The Role of Memory Load in Syntactic Ambiguity Resolution:

A Reply to Gibson (1998)

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Abstract

The Syntactic Prediction Locality Theory (SPLT) proposed in Gibson (1998) claims that a major determinant in syntactic ambiguity resolution is the memory load imposed by alternative syntactic structures: In situations of local syntactic ambiguity, the human parsing mechanism is claimed to prefer that structure with incurs least memory load. As evidence for this claim, Gibson (1998) cites several findings on the processing of Dutch and German. This article will report two experiments which have tested some of the claims made by the SPLT concerning the processing of German. Their major result is that in ambiguous sentences, dative case is dispreffered to accusative case, whereas in unambiguous sentences, there is either no difference or a disadvantage of accusative case in comparison to dative case. These results contradict the SPLT but are consistent with the garden-path theory of Frazier (1987a) when expanded by certain independently motivated assumption concerning the processing of German.

Keywords

Parsing, Memory Load, Syntactic Ambiguity Resolution

Introduction

Numerous studies have shown that the human sentence processing mechanism (HSPM), when faced with a local syntactic ambiguity, selects a single structure as the preferred one (cf. Mitchell, 1994, for an overview). This selection can be done either by discounting all alternative structures from further consideration (serial parsing), or by ranking the selected structure highest within a set of competing analyses (parallel parsing). According to the Syntactic Prediction Locality Theory (SPLT) recently proposed by Gibson (1998), memory load, as measured in terms of predictions about upcoming phrase-structure positions, is an important determinant of the HSPM's choice of a preferred structure. As evidence for this relationship between memory load and parsing preferences, Gibson (1998) cites several findings on the processing of Dutch and German. In this article, two experiments using German sentence material will be presented that have investigated the relationship that the SPLT claims to hold between ambiguous and unambiguous sentences. The SPLT's predictions will be compared to predictions made by the Garden-Path Theory of Frazier and colleagues (cf. Frazier & Rayner, 1982; Frazier, 1987a) as it has been applied to German by Meng & Bader (to appear). The results will show that memory load does not play the role ascribed to it by the SPLT, whereas the garden-path theory finds supportive evidence.

The SPLT of Gibson (1998) is a theory of processing complexity in both unambiguous and ambiguous sentences. Processing complexity within the SPLT comprises both a memory cost component measuring "what quantity of computational resources are required to store a partial input sentence" (Gibson, 1998, p. 8), and an integration cost component measuring "what quantity of computational resources need to be spent on integrating new words into the structure built thus far" (Gibson, 1998, p. 8). For the sentence material which will be discussed in this article, only memory load is of relevance, and we will therefore confine our discussion to this part of the SPLT's complexity measure.

Memory cost within the SPLT is defined in terms of predictions concerning upcoming syntactic structure. Each prediction of a head necessary to complete the current partial phrase structure tree (with the exception of the matrix verb) imposes some memory load which increases with the distance since the prediction was first made. A formal definition of memory cost is given in (1) (from Gibson, 1998, p. 15).

(1) Syntactic prediction memory cost

(a) The prediction of the matrix predicate, V_0, is associated with no memory cost.

(b) For each required head C_i other than V_0, associate a memory cost of M(n) memory units MU where M(n) is a monotone increasing function and n is the number of new discourse referents that have been processed since C_i was initially predicted.

The relationship which the SPLT claims to hold between memory load in unambiguous sentences and memory load in syntactic ambiguity resolution can be summarized as follows. Consider two syntactic structures A and B, with structure A incurring more memory load than structure B. The SPLT makes two claims with respect to A and B. (i) If both A and B are unambiguous, then the processing of A should be more difficult than the processing of B, where processing difficulty might show up, for example, in prolonged reading times in an eye-tracking or selfpaced reading experiment, or in reduced accuracy in experiments using a speeded grammaticality judgment procedure. (ii) If, due to a local syntactic ambiguity, there is a point of choice between A and B, the structure incurring less memory load will be selected, that is, B.

As evidence for this particular role of memory load for processes of syntactic ambiguity resolution, Gibson (1998) cites several findings on the processing of Dutch and German. The first finding comes from Frazier (1987b) who has found that in sentences like (2), which are ambiguous between a subject-before-object (SO) structure and an object-before-subject (OS) structure, the SO-structure is preferred on first-pass parsing.

(2) a. Karl hielp de mijnwerkers die de boswachter vonden.
Karl helped the mine workers who the forester found-PLURAL
”Karl helped the mine workers who found the forester.”

b. Karl hielp de mijnwerkers die de boswachter vond.
Karl helped the mine workers who the forester found-SINGULAR
”Karl helped the mine workers who the forester found.”

Within the SPLT, this SO-preference is claimed to follow from differential memory costs associated with the two competing structures (cf. Gibson, 1998, p. 56f.). When processing the relative pronoun die, the HSPM has two options: Analyzing die as a subject or as an object. For the former analysis, only a subject-trace and a verb have to be predicted, because the sentence could be completed by an intransitive verb. Analyzing die as an object, in contrast, does not only involve the prediction of an object-trace and a verb, but also the prediction of a subject. Given that the subject-analysis of die involves fewer predictions than the object-analysis, the former will be selected, and the observed SO-preference will result.

Since the SPLT is a theory of both the complexity caused by unambiguous sentences, and a theory of syntactic ambiguity resolution, the account developed for the SO-preference in ambiguous sentences applies in a similar manner to the processing of unambiguous SO- and OS-sentences. This can be seen when considering the second finding cited by Gibson (1998) in favor of the SPLT, a finding of Hemforth (1993) on processing German. In a self-paced reading study, Hemforth investigated unambiguous SO- and OS-sentences of the type shown in (3) and found that the unambiguous clause-initial NP and the immediately following verb were associated with longer reading times in object-initial sentences (cf. (3b)) than in subject-initial sentences (cf. (3a)).

(3) a. [Der rote Bär] küsste [die kleine blonde Frau].
[the red bear]-NOM kissed [the small fair woman]-ACC
”The red bear kissed the small fair woman”

b. [Den roten Bären] küsste [die kleine blonde Frau].
[the red bear]-ACC kissed [the small fair woman]-NOM
”The small fair woman kissed the red bear”

This finding is explained within the SPLT by assuming that on reading a nominative-marked NP in sentence initial position, only a verb needs to be predicted to arrive at a grammatical sentence. For a sentence starting with an accusative-marked NP, in contrast, both a verb and a subject have to be predicted because the presence of an accusative NP almost always is dependent on there also being a subject (given that German has only a handful of infrequent one-place verbs whose single argument bears accusative case). Involving more predictions, accusative-first sentences will incur a greater memory load than nominative-first sentences, which explains why the initial NP in (3b) took longer to read in Hemforth’s (1993) experiment than the initial NP in (3a).

