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Word Order in Sentence Processing: An Experimental Study of Verb Placement in German

Helga Weyerts[1], Martina Penke[1], Thomas F. Münte[2], Hans-Jochen Heinze[3], Harald Clahsen[4]*

[1] Department of Linguistics, University of Düsseldorf, Germany
[2] Department of Neuropsychology, University of Magdeburg, Germany
[3] Department of Neurology II, University of Magdeburg, Germany
[4] Department of Linguistics, University of Essex, UK

*** Corresponding Author:**
Harald Clahsen
Dept. of Linguistics
University of Essex
Colchester C04 3SQ
UK
email: harald@essex.ac.uk
fax: +44-1206-87-2085

Abstract

We examine the question of whether the human comprehension device exhibits word-order preferences during on-line sentence comprehension. The focus is on the positioning of finite verbs and auxiliaries relative to subjects and objects in German. Results from three experiments (using self-paced reading and event-related brain potentials) show that native speakers of German prefer to process finite verbs in second position, i.e. immediately after the subject and before the object. We will account for this order preference in terms of the relative processing costs associated with SV_fO and SOV_f. Our finding that word-order preferences play an important role in the on-line comprehension of German sentences is compatible with results from previous studies on English and other languages.

INTRODUCTION

Research on sentence processing indicates that sentences are comprehended incrementally. There also seems to be a broad consensus in psycholinguistic research that the intermediate stages in sentence comprehension correspond to incomplete surface structure representations that are assembled in a piecemeal fashion from left to right (see e.g. Phillips 1996, Gibson 1998). A great deal of sentence comprehension research has been aimed at determining how grammatical rules and constraints are used in the construction of these incomplete phrase markers.

One important grammatical property which affects sentence comprehension is word order. For example, evidence from psycholinguistic experimentation points to a general subject-first preference in on-line sentence comprehension (see e.g. Kaan 1997 for review). That is, the parser seems to find it easier to comprehend sentences in which the subject precedes the object than sentences with the reverse O-S order. This even holds for languages such as Dutch and German, in which the alternative O-S order is perfectly grammatical. The subject-first preference is consistent with findings from typological linguistics. Statistical analyses of the frequency distribution in the world's languages of the six logically possible orders of S(ubject), V(erb) and O(bject) have found a clear dominance of subject before object. In Tomlin's (1986) 402-language sample, for example, 96% came out as subject-before-object languages, the great majority of them (= 87%) as either SVO or SOV languages. OVS and VOS-languages were attested, but these accounted collectively for just 4% of Tomlin's sample. Given these distributional data, the order 'subject-before-object' is considered to be unmarked across languages (see e.g. Hawkins 1994: 420f.).

In contrast to the subject-first preference, there does not seem to exist a general preference for a particular verb placement pattern across languages. With respect to the order of verb and object, typological studies revealed that most languages fall into one of two families, VO or OV, see e.g. Lehmann (1973), Dryer (1991), with similar frequencies for both types. In Tomlin's (1986) sample, for example, there are 217 VO languages (i.e. SVO, VSO and VOS) and 185 OV languages (i.e. SOV, OVS). Similar counts are available from other sources (Mallinson & Blake 1979, Hawkins 1983). Moreover, psycholinguistic studies have not produced any indication that (S)OV sentences are in general more difficult to comprehend than (S)VO sentences or vice versa. Rather, order preferences for verbs, if any, are probably language-specific.

In the present paper, we will investigate word order preferences from a psycholinguistic perspective, focusing on the role of *finite* verb placement for sentence comprehension. We have examined a language (German) that allows for different surface positions of finite verbs relative to subjects and objects. In German, finite verbs may occur in the initial, the second, or the final

position of a clause, depending on the type of clause: Yes-no questions and imperatives have the finite verb in first position, declarative main clauses in second position, and embedded clauses in final position. This intralanguage difference raises the question of whether the parser shows a preference for any of these different placement patterns in on-line sentence processing. To address this question, we investigated the on-line comprehension of correct and incorrect word order in main and embedded clauses of German using different experimental paradigms, self-paced reading and event-related brain potentials (ERPs). ERPs are minute voltage fluctuations of the electrical activity produced by the neurons in the brain that are recorded from various points on the scalp while the participant is performing some task. ERPs possess time resolution in the millisecond range and thus provide an excellent on-line measure of language processing in real time.

