = 8.79, p < .01; F_2(2,58) = 9.33, p < .01$). The same was true for the sentence type by ambiguity interaction ($F_1(2,58) = 8.83, p < .01, F_2(2,58) = 5.49, p < .01$). Planned comparisons revealed that the difference between ambiguous and unambiguous active sentences (737 ms vs. 743 ms) was not significant (both t_1 and $t_2 < 1$) whereas the difference between ambiguous and unambiguous OS-sentences (851 ms vs. 620 ms) was highly significant ($t_1(58) = 4.06, p < .01; t_2(58) = 4.82, p < .01$).

The reaction time data showed the same two unanticipated results as the percentages of grammatical responses. First, unambiguous active sentences took more time to be judged as grammatical than unambiguous passive sentences (743 ms vs. 620 ms). A post-hoc Scheffé test showed this difference to be significant ($t_1(29) = 3.37$, $p < .01$; $t_2(29) = 2.67$, $p < .05$). Second, ungrammatical passive sentences took more time to be judged ungrammatical than ungrammatical active sentences (885 ms vs. 791 ms). However, this difference was neither significant by subjects nor by items.

Discussion

The results that were obtained in Experiment 1 for a particular subject-object-ambiguities not involving a filler-gap ambiguity confirm the predictions of Bader et al. (1996) and disconfirm the predictions of Babyonyshev and Gibson (1995). As expected under the former theory, which takes both syntactic and morphological information into account, disambiguation of ambiguous sentences in favour of the object-subject reading led to a measurable garden-path effect, indicating that the alternative subject-before-object reading is preferred on initial-pass parsing. Such a pattern of results is not compatible with the theory of Babyonyshev and Gibson (1995) because this theory predicts a garden-path effect for active sentences which is contrary to the results found in Experiment 1.

The garden-path effect found for ambiguous passive clauses had a reliable effect on reaction time data but not on percentages of sentences judged to be grammatical. This is in contrast to a typical filler-gap ambiguity like that in (6). Filler-gap sentences like (6b) lead to a decrement of 52% and an increase of 348 ms in reaction times in the experiment reported in Bader (1996b), compared to 9% and 231 ms for ambiguous passive sentences. This closely matches intuitive judgements about sentences of these kinds. When asking people for their intuitions, no conscious garden-path effects are reported for passive

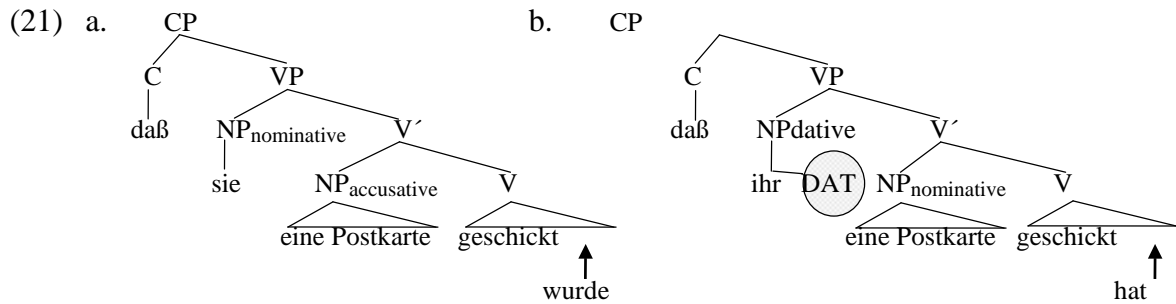
sentences like (9b), whereas sentences like (6), where a gap is initially overlooked, often elicit reports of conscious garden-pathing. This difference lends some credence to the syntactic assumptions outlined above because the distinction between easy and difficult reanalysis is reflected in a syntactic distinction that leads to a simple correlation between syntactic revisions and ease of reanalysis. Under the syntactic assumptions outlined above, switching to an object-before-subject order is difficult if reanalysis involves the insertion of a chain but easy if it does not. Furthermore, since switching to the object-subject order in ambiguous passive clauses does not involve alterations to the phrase-structural representation, but reaccessing the mental lexicon in order to get the required dative entry, we may conclude that such a reaccess is easier than a revision of the phrase-marker by inserting a chain (for a more thorough discussion of the relation between these two kinds of subject-object ambiguities, cf. Meng & Bader, 1997).

Besides evidence for a subject-object preference, Experiment 1 has delivered two unexpected results. First, regardless of the factor ambiguity, active sentences needed more time to be judged as grammatical and were judged as grammatical less often than unambiguous passive clauses. A first explanation might be that this difference is caused by the ambiguity of the pronoun sie. As said in the description of the sentence material, two thirds of the unambiguous control sentences contained the feminine pronoun sie, which cannot bear dative case but is ambiguous between nominative and accusative case. However, this explanation is rather improbable because there is strong independent evidence that sie in clause initial position is preferentially understood as subject. This evidence comes from experiments testing sentences like (6). For sentences of this kind, a strong subject-before-object preference has been found in several experiments (cf. Bader, 1994, 1996b). A more probable reason for the disadvantage of active sentences in comparison to unambiguous passive sentences lies in a certain syntactic difference

between active and passive sentences of the sort used in Experiment 1. All verbs in the sentences of Experiment 1 contained ditransitive verbs with an optional dative object. In the active sentences, this object was simply omitted. Although this omission was always grammatically licit, in some cases it might nevertheless have resulted in reduced acceptability. In passive sentences, in contrast, the former subject was not simply omitted but suppressed by passivization which leads generally to both grammatical and completely acceptable sentences. This difference between active and passive clauses, which also exists in English, as shown by the examples in (20), will be clarified in Experiment 2 by using only the masculine subject pronoun er in unambiguous active sentences, thus making these sentences completely unambiguous.

- (20) a. Peter transferred some money.
b. Some money was transferred to Peter.

A second unexpected result was that the ungrammaticality of active sentences containing a dative pronoun instead of a nominative one was easier to detect than the ungrammaticality of passive sentences containing a nominative pronoun instead of a dative one, as shown by the decrease in the percentages of correct answers for ungrammatical passive sentences. Although this effect was not anticipated, it is easily explained under the grammatical representations assumed for the sentences investigated in Experiment 1. The syntactic representations of the two ungrammatical sentences, excluding the auxiliary, are shown in (21) (Structure (21a) is identical to (18b) above).



When discussing (18b), it was hypothesised that encountering the passive auxiliary wurde after having constructed the tree in (21a) will trigger a process of lexical reaccess in order to check the morphological case of sie. This is necessary because the phrase-marker in (21a) does not encode information about the availability of an alternative dative entry for sie. Such a rechecking does probably not occur in (21b) after insertion of the perfect auxiliary hat. Although the positive morphological marking on ihr is also no guarantee that there is no alternative structural case entry available for ihr, a clear asymmetry exists between sie and ihr with respect to the probability of finding an alternative entry. Since structural case is preferred in situations of ambiguity, from the fact that ihr is marked for dative case in (21b) the parser can conclude that this pronoun is unambiguously marked so. Otherwise, the case-preference principles in (17) would not have inserted the dative form but the one for structural case. From encountering the unmarked pronoun sie, in contrast, nothing can be concluded about the existence of an alternative lexical entry because the unmarked entry will be selected by the case preference principles independent from the existence of an alternative dative entry.