Extending this line of reasoning, Gibson (1998) explains the third and last finding which concerns locally ambiguous sentences like (4).[1]

(4) a. Menschen-NOM/ACC/DAT, die in Not sind, sollte man unterstützen-ACC.
persons who in distress are should one support
”One should support persons who are in distress.”

b. Menschen-NOM/ACC/DAT, die in Not sind, sollte man helfen-DAT.
persons who in distress are should one help
”One should help persons who are in distress.”

Sentences like (4) start with a case ambiguous NP. Since this NP does not agree with the immediately following finite auxiliary (sollte in (4)) with respect to number features, it becomes clear at the position of the auxiliary that this initial NP must function as an object of the incoming

clause final verb. However, there is still an ambiguity because this object could be either an accusative or a dative object. This remaining ambiguity is resolved by the clause-final main verb which either assigns accusative case (cf. (4a)) or dative case (cf. (4b)). Bader, Bayer, Hopf, & Meng (1996) have found that disambiguation by a clause-final accusative-assigning verb proceeds smoothly whereas disambiguation by a dative-assigning verb results in a garden-path effect. From this finding it can be concluded that the HSPM preferentially assigns accusative case to a case-ambiguous object.

To explain this accusative preference, the SPLT assumes that a dative NP imposes greater memory load than an accusative NP because most verbs with a dative object also have an accusative object whereas most verbs with an accusative object don't have an additional dative argument. On encountering a dative NP, the HSPM therefore has to entertain one prediction more than on encountering an accusative NP, namely the prediction of the additional accusative object. Given the assumption that the HSPM will prefer the analysis with least memory load, the accusative preference is an immediate consequence.

In what follows, we will compare Gibson's SPLT to the Garden-Path theory of Frazier and colleagues (cf. Frazier & Rayner, 1982; Frazier, 1987a) as far as this theory has been applied by Meng and Bader (2000; to appear) to the processing of case ambiguities in German. Like the SPLT, the Garden-Path theory assumes that syntactic complexity plays a crucial role for the parser's choice of a preferred syntactic structure. In contrast to the SPLT, however, the Garden-Path Theory assumes that complexity for purposes of syntactic ambiguity resolution derives from the HSPM's desire to structure material as quickly as possible. That is, when faced with a local syntactic ambiguity, the HSPM will prefer the first available structural alternative. This preference entails the well-known Minimal Attachment Principle according to which the HSPM will not postulate any

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[1] Here and in the following, the case assigned by a verb to its object will be indictated as a marker on the verb. On the NPs which are assigned this case, the cases morphologically

potentially unnecessary nodes (Frazier, 1987a, p. 562). Ultimately, the assumption that the HSPM tries to structure incoming material as quickly as possible also derives from memory considerations, namely from the idea dating back to Miller (1956) that it is easier to hold structured material in working memory than to hold unstructured material.

How would the three findings cited by Gibson (1998) in favor of the SPLT be explained by the Garden-Path Theory? The first finding would be explained under recourse to a further parsing principle of the Garden-Path theory, the Minimal Chain Principle of de Vincenzi (1991), which is shown in (5).

(5) Minimal Chain Principle (MCP)

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

The subject-object-preference found in sentences like (2) as well as in other kinds of subject-object ambiguities follows from the MCP because a subject-trace can be postulated earlier by the HSPM than an object-trace under the syntactic assumption that a subject-trace is located higher in the phrase-structure tree of a sentence than an object-trace (cf. Frazier, 1987b, for discussion).

Given that the Minimal Chain Principle is an ambiguity resolution principle, it does not apply to unambiguous sentences as in (3). However, it is in no way necessary to invoke a syntactic explanation for Hemforth's (1993) finding that unambiguous SO-sentences are easier to process than unambiguous OS-sentences. An alternative explanation can be given by noting the well-known fact of the grammar of German that the choice of a particular word-order has important effects on the focus or information structure associated with a sentence (cf. Vallduví & Engdahl (1996) for a recent review). As far as sentences like those in (3) are concerned, the main difference lies in the fact that SO-sentences are compatible with an unmarked, wide-focus interpretation. This means that

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compatible with the NP will be given. The possibility of assigning nominative case will be omitted if not relevant to the current discussion.

a sentence like (3a) can be used as an out-of-the-blue utterance, or as an answer to a question like ”What’s new?”. A sentence like (3b), in contrast, has to be understood with narrow focus on either the object or the subject. That is, it can be felicitely used as answer to a question like ”Who kissed the small fair woman” or ”Who did the red bear kiss?”, but not as answering a question like ”What’s new?”. In experiments where sentences are presented without a preceding context, that is, as out-of-the-blue utterances, processing disadvantages of OS-sentences in comparison to SO-sentences might simply result from the fact that only the former, but not the latter, are pragmatically licit. Syntactic complexity differences do not have to be invoked under this interpretation. Supporting evidence for such a focus-structure related explanation comes from a self-paced reading experiment by Bader, Meng & Bayer (1999) who investigated the processing of embedded SO- and OS-sentences in either wide or narrow focus contexts. This experiment replicated the processing disadvantage for unambiguous OS-sentences, but only when preceded by a wide-focus context question (”What happened?”). When preceded by a narrow-focus context question, in contrast, no processing differences between SO- and OS-sentences turned up.

With respect to the final finding, namely that accusative case is preferred to dative case in sentences like (4), Bader et al. (1996) have proposed the case preference principles given in (6).

(6) Case Preference Principles

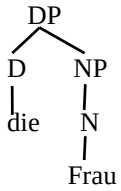
a. Prefer structural Case to lexical Case.

b. Prefer nominative Case to accusative Case.

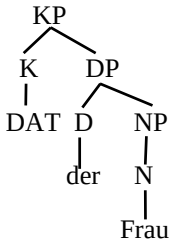
Given that dative case is a lexical case in German whereas nominative and accusative are structural cases, the Case Preference Principles entail that accusative case is preferred to dative case. However, given what is known about the case system of German, principles for preferred case assignments need no extra stipulation but follow from the independently motivated parsing principles of the garden-path theory. First, the subject (nominative) preference implicated by the Case Preference Principles follows from the independently necessary Minimal Chain Principle.

Second, both morphologically and syntactically, dative case is more complex than either nominative or accusative case (cf. Vogel & Steinbach, 1998). There are several ways to capture this increased complexity of dative case. We will adopt here the proposal by Bayer, Bader and Meng (to appear) according to which dative objects, but neither subjects nor accusative marked objects, are contained within an additional structural layer called Kase Phrase. Two sample representations for an accusative object and a dative object are shown in (7a) and (7b), respectively.

(7) a.



b.



