Abstract

In psycholinguistics, there is an ongoing debate over whether empty categories are freely generated by Move α and then filtered out by grammatical constraints on empty categories, or whether illicit representations are never generated in the first place. One central line of evidence for the overgenerate-and-filter view derives from the sentence matching task which shows strong effects of local grammatical violations but no effects of non-local ones. This paper presents results from sentence matching experiments on German to investigate how grammatical constraints on empty categories are implemented in the parser. We found that ungrammatical sentences involving agreement errors, illegal null subjects and verb placement errors in embedded clauses yielded significantly longer reaction times than the control sentences, but that Verb-second violations were cost-free in the sentence matching task. This finding provides new evidence for the overgenerate-and-filter view. Specifically, we will argue that sentence matching is accomplished on the basis of a representation which does not include operator–variable binding.

1. Introduction

Much of the experimental evidence concerning syntactic processing indicates that the parser uses phrase-structure rules or templates at early stages of syntactic
analysis. Frazier and Fodor (1978), for example, have argued that parsing is carried out in two stages. In the first stage, the preliminary phrase packager attempts to group lexical items into phrasal or clausal units, and in the second stage, the parser decides how these units are related. Many other investigators have also proposed sentence-processing systems in which the processor’s first analysis involves computing phrase-structure representations (cf. the overview in Goodluck and Rochemont 1992).

Recent syntactic theory has moved away from positing specific phrase-structure rules or templates towards describing syntactic constructions in terms of general grammatical constraints or principles, for example constraints on empty categories in sentences. This holds in particular for Chomsky’s Government and Binding (GB) framework (cf. Chomsky 1981, 1986) which is composed of such principles and in which construction-specific rules such as “tough-movement” or “raising” are theoretically irrelevant. Rather, GB-theory postulates a relatively free process (“Move α”) which allows constituents to move, leaving an empty element behind. Ungrammatical structures generated by Move α are assumed to be filtered out by various grammatical constraints on empty categories which operate on the output of Move α. How are grammatical constraints on empty categories implemented in the parser? Is there any evidence that the parser uses constraints on empty categories to filter out overgenerated syntactic structures? Does the parser generate intermediate levels of processing that are comparable to the output of Move α?

In psycholinguistic research, there is some controversy with respect to these questions. On one view, the effects of constraints on empty categories are taken to result from the structure of the parser itself (cf. Fodor 1989). This entails that constraints are used immediately on-line because they are part of how the parser operates and locates gaps. Moreover, in contrast to Move α in GB-theory, the parser never posits empty categories in positions where they would be ungrammatical. We may call this the indirect implementation hypothesis of grammatical constraints. On the second view, constraints function as filters in sentence processing, similarly to their role in syntactic theory (cf. Freedman and Forster 1985; Clifton and Frazier 1989). It is argued that the parser can posit an empty category in any position but that at a later stage of syntactic processing, constraints filter out ungrammatical structures. We may call this the direct implementation hypothesis because grammatical constraints on empty categories are taken to apply directly in sentence processing.

In several studies, Ken Forster and his colleagues have presented results from sentence-matching experiments which they interpret in support of the direct implementation hypothesis: constraints on empty categories are used late in processing and they filter out ungrammatical structures which were previously overgenerated by the parser. In their task, subjects were presented with two identical sentences from a computer screen and were then required to decide as
quickly as possible whether these sentences were the same or whether they were different, as in (1).

(1) WHO DID THE DUKE SELL A PORTRAIT OF?
WHO DID THE DUCHESS SELL A PORTRAIT OF?

The idea behind this experiment is that the presence of structure in the input sentence facilitates the same–different decision. For example, in cases where there is no sentential representation to compare, such as in word scrambles, response times are much longer than for grammatical sentences. Therefore, performance in sentence-matching tasks provides a way of determining the availability of structural representations in sentence processing. Forster and his colleagues used the sentence-matching technique to investigate the processing costs associated with constraints on \textit{wh}-movement in English, such as the Specified Subject Condition (cf. Chomsky 1981). They found no such processing costs for violations of these constraints despite evidence that other types of ungrammatical yield significant costs with the same task. They argued that the matching process is completed before binding of the \textit{wh}-operator is carried out, so that constraints on operator–variable binding do not operate during the matching process. According to their interpretation this finding provides evidence for the direct implementation hypothesis.

However, Forster’s and his colleagues’ sentence-matching experiments and the conclusions drawn from these experiments have been criticized in several studies. On the basis of a set of sentence matching experiments, Crain and Fodor (1987) argued that the matching task is not sensitive to properties of specific substages of sentence representation. In a review of the experimental literature on sentence matching, Stowe (1992) finds many contradictory results and concludes that any claims based on sentence matching results about the structure of the parser and about how levels of syntactic representation are implemented are premature. Furthermore, previous sentence-matching studies focused on syntactic phenomena, particularly on \textit{wh}-question formation, in just one language: English. Strictly speaking, the sentence-matching results tell us something about \textit{wh}-question formation in English, namely that the sentence-matching task seems to be insensitive to ill-formed \textit{wh}-questions. One might wonder, however, whether the observed sentence-matching effects are restricted to this kind of syntactic construction or whether they hold more generally for violations of constraints on empty categories.

The purpose of the present paper is to demonstrate that the sentence-matching effects found for \textit{wh}-question formation in English can be generalized to other cases of operator–variable binding and to languages other than English. Thus, the sentence-matching effects are neither construction-specific nor language-specific. We will interpret this finding as support for the direct implementation hypothesis. The linguistic focus will be on the properties of verb placement, particularly
the phenomenon of generalized Verb-second (V2). According to the standard GB-analysis of V2 (cf. for example Grewendorf 1988, among others), the finite verb must raise to the Comp-position in main clauses due to Comp hosting a finiteness operator ([+F]) which must bind a variable. Thus, if the matching process is completed before operator–variable binding, we would expect that, similar to Specified Subject Condition violations in English wh-questions, ungrammatical German sentences in which the operator [+F] cannot properly bind a variable should produce a reverse grammaticality effect, that is, they should not yield any processing costs in the sentence-matching task. In addition to the study of verb placement, we will present sentence-matching results on subject–verb agreement and compare our findings with corresponding results from English.

To preview, our findings indicate that the matching task is sensitive to various kinds of clause-bound grammatical processes, such as subject–verb agreement, the presence or absence of lexical subjects and phrase-structure properties, but that it is insensitive to constraints on operator–variable binding. Similar to the sentence-matching results on wh-movement, our results indicate that the matching task does not interfere with operator–variable binding in cases of generalized V2. We will argue that this supports the direct implementation hypothesis.

2. Sentence matching in English

In this section, we will briefly summarize the results of previous sentence-matching experiments on English which were taken to indicate that sentence-matching provides a way of determining how grammatical constraints and principles are implemented in the parser.

Freedman and Forster (1985) were the first to use results from sentence-matching experiments to support the view that grammatical constraints on empty categories function as a filter in syntactic processing. They used sentences as in (1) and to encourage the subjects to read each sentence from left to right, a delay of 2 seconds was introduced between the first sentence and the second. To make sure that the subjects were in fact performing the task accurately, half of the items contained a different pair of words, as in (2). In the data analysis, however, only the “same” items (= [1]) were included.

(2) WHO DID THE DUCHESS SELL A PORAIT OF?
    WHO DID THE DUCHESS BUY A PORAIT OF?