The poorer performance on sentences corresponding to structure (21a) than on sentences corresponding to structure (21b) can be related to the presence or absence of lexical reaccess in the following way. For sentences where no reaccess occurs, the parser can signal the occurrence of an ungrammaticality to higher-level decision processes immediately after the detection of a case mismatch. For sentences that trigger reaccess,

signalling that an ungrammaticality has occurred can only happen after reaccess has been completed. Therefore, it will take more time to recognise the sentences as ungrammatical. Furthermore, under the time pressure induced by a speeded-grammaticality-judgements experiment, it is to be expected that the decision to classify a sentence as grammatical or not will sometimes be made ahead of the arrival of sufficient information by simply guessing. Since guessing will be incorrect in a certain percentages of times, more errors will be made than in sentences where no reaccess is necessary.

Experiment 2

Experiment 1 has shown that ambiguous passive sentences that exhibit an object-before-subject order lead to a measurable garden-path effect. This garden-path effect was explained in terms of case: According to the case preference principles in (17), a sequence of two case-ambiguous NPs will preferentially be understood as exhibiting the order subject before object. If this preferred order must be withdrawn due to a passive participle, lexical reaccess will be triggered in order to seek a dative entry for the clause-initial proper name. Since reaccess is not necessary in unambiguous passive sentences, ambiguous passive sentences are associated with an increased processing load. Before this explanation can be accepted, it is necessary to exclude alternative explanations. An alternative to a case-based explanation might be given in terms of thematic roles. Thematic roles have attracted a great deal of attention in the recent literature on syntactic ambiguity resolution. A first question has been whether or not thematic roles influence the initial analysis of a syntactically ambiguous sentence (cf. e.g. Carlson & Tanenhaus, 1988; Tanenhaus & Carlson, 1989; Stowe, 1989; Clifton, 1995; Lipka, 1993). A second question concerns the role that thematic roles might play in processes of reanalysis (cf. Ferreira & Henderson, 1991; Clifton, 1995; Inoue & Fodor, 1995).

A third kind of question pertaining to thematic roles mainly concerns verb-final languages. In a verb-final language like German, arguments are processed before the verb is encountered. Therefore, the processing of arguments cannot be guided by verb-particular information. Instead, thematic roles can be assigned before encountering the clause final verb only on a default basis. Carlson and Tanenhaus (1988) and MacDonald, Pearlmutter, and Seidenberg (1994) have proposed that the parser tentatively assigns default thematic roles to arguments in verb-final languages. This would open the possibility that the results found in Experiment 1 could be explained in an alternative way, namely by the assumption that it is not the need to alter an initial case assignment but the need to alter an initial thematic role assignment that is responsible for the garden-path effects found in locally ambiguous passive clauses. However, neither Carlson and Tanenhaus (1988) nor MacDonald et. al (1994) are explicit about what happens if the initial thematic role assignment turns out to be wrong. One reason for this inexplicitness might be the lack of relevant empirical evidence. Such empirical evidence can be obtained by investigating the question as to whether the garden-path effect found in Experiment 1 is caused by withdrawing an initial case assignment or withdrawing an initial thematic role assignment.

In order to answer this question, we can take advantage of the fact that an ambiguous sentence fragment like that in (22) cannot only continue with the perfect auxiliary hat and the passive auxiliary wurde but also with the quasi-auxiliary bekam. All three possible continuations are shown in (23).

- (22) ... daß Fritz eine Postkarte geschickt ...
... that Fritz a postcard sent

(23) a. ... daß Fritz eine Postkarte geschickt HAT (has).

“that Fritz has sent a postcard”

c. ... daß Fritz eine Postkarte geschickt BEKAM (got)

lit. “that Fritz got a postcard sent” / “that Fritz was sent a postcard”

b. ... daß Fritz eine Postkarte geschickt WURDE (was)

“that a postcard was sent to Fritz”

The distribution of case and thematic roles within the sentences in (23) is shown in

(24).

(24) a. ... daß

nom acc

 / AGENT THEME geschickt HAT.

b. ... daß

nom acc

 /

RECIPIENT THEME

 geschickt BEKAM.

c. ... daß dat nom /

RECIPIENT THEME

 geschickt WURDE.

According to Carlson and Tanenhaus (1988) and MacDonald et. al (1994), in a sentence starting with daß Fritz eine Postkarte, the initial, animate NP will be assigned the agent role and the second, inanimate NP the theme role. The same will hold if the proper name is replaced by an animate nominative-marked pronoun like er. Only in case the sentence starts with a dative marked pronoun like ihm will the agent role not be assigned. Instead, the recipient role will be assigned because dative marked NPs are never agents but typically recipients. With these assumptions about the assignment of thematic roles before the verb is encountered, the results found for Experiment 1 might be explained as follows. Sentences ending in hat (either ambiguous or not) do not need any revision because the initial assignment of agent and theme turns out to be correct. Unambiguous sentences ending in wurde do not need any revision either, because they are initially assigned recipient followed by theme due to the restriction on dative marked NPs just

mentioned. Finally, ambiguous sentences ending in wurde need revision because the initial assignment of the agent role to the first NP has to be replaced by the assignment of the recipient role.

The structure of this explanation in terms of thematic roles is basically identical to the structure of the original explanation in terms of case with the main difference that in the case explanation nominative has to be replaced by dative case and accusative by nominative case, whereas in the thematic role explanation, agent has to be replaced by recipient. Since in the sentences of Experiment 1 case and thematic roles are confounded (nominative is always agent and dative always recipient), Experiment 1 cannot differentiate between these two explanations. However, different predictions emerge for sentences ending in bekam. If reanalysis is determined by the assignment of case, the processing of ambiguous sentences ending in bekam should not be different from the processing of unambiguous sentences ending in bekam because the initial case assignment need not be changed. Hence, sentences ending in bekam should not show any signs of a garden-path effect. In contrast, if reanalysis is determined by the assignment of thematic roles, a garden-path effect should be expected for sentences ending in bekam. This garden-path effect should be independent from the case-ambiguity of the NPs involved. The sequence AGENT THEME should be assigned both to an ambiguous sentence beginning like daß Fritz eine Postkarte and an unambiguous sentence beginning like daß er eine Postkarte. This follows from the assumption that agent is the preferred role for an animate NP and theme the preferred role for an inanimate NP as long as this assignment is grammatically licit. Therefore, on encountering bekam, the initial assignment of agent to the first NP must be changed to recipient. Since this is exactly the same reanalysis that would be necessary for ambiguous passive sentences, both ambiguous and unambiguous sentences ending in bekam should pattern like ambiguous passive clauses if the altering of

thematic role assignments is responsible for the garden-path effect observed in Experiment 1.

To summarise, for sentences ending in bekam different predictions emerge depending on whether reanalysis is determined by case or by thematic roles. An explanation in terms of case predicts that neither ambiguous nor unambiguous sentences ending in bekam should show any signs of a garden-path effect. An explanation in terms of thematic roles in contrast predicts that both ambiguous and unambiguous sentences should show garden-path effects comparable to ambiguous passive sentences. The main aim of Experiment 2 was to decide between these two predictions. As already pointed out above, neither of the two theories that have proposed that thematic roles are assigned in verb-end clauses already before the verb has been encountered makes clear predictions as to how difficult it will be to withdraw an initial thematic assignment. By deciding whether case or thematic roles are responsible for the garden-path effect found in Experiment 1, Experiment 2 will make it possible to assess the potential difficulty of withdrawing thematic roles.

A further aim of Experiment 2 was to remove a complication exhibited by unambiguous control sentences in Experiment 1, namely the use of the feminine pronoun sie, which is ambiguous between nominative and accusative case. In Experiment 2, only the completely unambiguous pronoun er was used. If, as suggested above, the difference between unambiguous SO- and OS-sentences is indeed due to the way these sentences are derived from corresponding three-arguments sentences, the same difference should show up in Experiment 2. Furthermore, sentences ending in bekam should pattern with sentences ending in wurde since both types of sentences are derived by a lexical-syntactic operation and not by simply omitting an optional argument.