We found that the results from all three experiments converge on one important point: Sentences with the finite verb in second position and immediately following the subject are easier to parse than sentences with the finite verb in final position, and this preference even holds for embedded clauses for which the grammar of German *requires* clause-final placement of finite verbs. Moreover, we found an $SV_{fin}O$ preference not only for content verbs but also for auxiliaries, indicating that the SV_fO preference is caused by the morpho-syntactic features (finiteness) of verbs rather than by their lexical-semantic properties.

WORD ORDER IN SENTENCE COMPREHENSION: PREVIOUS STUDIES

Several psycholinguistic studies have investigated the role of word order for the identification of grammatical functions such as subject and object in sentence comprehension (MacWhinney & Bates 1989, Love & Swinney 1998, Kaan 1997, among others). One set of findings concerns order preferences for subjects. Using a simple experimental paradigm in which participants were asked to decide as quickly as possible for each sentence which noun was the actor, or grammatical subject, Bates, MacWhinney and their collaborators found that native speakers of English strongly relied on word order, typically interpreting any preverbal NP as a grammatical subject (Bates et al. 1982, MacWhinney et al. 1984, MacWhinney & Bates 1989). This was found even in cases such as **The cow are hitting the horses* in which word order conflicts with morphological cues. By contrast, speakers of other languages (e.g. German and Italian) also rely on semantic properties of the nouns involved and on morphological information such as subject-verb agreement and case morphology to determine grammatical subjects in comprehension. Other experimental evidence has revealed a general preference for subjects preceding objects, even in languages such as Dutch and German in which both S-O and O-S orders are grammatically well-formed. Sentences with S-O orders are, for

example, responded to faster and more accurately than corresponding O-S versions of the same sentences (Frazier & Flores d'Arcais 1989). The subject-first preference was found across different types of NPs, different verb-placement patterns and clause types, for declarative main clauses, wh-questions (both main and embedded) and relative clauses (Frazier & Flores d'Arcais 1989, Hemforth 1993, Meng 1995). Moreover, the subject-first preference does not seem to depend on plausibility (Mecklinger et al. 1995) and is independent of contextual information (Bayer & Marslen-Wilson 1992). These results suggest that the S-O order is a syntactically-based preference.

Different accounts of the subject-first preference have been given in the parsing literature. From the perspective of generative parsing models, it has been argued that the subject-first order is more parsimonious in terms of processing. The S-O order is said to involve the construction of fewer phrasal nodes than the O-S order (Gorrell 1996) and to provide for a quicker way of integrating an NP into a parse (Kaan 1997). This account is compatible with syntactic analyses according to which the O-S order involves an extra transformational movement which is not required to derive S-O order (see e.g. Kayne 1994); we will return to this issue in the next section. From the perspective of constraint-based parsing models (MacDonald et al. 1994), the subject-first preference might be attributed to the fact that subject-initial clauses are more frequent than object-initial clauses. Note, however, that the S-O order preference seems to be independent of lexical and other specific properties of the NPs involved, indicating that 'subject-first' is an abstract syntactic preference. How such representations are constructed in constraint-based parsing models is not clear.

Another set of psycholinguistic studies investigating the role of word order in sentence comprehension looked at the positions of objects relative to verbs. The results of these studies have shown cross-linguistic differences. For example, Love & Swinney (1996, 1998) studied English sentences containing object-relative clauses, such as *Jimmy used the new pen that his mother-in-law recently #1 purchased #2*, in which the object (=*the new pen*) is dislocated or moved to the left of the verb (=*purchased*) that subcategorizes the object. They relied on the cross-modal lexical priming (CMLP) paradigm in which participants were listening to sentences and simultaneously performing a word/non-word lexical decision task at different points during the sentence. Love & Swinney (1996) found that lexical decision times at the position indicated by #2 were significantly shorter for visual targets that were semantically related to the object of the embedded verb than for unrelated ones; at the control position (= #1) preceding the verb *purchased*, there was no such difference. These results indicate that perceivers identify the underlying positions of dislocated constituents on-line, e.g. the the postverbal object position in English.