Freedman and Forster found that in cases where there is no sentential representation to compare (cf. [3]) response times are much longer than for grammatical sentences. Furthermore, they found that agreement errors (4a), illegal quantifier placements (4b), illegal VP-movement (4c) and combinations of two well-formed
phrases not forming a well-formed sentence (= 4d) caused significant increases in sentence-matching times compared to fully grammatical control sentences. These results were taken to indicate that the matching task is sensitive to ungrammaticality and that ungrammaticality leads to longer sentence-matching times.

(3) DID PORTRAIT THE A SELL WHO DUCHESS OF?
DID PORTRAIT THE A SELL WHO DUCHESS OF?

(4) a. *Mary were writing a letter to her husband.
b. *The baby ate up his cereal all.
c. *To go to Disneyland John wanted.
d. *The girl behind you the subsequent discussion.

However, Freedman and Forster also discovered an exception to this ungrammaticality effect: violations of the Specified Subject Condition (cf. [5a]) and Subjacency (cf. [5b]) did not show any associated processing costs in sentence-matching.

(5) a. *Who did you see Leonardo's painting of t?
b. *Who do the police believe [NP the claim that [S John shot t]]?

(5a) is ruled out by the Specified Subject Condition: since the subject Leonardo intervenes, the wh-element in Spec of Comp and the trace cannot form a legal A-chain. (5b) is ruled out by Subjacency: here, wh-movement is illegal because it crosses two bounding nodes, NP and S. Due to the ungrammaticality of (5a) and (5b) one would expect that no complete structural description is available for these sentences and that they therefore yield longer sentence-matching times than grammatical control sentences. However, what Freedman and Forster found was that the sentence-matching task was insensitive to the ungrammaticality of these sentences, that is, constraint violations did not show any associated processing costs in making the sentence-matching decision.

In order to explain the lack of costs in sentences such as (5) and the ungrammaticality effects in cases such as (4), Freedman and Forster argued that there is a level of syntactic processing, basically identical to S-structure in GB-theory, at which agreement violations and illegal word-order patterns, as in (4), are ungrammatical, but at which constraint-violation sentences as in (5) have a fully grammatical representation, and that the matching process has access to this intermediate stage of sentence processing. The fact that the constraint-violations in (5) are later marked as ungrammatical is irrelevant to sentence-matching times.

Similar effects were found by Crain and Fodor (1987): violations of the Specified Subject Condition and Subjacency did not result in different sentence-matching times when compared with grammatical control sentences, but other kinds of ungrammaticality, such as agreement and word order errors, yielded
significantly longer reaction times. Thus, Crain and Fodor replicated the results of Freedman and Forster (1985), but their explanation of the facts is different. Crain and Fodor suggested that the variable controlling processing costs in sentence matching is not well-formedness but correctability: when confronted with ungrammatical sentences subjects correct such items to the nearest well-formed sentence, and this results in confusion in the same-different matching decision. The correctability account is, however, controversial (cf. Forster and Stevenson 1987 and Stowe 1992), and there are some results from sentence-matching experiments which cannot be easily handled by Crain and Fodor’s theory, for example, Forster and Stevenson’s finding that sentence-matching times are shorter for phrase-structure scrambles (cf. [4c]) than for word scrambles (cf. [3]). Phrase-structure scrambles are easier to correct than word scrambles. Thus, if correctability was the crucial variable in sentence-matching, reaction times for items such as (4c) should be higher than for items such as (3c). Forster and Stevenson found that the reverse holds: sentence-matching times are higher for word scrambles than for phrase-structure scrambles, which indicates that sentence-matching is affected by the degree of ungrammaticality rather than by correctability. In the discussion of our sentence matching findings on German, we will come back to the issue of correctability.

Further evidence for the idea that variables have not yet been bound to wh-operators at the level of representation at which sentence matching takes place comes from Stevenson (1984) (reported in Forster 1987) who tested sentences such as those in (6):

(6)  
   a. What did the mayor order them to unfurl it?  
   b. Who did the mayor order them to unfurl it?  
   c. The mayor ordered them to unfurl it.  
   d. The mayor ordered them to unfurl her.

Stevenson found a significant plausibility effect of 65 ms (milliseconds) for sentences without wh-elements; the mean reaction times for items such as (6c) were 1,353 ms and for items such as (6d) 1,418 ms. For the sentences containing wh-elements, however, no such plausibility effect was found; the mean reaction time for items such as (6a) was 1,523 ms versus 1,518 for items such as (6b). This result provides evidence for the claim that wh-operator binding has not yet occurred at the level of representation at which sentence matching takes place, since otherwise one would expect plausibility effects in wh-sentences similar to those in sentences without wh-elements.

Stevenson’s study also shows that the sentence matching task is not insensitive to binding in general, but only to wh-operator binding, that is, to cases in which one of the elements is moved. If, however, the antecedent and the anaphoric element are both in their base-generated positions as in (7a) and (7b), then the expected ungrammaticality effect occurs: items such as (7a) produced a
significant increase in matching times of 93 ms compared with the grammatical control (7b):

(7)  
   a. *John smiled for he knew herself to be innocent.
   b. John smiled for he knew himself to be innocent.

Forster and Stevenson (1987) provide similar evidence from a sentence matching experiment using subcategorization violations:

(8)  
   a. *Who did John disappear during the party?
   b. *John disappeared Mary during the party
   c. *Who did Harry believe that John liked Bill?

Subcategorization violations in declarative sentences such as those in (8b) yielded significantly higher sentence matching times than the corresponding grammatical sentences. However, there was no effect of ungrammaticality in items such as (8a) and (8c), which contain \textit{wh}-elements. These results indicate that \textit{wh}-sentences have a fully grammatical representation at the point at which sentence matching is performed and that \textit{wh}-operator binding (by which [8a] and (8c) are marked as ungrammatical) is a subsequent process.

In contrast to previous studies, Eubank (1992, 1993) has argued that the sentence matching task is sensitive to Specified Subject Condition violations in English. He uses items in which \textit{wh}-movement was held constant, while the effects of three kinds of structural positions of "specified subjects" were examined:

(9)  
   a. Who did the brother see a picture of t?
   b. Who did Bob's brother see a picture of t?
   c. *Who did the brother see Bob's picture of t?

The mean reaction times for items such as (9a), (9b) and (9c) yielded significant differences between all three conditions. Eubank concludes from these findings that the matching technique is sensitive to violations of the Specified Subject Condition.

Eubank's results are, however, confounded with several non-controlled variables. Notice, with respect to the contrast between (9a) and (9c), that Freedman and Forster found a clear difference in sentence matching times between sentences containing possessive NPs and sentences without possessives, other things being equal: in Freedman and Forster's experiment, the mean reaction time for sentences such as (10a) was 1,511 ms and for items such as (10b) 1,199 ms:

(10)  
   a. The duchess sold Turner's portrait of her father.
   b. The duchess sold a portrait of her father.

Clearly, this difference is independent of \textit{wh}-movement and simply indicates that sentence matching times are longer in sentences in which the object contains a
possessive NP than in sentences in which the object contains a simple article + noun combination. The same applies to the reaction time difference between Eubank’s items (9a) and (9c): in (9c) the same-different decision takes longer, because this sentence contains a possessive NP in object position, while in (9a) there is only an indefinite article plus a noun. The same can be said with respect to Eubank’s items (9a) and (9b), in which a significant difference of 329 ms was found. This difference can also be attributed to the cost of the possessive NP in the subject position of (9b), which is absent from (9a).