Method

Subjects. 36 students of the University of Jena participated in Experiment 2. Subjects were either paid 5 DM or received course credit. All subjects were native speakers of German and naive with respect to the purpose of the experiment. No subject had already participated in Experiment 1.

Materials. 30 sentences were created, with each sentence appearing in six versions according to the two experimental variables auxiliary (hat versus wurde versus bekam) and ambiguity (ambiguous versus unambiguous). A sample item from Experiment 2 is shown in Table 3. These 30 sentences were partially based on the stimulus material constructed for Experiment 1. In contrast to the almost unrestricted productivity of passivization, the use of the quasi-auxiliary bekommen together with a ditransitive verb underlies certain semantic restrictions (cf. Wegener, 1985). Due to these restrictions, only a subset of the sentences used in Experiment 1 could be used again in Experiment 2.

Insert Table 3 about here

Ambiguous and unambiguous sentences ending in hat were either taken from the conditions ambiguous or unambiguous active sentences of Experiment 1, respectively, or were newly constructed in the same way as described for the corresponding sentences of Experiment 1. In order to remove the ambiguity of the pronoun sie in the unambiguous sentences, all ambiguous sentences of Experiment 2 contained masculine proper names. For unambiguous sentences ending in hat, this proper name was replaced by the unambiguously nominative-marked pronoun er, with a concomitant change in the main clause. For sentences ending in wurde, the auxiliary hat in the sentences ending in hat was replaced by wurde. In addition, the pronoun er was replaced by the pronoun ihm, which is

unambiguously marked for dative case, in order to create unambiguous sentences. Finally, by replacing the auxiliary hat with the quasi-auxiliary bekam, sentences ending in bekam were created. As was the case for unambiguous sentences ending in hat, unambiguous sentences ending in bekam contained the pronoun er.

From the experimental sentences, six sentence lists were created which contained an equal number of sentences within each condition but with each sentence appearing in only one of its six versions. The experimental lists were embedded in a list of 94 filler sentences which were of a variety of syntactic constructions. Some of the filler sentences came from experiments unrelated to the present experiment. The experimental sentences were randomised individually for each subject.

Procedure. The same procedure as for Experiment 1 was used for Experiment 2.

Results

Figure 3 shows the percentages of times subjects judged the sentences to be grammatical. The factor auxiliary was significant in both the subject and the item analysis ($F_1(2,70) = 13.36, p < .01$; $F_2(2,58) = 8.10, p < .01$). The factor ambiguity was not significant in either analysis ($F_1(1,35) = .87, F_2(1,29) = 1.02$). The interaction between auxiliary and ambiguity was significant in both subject and item analysis ($F_1(2,70) = 11.08, p < .01$; $F_2(2,58) = 16.15, p < .01$).

Insert Figure 3 about here

Planned comparisons showed that ambiguous sentences ending in wurde received significantly less grammatical responses than unambiguous sentences ending in wurde (75% vs. 92%; $t_1(35) = 4.39, p < .01$; $t_2(29) = 4.76, p < .01$). In contrast, the difference between ambiguous and unambiguous sentences ending in hat was not reliable (78% vs.

72%; $t_1(35) = 1.61, p > .1$; $t_2(29) = 1.74, p > .1$), nor was the difference between ambiguous and unambiguous sentences ending in bekam (93% vs. 89%; $t_1(35) = 1.17, p > .1$; $t_2(29) = 1.27, p > .1$). Considering only unambiguous sentences, sentences ending in wurde did not differ from sentences ending in bekam (92% vs. 89%; both t's < 1), but these two kinds of sentences received significantly more grammatical responses compared to sentences ending in hat (91% vs. 72%; $t_1(58) = 4.81, p < .01$; $t_2(58) = 3.75, p < .01$).

Reaction times for correct responses are shown in Figure 4. Outliers were treated as in Experiment 1. This affected less than 5% of the data. The factor auxiliary was significant in the subject analysis and the item analysis ($F_1(2,70) = 10.46, p < .01$; $F_2(2,58) = 10.29, p < .01$). The factor ambiguity was significant by subjects and marginally significant by items ($F_1(1,35) = 8.06, p < .01$; $F_2(1,29) = 3.96, p < .1$). The interaction between auxiliary and ambiguity was significant in both analyses ($F_1(2,70) = 15.24, p < .01$; $F_2(2,58) = 5.92, p < .01$).

Insert Figure 4 about here

Planned comparisons showed that ambiguous sentences ending in wurde took significantly more time than unambiguous sentences ending in wurde (862 ms vs. 657 ms; $t_1(35) = 5.74, p < .01$; $t_2(29) = 4.05, p < .01$). In contrast, there was no significant difference between ambiguous and unambiguous sentences for either the hat-condition (793 vs. 810; both t's < 1) or the bekam-condition (681 ms vs. 685 ms; both t's < 1). Considering only unambiguous sentences, sentences ending in wurde and sentences ending in bekam again did not differ from each other (657 ms vs. 685 ms; both t's < 1) but differed from sentences ending in hat (671ms vs. 810 ms) ($t_1(70) = 4.26, p < .01$; $t_2(58) = 4.26, p < .01$).

Discussion

The results of Experiment 2 show that the garden-path effect found for ambiguous passive sentences is caused by the need to withdraw an initial case assignment rather than by the need to withdraw an initial thematic role assignment. Sentences ending in bekam, which are crucial for deciding between the two alternative explanations, did not show any signs of garden-path effects and were indeed judged to be grammatical more often than active sentences. This is easily explained with reference to case, since these sentences exhibit the case pattern nominative followed by accusative which is the preferred case pattern according to the Case Preference Principles in (17). In consequence, nothing needs to be changed when a sentence is disambiguated by bekam, and no difficulties are encountered.

From Experiment 2 we can conclude that for sentences like those under consideration, garden-path effects are in no way related to retracting initial thematic role assignments. This is in line with prior results reported by Frazier (1990) who found no evidence for an immediate thematic assignment in English nominalizations. However, we cannot conclude that thematic roles do not play any role in processing verb-end sentences. There are two possibilities why thematic roles should have no influence on reanalysis. First, thematic roles are not assigned before the clause final verb and therefore no reanalysis of thematic roles is necessary. Second, thematic roles are already assigned before the clause final verb as suggested by Carlson and Tanenhaus (1988) and MacDonald et al. (1994), but to withdraw an initial assignment of thematic roles is too easy to be detected by the current experimental method.

While Experiment 2 cannot decide between these two possibilities, certain considerations speak against the second one. First of all, as long as no evidence has been found that indicates that thematic roles are assigned before the verb is encountered, the

assumption that this is not so is more parsimonious. Furthermore, assuming that the retraction of certain initial decisions might be almost cost-free makes it rather hard to test empirically whether these decisions are indeed made (cf. MacDonald et al., 1994, p. 696). Secondly, it is unclear why thematic roles should be assigned already in advance of the verb in its clause-final position. Even for NPs that are case-unambiguous, there are often rather weak constraints on thematic role assignment. Subjects in particular are almost completely underspecified with respect to the thematic role they may bear. A final point speaking against the early assignment of thematic roles concerns a principal difference between thematic roles and case. Current theories of lexical-semantic structure (cf. Jackendoff, 1990; Levin & Rappaport Hovav, 1995) assume that notions like agent, theme etc. are only shorthands for certain semantic relations that might hold between a verb and its arguments. This means that thematic roles are basically relational notions and not feature-like entities that have an existence of their own, independent from the lexical-conceptual structures of verbs. This contrasts with cases like nominative or accusative which are discrete features and non-relational. While it is completely sensible to speak of a noun like e.g. he as being a nominative pronoun without recourse to a particular sentence context, it is obscure to speak of he as bearing e.g. the agent role without any sentence context. Therefore, it makes good sense and is indeed necessary to assume that case information is part of the lexical entry of a noun whereas this is much less clear for thematic roles. It comes therefore as no surprise that an ambiguous noun like a proper name is fixed immediately with respect to its case but not with respect to its thematic role.