Given the syntactic representations shown in (7), the accusative preference found in sentences of the sort shown in (4) simply reduces to a further instance of the Minimal Attachment Principle. Given a phrase which might either be an accusative or a dative object, the HSPM will prefer the accusative analysis because it involves less structure than the alternative dative analysis.[2]

This concludes our review of the SPLT and the garden-path theory. As this review has made clear, both theories can account for the three findings on Dutch and German cited by Gibson (1998). In the remainder of this paper, we will present two experiments which have investigated ambiguous and unambiguous sentence structures on which the SPLT and the Garden-Path Theory make divergent predictions. All sentence structures will involve the contrast between accusative and dative object that was introduced in connection with example (4). Experiment 1 will investigate sentences with the (accusative or dative) object following the subject. Experiment 2 will then extend the findings of Experiment 1 to sentences where the object precedes the subject.

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[2] Alternatively, the grammatical distinction between nominative and accusative case on the one hand and dative case on the other hand might be explained in terms of featural complexity (cf. Meng & Bader, 2000). Such an analysis would still make the first part of the Case Preference Principles superfluous as an independent parsing principle given the generalized ”Minimal Everything Principle” of Fodor & Inoue (1994; 2000).

Experiment 1

Experiment 1 will test ambiguous, unambiguous grammatical, and unambiguous ungrammatical sentences. Ambiguous sentences as in (8a) and (8b) were included to test whether the finding of Bader et al. (1996) that accusative case is preferred to dative case in situations of local ambiguity extends from non-canonical OS word-order to canonical SO word-order.

(8) a. Ambiguous Dative Sentence

Der Lehrer hat Peters Tante-ACC/DAT (während des Gesprächs) widersprochen-DAT.
the teacher has Peters aunt during the conversation contradicted.
"The teacher contradicted Peter's aunt (during the conversation)"

b. Ambiguous Accusative Sentence

Der Lehrer hat Peters Tante-ACC/DAT (während des Gesprächs) unterbrochen-ACC.
the teacher has Peters aunt during the conversation interrupted
"The teacher interrupted Peter's aunt (during the conversation)"

The two sentences in (8) are simple main clauses with unmarked SO word-order and the main verb following the object, which is obligatory in sentences with a composite tense (perfect tense in (8)). The first NP in these sentences is unambiguously marked for nominative case from which it follows that the second NP must be an object. However, since the second NP is morphologically completely case-ambiguous, these sentences contain a local object-object ambiguity which is resolved only at the clause-final participle. In (8a), the clause-final particple assigns dative case to its object; in (8b), it assigns accusative case.

An accusative preference, and therefore a garden-path effect in sentences disambiguated by a dative verb, is predicted by both the SPLT and the garden-path theory. However, the generality of this preference has recently been disputed by Scheepers, Hemforth, & Konieczny (1997). According to Scheepers et al., an accusative preference is only found in sentences of the sort investigated by Bader et al. (1996), that is, sentences where the object has been topicalized to

sentence-initial position. For sentences where the object remains in its canonical VP-internal position, in contrast, the HSPM is claimed to leave the case ambiguity unresolved. Neither in (8a) nor in (8b) should therefore a garden-path effect become visible, and this is what Scheepers et al. (1997) found in an eye-tracking experiment. However, it might well be that Scheeper et al.'s experiment lacked the power to detect the presumably rather small garden-path effect in sentences like (8b). In order to overcome this difficulty, Experiment 1 will use a speeded-grammaticality judgment task, which has proven to be quite sensitive to even small garden-path effects elicited by clause-final disambiguation (cf. Meng, 1997), and it will test a much greater number of participants and sentences. Furthermore, Experiment 1 will test both sentences where the disambiguating clause-final main verb immediately follows the ambiguous object-NP and sentences where this NP is separated from the point of disambiguation by some adverbial modifiers in order to test the claim made by Bader et al. (1996) that the strength of the garden-path effect on encountering a dative-disambiguating verb is a function of the length between case-ambiguous NP and case-assigning verb.

The unambiguous counterparts to the sentences in (8) are shown in (9).

(9) a. <u>Unambiguous Dative Sentence</u>

Der Lehrer hat seiner Tante-DAT (während des Gesprächs) widersprochen-DAT.
the teacher has his aunt during the conversation contradicted.
"The teacher contradicted his aunt (during the conversation continuously)"

b. <u>Unambiguous Accusative Sentence</u>

Der Lehrer hat seine Tante-ACC (während des Gesprächs) unterbrochen-ACC.
the teacher has his aunt during the conversation interrupted
"The teacher interrupted his aunt (during the conversation)"

The sentences in (9) are unambiguous because of the morphological marking of the possessive pronoun that has replaced the proper name in the second NP.[3] Given that the SPLT's account of the accusative preference in sentences of the type shown in (4) relies on the assumption that introducing a dative object into the CPPM incurs more memory load than introducing an accusative object, the predictions of the SPLT with respect to unambiguous sentences as in (9) are straightforward: Sentences with a dative object (9a) should be more difficult to process than sentences with an accusative object (9b). The Garden-Path Theory, in contrast, does not predict a difference between (9a) and (9b). As explained in connection with the unambiguous sentences investigated by Hemforth (1993) (cf. (3)), we assume that the major determinant of processing difficulties in simple, unambiguous SO- or OS-sentences derives from the information structure associated with a particular word-order. Since both sentences in (9) have a SO word-order which makes them unmarked with respect to their information structure, a processing difference between them is not to be expected.

The third and final type of sentences investigated by Experiment 1 are ungrammatical dative and accusative sentences of the sort shown in (10).

(10) a. <u>Ungrammatical Dative Sentence</u>

*Der Lehrer hat seine Tante-ACC (während des Gesprächs) widersprochen-DAT.

the teacher has his aunt during the conversation contradicted.

"The teacher contradicted his aunt (during the conversation)"

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[3] In fact, the determiner of the second NP by itself did not lead to complete morphological disambiguation. The determiner for dative sentences was also compatible with genitive case. However, the use of genitive case to mark the argument of a verb is almost extinct in German. The determiner in an accusative sentence was morphologically also compatible with nominative. However, since the sentences already contained an unambiguously nominative-marked NP, a nominative-interpretation of the second NP was excluded.

b. Ungrammatical Accusative Sentence

*Der Lehrer hat seiner Tante-DAT (während des Gesprächs) unterbrochen-ACC.

the teacher has his aunt during the conversation interrupted

”The teacher interrupted his aunt (during the conversation)”

(10a) and (10b) have been derived from (9a) and (9b), respectively, by exchanging the determiner of the second NP. As a result, (10a) contains the NP seine Tante which is not compatible with the dative feature assigned by the clause final verb widersprechen. In a similar vain, (10b) contains the NP seiner Tante which cannot bear the accusative feature assigned by unterbrochen. Ungrammatical sentences as in (10) are of interest for an evaluation of the SPLT because prior research has shown that sentences with certain types of case violations are falsely accepted as grammatical to a rather high degree (cf. Meng, 1997), and the SPLT has recently been extended to account for the phenomenon of participants erroneously overlooking certain types of ungrammaticalities (cf. Gibson & Thomas, 1999). Gibson & Thomas (1999) propose that a word string together with its syntactic predictions might get forgotten during on-line parsing if this word string is associated with high memory cost. Structural forgetting in the examples considered here might have the effect that predictions with respect to the case required by the clause-final verb get lost, with the consequence that a clause-final verb will be accepted as correctly completing a sentence even if there is a case violation. Since we are not dealing with sentences of particular complexity, the SPLT does not necessarily predict that structural forgetting should occur with ungrammatical sentences as in (10). However, if it occurs, it should affect the word string of a dative object more than the word string of an accusative object given that the former is associated with more memory load than the latter. Therefore, if there are any differences at all, ungrammatical sentences as in (10a) should be erroneously accepted to a higher rate than ungrammatical sentences as in (10b).