Finally, compare items (9b) and (9c) from Eubank. Both sentences contain a possessive NP, but still (9c) takes longer to match than (9b). However, the sentence matching times for these two types of sentences are not directly comparable, because they differ with respect to two structural parameters: (9b) contains a possessive NP in subject position, (9c) one in object position; (9b) has an indefinite article in object position, (9c) a definite article in subject position. Typological studies indicate that the occurrence of nominal elements in (9b) is distributionally more common than in (9c): indefinite articles typically occur with objects rather than with subjects. Such distributional preferences concerning the internal constituents of subject- and object-NPs may have effects on sentence matching times, leading to longer reaction times for (9c). To conclude, we think that Eubank’s results fail to demonstrate that violations of the Specified Subject Condition yield ungrammaticality effects in sentence matching.

Summarizing, the sentence matching experiments on English indicate that the sentence matching task yields reverse grammaticality and plausibility effects in grammatical processes, such as subject–verb agreement, subcategorization, semantic selection, and binding of anaphoric pronouns. Violations of the Specified Subject Condition and Subjacency, however, do not yield longer sentence matching times when compared with control sentences.

3. Verb placement, wh-movement and subjects in German

In this section we will present a brief outline of the phenomena under investigation in the grammar of German. There is an extensive linguistic literature (cf. Haider 1993; Grewendorf 1988; among others) on this topic, which however will not be discussed here. Rather, the following remarks are just meant as background information for those unfamiliar with German.

3.1. Verb placement

In German, finite verbs occur in the initial, the second, or the final position of a clause. Consider the following examples:
(11) a. *Adrian hat gerade das Radio angestellt.*
   Adrian has just the radio on-turned
   'Adrian has just turned on the radio.'

b. *Das Radio hat Adrian gerade angestellt.*
   the radio has Adrian just on-turned
   'The radio, Adrian has just turned on.'

c. *Hätte Adrian doch das Radio angestellt!*
   had-COND Adrian just the radio on-turned
   'If only Adrian had turned on the radio!'

d. *Julia sagte, daß Adrian gerade das Radio angestellt hat.*
   Julia said that Adrian just the radio on-turned has
   'Julia said that Adrian has just turned on the radio.'

In all cases the main verb occupies clause-final position. In (11d) it is a finite
verb in a subordinate clause, while in the other examples it is a non-finite verb.
These cases, and the difficulty of formulating a rule which generates these
structures, have led to the hypothesis that the final position is basic, and that the
cases in which the main verb occurs in a non-final position are derived via verb
movement (cf. Koster 1975, among others). In (11a) and (11b) the finite verb
occupies the second position in the sentence. Crucially, this is not always the
post-subject position, as is usually the case in unmarked English clauses of the
same type (cf. example [11b]). Moreover, it is always a finite verb that appears
in second position and it only appears there in main clauses. Finally, in some
constructions (for example in conditionals, cf. [11c], yes–no questions and in
imperatives) the finite verb is the initial element of the clause.

According to the standard GB-analysis of verb placement in German, both IP
and VP are head final in German, and generalized V2 involves head movement
at S-structure, that is, the verb raises from V₀ to Infl₀ to the Comp-position
(= C₀) in main clauses (cf. [12]). In addition, a rule of A-movement moves some
constituent to the Specifier of CP position in non-embedded sentences. This
double-movement analysis assures that the finite verb will always be in second
position in declarative clauses. Since it is to the Comp-position that the finite
verb moves, and since this position is filled with a lexical complementizer such as
däß 'that' in subordinate clauses, the analysis also ensures that the verb can
move only in main clauses. Specifically, we adopt the V2-analysis of Platzack
and Holmberg (1989). They argued that the finiteness feature [+F] is an operator
similar to the feature [+wh] in questions which has to bind an empty category.
In all Germanic V2 languages, such as in the Scandinavian languages, in Dutch
and in German, the finiteness operator is situated in Comp. Furthermore,
Platzack and Holmberg propose a licensing condition on case marking requiring
that nominative Case be governed by [+F]. Thus, as in Icelandic, the nominative
in German is licit if it is governed by [+F]. In order for [+F] to govern
nominative Case, [+F] has to be lexicalized. There are two ways for the operator
[+F] to be lexicalized: it may be realized as a subordinate complementizer, or it may be filled with the finite verb. Platzack and Holmberg conclude that verb movement to C (that is, the V2-phenomenon) makes C a governor of nominative Case in languages where [+F] is in C. Thus, according to this analysis, Verb-second and wh-movement are similar in that both involve operator-variable binding. In the case of V2 this is due to Comp hosting the finiteness operator and in the case of wh-movement due to the wh-operator in Spec-CP.

(12)

\[
\begin{array}{c}
\text{CP} \\
\text{Spec} \\
\text{C'} \\
\text{C} \\
\text{IP} \\
\text{Spec} \\
\text{Infl'} \\
\text{VP} \\
\text{Neg} \\
\text{VP} \\
\text{Spec} \\
\text{V'} \\
\text{V}
\end{array}
\]

3.2. Subject–verb agreement and empty subjects

Consider, finally, the two properties of subjects in German that will be investigated: subject agreement and empty subjects.

In German, grammatical person and number of the subject are marked on the finite verb. These features are encoded by suffixes or by changes in the root vowel. With respect to empty subjects, there is a difference in German between root and embedded clauses. In root clauses with the finite verb in Comp, preverbal subjects can be left out in colloquial German, if the appropriate context is given; this phenomenon is sometimes referred to as topic-drop. In embedded clauses, however, empty referential subjects are always ungrammatical; cf. the contrast in (13):

(13) a. 
\begin{verbatim}
hab das Buch schon gelesen
\end{verbatim}

have the book already read
‘I’ve already read the book.’

b. 
\begin{verbatim}
*daß das Buch schon gelesen hab
\end{verbatim}
There is a controversy in the syntactic literature as to how empty root subjects can be analyzed. Some syntacticians have argued that these are identified through topic-chains, like empty topics in Chinese (cf. Huang 1984). However, the phenomenon is much more restricted in German than in true topic-prominent languages. In this paper, we will not investigate empty root subjects; see Cardinaletti (1992) for a recent syntactic analysis. Our focus will rather be on null subjects in embedded clauses.

With respect to non-root empty subjects the following contrasts hold for German:

\[(14)\]

\[a. \text{*daβ e kommt} \]
\[\text{that comes} \]
\[b. \text{*daβ e regnet} \]
\[\text{that rains} \]
\[c. \text{daβ e mir scheint, ...} \]
\[\text{that to-me seems} \]
\[\text{'that it seems to me'} \]

In (14a), the empty element \(e\) replaces a referential subject, in (14b) a quasi-argument (Travis 1984) and in (14c) a nonargument. As in English, empty referential subjects as well as empty quasi-arguments are not possible in German. In contrast to English, however, nonargument subjects (14c) can be empty in German.

In Rizzi’s (1986) theory of \(\text{pro}\) two parameters are hypothesized to account for the distribution of empty subjects: 2 (a) licensing of \(\text{pro}\) and (b) identification/recovery of the content of \(\text{pro}\). The licensing of the empty subject can be accomplished through government by Infl (or Agr). In English, Infl does not license, whereas in German it does.

The identification parameter involves complex values. Specifically, whether or not a language identifies the content of \(\text{pro}\) (\(\phi\)-features in Rizzi’s terminology) via person and number features is parameterized. In other words, recovery of features — if there are any — via the licensor Infl/Agr — can be in terms of person and number affixes. Rizzi claimed that in languages such as Korean, \(\phi\)-features do not exist and that empty subjects are identified through topic-chains (cf. Huang 1984). In contrast, \(\phi\)-features exist in languages such as Italian and German. For these languages, Universal Grammar offers two options. If Infl (or Agr) has the feature [+pronominal], \(\text{pro}\) is identified via head binding (cf. Rizzi 1986: 520, 521) and receives a thematic role. This allows \(\text{pro}\) to be used just like a definite pronoun as in the so-called \(\text{pro}\)-drop languages, such as in Italian. If Agr/Infl has the feature [−pronominal], empty referential subjects are

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2. Rizzi (1986) also discusses empty objects, but here the discussion will be restricted to subject \(\text{pro}\).
impossible, as in German and English. Non-argumental subjects, however, which do not have to be specified in terms of φ-features, may be empty in German (cf. [14c] above).