In a CMLP experiment on Spanish, Basilico et al. (1995) examined VSO and VOS constructions[1], in this case focusing on reactivation effects of the fronted verb between the subject and the object. They found a reactivation effect only between S and O in the VSO construction, but not between O and S in the VOS construction. This result has been interpreted to reflect the underlying SVO order of Spanish and to show that the comprehension device reconstructs a dislocated element in its underlying position; see Love & Swinney (1998). Evidence for an advantage of the SVO order in Spanish has also been obtained by Ostrosky-Solis et al. (1996) in a study recording ERPs to SVO versus OVS sentences (e.g. *Lo que un elefante empujo fue un oso* 'What an elephant pushed was a bear' respectively *Un elefante fue lo que empujo un oso* 'An elephant was what a bear pushed'). OVS sentences elicited an anterior negativity relative to the SVO sentences, i.e. an ERP effect similar to the one that is produced by phrase-structure violations and morpho-syntactic incongruencies (Neville et al. 1991, Coulson et al. 1998, Münte et al. 1998)[2].

Stamenow & Andonova (1998) adopted the CMLP technique and the design from Love & Swinney (1996) to examine object-relative clause structures in Bulgarian with respect to antecedent reactivation of dislocated objects. However, even though Bulgarian is typologically of the V-O type (like English and Spanish), they did not find any particular reactivation effect of the object at the hypothesized gap position after the verb. Stamenow & Andonova (1998) speculate that this finding may reflect the fact that word order is less rigid in Bulgarian than in English.

Recently, the CMLP task has also been employed to study (object) reactivation effects in OV languages such as German and Japanese. Clahsen & Featherston (1999) examined the short scrambling construction of German in which a direct object (DO) is moved across an indirect object (IO), yielding a derived word order such as [NP_{Subj} NP_{DO} NP_{IO}… t_i (Verb)]. They found that the direct object is reactivated at the gap position (indicated t_i), thus confirming that dislocated constituents are reconstructed in their underlying positions, i.e. in the case of German, a direct object in the immediate preverbal position. Nakano et al. (2000) investigated the long-distance scrambling construction of Japanese using the CMLP technique. In their sentences, a direct object (case marked by –o) is moved from inside an embedded clause across the embedded and the main clause subjects (case marked by –ga) and across the indirect objects (case marked by –ni), yielding a surface order of the form *NP-o*$_i$ [$_{IP}$ NP-ga NP-ni [$_{CP}$ NP-ga NP-ni t_i V COMP] V]. Nakano

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[1] Note that the materials used had unambiguous object markings (signaled by the preposition *à* for objects).

[2] It should be noted, however, that the two sentence types used in this experiment are quite distinct constructions, differing in more than mere surface word order. It is therefore not entirely clear whether the observed ERP effect can be attributed to just the word-order differences.

et al. found reactivation effects for the scrambled direct object at the trace position t_i. As in the German study, but in contrast to the English CMLP experiment, the reactivation effect for the direct object in the Japanese study was seen at the position immediately *before* the verb, thus reflecting the underlying OV order of Japanese.

Although the picture we get from these studies is not entirely clear, the cross-linguistic results suggest that verb placement preferences in sentence comprehension vary across languages, probably reflecting corresponding structural differences between VO and OV languages.

VERB PLACEMENT IN GERMAN

Finite verbs are inflected for tense, mood and subject-verb agreement in German, and they may occur in the initial, the second, or the final position of a clause; see (1) for examples. In declarative main clauses such as (1a) and (1b), 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. Moreover, it is always a finite verb or auxiliary that appears in second position, and it only appears there in main clauses. In embedded clauses (1c), the finite verb appears clause-finally, and in some constructions (e.g. in conditionals (1d), yes-no questions and in imperatives) the finite verb is the initial element of the clause.

(1) a. Pauline *hat* mittlerweile die Aufgabe gelöst[3].
'Pauline has in the meantime the task solved'
(= In the meantime, Pauline has solved the task.)

b. Die Aufgabe *hat* Pauline gelöst.
'The task has Pauline in the meantime solved'
(= As to the task, Pauline has solved it in the meantime.)

c. Der Lehrer bemerkte, daß Pauline mittlerweile die Aufgabe *gelöst hat.*
'The teacher realized that Pauline in the meantime the task solved has'
(=The teacher realized that in the meantime, Pauline has solved the task.)

d. *Hätte* Pauline doch die Aufgabe mittlerweile gelöst!
'Had-conditional Pauline Partikel the task in the meantime solved'
(=If only Pauline had solved the task in the meantime!)

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[3] German examples are glossed word-for-word and are marked by inverted commas ('…'). When required, standard English translations are added in parentheses (=…).