The Garden-Path theory itself does not make specific predictions concerning the processing of ungrammatical sentences as in (10). However, we can draw on work by Meng & Bader (2000, to appear) who have found several instances where nominative case is erroneously overridden by dative case but not vice versa. There are several reasons why this should be so. Given that dative case is more complex than nominative case in German (cf. Vogel & Steinbach, 1998), we can assume that the memory trace of a dative NP is more robust than the memory trace of an nominative NP because dative NPs but not nominative NPs might profit from already being interpreted to some degree. This follows from the fact that dative NPs are usually associated with a goal/recipient interpretation whereas nominative NPs are completely unrestricted as to their interpretation. Furthermore, erroneously assigning dative case to a nominative marked NP consists in structure addition whereas in the reverse situation, already created structure has to be withdrawn (cf. (7)), and adding structure seems to generally easier than withdrawing structure (cf. Sturt & Crocker, 1998). For these reasons, the chance of dative erroneously overriding nominative is higher than the chance of nominative overriding dative (for details, cf. Meng & Bader, to appear). Since accusative case is syntactically on a par with nominative case, that is, it is less complex than dative case, we can hypothesize that ungrammatical dative sentences should be more susceptible to be erroneously accepted as grammatical than ungrammatical accusative sentences.

Method

Participants. 72 students of the University of Jena participated in this experiment. All were native speakers of German and naive with respect to the purpose of the experiment. Participants received either 10 DM or course credits for participating in the experiment.

Materials. 72 sentences were constructed, with each sentence appearing in 12 versions according to the three factors case (dative vs. accusative), status (unambiguous vs. ambiguous vs. ungrammatical), and length (short vs. long). All sentences were constructed around unambiguous

sentence pairs as in (9). Sentences always started with a masculine subject-NP that was unambiguously marked for nominative case. The subject NP was followed by the perfect auxiliary hat (has) which in turn was followed by the object-NP. This object NP consisted of a feminine noun preceded by either a definite article or a possessive pronoun. The case marking was always on the determiner (article, possessive pronoun) and never on the noun. This is typical of German where most nouns do not inflect for case. As indicated in (9) by the material in brackets, the object NP was either immediately followed by the clause-final main verb (short sentences), or separated from the main verb by some adverbial modifiers (long sentences). All sentences ended in a participle which assigned either dative or accusative case to its object.

Ambiguous sentences were obtained from unambiguous sentences by replacing the determiner of the object NP with a proper name marked for genitive case (cf. (8)). Since the morphological information concerning the case of the object NP was exclusively provided by the determiner, this manipulation created sentences with a local syntactic ambiguity that was subsequently resolved by the clause-final verb.

Ungrammatical sentences were obtained from unambiguous sentences by switching around the object NPs (cf. (10)). This resulted in sentences where the case-morphology on the object-NP did not match the case assigned by the clause-final participle.

The experimental sentences were divided into 12 sets, each set containing only one version of a sentence and an equal number of sentences in each condition. The resulting lists of experimental sentences were randomly intermixed with 284 filler sentences. A repeated measures design incorporating a Latin square was used. Each subject was exposed to all conditions but saw each experimental sentence only once.

Procedure. This experiment - as well as the following one - was run using the DMASTER software developed by K. Forster and J. Forster at Monash University and the University of Arizona. Participants were seated in front of a computer monitor. They were told that they would be

presented sentences on the screen and that their task was to judge the grammaticality of each sentence as quickly and as accurately as possible. The concept of grammaticality was explained by examples. Participants initiated each trial by pressing a foot-pedal which triggered a fixation point to appear in the center of the screen for 1,050 milliseconds. Thereafter, the sentence appeared on the screen in a word by word fashion with each word appearing at the same position (mid-screen). Each word was presented for 224 milliseconds plus an additional 14 milliseconds for each character to compensate for length effects. There was no interval between words. Immediately after the last word of a sentence, three red question marks appeared on the screen, signaling to the participants that they now were to made their judgment. Participants indicated their judgment by pressing one of two response buttons. They used their dominant hand to indicate that a sentence was grammatical and their non-dominant hand to indicate that it was ungrammatical. If participants did not respond within 2000 ms, a warning line ”zu langsam” (too slow) appeared on the screen and the trial was finished.

Prior to the experimental session, participants received practice trials to ensure that they had understood the task. During the practice trials but not during the experimental session participants received feedback as to the correctness of their judgments.

Results

Judgments. Table 1 shows the percentages of correct responses for Experiment 1. In this and the next experiment, percentages of correct judgments were analyzed with both participants ($F1$) and items ($F2$) as random effects. Three-way ANOVAS (2 cases $\times$ 3 status $\times$ 2 lengths) revealed a significant main effect of case ($F1(1,71) = 85.62$, $p < .001$; $F2(1,71) = 62.30$, $p > .001$), a significant main effect of status ($F1(2,142) = 60.60$, $p < .001$; $F2(2,142) = 86.35$, $p < .001$), and a significant main effect of length ($F1(1,71) = 25.64$, $p = .001$; $F2(1,71) = 33.02$, $p < .001$). Of the four possible interactions, two were significant: the two-way interaction between status and length ($F1(2,142) = 29.14$, $p < .001$; $F2(2,142) = 42.78$, $p < .001$) and the two-way interaction between case and status

($F1(2,142) = 14.35$, $p < .001$; $F2(2,142) = 15.78$, $p < .001$). The two-way interaction between case and length (both F-values less than 1) and the three-way interaction ($F1(2,142) = 2.28$, $p > .1$; $F2(2,142) = 2.17$, $p > .1$) were not significant.

Table 1
Percentage of Correct Judgments for Each of Two Cases (Dative vs. Accusative), Three Status (Unambiguous vs. Ambiguous vs. Ungrammatical), and Two Lengths (Short vs. Long). Standard Errors (by Participants) are Shown in Parentheses.