4. Sentence-matching experiments on German

In the following we will report results from two sentence matching studies (= experiments I and II) and a correctability judgment task (= experiment III). The major results come from experiment I; experiments II and III are control studies and allow us to test alternative interpretations of the results of experiment I.

Experiment I

Method

20 native speakers of German (14 females and 6 males) were tested. All of them were students at the University of Düsseldorf, their ages ranging from 19 to 28 years. The task of the subjects was to judge as rapidly and precisely as possible whether two sentences which appeared on a PC-screen were identical or not.3 After the subjects gave the start signal by pressing any key on the keyboard, the first sentence appeared on top of the screen, followed after 500 ms by the second sentence, which was presented indented at the bottom of the screen. Both sentences remained on the screen for the following 2,400 ms. After they disappeared, 2,900 ms waiting time was provided.

Subjects responded by pressing a colored key on the keyboard: a blue button for “matching” items and a red one for “non-matching” items. Subjects’ reaction times (RT) were measured from the moment the second sentence appeared on the screen up to the subjects’ response reaction. The presentation of items as well as the recording of response latencies were controlled by a computer program. After each trial, some feedback was provided to check whether the response had been correct or not. The subjects started the next test item by pressing an arbitrary key. A warning appeared on the screen if the subject did not respond within the given time or if an invalid key was pressed.

Before the experiment began, subjects were provided with a detailed oral introduction, accompanied by a short practice session to familiarize them with their task. The experiments were carried out at the University of Düsseldorf, using 10 Siemens personal computers. Subjects were tested in several groups on separate days.

The main items of experiment I were grammatical sentences as well as ungrammatical ones containing violations of subject–verb agreement, the null-

3. In our experiment, we used a modified and adapted version of a computer program (PASCAL-code) originally written by Bley-Vroman and Eubank (1989).
subject property or verb placement (cf. Appendices A–D). The overall ratio of grammatical and ungrammatical items was set at 1:1. In addition to the actual test items, two kinds of filler items were used to make sure that the subjects were in fact performing the task accurately: (a) non-matching pairs, in which one word of the second sentence was replaced by a different one of the same length (cf. [15]) and (b) meaningless word strings consisting of 6/7 constituents (cf. [16]). These filler items were not included in the data analysis.

(15)  
_Du schwimmst jeden Morgen_  _in der Schwimmhalle._
_Du schwimmst jeden Abend_  _in der Schwimmhalle._
you swim every morning/evening in the swimming pool

(16)  
_Zu Blume die kochen Auto deutsch_
_Zu Blume die kochen Auto Deutsch_
to flower the cook car German

For both (i) and (ii), the overall ratio between matching and non-matching pairs was set at 3:1.4 The structure of the filler items was quite different from that of the experimental items; the filler items were used to prevent subjects from attempting to develop special strategies for the experimental items (cf. Freedman and Forster 1985).

To reduce the number of sentences per trial, test items were presented in two separate trials. The first one investigated subject–verb agreement and verb placement in main clauses, the second one the null subject property and verb placement in embedded clauses.5 There was a break of approximately 30 minutes between the two trials for each subject.

As proposed in Freedman and Forster (1985), only those matching items for which a correct response had been obtained were included in the data analysis. Test items leading to wrong or invalid responses were not included because other non-controlled factors might have been involved, which prohibit any direct comparison to the reaction times of correct responses. Furthermore, the effects of occasional trials with extremely long or short response latencies were minimized by establishing cutoff points two standard deviation (SD) units above or below the mean response time for each subject. Values above or below these cutoff points were set equal to the appropriate cutoff value; this procedure was

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4. In other studies using the matching paradigm, the ratio between matching and non-matching items was set either at 1:1 or at 3:1. We have chosen the latter because of the large number of test items included in our experiments. In general, there seems to be no compelling reason to take any particular ratio between matching and non-matching items; cf. Bley-Vroman and Masterson (1989: 231) for discussion.

5. The second trial contained twice as many distractor items as the first one. The reason for this was that otherwise, test items would have been too monotonous in the second trial, because in contrast to the first trial all test items in the second one were embedded sentences containing the complementizer _daß_ 'that'.
also adopted from Freedman and Forster (1985). In order to determine significant differences, separate ANOVAs (analysis of variance) were calculated for subjects and items, with the resulting F values being combined to form min F’ (cf. Clark 1973).

**Results**

**Subject–verb agreement**

The purpose of the agreement condition was to replicate the ungrammaticality effects that have been found in sentence matching experiments on English in another language. Three grammatical sentences were constructed for each possible combination of three grammatical persons in singular or plural, resulting in 18 items altogether. To minimize the effect of lexical idiosyncracy, only regular high frequency verbs of German were used. In addition, the length of the sentences was controlled with respect to number of words and number of syllables: for each sentence, the number of words was either 6 or 7, and the number of syllables 10 or 11. Ungrammatical sentences differed from their grammatical counterparts only in their verbal suffixes (cf. Appendix A), as illustrated by the following sentence pair:

(17) a. *Du fliegt nach Korea am nächsten Sonntag.
    you fly-3SG to Korea on the next sunday

b. *Du flygt nach Korea am nächsten Sonntag.
    you fly-2SG to Korea on next sunday

The results on subject–verb agreement are summarized in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>grammatical</th>
<th>ungrammatical</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>reaction time</td>
<td>1,674 ms</td>
<td>1,953 ms</td>
<td>min F'(1,35) = 20.74, p &lt; .001</td>
</tr>
</tbody>
</table>

The mean response time for ungrammatical items such (17b) was 279 ms longer than for the corresponding grammatical items such as (17a). The ANOVA results indicate that this difference is significant. In fact, 19 out of 20 subjects had shorter mean reaction times for grammatical items than for ungrammatical ones.

These observations clearly replicate findings from previous sentence matching studies on English and suggest that sentence matching is sensitive to ungrammaticality resulting from agreement mistakes.

**Null subjects**

Studies on English found that *wh*-questions involving illegal *wh*-traces do not yield ungrammaticality effects in sentence matching. One possible explanation for this might be that sentence matching is generally insensitive to illegal empty elements. The purpose of the null-subject condition in our experiment was to
investigate whether (ungrammatical) sentences containing illicit empty categories yield longer reaction times than the corresponding grammatical control items. Recall that in German, embedded sentences with empty referential subjects are ungrammatical because (following Rizzi 1986) German Infl is [−pronominal] and cannot identify pro. If sentence matching is sensitive to this kind of violation, embedded sentences with null subjects should take longer to match than grammatical control sentences.

24 embedded sentences were constructed, 12 with and 12 without overt referential subjects (cf. Appendix B). In the grammatical sentences, the subjects of the matrix clause were either proper names or common nouns, while in the embedded sentences the subjects were personal pronouns (cf. [18a]). In the ungrammatical items, the pronominal subjects of the grammatical sentences were replaced by adverbs which contained the same number of syllables as the pronouns (cf. [18b]). Each embedded sentence was introduced by the complementizer daβ 'that'. The test items contained 7 words and 8 or 9 syllables each. To exclude the potential influence of different verbal suffixes on reaction times, only 3rd person singular subjects were used, in both embedded and matrix clauses.