Most syntacticians have argued that verb-second placement in German can be accounted for in terms of a double-movement analysis illustrated in (2); see e.g. Thiersch (1978), Fanselow (1988), von Stechow & Sternefeld (1988), Grewendorf (1988), Schwartz & Vikner (1996), among others. Here, finite verbs first move to a clause-final INFL head (see $[e_j]$ in (2)) and in main clauses subsequently raise to the COMP position of a head-initial CP. In addition, some constituent will raise to Spec-CP in declarative main clauses, i.e. in front of the finite verb. This double-movement analysis assures that the finite verb will always be in second position in this type of clause. Since the COMP-position is filled with lexical complementizers such as *daß* 'that' in embedded clauses, the analysis also assures that the finite verb only raises in main clauses. In this way the double-movement analysis accounts for all possible verb positions.

(2) $[_{CP}$ [Die Aufgabe]$_i$ $[_{C'}$ $[_{COMP}$ hat$_j$] $[_{IP}$ Pauline mittlerweile $[_{VP}$ $[e_i]$ gelöst] $[_{INFL}$ $e_j]]]$

This analysis is, however, controversial among syntacticians, and a number of alternative accounts have been given. One critical issue concerns the claim made by the double-movement account that all types of V2/V1 clauses have the same syntactic representation. Travis (1984, 1991) pointed out, for example, that the double-movement analysis treats clause-initial subjects in the same way as clause-initial objects, even though there are syntactic and interpretative differences between the two. For example, subject pronouns can readily appear in clause-initial position, while object pronouns may only do so if they are stressed. Moreover, the double-movement analysis has been claimed to be counter-intuitive as it takes the position of finite verbs in embedded clauses as the base order and the order in declarative main clauses as derived (see e.g. Fritzenschaft et al. 1990). Note also that whereas main clauses do not permit (S)OV$_f$ order, some embedded clauses show SV$_f$O, e.g. *weil* 'because' sentences, or V$_f$SO order, e.g. *…als wäre er sein eigener Sohn '...* as (if) was he was his own son'.

For these reasons, several syntacticians have proposed alternatives to the double-movement analysis. Haider (1993) believes that there is no convincing evidence for a head-final IP projection in German. Travis (1984, 1991) suggests that in German SV$_f$X clauses, finite verbs are located in a head-initial IP, so that in sentences with preverbal subjects such as (1a) neither the finite verb nor the subject have to undergo any movement to COMP or Spec-CP. Sentences with postverbal subjects (e.g. 1b), on the other hand, involve leftward movements of the finite verb and other constituents, as illustrated in (2), and in embedded sentences such as (1c), the finite verb is said to be located within VP in clause-final position; see Reis (1985), Kathol (1990) and Zwart (1993) for

similar proposals. This account is meant to capture the syntactic and interpretative differences between SV_fX sentences such as (1a) with the subject directly preceding the finite verb, sentences with derived main clause word orders (1b, 1d), and clause-final finite verb placement in embedded sentences (1c).

In addition to their grammatical properties, the frequency of use of certain verb-placement patterns may influence the way they are processed. We are not aware of any published reports of the frequency of relevant verb-placement patterns in German. We therefore rely on counts provided to us by Monika Schmid (personal communication), based on her spontaneous speech corpora from 45 native speakers of German (mean age: 74); see Schmid (2002). The total corpus size was 186.858 words, and 16.292 sentences went into an analysis of verb placement, from which ambiguous word orders were excluded. It was found that of the 16.292 unambiguous sentences, 32% had a simple finite verb in second or first position (e.g. *Paul löst die Aufgabe* 'Paul is solving the task'), 26% had a finite verb in final position (e.g. 1c), and 41% had a finite verb or auxiliary in second or first position and a non-finite verbal element in final position (e.g. 1a, 1b, 1d). These frequency counts indicate that discontinuous verb placement is the most frequent pattern and that overall, verbs are common in both second or first position and/or final position, with similar frequencies. With respect to the placement of *finite* verb forms, however, there is a clearly dominant pattern: 74% of the finite verb forms appear in second or first position, and only 26% in final position.

EXPERIMENT 1: A READING-TIME STUDY OF GERMAN VERB PLACEMENT

Self-paced reading times have been shown to reflect the amount of parsing effort required in sentence processing (e.g. Günther 1989, Gibson 1998, among others). Given the assumption that ungrammatical sentences require more parsing effort than corresponding grammatical ones, a comparison of reading times for sentences with correct and incorrect verb placement should reveal an effect of ungrammaticality. Thus, reading times for sentences with incorrect verb placement should be significantly longer than reading times for sentences with correct verb placement. In addition, if there is an order preference for SV_fO or SOV_f, then the preferred order should produce shorter reading times than the non-preferred one on the assumption that the preferred one requires less parsing effort than the non-preferred one. To test these predictions, we measured the reading times for main and embedded clauses with correct and incorrect verb placement using a self-paced reading task with a stationary window (Aaronson & Scarborough 1977, Just et al. 1982).