	Dative			Accusative		
	Unambiguous	Ambiguous	Ungrammatical	Unambiguous	Ambiguous	Ungrammatical
Short	90 (1.5)	81 (2.1)	74 (3.2)	93 (1.3)	94 (1.1)	88 (1.5)
Long	91 (1.4)	82 (2.1)	53 (3.4)	93 (1.3)	92 (1.4)	73 (3.2)

Planned comparisons were conducted to test the hypothesis of interest. (i) Both short and long ambiguous dative sentences received significantly less correct answers than their unambiguous counterparts (short: 81% vs. 90%, $t1(142) = 2.44$, $p < 0.05$; $t2(142) = 2.91$; $p < 0.01$; long: 82% vs. 91%, $t1(142) = 2.32$, $p < 0.05$; $t2(142) = 2.76$, $p < 0.01$). For accusative sentences, in contrast, there was no significant difference between unambiguous and ambiguous sentences. (ii) Both long and short ungrammatical dative sentences were judged worse than the respective ungrammatical accusative sentences (short: 74% vs. 88%, $t1(71) = 5.10$, $p < 0.001$; $t2(71) = 4.35$, $p < 0.001$; long: 53% vs. 73%, $t1(71) = 7.26$, $p < 0.001$; $t2(71) = 6.19$, $p < 0.001$). (iii) Length, finally, had only a significant effect on ungrammatical sentences with short ungrammatical sentences receiving less correct answers than long ones (dative: 74% vs. 53%, $t1(71) = 7.13$, $p < 0.001$; $t2(71) = 8.09$, $p < 0.001$; accusative: 88% vs. 73%, $t1(71) = 5.19$, $p < 0.001$; $t2(71) = 5.89$, $p < 0.001$). All other comparisons involving length were insignificant.

Table 2
Mean Reaction Times (ms) to Make Correct Judgments, for Each of Two Cases (Dative vs. Accusative), Three Status (Unambiguous vs. Ambiguous vs. Ungrammatical), and Two Lengths (Short vs. Long). Standard Errors (by Participants) are Shown in Parentheses.

	Dative			Accusative		
	Unambiguous	Ambiguous	Ungrammatical	Unambiguous	Ambiguous	Ungrammatical
Short	516 (20.5)	590 (24.1)	702 (25.4)	487 (19.7)	491 (21.6)	626 (16.6)
Long	496 (23.1)	646 (30.2)	758 (32.4)	490 (23.6)	468 (21.2)	703 (28.5)

Judgment times. Response times for correct judgments are shown in Table 2. In this and the next experiment, response time data were corrected for outliners in the following way. 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. Response times were analyzed with both participants (F1) and items (F2) as random effects. In the condition ungrammatical, there were some empty cells. Since the reaction time pattern for ungrammatical sentences closely mirrors the pattern provided by the percentages of correct responses and would thus not deliver additional information, these sentences were excluded from the reaction time analysis. Three-way ANOVAS (2 cases × 2 status × 2 lengths) revealed a significant main effect of case ($F1(1,71) = 52.98$, $p < .001$; $F2(1,71) = 20.10$, $p > .001$) and a significant main effect of status ($F1(1,171) = 26.33$, $p < .001$; $F2(1,71) = 32.21$, $p < .001$). The factor length was not significant (both F-values < 1). Of the four possible interactions, two were significant: the two-way interaction between status and case ($F1(1,71) = 31.20$, $p < .001$; $F2(1,71) = 11.39$, $p < .01$) and the three-way interaction between case, status, and length ($F1(1,71) = 6.94$, $p = .01$; $F2(1.71) = 6,25$, $p < .05$). The two-way interactions between case and length and between status and length were not significant (all p's > .1).

Planned comparisons revealed the following: (i) The factor ambiguity affected dative sentences with ambiguous sentences needing more time to be judged as grammatical than unambiguous sentences (short: 516ms vs. 590ms, $t1(142) = 3.69$, $p < 0.001$; $t2(142) = 2.47$; $p < 0.05$; long: 496ms vs. 646ms, $t1(142) = 7.48$, $p < 0.001$; $t2(142) = 5.95$, $p < 0.001$). Accusative sentences, in contrast, were not affected by ambiguity. (ii) The factor length only had an effect on ambiguous dative sentences with short sentences needing less time than long sentences (590ms vs. 646ms, $t1(142) = 2.41$, $p < 0.05$; $t2(142) = 2.00$; $p < 0.05$).

Discussion

Experiment 1 yields three major results. First, it has shown that the accusative preference found by Bader et al. (1996) is not confined to sentences where the object has been topicalized. Contrary to the claims of Scheepers et al. (1997), such a preference also holds in sentences where the object is located in its canonical VP-internal position. Furthermore, Experiment 1 has found evidence for the claim that the strength of the garden-path effect occurring on encountering a dative verb increases with the distance between the point where the ambiguity first arose and the point of disambiguation, although this increase was a slight one and only visible in the reaction times. This part of the results is predicted by both the SPLT and the Garden-Path Theory.

In contrast to the findings on ambiguous sentences, the results obtained for unambiguous grammatical and ungrammatical sentences were predicted by the Garden-Path theory but not by the SPLT. Unambiguous grammatical sentences did not show the processing disadvantage for dative sentences in comparison to accusative sentences that was predicted by the SPLT. Instead, as expected under the Garden-Path Theory, the two types of unambiguous grammatical sentences did not differ from each other.

For ungrammatical sentences, finally, the results show a higher error rate for ungrammatical dative sentences than for ungrammatical accusative sentences. This contradicts Gibson & Thomas' (1999) extension of the SPLT to errors occurring with ungrammatical sentences because sentences

with purported greater memory load (dative sentences) caused less structural forgetting than sentences with less memory load (accusative sentences). Based on earlier findings by Meng & Bader (2000, to appear) that a more complex case might override a less complex one but not vice versa, the Garden-Path theory, in contrast to the SPLT, predicted the results we have obtained for ungrammatical sentences. Accusative case is less complex in German than dative case. Therefore, the memory trace of a dative NP is more durable than the memory trace of an accusative NP which implies that a mismatching dative feature is less likely to be overlooked than a mismatching accusative feature. Under this account, the effect of sentence length also follows straightforwardly, because the strength of a memory trace will have decayed more in longer than in shorter sentences.

In sum, Experiment 1 has not found the relationship between syntactic ambiguity resolution and the processing of unambiguous sentences that the SPLT claims to hold. We now turn to Experiment 2 in order to test whether the conclusions obtained from SO-sentences will be corroborated when corresponding OS-sentences are investigated.

Experiment 2

Experiment 2 will compare two types of object-before-subject sentences, i.e. sentences in which the object has been moved to the left of the subject: Sentences where the object bears dative case and sentences where the object bears accusative case. Both unambiguous and ambiguous sentences will be tested. A sample unambiguous sentence pair is given in (11).