(18)  
a. Der Lehrer sagt daβ er Musik hör-t.
   the teacher says that he music hear-s
   b. *Der Lehrer sagt daβ oft Musik hör-t.
      the teacher says that often music hear-s

The results are summarized in Table 2.

**Table 2. Subjects’ mean reaction times for overt versus null subjects**

<table>
<thead>
<tr>
<th></th>
<th>grammatical</th>
<th>ungrammatical</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,872 ms</td>
<td>2,141 ms</td>
<td>min F'(1,28) = 21.08, p &lt; .001</td>
</tr>
</tbody>
</table>

The figures are parallel to those on subject–verb agreement: the mean correct “same” response time for ungrammatical items involving illegal empty subjects such as (18b) was 269 ms longer than for the corresponding grammatical sentences, and 19 out of 20 subjects had shorter mean reaction times to grammatical items than to ungrammatical ones. These figures indicate that sentence matching is sensitive to ungrammaticality resulting from illegal empty subjects. Therefore the assumption that illegal empty categories in general do not affect sentence matching latencies can be ruled out.

**Verb movement**

Ungrammatical wh-questions did not yield longer reaction times in sentence matching experiments on English when compared with control sentences. Forster
(1987) explained this result by claiming that the matching process is completed before binding of the who-operator is carried out. Since this result has so far only been obtained for who-questions, one might wonder whether it is restricted to this kind of syntactic construction or whether it holds more generally. Investigating the Verb-second phenomenon in German allows us to answer this question. Recall that according to the standard GB-analysis of V2, the finite verb must raise to the Comp-position in main clauses due to Comp hosting a finiteness operator ([+F]) which must bind a variable. Thus, if the matching process is completed before operator–variable binding, we would expect that, similar to Specified Subject Condition and Subjacency violations in English, ungrammatical German sentences in which the operator [+F] cannot properly bind a variable should produce a reverse grammaticality effect, that is, they should not yield any processing costs in the sentence matching task.

With respect to verb placement in main clauses, 15 grammatical V2-sentences containing adverbial phrases in clause-initial position were constructed (cf. for example [19a] and Appendix C). In the corresponding ungrammatical sentences, the finite verbs were shifted to clause-final position, leaving all other parts of the sentences unchanged (cf. [9b]). The subject always appeared in the 2nd singular. Each sentence consisted of 6 or 7 words and 10/11 syllables.

(19)  

   now learn-2SG you English in a language-course

b. *Jetzt du Englisch in einem Sprachkurs lernst

To investigate the effects of verb placement in embedded clauses, 12 grammatical and 12 ungrammatical sentences were constructed, the latter containing a finite verb immediately after the subject, otherwise everything else being the same as in the grammatical control sentences (cf. [20a] versus [20b] and Appendix D):

(20)  

a. Der Lehrer sagt daß er Musik hört.  
   the teacher says that he music hears

b. *Der Lehrer sagt daß er hört Musik.

The results on verb placement are summarized in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>grammatical</th>
<th>ungrammatical</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAIN</strong></td>
<td>1,827 ms</td>
<td>1,867 ms</td>
<td>min F'(1,27) = 0.93, NS</td>
</tr>
<tr>
<td><strong>EMB</strong></td>
<td>1,872 ms</td>
<td>1,980 ms</td>
<td>min F'(1,29) = 4.22, p &lt; .05</td>
</tr>
</tbody>
</table>
The ungrammaticality resulting from illegal verb placement in embedded clauses yielded significantly longer reaction times than the control sentences (cf. [20]), whereas the ungrammaticality of verb placement in main clauses produced a nonsignificant 40-ms increase in sentence matching times compared to the grammatical control sentences (cf. [19]).

Discussion
The ungrammaticality effect for embedded sentences such as (20b) indicates that the sentence matching task is sensitive to phrase-structure violations. Recall from (12) that IP is head-final in German and that finite verbs may appear either in Comp or in Infl. In embedded clauses in which Comp is filled with a lexical complementizer there is no phrase-structure position above IP to which the finite verb could be moved; therefore it must remain in clause-final position. Thus, the ungrammaticality effect for items such as (20b) of our experiment replicates findings from sentence matching studies on English and shows that violations of syntactic phrase structure produce processing costs in sentence matching.

In contrast, illegal main clause patterns such as in (19b) proved to be cost-free in the sentence matching task. Notice that in items such as (19b), the finite verb is in clause-final position, that is, in Infl as required in embedded clauses of German. The ungrammaticality of (19b) results from a violation of operator–variable binding: since the finite verb has not been raised in (19b), the finiteness operator located in Comp cannot find a variable to bind. With respect to this, V2-violations such as in (19b) and Specified Subject Condition violations such as those that have been studied in sentence matching experiments on English are parallel in structural terms. The only difference is that the wh-questions studied in English sentence matching experiments involved wh-phrases that had been moved too far away to be properly bound to their variables, whereas in our illegal main clause patterns the empty variable required was simply absent. These two circumstances lead to similar results concerning binding: in both cases an operator ([+wh] or [+F]) cannot properly bind a variable.

There are, however, two alternative explanations for the missing ungrammaticality effect in our illegal main clause patterns (19b).

First, suppose movement rules are not cost-free in the sentence matching task, such that the operation of Infl-to-Comp raising as in (19a) produces processing costs of X ms in the sentence matching experiment. Then, disregarding the ungrammaticality of (19b), we would expect sentence (19b) to lead to reaction times which are X ms shorter than those of (19a) due to the absence of Infl-to-Comp raising in (19b). On the other hand, the fact that (19b) is ungrammatical may produce processing costs of Y ms in sentence matching. If the respective values of X and Y happen to be similar, then there would be no difference in sentence matching times between (19a) and (19b). This would mean that the ungrammaticality of (19b) is not in fact cost-free, but that in our experiment the
ungrammaticality effect would have been masked by the processing costs of verb movement in the grammatical control sentences.

Second, our results could be due to correctability (cf. Crain and Fodor 1987). Specifically, illegal verb-placement patterns such as (19b) could be difficult or impossible to correct and might therefore not cause longer reaction times in the sentence matching task than the corresponding grammatical items (19a).

In order to test these alternative explanations, an additional sentence matching experiment and a correctability judgment task were carried out.

**Experiment II**

The purpose of this experiment is to determine whether verb raising produces processing costs in the sentence matching task. If this is the case, the unexpectedly short sentence matching latencies for ungrammatical sentences such as (19b) could be attributed to the lack of verb raising in these sentences.

**Method**

Two kinds of sentences were constructed for this experiment: (21a) conditional clauses without verb movement, (21b) conditional clauses with Infl-to-Comp raising. Notice that all the test items used in this experiment were perfectly grammatical in German and that potential reaction time differences in sentence matching must be due to other factors.

(21)  

a. Conditional clauses without verb movement

\textit{Ob die schöne Frau aus dem kleinen Dorf wohl anrufen wird?}  
‘Whether the nice woman from the small village will call?’

b. Conditional clauses with Infl-to-Comp raising

\textit{Wird die schöne Frau aus dem kleinen Dorf wohl noch anrufen?}  
‘Will the nice woman from the small village still call?’