Replicating a finding already obtained in Experiment 1, Experiment 2 found that active sentences were at a disadvantage in comparison to unambiguous passive sentences both with respect to percentages of sentences correctly judged as grammatical and response times needed to judge sentences as grammatical. Since only the unambiguously

nominative-marked pronoun er was used in unambiguous active sentences ending in hat, it can be excluded that this disadvantage is caused by any kind of ambiguity effect. Instead, as already suggested in the discussion of Experiment 1, this disadvantage seems to be related to the way the experimental sentences, which always contained two arguments, are derived from active sentences with three arguments. This interpretation is strengthened by the fact that with respect to both percentages of correct responses and with respect to reaction times, sentences ending in bekam patterned with unambiguous passive sentences and not with sentences ending in hat. In sentences ending with hat, the dative argument is simply omitted. This is possible since the dative argument of many ditransitive verbs is optional. However, as pointed out above, sometimes the result of omitting the dative object might nevertheless lead to reduced acceptability. For sentences ending in bekam or hat, the situation is different. For both types of sentences, the subject argument of the ditransitive verb is suppressed by a lexical-syntactic operation, and the resulting two-argument-sentences are fully acceptable, therefore leading to high percentages of correct responses.

Experiment 3

So far, the evidence for the claim that case influences the processing of certain syntactic ambiguities stems from the fact that the notion of case allows a coherent explanation for the results of Experiment 1 and Experiment 2 as well as for the results found by Bader et al. (1996) for object-object ambiguities (cf. the examples in (14)). What is still missing is a direct demonstration that case can influence first-pass parsing decisions. In order to gain direct evidence for case playing a vital part in syntactic processing, we have to reconsider what was said above about the case system of German. When introducing the German morphological case system, it was claimed that structural

case is the default case for arguments of verbs, whereas dative case is a non-default case that must be signalled by morphological means. This distinction between default and non-default case has been represented by assuming that nominal elements that can realise structural case in general are morphologically underspecified, whereas an element that realises dative case is always associated with a morphological dative feature. This kind of representation makes a special prediction that will be tested in experiment 3.

This prediction derives from experimental results found for speech production. Several experiments have investigated the phenomenon of ATTRACTION ERRORS (cf. Bock & Miller, 1991; Bock & Cutting, 1992). An example of such an error is given in (25), where the verb does not agree with the singular subject noun. Instead, it incorrectly agrees with the plural noun inside the PP that modifies the subject noun. In a sense, the subject has “attracted” the plural feature of the modifying noun, thereby leading to erroneous plural morphology on the verb.

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

Attraction errors have been studied by giving subjects sentence beginnings and asking them to repeat and immediately complete these beginnings. One of the most stable results of these experiments has been that there exists an asymmetry between singular and plural NPs (cf. Bock & Miller, 1991; Bock & Cutting, 1992). Subject NPs like the owner of the houses elicit a certain amount of agreement errors whereas agreement errors for NPs of the form the owners of the house are very rare. That is, singular nouns attract the number feature of plural nouns much more often than plural nouns attract the number feature of singular nouns. This asymmetry between singular and plural with respect to attraction errors has been explained by a further asymmetry between singular and plural, namely the asymmetry in morphological realisation (cf. Eberhard, 1993). Whereas singular nouns do

not bear a morphological marker, plural nouns must be morphologically marked for plurality. In short, singular is the default number specification for a noun whereas plural is the non-default specification that must be explicitly marked.

The relation between abstract feature and morphological realisation that holds for the number system of English is paralleled by the relation that holds for the case system of German. With respect to the German case system, structural case is the unmarked default case whereas dative case is a marked, non-default case. Therefore, if a phenomenon similar to number attraction errors could be found for case, it is predicted that an item marked for dative case might have an interfering influence whereas an unmarked item should not. This prediction can be tested by investigating ambiguous sentences like those in Experiment 1 and Experiment 2 and adding a relative clause that modifies the case-ambiguous proper name, as in the examples given in (26) and (27). In (26), the name Maria is modified by a relative clause with a relative pronoun that is unambiguously marked for dative case. (This can be figured out from Table 1, because nominative, accusative, and dative singular relative pronouns are identical to definite determiners). In contrast, the relative clauses in (27) contain a relative pronoun that can realise both nominative and accusative case (i.e., structural case in general) and bears accusative case in the particular relative clauses in (27).

(26) a. ..., daß Maria, DER ich gestern begegnet bin, eine Postkarte geschickt hat.

that Maria who I yesterday met am a postcard sent has

“... that Maria, who I met yesterday, sent a postcard”

b. ..., daß Maria, DER ich gestern begegnet bin, eine Postkarte geschickt wurde.

that Maria who I yesterday met am a postcard sent was

“... that a postcard was sent to Maria, who I met yesterday.”

(27) a. ..., daß Maria, DIE ich gestern gesehen habe, eine Postkarte geschickt hat.

that Maria who I yesterday seen have a postcard sent has

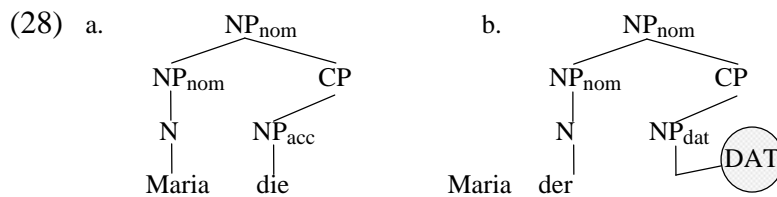
“... that Maria, who I saw yesterday, sent a postcard”

b. ..., daß Maria, DIE ich gestern gesehen habe, eine Postkarte geschickt wurde.

that Maria who I yesterday seen have a postcard sent was

“... that a postcard was sent to Maria, who I saw yesterday.”

The syntactic structures corresponding to the ambiguous NPs modified by a relative clause are shown in (28a) and (28b), respectively. In (28), case is represented in the same way as introduced above (cf. (16)): Abstract case is indicated by small letters, morphological case by capital letters and additionally by circling.



(28) makes clear the asymmetry between structural and dative case with respect to morphological realisation. Whereas a relative pronoun bearing abstract dative case also bears a morphological marking for dative case, a relative pronoun bearing structural case lacks any specific morphological marking. If something analogous to attraction errors occurs for case in the constellation shown in (28), it is predicted that the head noun of the relative clause might attract dative case but none of the structural cases, since only the former has a morphological manifestation but not the latter ones. This means that the NP starting with Maria might sometimes attract dative case if followed by a dative relative pronoun. Whenever this happens, sentences like those in (26) should exhibit a preference for object followed by subject instead of the usually preferred subject-before-object order found for such sentences without relative clauses. This in turn should reduce or even

reverse the garden-path effect found in the preceding experiments, depending on how often dative case is erroneously attracted.