(11) a. <u>Unambiguous Dative Sentence</u>

Ich weiß, daß dem Sohn-DAT (nur) die Tante geholfen hat-DAT.

I know that the son (only) the aunt helped has

”I know that (only) the aunt helped the son.”

b. Unambiguous Accusative Sentence

Ich weiß, daß den Sohn-ACC (nur) die Tanten unterstützt haben-ACC.

I know that the son (only) the aunts supported have

”I know that (only) the aunts supported the son.”

The sentences in (11) contain an embedded verb-final clause with OS word-order. In (11a), the clause initial object dem Sohn is morphologically marked for dative case. In (11b), the object den Sohn is marked for accusative case. As indicated in (11) by the focus particle in brackets, Experiment 2 will not only test the influence of different case markings, but also the influence of whether the marked focus-structure associated with OS-sentences is reinforced by an overt focus-marker or not.

The SPLT and the garden-path theory differ in their predictions they make for sentences as in (11). As reviewed in the introduction to this article, the SPLT claims that the accusative preference in ambiguous sentences stems from dative case imposing a greater memory load than accusative case because a dative NP leads to the prediction of an additional accusative NP whereas the reverse does not hold. Applying this kind of reasoning to the sentences in (11), we arrive at the prediction that unambiguous dative-first sentences like (11a) should be more difficult to process than unambiguous accusative-first sentences like (11b).

With respect to the focus-structure manipulation, the SPLT predicts that sentences where the second NP is preceded by a focus particle should be easier than sentences where it is not. This prediction derives from a refinement of the SPLT proposed by Warren and Gibson (1998). According to Warren and Gibson (1998), processing a focused NP is less costly than processing an unfocused NP because focused entities are more accessible in the discourse than nonfocused entities and therefore require less processing resources.

What predictions does the Garden-Path theory make for unambiguous OS-sentences? As explained when discussing example (3), OS-sentences are associated with a marked focus-structure

where the subject is narrowly focused. This marked focus-structure is - according to our hypothesis - responsible for the fact that OS-sentences often show increased processing difficulty. Introducing a focus-particle in front of the subject, which overtly signals the narrow focus on the subject, should reduce the increased processing load caused by focus-structure markedness. Sentences with a focus particle should therefore be easier to process than sentence without one. With respect to case, we get the further prediction that, if there are any processing differences at all between unambiguous accusative and dative sentences, sentences with an accusative object should lead to poorer performance than sentences with a dative object. This is so because, as shown by Experiment 1, the memory trace of a dative NP is stronger than the memory trace of an accusative NP. While this difference did not affect unambiguous SO-sentences of the type investigated in Experiment 1, an effect on OS-sentences might show up given that such sentences are already somewhat difficult to process due their marked focus-structure. In particular, when processing an OS-sentence with an accusative object the HSPM might get confused, if the accusative marking is no longer visible, whereas an OS-sentence with a dative-object might be exempt from such problems. Furthermore, given that nominative and accusative NPs are syntactically rather similar, they might show some syntactic interference (cf. Lewis, 1999). Due to their greater syntactic distance, nominative and dative NPs should show no, or at least less, interference.

The locally ambiguous counterparts of the sentences in (11) are shown in (12). The sentences in (12) differ from the sentences in (11) only in that the first NP has been replaced by a proper name. Since proper names are lexically ambiguous between nominative, accusative and dative case, the sentences in (12) allow for a SO-structure until the clause final verbs are processed.

(12) a. <u>Ambiguous Dative Sentence</u>

Ich weiß, daß Eva-NOM/ACC/DAT (nur) die Tante-NOM/ACC geholfen hat-DAT.

I know that Eva (only) the aunt helped has

”I know that (only) the aunt helped Eva.”

b. Ambiguous Accusative Sentence

Ich weiß, daß Eva-NOM/ACC/DAT (nur) die Tanten-NOM/ACC unterstützt haben-ACC.

I know that Eva (only) the aunts supported have

”I know that (only) the aunts supported Eva.”

By including ambiguous sentences of the sort shown in (12), it becomes possible to inquire into the relationship that might hold between memory load in unambiguous sentences and processes of second-pass parsing, or reanalysis. According to the SPLT, the HSPM is a parallel mechanism that computes all possible syntactic structures when encountering a local syntactic ambiguity. These structures are ranked according to the memory load they incur, with the structure incurring least memory load ranked highest.[4] A garden-path effect occurs if disambiguation is not towards the most highly ranked syntactic structure. Furthermore, it is assumed that the strength of a garden-path effect increases with the memory load difference between the highest ranked structure and the structure ultimately needed at the point of disambiguation. For sentences as in (12), the SO-structure will be ranked highest, the OS-structure with an accusative object will be ranked below the SO-structure, and the OS-structure with a dative object will be ranked lowest. Disambiguation in favor of an OS-structure is therefore expected to lead to a garden-path effect which should be more severe in dative than in accusative sentences. By the same reasoning, the SPLT makes the further prediction that sentences with a focus-particle should cause a weaker garden-path effect than sentences without such a particle.

In contrast to the SPLT, the garden-path theory is a serial theory of the HSPM. Only a single structure is computed when encountering a local ambiguity. If the structure computed on first-pass parsing is contradicted by later input-material, processes of reanalysis have to be invoked in order

to arrive at the ultimately correct structure. As recent research within the framework of serial parsing has made clear, processes of reanalysis have to be broken down into a diagnostic component and a revision component (e.g., Fodor & Inoue, 1998). With respect to both components, it is predicted that dative sentences as in (12a) should be more troublesome than accusative sentences as in (12b). With respect to revision, Bader, Meng & Bayer (2000) have shown that, when ease of diagnosis is held constant, assigning dative case on second-pass parsing is more difficult than assigning accusative case. With respect to diagnosis, the correct syntactic structure might be easier to diagnose in accusative sentences than in dative sentences because the obligatory agreement between subject and verb might give the HSPM a direct hint as to what the subject is in accusative sentences. In dative sentences, in contrast, diagnosing the correct OS-structure has to rely on a more complex chain of inferences, taking into account both that the second NP is not compatible with dative case and therefore cannot function as dative object, and that the first NP is unmarked for case and therefore can be assigned dative case.

Method

Participants. 40 students of the University of Jena participated in this experiment. All were native speakers of German and naive with respect to the purpose of the experiment. Participants received either 5 DM or course credits for participating in the experiment.