10 grammatical sentences were constructed for each condition (21a) and (21b), resulting in 20 test items altogether (cf. Appendix E). In test items without lexical complementizers, an adverbial modifier was added, cf. \textit{noch} ‘still’ in (21b) so that for all test sentences the number of words was 11, and the number of syllables either 16 or 17. To minimize lexical differences, test items only differed in the Comp-position: in (a) Comp is filled with \textit{ob} ‘whether’ and in (b) with monosyllabic finite verbs (\textit{hat} ‘have-3SG’, \textit{wird} ‘will’ and \textit{kommt} ‘comes’). To exclude content effects, high-frequency words describing simple events were used in the test items. In addition to the actual test items in which both sentences of each pair were completely identical, 20 non-matching pairs of sentences were constructed by replacing one word of the second sentence with a different one of the same length. Otherwise the sentences used in the non-matching pairs were similar to the matching ones. The non-matching pairs served as filler items and
were not included in the data analysis. Matching and non-matching pairs were randomized in the actual experiment.

22 native speakers of German (16 females and 6 males) were tested, all of them were students at the University of Düsseldorf, the age-range is between 21 and 38. The experimental procedure and data analyses are identical to experiment I, except for a slightly longer delay (2,500 ms) between the presentation of the two sentences to be matched. The reason for this difference is that the items of experiment II were longer than those used in experiment I.

Results
Table 4 summarizes the quantitative results of experiment II.

Table 4. Subjects’ mean reaction times for two grammatical verb-placement patterns in main clauses

<table>
<thead>
<tr>
<th></th>
<th>verb-final</th>
<th>verb-second</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2,104 ms</td>
<td>2,128 ms</td>
<td>min $F^*(1,10) = 0.03$, NS</td>
</tr>
</tbody>
</table>

The mean correct “same” response time for conditional clauses with verb movement was slightly longer than for the corresponding conditional clauses without verb movement; this difference is not significant, neither for subjects nor for items. Thus the operation of verb movement does not produce processing costs in the sentence matching task. Since the operation of Infl-to-Comp raising seems to be cost-free in sentence matching, the idea that patterns such as (19b) could yield ungrammaticality effects in sentence matching which are masked by the advantage of not having to raise the finite verb can be ruled out.

Experiment III
The purpose of this experiment is to investigate whether our results from experiment I could be explained in terms of correctability. Recall that according to Crain and Fodor (1987), subjects when confronted with ungrammatical sentences in the sentence matching task attempt to internally correct ungrammatical sentences to the nearest well-formed sentence, and this should result in confusion in the same-different matching decision. This predicts that those ungrammatical sentences which subjects find easy to correct should yield processing costs in the sentence matching task, whereas sentences which subjects find difficult or impossible to correct should not increase sentence matching latencies, even though they are ungrammatical. Specifically, we will have to test the possibility that subjects may find illegal verb-placement patterns such as (19b) hard to correct, because if this is the case the relatively short sentence matching times we found in experiment I for these items could be attributed to non-correctability.
Method
We investigated 90 sentences with respect to correctability: (a) all the ungrammatical test sentences of experiment I, (b) 9 grammatical sentences and (c) 24 ungrammatical sentences involving illegal quantifier placement (cf. [22]). Sentence types (b) and (c) served as distractors.

(22) *Die Urlauber fahren manchmal sogar an das Mittelmeer.

'The tourists drive sometimes even at the Mediterranean.'

The procedure was taken over from Crain and Fodor (1987: 140). The test items were presented for correction in a booklet. Subjects were asked to read each sentence and to rate it either “OK” or else correct its ungrammaticality, for example by rewriting it. After correcting the sentence, the subject had to circle a point on a 5-point scale directly beneath it, whose end points were labeled ‘very easy’ and ‘very hard’. 40 native speakers of German (29 females, 11 males) were tested, the age range was between 21 and 46 years. 32 were students at the University of Düsseldorf, the remaining 8 subjects had other professions.

Results
Table 5 presents the quantitative distribution of correctability judgments for the five ungrammatical sentence types. The first five columns provide the proportion of each score on the correctability scale (in percent), and the last column the mean score for each sentence type where “1” is “very easy” and “5” is “very hard”.

<table>
<thead>
<tr>
<th>Sentence Type</th>
<th>Very Easy</th>
<th>Easy</th>
<th>Medium</th>
<th>Hard</th>
<th>Very Hard</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreement violations (17b)</td>
<td>42.36%</td>
<td>45.69%</td>
<td>9.03%</td>
<td>1.53%</td>
<td>0.69%</td>
<td>1.72</td>
</tr>
<tr>
<td>Illegal null subjects (18b)</td>
<td>43.33%</td>
<td>43.33%</td>
<td>10.83%</td>
<td>1.04%</td>
<td>0.41%</td>
<td>1.71</td>
</tr>
<tr>
<td>V2-violations (19b)</td>
<td>28.17%</td>
<td>48.33%</td>
<td>22.00%</td>
<td>1.50%</td>
<td>0%</td>
<td>1.97</td>
</tr>
<tr>
<td>Illegal embedded clauses (20b)</td>
<td>30.42%</td>
<td>51.46%</td>
<td>15.63%</td>
<td>2.50%</td>
<td>0%</td>
<td>1.91</td>
</tr>
<tr>
<td>Illegal quantifier placement (22)</td>
<td>17.40%</td>
<td>46.98%</td>
<td>25.73%</td>
<td>7.30%</td>
<td>1.15%</td>
<td>2.27</td>
</tr>
</tbody>
</table>

Table 5 shows that agreement violations are easy to correct; this replicates Crain and Fodor’s findings for English. Moreover, subjects find sentences containing illegal null subjects and main as well as embedded clauses with incorrect verb placement also easy to correct, whereas illegal quantifier placements such as (22) cause more correctability problems. The most interesting finding is that there are no differences in terms of correctability judgments between V2-violations such as (19b) and illegal embedded clauses such as (20b). This means that correctability can be excluded as the major variable controlling the sentence matching latencies we found in experiment I. Specifically, the relatively short sentence matching times for V2-violations cannot be attributed to non-correctability.
5. General discussion

The main result of our experiment I is that violations of V2-placement do not produce processing costs in the sentence matching task. By contrast, we found that subject–verb agreement errors, illegal empty subjects and violations of syntactic phrase structure yield significantly longer sentence matching latencies than the corresponding control sentences. Two additional experiments indicate that the sentence matching effect we found is real and cannot be attributed to peripheral factors such as "correctability".

In the following, we will compare our sentence matching findings with those on English and discuss different linguistic explanations. In Table 6 the major sentence matching findings are listed together with a reference to an example sentence previously mentioned in this paper. In the upper part those phenomena are represented in which ungrammatical or implausible sentences yielded significantly longer sentence matching latencies than corresponding control sentences; the lower part of Table 6 lists those phenomena in which no such ungrammaticality/implausibility effects occurred.

<table>
<thead>
<tr>
<th>longer reaction times for ungrammatical or implausible sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>agreement errors (4a, 17)</td>
</tr>
<tr>
<td>phrase-structure violations (4b, 4c, 4d, 20b)</td>
</tr>
<tr>
<td>implausible arguments (6d)</td>
</tr>
<tr>
<td>ungrammatical binding of anaphors and reciprocals (7a)</td>
</tr>
<tr>
<td>subcategorization errors (8b)</td>
</tr>
<tr>
<td>illicit empty subjects (18b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>similar reaction times for ungrammatical or implausible sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specified Subject Condition violations in wh-questions (5a)</td>
</tr>
<tr>
<td>implausible arguments in wh-questions (6b)</td>
</tr>
<tr>
<td>subcategorization errors in wh-questions (8c)</td>
</tr>
<tr>
<td>V2-violations (19b)</td>
</tr>
</tbody>
</table>

LF-insensitivity

Sentence matching could be insensitive to violations at higher levels of grammatical representation such as LF and sensitive to violations at levels lower than LF, for example D- and S-structure (cf. Freedman and Forster 1985). This would explain the difference observed in the sentence matching experiments between agreement errors, phrase-structure violations and subcategorization errors on the one hand, and ungrammatical constraint violations in wh-questions.
on the other hand. However, the complete set of phenomena which yielded ungrammaticality and implausibility effects in sentence matching cannot be uniquely represented at S- and D-structure. Binding of lexical anaphors is an LF-process. Similarly, the identification of empty subjects through $\phi$-features of Infl/Agr is taken to be a case of head binding at some interpretative level. If the LF-insensitivity idea were correct, ungrammatical binding of lexical anaphors and sentences with non-identified empty subjects should not produce processing costs in the sentence matching task. These predictions, however, have turned out to be wrong.