For sentences like those in (27), a different set of predictions is derived. Ambiguous sentences of this kind have already been shown to exhibit a preference for the order subject before object, which results in a garden-path effect for passive sentences where this order is reversed. Since this preference indicates that the case-ambiguous proper name is initially assigned nominative case, modifying this proper name with a relative-clause headed by a relative-pronoun bearing structural case should have no influence on initial-parsing decisions. A difference in comparison to sentences without a relative clause can therefore only be expected for processes of reanalysis. For active sentences, such reanalysis processes are not necessary, and no differences between sentences like (27a) and corresponding active sentences without relative clauses are expected. For passive sentences, reanalysis becomes necessary. Since there is independent evidence that the ease of reanalysis is dependent on the length of the ambiguous region (cf. Frazier & Rayner, 1982; Ferreira & Henderson, 1991), we should expect that reanalysis is more difficult if the ambiguous proper name is modified by a relative clause compared to when it is not.

The predictions just developed are summarised in (29). “>” means “is easier to process”, where processing difficulty should be reflected in prolonged reaction times or reduced percentages of sentences judged as grammatical. These predictions were tested in experiment 3.

- (29) Disambiguation by hat Maria = Maria,die > Maria, der
 Disambiguation by wurde: Maria, der > Maria > Maria,die

Method

Subjects. 42 students of the University of Jena participated in experiment 3. All subjects were native speakers of German. They either received course credits or were paid 5 DM for participating.

Materials. The material for experiment 3 consisted of 30 sentences with each sentence appearing in one of six versions according to the two factors sentence type (active vs. passive) and relative clause (without relative clause vs. relative clause with structural relative pronoun (die) vs. relative clause with dative relative pronoun (der)). A sample sentence is shown in Table 4. The active and passive sentences without relative clause were taken from the ambiguous condition of Experiment 1. All masculine proper names in the original sentences were replaced by feminine proper names in order to increase the discriminability of the relative pronouns (die for structural case, der for dative case). For the two conditions with relative clauses, relative clauses were created which were either headed by a relative pronoun marked for structural case (die) or by a dative-marked relative pronoun (der). All relative clauses were non-restrictive relative clauses. For a given sentence, the dative relative clause and the structural relative clause consisted of an equal number of words.

Insert Table 4 about here

The experimental sentences were divided into six lists so that each list contained an equal number of sentences in each condition, but no more than one version of any sentence appeared in a single list. Each list of experimental sentences was embedded in a list of 98 filler sentences. These filler sentences consisted of a variety of sentence types. Some of the filler sentences came from experiments unrelated to the present experiment.

The order of presentation of experimental sentences was randomised individually for each subject.

Procedure. Experiment 3 used the same procedure as Experiment 1 and Experiment 2.

Results

Figure 5 shows the percentages of times subjects judged the sentences to be grammatical. The factor relative clause was significant in the subject and item analysis ($F_1(2,82) = 7.77, p < .01$; $F_2(2,58) = 12.85, p < .01$). The factor sentence type was also significant in both analyses ($F_1(1,41) = 8.97, p < .01$; $F_2(1,29) = 5.25, p < .05$), as was the interaction between relative clause and sentence type ($F_1(2,82) = 15.16, p < .01$; $F_2(2,58) = 10.79, p < .01$).

Insert Figure 5 about here

The specific predictions derived above were tested by planned comparisons. Comparisons between active and passive clauses showed only one significant difference. Active sentences containing a dative relative clause received significantly less correct responses than passive sentences with a dative relative clause (56% versus 81%; $t_1(41) = 4.83, p < .01$; $t_2(29) = 3.69, p < .01$). Within active and passive clauses, the following differences were significant. Active sentences with a dative relative clause were judged as grammatical less often than active sentences with or without a structural relative clause (56% versus 79%; $t_1(82) = 5.74, p < .01$; $t_2(58) = 7.38, p < .01$). Passive sentences containing a structural relative clause received less correct responses than passive sentences containing no relative clause (77% versus 83%). This difference was not

significant by subjects and marginal significant by items ($t_1(82) = 1.36, p > .1$; $t_2(82) = 1.74, p < .1$).

Figure 6 shows reaction times for correct responses. Outliers were treated as in the preceding experiments. This affected less than 5% of the data. The factor relative clause was not significant ($F_1(2,82) = 2.09, p > .1$; $F_2(2,58) = 1.05, p > .1$). The factor sentence type was marginally significant in the item analysis and not significant in the subject analysis ($F_1(1,41) = 3.39, p < .1$; $F_2(1,29) = 2.43, p > .1$). The interaction between relative clause and word order was significant in both analyses ($F_1(2,82) = 4.00, p < .05$; $F_2(2,58) = 5.08, p < .01$).

Insert Figure 6 about here

Planned comparisons were conducted to test the hypotheses summarised in (29). Active-sentences without a relative clause needed less time to be judged as grammatical than passive-sentences without a relative clause (765 ms vs. 857 ms), replicating a finding already found in Experiment 1 and Experiment 2. This difference was marginally significant by subjects and not significant by items ($t_1(41) = 2.00, p < .1$; $t_2(41) = 1.6, p > .1$). Active sentences with a structural relative clause also needed less time to be judged as grammatical than passive sentences with a structural relative clause (790 ms vs. 924 ms). This difference was significant both by subject and by items ($t_1(41) = 2.77, p < .01$; $t_2(41) = 2.35, p < .05$). A reverse effect was found for sentences with dative relative clause. Active sentences needed more time than passive sentences (861 ms vs. 790 ms), but this difference was not significant ($t_1(41) = 1.32, p > .1$; $t_2(41) = 1.33, p > .1$).

Considering reaction time differences within active and passive sentences, respectively, the following results were obtained. For active sentences, sentences with a

structural relative clause did not differ from sentences without a relative clause (790 ms vs. 765 ms; both t 's < 1). The difference between these two types of sentences and sentences with a dative relative clause was marginally significant by subjects and significant by items (778ms vs. 861ms; $t_1(82) = 1.97$, $p < .05$; $t_2(82) = 2.45$, $p < .01$). For passive sentences, sentences with a dative relative pronoun needed less time than sentences without a relative clause (790 ms vs. 857 ms), a difference that was not significant in the subject analysis and marginally significant in the item analysis ($t_1(82) = 1.65$, $p > .1$; $t_2(82) = 1.67$, $p < .1$). Sentences without a relative clause, in turn, needed less time than sentences with a structural relative clause (857 ms vs. 924 ms). This difference was significant by subjects and marginally significant by items ($t_1(82) = 2.06$, $p < .05$; $t_2(82) = 1.70$, $p < .1$).

Discussion

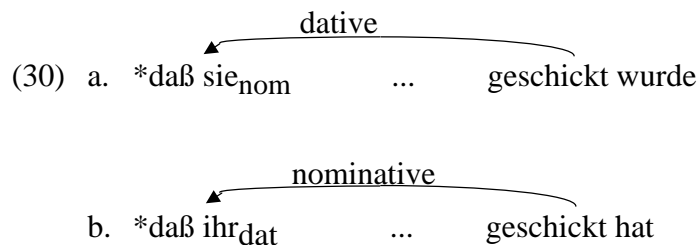
The results of experiment 3 confirm the predictions derived above. The most important finding is the strong drop in the percentages of correct responses for active sentences containing a dative relative clause. This shows that the preference for subject before object that was found in Experiment 1 and Experiment 2 can be overwritten by a preference for object before subject. This was achieved by modifying a case-ambiguous proper name with a relative clause in which the relative pronoun bore dative case. As in attraction errors found in speech production for subject-verb agreement, the ambiguous head noun of the relative clause seems to attract the case feature of the relative pronoun. Thereby, it becomes marked for dative case and causes the whole sentence to exhibit the order dative object in front of subject. This in turn leads to a rather strong garden-path effect if the sentence is disambiguated by the perfect auxiliary hat, which requires the word order subject before object. In contrast, processing the passive auxiliary wurde was

somewhat facilitated by the introduction of a dative relative clause as shown by the decrease in reaction times. This is further evidence that these relative clauses lead to an object-before-subject preference.