Materials. 40 sentences were constructed. Each sentence appeared in eight versions according to the factors case (dative vs. accusative), ambiguity (unambiguous vs. ambiguous), and focus particle (with vs. without focus particle). All sentences consisted of a main clause followed by an

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[4] When the memory-load difference between a lower-ranked structure and the highest-ranked structure gets too great, the lower-ranked structure will not be elaborated further on (pruning). By judging from the examples discussed in Gibson (1998), the memory load differences holding in the sentences under consideration do not seem to be great enough to lead to such a pruning.

embedded clause. All main clauses were of the type Ich glaube (I believe), Ich habe gehört (I have heard), Jemand hat gesagt (Someone has said), or something similar. All experimental manipulations were confined to the embedded clause. The embedded clause always consisted of the complementizer daß (that), an object NP, a subject NP, and a verbal complex made up of a participle and an auxiliary verb. In unambiguous sentences, the first NP was always a masculine NP (cf. (11)) which contained a form of the definite article. This made the whole NP unambiguously marked for either dative case or accusative case. The second NP was a feminine NP also containing a definite article and morphologically compatible with either nominative or accusative case. In sentences with a dative object, the second NP was a singular NP; in sentences with an accusative object, the singular NP was a plural NP. Some of the second NPs also contained an adjective like neue (new) in order to enhance semantic plausibility. The second NP was either introduced by a focus particle (e.g. nur (only), auch (also)) or not.

Ambiguous sentences were created from unambiguous sentences by replacing the first NP with a proper name (cf. (12)). In all other respects, ambiguous sentences were identical to unambiguous sentences. Proper names in German are morphologically ambiguous between nominative, accusative, and dative case. Up to the clause-final verb, ambiguous sentences therefore allowed a reading with the first NP as subject and the second NP as accusative object. In dative sentences, disambiguation was achieved by the main verb: Of the two NPs in sentences like (12a) only the first NP, the proper name, is morphologically compatible with dative case. In accusative sentences, disambiguation was effected by the number marking on the finite auxiliary due to the obligatory number agreement between subject and finite verb.

The experimental sentences were divided into 8 sets, each set containing only one version of a sentence and an equal number of sentences in each condition. The resulting lists of experimental sentences were randomly intermixed with 132 filler sentences. A repeated measures design incorporating a Latin square was used. Each subject was exposed to all conditions but saw each experimental sentence only once.

Procedure. The same speeded grammaticality judgment procedure was used as in Experiment 1.

Results

Table 3
Percentage of Correct Judgments for Each of Two Cases (Dative vs. Accusative), Two Ambiguities (Unambiguous vs. Ambiguous), and Two Focus Particles (With vs. Without Focus Particle). Standard Errors (by Participants) are Shown in Parentheses.

	Dative		Accusative	
	Unambiguous	Ambiguous	Unambiguous	Ambiguous
- Focus Particle	85 (2.7)	40 (4.5)	70 (4.1)	55 (4.8)
+ Focus Particle	87 (2.7)	40 (4.6)	83 (3.0)	67 (4.3)

Judgments. Table 3 shows the percentages of correct responses for Experiment 2. Three-way ANOVAS (2 cases × 2 status × 2 focus particles) revealed a significant main effect of ambiguity ($F1(1,39) = 84.33$, $p < .001$; $F2(1,39) = 131.01$, $p > .001$) and a significant main effect of focus particle ($F1(1,39) = 6.16$, $p < .05$; $F2(1,39) = 5.40$, $p < .05$). The main effect of case was only marginal significant in the subject analysis but significant in the item analysis ($F1(1,39) = 3.47$, $p > .1$; $F2(1,39) = 4.44$, $p < .05$). Of the four possible interactions, two were significant: the two-way interaction between case and ambiguity ($F1(1,39) = 36,49$, $p < .001$; $F2(1,39) = 65,82$, $p < .001$) and the two-way interaction between case and focus-particle ($F1(1,39) = 14,91$, $p < .001$; $F2(1,39) = 11,82$, $p < .01$). The two-way interaction between ambiguity and focus particle and the three-way interaction were not significant (all F-values less than 1).

Planned comparisons were conducted in order to test for the various predictions summarized in the introduction to Experiment 2. (i) The factor focus particle had an effect on accusative sentences in that sentences with a focus particle received more correct answers than sentences without a focus particle (unambiguous: 83% vs. 70%, $t1(39) = 2.91$, $p < .01$; $t2 = 2.71$, $p < .01$; ambiguous: 67% vs.

55%, t1(39) = 2.60, p < .05; t2(39) = 2.45, p < .05). Dative sentences were not affected by the factor focus particle (all t-values less than 1). (ii) The factor case had an effect on both types of ambiguous sentences with dative sentences receiving fewer correct answers than accusative sentences (with focus particle: 40% vs. 83%; t1(39) = 4.60, p < .01; t2(39) = 5.22, p < .05; without focus particle: 40% vs. 70%, t1(39) = 2.53, p < .05; t2 = 2.85, p < .01). For unambiguous sentences, case had only an effect on sentences without a focus particle with dative sentences receiving more correct answers than accusative sentences (85% vs. 70%, t1(39) = 2.98, p < .01; t2 = 3.38, p < .01). Unambiguous sentences with a focus particle, in contrast, did not significantly differ from each other (87% vs. 83%, both t-values < 1). (iii) The factor ambiguity, finally, had an effect on all sentence types in that all ambiguous sentences were judged worse than their respective unambiguous counterparts (all p's < 0.05).

Table 4
Mean Reaction Times (ms) to Make Correct Judgments

	Dative		Accusative	
	Unambiguous	Ambiguous	Unambiguous	Ambiguous
- Focus Particle	692 (43.4)	874 (61.4)	745 (47.7)	1028 (57.9)
+ Focus Particle	621 (38.5)	829 (66.5)	745 (54.7)	927 (45.5)

Judgment times. Response times for correct judgments are shown in Table 4. Outliners were treated as above. Less than 5% of the response times were replaced by this criterion. Given the rather low performance for ambiguous sentences, the analysis of the reaction time data was beset with the problem of empty cells. For an analysis of the complete design, it would have been necessary to exclude 16 subjects and 9 sentences from the analysis in order to remove all empty cells. The reaction time analysis was therefore restricted to the question of whether the factor focus particle had an effect on dative sentences or not. By collapsing across unambiguous and ambiguous dative sentences, analyses with all subjects and all sentences were possible. In the subject analysis,

the factor focus particle was marginally significant, in the item analysis it was significant ($F1(1,39) = 2.92$, $p < .1$; $F2(1,39) = 4.38$, $p < .05$).

Discussion

The main results of Experiment 2 can be summarized as follows. (i) Unambiguous sentences were easier to process when the clause initial noun phrase was marked for dative case than when it was marked for accusative case, and when the marked OS-structure was supported by a focus particle. That the focus-structure manipulation had only a very slight influence on unambiguous dative sentences can probably be considered a ceiling effect given that such sentences where judged rather accurately even in the absence of a focus particle. (ii) Ease of reanalysis in locally ambiguous sentences was also affected by both the case on the object and the absence versus presence of a focus particle. Sentences with a dative object preceding the subject led to a much stronger garden-path effect than sentences with an accusative object. Furthermore, the strength of the garden-path effect was reduced by the insertion of a focus particle, substantially for accusative sentences and slightly for dative sentences.