**Insensitivity to global well-formedness and implausibility**

Forster and Stevenson (1987) suggested that the only feature affecting sentence matching is the *local* well-formedness or plausibility of the string. Agreement errors are locally ill-formed, because two structurally adjacent constituents are incompatible. The same would hold for illicit empty subjects, if we count the empty subject *pro* as being structurally adjacent to Infl/Agr. Phrase-structure violations (cf. for example [4b]) are also locally ill-formed since they contain one transition between contiguous words that is ungrammatical. Subcategorization violations and implausible arguments such as those in (8b) and (6d) are local because the problem involves two structurally adjacent constituents, the verb and its object. In all cases in which the ungrammaticality or implausibility is local, sentence matching shows a significant increment compared to the control sentences.

Sentences with moved *wh*-elements, however, involve *wh*-variable binding, which is carried out, when the overall interpretation of the entire sentence is performed. The lack of ungrammaticality and implausibility effects in these sentences is attributed to the fact that these sentences do not contain any local anomalies, and that sentence matching times are only affected by local well-formedness. This reasoning could equally well be applied to the V2-violations that were examined in our experiment: sentences with a finite verb in clause-final position are locally well-formed in German, and the fact that these sentences are marked as ungrammatical when they are used as main clauses is determined at some global level of sentence interpretation which is irrelevant to the sentence matching task.

Given the phenomena listed in Table 6, Forster and Stevenson’s claim is intuitively appealing. Clearly, phenomena such as subject–verb agreement, subcategorization etc. are more local than *wh*-movement and verb raising. However, Forster and his colleagues found it hard to define locality in such a way that the experimental findings could be explained. For example, defining locality in terms of structural adjacency would account for the ungrammaticality effects found for agreement violations but not for the ungrammaticality effect in cases of binding of anaphors and reciprocals, because these elements are not structurally adjacent to their antecedents. Forster (1987) explored the possibility
of defining locality in terms of c-command. C-command is involved in all the phenomena that produced ungrammaticality or implausibility effects in the sentence matching task. But c-command is also involved in the phenomena that did not have such effects in sentence matching: in wh-questions and in cases of verb raising, some element is moved to Comp and from there it c-commands its trace. Thus, the notion of c-command does not help to distinguish the two classes of phenomena. What is required to improve the explanatory value of the global insensitivity hypothesis is an operational definition of locality that would cover the contrast between the phenomena listed in Table 6.

**CP-insensitivity**

Eubank (1992, 1993) suggested that sentence matching is performed at an early stage of parsing at which the CP-level has not yet been constructed. Eubank assumed that parsing proceeds only as far as is demanded by the task at hand, and he speculated that in the sentence matching task parsing might only proceed up to the IP level. As a result, ungrammaticality or implausibility at levels lower than CP would produce processing costs, whereas ungrammatical or implausible sentences that crucially involve the CP-level would be cost-free in sentence matching. If this idea is correct, then Specified Subject Condition violations and V2-violations should not have sentence matching effects, because both phenomena are represented at the CP-level. On the other hand, agreement violations, illicit empty subjects, subcategorization errors and binding violations such as in (7a) only involve IP or even lower levels of phrase-structure representation. These findings are correctly predicted by Eubank’s CP-insensitivity hypothesis.

Consider, however, the various cases of phrase-structure violations, all of which elicited significant ungrammaticality effects in sentence matching. In the case of illegal quantifier placement (4b), illegal VP-preposing (4c) and phrase-structure scrambling (4d), one might argue that CP is not involved. This reasoning, however, cannot be applied to phrase-structure violations such as those in (20b), repeated in (23a) for convenience. Notice that the ungrammaticality of (23a) crucially depends on the presence of a lexical complementizer. The pattern *er hört Musik* ‘he hears music’ is perfectly grammatical in subordinate clauses such as (23b) without lexical complementizers. Thus, detecting the ill-formedness of (23a) requires a CP representation, which according to Eubank should be cost-free. The ungrammaticality effect found in our experiment I shows that this prediction does not hold. Therefore, the CP-insensitivity hypothesis must be rejected.

(23)  

a. *Der Lehrer sagt daß er hört Musik.  
the teacher says that he hear-s musik

b. Der Lehrer sagt er hört Musik.
Insensitivity to operator-variable binding

We suggest that sentence matching is insensitive to violations of operator-variable binding and sensitive to other kinds of ungrammaticality or implausibility. This means that sentence matching is completed before variables are bound to their operators and it predicts that violations of operator-variable binding should be cost-free in the sentence matching task, whereas other kinds of ungrammaticality or implausibility should have sentence matching effects. The latter should also hold for the binding of anaphors and for head binding as in the case of pro identification. The sentence matching experiments show that these predictions are correct. The phenomena in the upper part of Table 6 do not involve violations of operator-variable binding and produced longer sentence matching latencies than corresponding control sentences. The phenomena in the lower part of Table 6 all involve violations of operator-variable binding, and in the sentence matching experiments these did not produce processing costs.

6. Conclusion

Looking at previous sentence matching experiments on English, one might argue that the crucial variable to explain the sentence matching findings is a specific syntactic construction, namely wh-question formation: sentence matching is sensitive to ungrammaticality or implausibility in all other syntactic constructions but insensitive to ill-formed wh-questions. In syntactic theory, however, notions such as wh-question formation or other kinds of construction-specific rules are irrelevant. Thus, if the sentence matching findings could be accounted for in terms of the presence or absence of a specific syntactic construction, they would not provide any interesting evidence as to how grammatical constraints and principles are implemented in the parser.

The main finding from our sentence matching experiments is that illegal verb placement patterns in German main clauses have the same effects in sentence matching as ill-formed wh-questions in English. These two kinds of ungrammaticality did not yield longer sentence matching latencies, whereas other kinds of ungrammaticality, such as agreement errors, illicit empty subjects and phrase-structure violations produced processing costs in the sentence matching task. This finding rules out a construction-specific explanation of the sentence matching results because the illegal V2 patterns from our experiment and the ill-formed wh-questions from previous sentence matching experiments are different syntactic constructions.

From a theoretical perspective, however, V2 in German and wh-question formation in English are similar in that both involve operator-variable binding. The finiteness operator in the case of V2, and the +wh-operator in the case of wh-questions must bind a variable at some level of sentence interpretation. What we suggest, then, is that sentence matching is completed before operator-variable
binding has taken place. Ungrammaticality or implausibility resulting from impossible operator–variable binding are therefore cost-free in the sentence matching task. Further evidence for the view that the sentence matching results can be explained in terms of operator–variable binding might come from investigating violations of constraints on quantifier interpretation. Since, to the best of our knowledge, quantifier interpretation has not yet been investigated with the sentence matching task, this issue must be left open for further research.

Appendix

A. Subject–verb agreement

In the ungrammatical items, the verb (= underlined) was replaced with the element in parentheses.