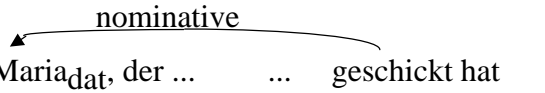
For sentences with a relative clause headed by the relative pronoun die, a rather different picture emerges. Since for sentences without a relative clause it has already been shown that a clause-initial ambiguous proper name is preferentially assigned nominative case, a relative pronoun marked for a structural case could not reverse the usual subject-object preference. Instead, it could only make the reanalysis harder that is necessary on encountering the passive auxiliary wurde. The results of experiment 3 provide some evidence that the garden-path effect found in subject-object sentences without a relative clause was indeed strengthened albeit only slightly.

The finding of an object-subject preference for sentences containing a dative relative clause provides direct evidence for the involvement of case morphology in the processing of ambiguous subject-object sentences. Since the only relevant grammatical difference between sentences containing a dative relative clause and sentences containing a structural relative clause consists in the case of the relative pronoun, the reversal of the usual subject-object preference to an object-subject preference must be attributed to the difference in the case specification on the relative pronoun. The claim that case plays an active role in the processing of subject-object ambiguities is strengthened further by the fact that the garden-path effect found for ambiguous passive clauses and the one for ambiguous active clauses under the influence of a dative relative clause differ strongly in their magnitude. Whereas the garden-path effect elicited by passive clauses was reflected mainly in reaction time data, the garden-path effect elicited by active sentences containing a dative relative clause resulted in a sharp drop in the percentages of sentences judged to be grammatical. This can be taken as an indication that active sentences containing a

dative relative clause elicit a stronger garden-path effect than passive sentences, independently of whether the passive clause contains a structural relative clause or not. This difference in garden-path strength can be traced back to the same source that was made responsible for a difference obtained in Experiment 1. There it was found that ungrammatical sentences containing a pronoun that is unambiguously marked for structural case (sie/er) elicited more errors than sentences containing an unambiguously marked dative pronoun (ihr/ihm). The case assignment relations obtaining in these ungrammatical sentences are visualised in (30).



Although ambiguous sentences are globally grammatical, they may exhibit a temporary ungrammaticality, namely when the partial structure that is computed on first-pass analysis is continued with an item that contradicts the initial analysis. This is the situation where reanalysis becomes necessary. (31) shows this temporary ungrammaticality for the sentences under investigation. Simple proper names or proper names modified by a structural relative clause (cf. (31a)) are preferentially assigned nominative case. This leads to a temporary ungrammaticality if the sentences ends in a passive verb. Proper names modified by a dative relative clause (cf. (31b)) are initially taken as marked for dative case. Hence, they become temporarily ungrammatical if completed by an active verb.

- (31) a. daß Maria_{nom}(, die ...) ... geschickt wurde

- b. daß Maria_{dat}, der geschickt hat


A comparison of (30) and (31) shows a striking pattern: (i) The temporary ungrammaticality exhibited by sentences leading to a weak garden-path effect corresponds to a real, permanent ungrammaticality that leads to a fair amount of errors (cf. (30a) and (31a)). (ii) The temporary ungrammaticality exhibited by sentences leading to a strong garden-path effect corresponds to a permanent ungrammaticality that leads only to a very small amount of errors (cf. (30b) and (31b)). In other words, a salient ungrammaticality leads to a strong garden-path effect and a less salient ungrammaticality to a weak one. This relationship follows naturally from the explanation given above for the processing of ungrammatical sentences (cf. the discussion of (21)) and can ultimately be traced back to the different status of structural and dative case within the case system of German. Consider first ambiguous and ungrammatical passive clauses. It was assumed above that after encountering the case-mismatch in (30a), lexical reaccess for the pronoun sie is initiated in order to check whether a lexical entry specified for dative case is available for sie. This lexical reaccess will not succeed for sie but will succeed for the parallel temporary ungrammaticality in (31a) since the proper name Maria has indeed a dative entry. For (31a) this means that the temporary ungrammaticality will be cured. Since this will take some extra time, ambiguous sentences like (31a) are processed more slowly than corresponding unambiguous sentences.

Turning to active clauses, consider first the real ungrammaticality in (30b) where an unambiguously dative marked pronoun receives nominative case. It was assumed above

that no lexical reaccess is triggered in this situation so that the ungrammaticality of (30b) is detected immediately. The reason for the absence of lexical reaccess was explained by the marked status of dative case. From the parser's point of view, (31b) looks identical to (30b) and will therefore be judged as ungrammatical too. The fact that, in contrast to the pronoun ihr in (30b), the proper name in (31b) is not really unambiguously specified for dative case does not matter for the parser. What matters is the dative feature on these words rather than whether this dative feature is grammatically justified or not. That is, as soon as Maria has erroneously attracted its dative feature from the nearby relative pronoun, it becomes indistinguishable for the parser from the truly unambiguous dative pronoun ihr. The fact that ungrammatical active sentences are nevertheless judged as ungrammatical much more often than ambiguous active sentences containing a dative relative pronoun must then be due to the fact that case attraction does not occur all of the time. However, if case attraction is really the same kind of phenomenon as attraction errors found for subject-verb agreement in speech production, this comes at no surprise. Indeed, the high percentage of errors found for dative attraction (more than 40%) might be more surprising because attraction errors in subject-object agreement are only in the range of 5% or less (cf. Bock & Cutting, 1992; Bock & Miller, 1991). This difference might at least partially be due to a grammatical difference. While case attraction occurred between two elements that are in a close syntactic relation, namely a relative pronoun and its head noun, the elements in agreement attraction errors (e.g. the owner of the houses) are only loosely related.

General Discussion

This paper investigated a subject-object ambiguity that holds between active and passive sentences like (9) (repeated here).

- (9) a. Jemand hat behauptet, daß Uli eine Postkarte geschickt hat.

Someone has claimed that Uli a postcard sent has

“Someone claimed that Uli sent a postcard”

- b. Jemand hat behauptet, daß Uli eine Postkarte geschickt wurde.

Someone has claimed that Uli a postcard sent was

“Someone claimed that a postcard was sent to Uli”

The major empirical findings of the preceding experiments can be summarised as follows. (i) For ambiguous active and passive clauses of the type illustrated in (9), a clear subject-before-object preference exists. If this preference is contradicted by a passive auxiliary, a consistent garden-path effect emerges. This garden-path effect manifests itself mainly in prolonged reaction times in the speeded grammaticality judgement task used in the preceding experiments. (ii) A garden-path effect is found if an initial case assignment has to be revised but not if an initial assignment of thematic roles needs to be altered. (iii) The subject-before-object preference reverses to an object-before-subject preference if the ambiguous proper name is modified by a relative clause headed by a dative-marked relative pronoun.

These findings find a natural explanation by giving the grammatical device of case its proper place within a model of the human sentence processing mechanism, thereby taking seriously the phenomenon of case ambiguity. The most important grammatical ingredient of the explanation given above is an asymmetry between structural and lexical case: The two structural cases nominative and accusative are default cases whereas dative case is a marked, non-default case. This asymmetry was captured representationally by assuming that a lexical item bearing dative case must always be marked by a morphological feature

whereas a lexical item bearing structural case may be left underspecified for morphological case.