What conclusions does this pattern of results allow with respect to the two theories under consideration? The SPLT correctly predicted that dative disambiguation should lead to a stronger garden-path effect than accusative disambiguation and that inserting a focus particle should result in a weaker garden-path effect. However, when considered in relation to the results on unambiguous sentences, only the latter finding can be taken as supportive for the SPLT. The presence of a focus particle reduces memory load in both ambiguous and unambiguous sentences, and both sentence types are therefore easier to process when containing such a particle. Case, in contrast, affects ambiguous and unambiguous sentences differentially. In unambiguous sentences, dative case is easier to process, in ambiguous, it is harder. This pattern of results - the focus-structure manipulation affecting ambiguous and unambiguous sentences in the same direction, the case

manipulation in opposite directions - shows that there is no simple relationship between memory load in ambiguous and unambiguous sentences, contrary to what is claimed by the SPLT.

In contrast to the SPLT, the Garden-Path Theory is supported by the results of Experiment 2. First, the Garden-Path Theory correctly predicted that ambiguous and unambiguous sentences with focus-particle should be easier to process than sentences without such a particle. Second, it also predicted that unambiguous dative sentences should be easier to process than unambiguous accusative sentences whereas the reverse relation should hold for ambiguous sentences. With respect to ambiguous sentences, finally, the Garden-Path theory correctly predicted that dative sentences should cause a stronger garden-path effect than accusative sentence. This prediction could be derived from considerations regarding ease of diagnosis or ease of revision. A decision between a diagnosis and a revision account, which are not mutually exclusive, is not possible on the basis of the results of Experiment 2.

General Discussion

This paper has presented two experiments which tested the claim made by Gibson's (1998) SPLT that in German sentences with a local ambiguity between accusative and dative case, accusative case is preferred because it causes less memory load than dative case. Experiment 1 confirmed the existence of an accusative preference in sentences where there is only an ambiguity between accusative and dative case. However, when the purported memory load difference between accusative and dative case was tested in a range of other constructions, the predictions of the SPLT consistently failed. (i) For unambiguous grammatical sentences, there was either no difference between accusative and dative sentences (SO-sentences, Experiment 1), or accusative sentences were significantly harder to process than dative sentences (OS-sentences, Experiment 2). (ii) The errors seen on ungrammatical sentences in Experiment 1 look like an instance of structural forgetting in the sense of Gibson & Thomas (1999), but the difference found between ungrammatical dative and ungrammatical accusative sentences was in the opposite direction as the

one predicted by the SPLT. (iii) With respect to processes of second-pass parsing or reanalysis, finally, Experiment 2 revealed a stronger garden-path effect for dative than for accusative sentences, which contradicts the SPLT's claim that increasing the memory load difference between preferred and unpreferred structure should increase the strength of the garden-path which results when disambiguation is toward the unpreferred structure.

In sum, the accusative preference originally reported by Bader et al. (1996) presents an instance where an ambiguous string is preferentially assigned an analysis which, when unambiguously signaled by morphological means, is either equal or more difficult to process than the competing analysis. This allows the conclusion that memory load does not play the role for processes of syntactic ambiguity resolution ascribed to it by the SPLT: Preferences seen on first-pass parsing do not (generally) follow from the HSPM's desire to minimize memory load.

In contrast to the SPLT, the Garden-Path Theory can give a unified explanation of the results presented in this paper when augmented by certain assumptions which are independently necessary to account for a broad range of findings on parsing German sentences. A first set of assumptions, which concern the grammar of case, derives from the fact that dative case is a more complex case in comparison to accusative case, as captured by the postulation of a Kase Phrase for dative NPs but not for accusative NPs (cf. Bayer et al., to appear). (i) The mere fact that dative case is associated with a more complex representation within the CPPM than accusative case already accounts for the accusative preference in ambiguous sentences given the Minimal Attachment Principle of the Garden-Path theory. (ii) By augmenting the representational assumptions about case with assumptions concerning the strength of memory traces, an explanation is provided for the better performance on unambiguous OS-sentences with a dative object than on unambiguous OS-sentences with an accusative object. (iii) The same assumption also accounts for the asymmetry in ungrammaticality detection. (iv) With respect to the last finding involving case, namely that ambiguous dative OS-sentences caused a stronger garden-path effect than ambiguous accusative OS-sentences, two independent, non-exclusive accounts are possible, either in terms of revision

difficulty or in terms of diagnosis. On the basis of the results found in Experiment 2 a decision between these accounts is not possible.

Besides the grammar of case, the notion of information structure plays an important role when considering different word-orders in German. In particular, OS-sentences of the kind investigated in this paper give rise to marked information structures in that they require narrow focus on the subject. As shown in other work on parsing German OS-sentences (cf. Bader et al., 1999), the marked focus-structure of OS-sentences leads to an increased processing load if not supported by special discourse contexts. As shown in the present work, signaling the existence of a marked focus-structure by overt means, namely the presence of a focus-particle, does also decrease the processing load otherwise associated with OS-sentences. Furthermore, there is an aspect of the results obtained in Experiment 1 and Experiment 2 not yet discussed which also allows for an explanation in terms of focus-structure properties. This aspect pertains to the fact that the garden-path effects observed in Experiment 2 were much stronger than those observed in Experiment 1. This follows if, as argued by Bader & Meng (1999), the need to compute a marked focus-structure on second-pass parsing leads to a more difficult reanalysis than the computation of an unmarked focus-structure.

In concluding, we should ask what general lesson one might learn from the SPLT's failure to account for the relationship that the two experiments reported in this paper have shown to hold between processing load in unambiguous sentences and processes of syntactic ambiguity resolution. The SPLT is a theory which tries to account for a wide variety of processing phenomena by a single notion of resource-boundedness. However, the processing differences between accusative and dative case that were the focus of the present paper do not seem to lend themselves to a description in terms of resource consumption. While a phrase marked for dative case is structurally somewhat more complex than a phrase marked for accusative case - due to the presence of a Kase Phrase in the former but not in the latter - this does not seem to make much of a difference with respect to the resources needed to compute and maintain theses phrases. Instead, what is going on in the sentences

under consideration here can be described as follows. When the parser has a choice between accusative and dative case, it will choose accusative case because it is representationally less complex than dative case. However, when case is signaled overtly, the higher representational complexity of dative case leads to a more robust memory representation, and therefore to an advantage of dative in comparison to accusative case. In sum, our results point to the conclusion that the notion of resource boundedness is a much less important notion than assumed by theories like those of Gibson (1998), and that instead more weight should be given to the more traditional notion of working memory, according to which sentence comprehension leads to memory traces that are subject to decay and interference (for similar conclusions, cf. Lewis, 1999; Towse, Hitch, & Hutton, 1999).

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