1. \textit{Ich \underline{besuche} heute abend ein Mädchen.} (besucht)
   I see tonight a girl

2. \textit{Du \underline{wartest} sehr lange in dem Warteraum.} (wartet)
   you-2SG wait very long in the waiting room

3. \textit{Er \underline{lebt} in München mit einem Ausländer.} (lebt)
   he lives in Munich with a foreigner

4. \textit{Wir \underline{gehen} nach Hause mit dem Professor.} (geht)
   we go home with the professor

5. \textit{Peter \underline{und Inge wohnen} in Düsseldorf.} (wohnt)
   Peter and Inge live in Düsseldorf

6. \textit{Ihr \underline{macht} einen Spaziergang im Volksgarten.} (macht)
   you-PL have a walk in the Volksgarten have-2SG a walk

7. \textit{Du \underline{fliegest} nach Korea am nächsten Sonntag.} (fliegen)
   you-2SG fly to Korea next Sunday

8. \textit{Er \underline{braucht} das Auto heute nachmittag.} (brauchen)
   he needs the car this afternoon

9. \textit{Ich \underline{arbeite} morgen in der Bibliothek.} (arbeiten)
   I work tomorrow in the library

10. \textit{Ihr \underline{kaufen} eine Lampe auf dem Flohmarkt.} (kaufen)
    you-2PL buy a lamp at the flea-market

11. \textit{Wir \underline{spielen} Tennis in der Sporthalle.} (spielen)
    we play tennis in the sports hall

12. \textit{Ich \underline{schreiben} dem Professor einen Brief.} (schreiben)
    I write the professor a letter

13. \textit{Du \underline{bezahlt} fünfzig Mark für einen Tisch.} (bezahlen)
    you-2SG pay fifty marks for a table

14. \textit{Inge und Hans lernen fleißig Englisch.} (lernen)
    Inge and Hans learn diligently English

15. \textit{Ihr \underline{sucht} das Auto in einem Parkhaus.} (suchst)
    you-PL look-for the car in a car-park
(16) Maria und Peter kommen aus Heidelberg. (komme)
Maria and Peter come from Heidelberg

(17) Er findet eine Wohnung in Wuppertal. (finden)
he finds a flat in Wuppertal

(18) Wir bestellen drei Bier in einer Kneipe. (bestellt)
we order three beers in a pub

B. Null subjects
In the ungrammatical items, the subject pronoun of the embedded clause (= underlined) was replaced with the element in parantheses.

(1) Peter sagt, daß er zu Hause bleibt. (nur)
Peter says that he at home stays only

(2) Inge sagt, daß sie einen Freund hat. (nur)
Inge says that she a friend has only

(3) Hans sagt, daß er das Museum besucht. (oft)
Hans says that he the museum visits often

(4) Der Mann sagt, daß er Kaffee trinkt. (germ)
the man says that he coffee drinks gladly

(5) Peter sagt, daß er nach München fährt. (jetzt)
Peter says that he to Munich drives now

(6) Maria sagt, daß sie die Zeitung liest. (oft)
Maria says that she the paper reads often

(7) Der Arzt sagt, daß er Kopfschmerzen hat. (oft)
the doctor says that he headache has often

(8) Hans sagt, daß er zur Mensa geht. (jetzt)
Hans says that he to-the students' union goes now

(9) Die Frau sagt, daß sie Tennis spielt. (germ)
the woman says that she tennis plays with pleasure

(10) Maria sagt, daß sie ein Regal kauft. (bald)
Maria says that she a shelf buys soon

(11) Inge sagt, daß sie einen Brief schreibt. (jetzt)
Inge says that she a letter writes now

(12) Der Lehrer sagt, daß er Musik hört. (oft)
the teacher says that he to-music listens often

C. Verb placement in main clauses
In the ungrammatical items, the finite verbs (= underlined) appear in clause-final position.

(1) Heute nachmittag kaufst du einen Stuhl.
this afternoon buy you a chair

(2) Morgen spielst du Fußball auf dem Spielplatz.
tomorrow play you football in the playground
(3)  *Jetzt lernst du Englisch in einem Sprachkurs.*
    now learn you English in a language-course

(4)  *Jeden Abend trinkst du Bier in der Kneipe.*
    every evening drink you beer in the pub

(5)  *Jetzt kochst du die Suppe in der Küche.*
    now cook you the soup in the kitchen

(6)  *Morgen besuchst du die Fahrschule in Köln.*
    tomorrow visit you the driving-school in Cologne

(7)  *Heute abend schreibst du die Seminararbeit.*
    today evening write you the assignment

(8)  *Jetzt suchst du eine Wohnung in Düsseldorf.*
    now look you a flat in Düsseldorf

(9)  *Jetzt kopierst du ein Buch in der Bibliothek.*
    now xerox you a book in the library

(10)  *Heute schenkst du dem Professor ein Buch.*
    today donate you the professor a book

(11)  *Morgen verkaufst du dem Mann das Auto.*
    tomorrow sell you to-the man the car

(12)  *Heute telefonierst du mit dem Lehrer.*
    today talk you to the teacher [on the phone]

(13)  *Heute nachmittag bekommst du ein Geschenk.*
    this afternoon get you a present

(14)  *Jetzt zeigt du dem Polizisten das Foto.*
    now show you to-the policeman the photo

(15)  *Morgen gehst du zur Fete mit einem Freund.*
    tomorrow go you to-the party with a friend

D. Verb placement in embedded clauses

The items (B.1) to (B.12) were used as grammatical sentences. In the ungrammatical sentences, the finite verbs were shifted to a position immediately after the subject.

(1)  *Peter sagt, daß er zu Hause bleibt.*

(2)  *Inge sagt, daß sie einen Freund hat.*

(3)  *Hans sagt, daß er das Museum besucht.*

(4)  *Der Mann sagt, daß er Kaffee trinkt.*

(5)  *Peter sagt, daß er nach München fährt.*

(6)  *Maria sagt, daß sie die Zeitung liest.*

(7)  *Der Arzt sagt, daß er Kopfschmerzen hat.*

(8)  *Hans sagt, daß er zur Mensa geht.*

(9)  *Die Frau sagt, daß sie Tennis spielt.*

(10)  *Maria sagt, daß sie ein Regal kauft.*

(11)  *Inge sagt, daß sie einen Brief schreibt.*

(12)  *Der Lehrer sagt, daß er Musik hört.*
E. Conditional clauses

(1) Wird die schöne Frau aus dem kleinen Dorf wohl noch anrufen?
will the nice woman from the small village wohl still call

(2) Wird das kleine Kind den bunten Fußball wohl sehr gern abgeben?
will the small child the coloured football very happily give-away

(3) Wird der neue Gärtner den großen Rasen denn auch gut pflegen?
will the new gardener the large lawn really also well tend

(4) Wird der dumme Wirt das kalte Bier wohl wieder falsch servieren?
will the silly innkeeper the cold beer wohl again wrongly serve

(5) Hat der Meister ihn mit seinen Worten wohl zu sehr beleidigt?
has the chief him with his words wohl too much insulted

(6) Hat das Mädchen neulich auf dem großen Platz denn etwas verloren?
something lost

(7) Hat er seinen jungen Herrn wohl auch auf den Sportplatz begleitet?
has he his young master wohl also to the sports-field accompanied

(8) Kommt denn auch Butter in den guten Obstkuchen für die Freundin?
goes then also butter into the nice fruit-cake for the girl-friend

(9) Hat er sein Nest ganz heimlich in dem alten Walnußbaum gebaut?
has he his nest rather secretly in the old walnut-tree built

(10) Wird das Flugzeug mit Urlaubern aus dem Süden wohl zu spät ankommen?
too late arrive

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References