With respect to processing, the distinction between default and non-default case figured prominently in several assumptions about how case-ambiguous sentences are processed lexically and syntactically. First, the preference for the order subject-before-object that was found for sentences that do not differ phrase-structurally can be explained by the Case Preference Principles in (17). According to these principles, structural case is preferred to lexical case and nominative case in turn is preferred to accusative case. Secondly, when the initial subject-object structure is contradicted by a passive auxiliary, the resulting garden-path effect can be attributed to lexical reaccess triggered by the case-mismatch between passive verb and the initially computed subject-object structure. Such a reaccess is necessary because a phrase-marker only contains positive but no negative information. That is, it does not contain the information as to whether a lexical item bearing nominative case might also be compatible with dative case. Furthermore, because nominative case is a default case, the parser cannot know whether nominative was assigned because of an unambiguous morphological marking or because of a default assignment to a case-ambiguous NP. Therefore, for a nominative marked NP there is always a chance that this NP is also compatible with dative case. This is not true for a dative marked NP. If a case-mismatch arises that involves a dative-marked NP, no lexical reaccess will be triggered because an NP can only be marked for dative case by an unambiguous morphological marker and not by default. Hence, the morphological marking already signals that lexical reaccess will not succeed and is therefore unnecessary.

By assuming that a nominative-marked NP might trigger lexical reaccess, whereas a dative marked NP will not, two seemingly unrelated experimental findings received a

unified explanation. The first finding was a difference between different types of ungrammatical sentences. The assignment of dative case to a pronoun marked for nominative case elicited more errors than the assignment of nominative case to an unambiguously marked dative pronoun. If trying to assign dative case to a pronoun marked for nominative case triggers lexical reaccess, this kind of ungrammaticality will take more time than the reverse ungrammaticality, assignment of nominative case to a dative pronoun where no reaccess is initiated. Due to the time pressures induced by the speeded grammaticality judgements task, the additional time needed for lexical reaccess will lead to a certain amount of responses made ahead of the arrival of sufficient information and therefore to an increased error rate.

The second finding that receives an explanation by assuming that a nominative marked NP triggers lexical reaccess whereas a dative marked NP does not comes from experiment 3. There it was found that a case-ambiguous proper name can erroneously attract a dative feature from an adjacent dative relative pronoun. This causes the usual subject-before-object preference to reverse to an object-before-subject preference. In contrast to the slight garden-path effect found for passive sentences, the garden-path effect caused by active sentences containing a dative relative clause is rather strong. This difference in garden-path strength is explained by the notion of lexical reaccess in the following way. Due to lexical reaccess, ambiguous passive clauses will ultimately be judged as grammatical, albeit with some delay. For ambiguous active sentences that exhibit a preference for dative object before subject, no lexical reaccess will be triggered. Therefore there is no chance to detect that these sentences are indeed grammatical. In consequence, they will be judged as ungrammatical.

How might the results of the preceding experiments be explained by alternative accounts of syntactic ambiguity resolution? Most previous accounts of syntactic ambiguity

resolution have not paid attention to the phenomenon of syntactic and morphological case, probably because case plays only a minor role in English, the principal language in the study of the human parsing mechanism. Studies of English that have investigated issues of case have concentrated on the question as to whether unambiguous information about case features as found with pronouns is used immediately or not to resolve phrase-structure ambiguities (cf. Trueswell, Tanenhaus, & Kello, 1993; Traxler & Pickering, in press) and found evidence for an immediate use of morphological case information. Since these studies compared case-ambiguous and unambiguous NPs within the context of a phrase-structure ambiguity, they do not allow any conclusions as to the role of case-ambiguity as such, that is, case-ambiguity in the absence of phrase-structure ambiguity.

The theory of Babyonyshev & Gibson (1995) is one of the rare theories that makes explicit claims about the processing of case, in particular about the processing of dative case. As shown above, this theory makes the prediction that active sentences should produce a garden-path effect but passive sentences should not. Experiment 1 and Experiment 2 have shown that this is a false prediction: it is the passive structure that gives rise to processing difficulties and not the active one. The proposal that Babyonyshev & Gibson (1995) make with respect to dative case stems from an investigation of phenomena of processing overload. The failure of this proposal when it comes to processes of syntactic ambiguity resolution might be taken as an indication that dative case plays completely different roles for processing load and syntactic ambiguity resolution. However, this conclusion only holds for the particular parallel framework of Babyonyshev & Gibson (1995). Under a serial account of the human parsing mechanism, as pursued in this paper, the discrepancy between the findings of Babyonyshev & Gibson (1995) and our findings find a natural explanation which has its root in the particular status of dative case. Besides its morphological status, dative case is characterised by a

relatively tight connection with a particular thematic role, namely the role of recipient (comparable to the to-PP of ditransitive verbs in English). Although there is no one-to-one relation between dative case and the thematic role of recipient, this relation is much more reliable than, say, the relation between nominative case and the thematic role of agent (cf. Wegener, 1985). Due to its particular status, an NP that is unambiguously marked for dative case might incur less processing costs than an NP marked for structural case. On the other hand, an NP that is ambiguous between dative and structural case will be preferentially analysed as bearing structural case because this analysis presupposes less specific hypotheses than an analysis of an ambiguous NP as bearing dative case. In short, by assuming a serial parsing mechanism, the discrepancy between dative case in phenomena of processing overload and dative case in syntactic ambiguity resolution is only an apparent one, whereas this discrepancy is a serious problem for the parallel parsing model of Babyonyshev & Gibson (1995).

In concluding we may ask what general implications the proposals made in this paper have for theories of the human parsing mechanism. A first implication comes from the need to invoke non-syntactic, namely morphological information in order to explain differences with respect to the strength of observed garden-path effects. Recall that the difference in garden-path strength found in experiment 3 between active and passive sentences did not follow from syntactic differences alone but from the interaction of syntactic and morphological information, namely the different morphological realisation of nominative and dative case. As far as this explanation is on the right track, the experiments reported in this paper add to the growing body of evidence that there are non-syntactic contributions to garden-path strength. For example, both Frazier and Rayner (1982) and Ferreira & Henderson (1991) found length effects on garden-path strength. Ferreira and Henderson (1991) have proposed an explanation for certain length effects that

resembles the explanation given above, namely by the need to reaccess the mental lexicon. Clifton (1995) has proposed that thematic information might aid in the recovery of syntactic misanalysis. Bader (1994, 1996a) has shown that certain garden-path effects during reading must be explained by recourse to prosodic structures that readers assign to sentences via phonological coding. Taking together, these findings indicate that there is no single source for garden-path strength. Instead, the ease with which the human sentence processing mechanism can recover from a syntactic misanalysis seems to depend on the interplay of several factors (cf. Frazier & Clifton, 1996). This means that theories which capitalise on syntactic factors as the main or sole determinants of garden-path strength (e.g. Gibson, 1991; Pritchett, 1992; Weinberg, 1993) are in need of revision.

A second general implication concerns the way the existence and strength of garden-path effects in passive sentences and in active sentences containing a dative relative clause were explained. The explanation proposed above has given equal weight to particular pieces of grammatical knowledge and to the processes that use this knowledge. By invoking the concept of lexical reaccess and assuming that lexical reaccess is dependent on the distinction between structural and lexical case, it became possible to identify the processes that will occur in sentences where the structure computed on first-pass parsing turns out to be contradicted by later input material. Thereby, several experimental results received an explanation that goes beyond the mere assertion that certain decisions of the parser are hard to revise whereas others are easily revised. Furthermore, it seems reasonable to assume that lexical reaccess is basically the same process as lexical access - the only difference being that the input to lexical access derives from an auditory or visual representation of an external stimulus whereas the input to lexical reaccess is an internal representation of a lexical item. As far as our assumptions about lexical reaccess and its role in processing of ambiguous active and passive sentences are tenable, we can conclude

that second-pass parsing uses the same processes as first-pass parsing and that it is not necessary to postulate new mechanisms solely dedicated to reanalysis (cf. Fodor & Inoue, 1994).

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Author Notes

I would like to thank the following people for helpful discussions and comments:

Josef Bayer, Anette Dralle, Anke Feldhaus, Lyn Frazier, Sigrid Lipka, and Michael Meng.

Footnotes

¹ German is not only a verb-end language but also a verb-second language (cf. Vikner, 1995). The latter property means that finite verbs are moved to the second position in main clauses. In embedded clauses, in contrast, all verbs, finite or infinite, are located in clause-final position. This paper will concentrate on the processing of verb-end sentences. Therefore, all ambiguous clauses will be embedded clauses.

² For reasons of space, I must leave open the question whether these case principles can be derived from other, more basic principles. In particular, it might be possible to see (17b) as an automatic consequence of the Minimal Chain Principle. Cf. Bader & Meng (1997) for discussion.

³ Indeed there is a third possibility according to which the first NP bears accusative case and the second NP bears nominative case. Such a case assignment would be appropriate for certain psych-verbs like begeistern (to fill with enthusiasm) or ärgern (to annoy). This third possibility does not affect the following argument.

⁴ The full set of experimental materials for this and the following experiments are available from the author.

⁵ Both raw percentages and percentages transformed according to the arcsin-procedure described in Kirk (1995) were analyzed. Since no differences showed up, I will only report analyses based on raw percentages.

⁶ All planned comparisons reported in this paper are based on two-tailed tests.

Table 1
The inflection paradigm for definite articles

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

Table 2
Sample item from Experiment 1

Ambiguous

Active Alle waren erstaunt darüber,
All were astonished about
daß Franz in München ein so gutes Angebot unterbreitet hatte.
that Franz in Munich a so good offer made had
“Everyone was surprised that Franz made such a good offer in Munich”

Passive Alle waren erstaunt darüber,
All were astonished about
daß Franz in München ein so gutes Angebot unterbreitet wurde.
that Franz in Munich a so good offer made was
“Everyone was surprised that such a good offer was made to Franz in Munich”

Unambiguous

Active Bezüglich Franz waren alle erstaunt darüber,
Concerning Franz were all astonished about
daß er in München ein so gutes Angebot unterbreitet hatte.
that he in Munich a so good offer made had
“Concerning Franz, everyone was surprised that he made such a good offer in Munich”

Passive Bezüglich Franz waren alle erstaunt darüber,
Concerning Franz were all astonished about
daß ihm in München ein so gutes Angebot unterbreitet wurde.
that him in Munich a so good offer made was
“Concerning Franz, everyone was surprised that such a good offer was made to him in Munich”

Ungrammatical

Active Bezüglich Franz waren alle erstaunt darüber,
Concerning Franz were all astonished about
daß er in München ein so gutes Angebot unterbreitet was.
that he in Munich a so good offer made was

Passive Bezüglich Franz waren alle erstaunt darüber,
Concerning Franz were all astonished about
daß ihm in München ein so gutes Angebot unterbreitet hatte.
that him in Munich a so good offer made had

Table 3
Sample item from Experiment 2

“Hat”	
Ambiguous	<p>Am Wochenende wurde erzählt, <u>At weekend was told</u> daß Peter beim letzten Treffen eine gute Stelle angeboten hat. <u>that Peter at last meeting a good job offered has</u> <u>At the weekend it was told that Peter had offered a good job at the last meeting</u></p>
Unambiguous	<p>Peter hat am Wochenende erzählt, <u>Peter has at weekend told</u> daß er beim letzten Treffen eine gute Stelle angeboten hat. <u>that he at last meeting a good job offered has</u> <u>At the weekend Peter told that he had offered a good job at the last meeting</u></p>
“Wurde”	
Ambiguous	<p>Am Wochenende wurde erzählt, <u>At weekend was told</u> daß Peter beim letzten Treffen eine gute Stelle angeboten wurde. <u>that Peter at last meeting a good job offered was</u> <u>At the weekend it was told that a good job had been offered to Peter at the last meeting</u></p>
Unambiguous	<p>Peter hat am Wochenende erzählt, <u>Peter has at weekend told</u> daß ihm beim letzten Treffen eine gute Stelle angeboten wurde. <u>that him at last meeting a good job offered was</u> <u>At the weekend Peter told that a good job had been offered to him at the last meeting</u></p>
“Bekam”	
Ambiguous	<p>Am Wochenende wurde erzählt, <u>At weekend was told</u> daß Peter beim letzten Treffen eine gute Stelle angeboten bekam. <u>that Peter at last meeting a good job offered got</u> <u>At the weekend it was told that Peter had been offered a good job at the last meeting</u></p>
Unambiguous	<p>Peter hat am Wochenende erzählt, <u>Peter has at weekend told</u> daß er beim letzten Treffen eine gute Stelle angeboten bekam. <u>that he at last meeting a good job offered got</u> <u>At the weekend Peter told that he had been offered a good job at the last meeting</u></p>

Table 4
Sample item from experiment 3

Without relative clause

Active Beinahe wäre uns entgangen, daß Stefanie am gleichen Abend eine Zusage gegeben hat.
almost were us missed that Stefanie at same evening a confirmation given has
We almost missed that Stefanie gave a confirmation the same evening.

Passive Beinahe wäre uns entgangen, daß Stefanie am gleichen Abend eine Zusage gegeben wurde.
almost were us missed that Stefanie at same evening a confirmation given was
We almost missed that a confirmation was given to Stefanie the same evening.

Structural relative pronoun (die)

Active Beinahe wäre uns entgangen, daß Stefanie, die immer ziemlich spontan gewesen ist,
almost were us missed that Stefanie who always rather spontaneous been is
 am gleichen Abend eine Zusage gegeben hat.
at same evening a confirmation given has
We almost missed that Stefanie, who has always been spontaneous, gave a confirmation the same evening.

Passive Beinahe wäre uns entgangen, daß Stefanie, die immer ziemlich spontan gewesen ist,
almost were us missed that Stefanie who always rather spontaneous been is
 am gleichen Abend eine Zusage gegeben wurde.
at same evening a confirmation given was
We almost missed that a confirmation was given to Stefanie, who has always been spontaneous, the same evening.

Dative relative pronoun (der)

Active Beinahe wäre uns entgangen, daß Stefanie, der immer spontane Sachen gefallen haben,
almost were us missed that Stefanie who always spontaneous things pleased have
 am gleichen Abend eine Zusage gegeben hat.
at same evening a confirmation given has
We almost missed that Stefanie, who has always liked spontaneous things, gave a confirmation the same evening.

Passive Beinahe wäre uns entgangen, daß Stefanie, der immer spontane Sachen gefallen haben,
almost were us missed that Stefanie who always spontaneous things pleased have
 am gleichen Abend eine Zusage gegeben wurde.
at same evening a confirmation given was
We almost missed that a confirmation was given to Stefanie, who has always liked spontaneous

things, the same evening

Figure Captions

Figure 1: Percentages of correct responses in Experiment 1

Figure 2: Reaction times for correct responses of Experiment 1

Figure 3: Percentages of correct responses in Experiment 2

Figure 4: Reaction times for correct responses of Experiment 2

Figure 5: Percentages of sentences judged grammatical in experiment 3

Figure 6: Reaction times for correct responses of experiment 3