Materials

48 test sentences were constructed, 12 for each of the four experimental conditions shown in (3). To control for differences in sentence length between main clauses and embedded clauses, the 48 test sentences were presented as the second clauses of complex sentences that consisted of two clauses joined by a coordinating or subordinating conjunction. Half of these sentences thus consisted of two main clauses, and in the other half a main clause was followed by an embedded clause[4]. The critical final clauses in both conditions were presented with correct and incorrect word order; ungrammatical main clauses had the finite verb after the object in clause-final position, and in ungrammatical embedded clauses the finite verb appeared before the object and immediately after the subject. Otherwise each pair of embedded and main clauses was identical. Moreover, to allow for comparisons across sentence types, the critical verbs and objects were identical in all four test conditions and sentence length was matched. The complete set of experimental items is presented in the appendix.

(3) a. Main clause with correct SV_fO word order
Hans facht das Lagerfeuer an, und Paul *öffnet die Dosen*.
'John fans the camp fire and Paul opens the cans'

b. Main clause with incorrect SOV_f word order
* Hans facht das Lagerfeuer an, und Paul *die Dosen öffnet*.
'John fans the camp fire and Paul the cans opens'

c. Embedded clause with correct SOV_f word order
Die Leiterin des Kochkurses bestimmt, daß Erika *die Dosen öffnet*.
'The director of the cookery course decides that Heather the cans opens'

d. Embedded clause with incorrect SV_fO word order
* Die Leiterin des Kochkurses bestimmt, daß Erika *öffnet die Dosen.*
'The director of the cookery course decides that Heather opens the cans'

As reading time increases with the length of words and decreases with word frequency (Just et al. 1982), the critical verbs and nouns were matched for their frequency of occurrence and for their syllable structure. According to the CELEX database (Baayen et al. 1993), the mean word-form frequencies of the critical items (shown in italics in (3)) were 5.9 per million for nouns, and 2.8 per

[4] Note that subordinating conjunctions which do not require verb-final placement in the embedded clause (such as *weil* 'because') were not used in the experimental materials.

million for verbs. All nouns and verbs were bisyllabic. Object nouns appeared in the plural form, verbs were presented in the 3rd person singular. Furthermore, the critical verbs were all highly transitive and likely to co-occur with a direct object. Note that if we had used intransitive verbs, participants may have posited a clause boundary after encountering the subject and the verb in which case verb-second and verb-final word order would have been indistinguishable. By using highly transitive verbs, this problem was avoided[5].

We also constructed 96 filler sentences covering different syntactic constructions. Half of these sentences were grammatical, the other half ungrammatical, displaying errors in case marking, subject-verb agreement or word order. Similarly to the experimental sentences, 24 of these filler items occurred both in a grammatical and an ungrammatical form.

The 144 sentences were pseudo-randomized making sure that related test sentences would not be presented immediately one after the other and ensuring that the related test sentences would not be presented in an identical sequence of grammatical and ungrammatical sentences throughout the experiment.

Method

Twenty students, all unfamiliar with the aim of the study, volunteered to participate in the experiment (14 women, 6 men, mean age 26).

Participants performed a stationary-window self-paced reading task in which they had to push a button to initiate the presentation of successive sentential segments on a computer screen. The presentation of each sentence started with the first segment of words appearing on the screen. After pressing the right response button on the push-button box, the words disappeared and the words of the next segment appeared in the center of the screen. Participants were asked to perform the task as quickly as possible. Self-paced reading times were measured from the presentation of each segment on the screen up to the pressing of the response button. To ensure that participants accurately read the words presented on the screen, they were also asked to monitor whether a word presented after the end of each sentence had been part of the sentence or not. Half of these words had been part of

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[5] To ensure that an intransitive reading was indeed unlikely for the verbs, the critical sentences were pre-tested in an acceptability judgment task in which subjects were asked to decide whether the sentences sounded better with or without a direct object, or whether they had no preference. We included all of the critical sentences (n =136) that were used in experiments 1 and 2 (68 main clauses and 68 embedded clauses). There were 15 participants none of whom took part in any of the main experiments. The results confirmed that the verbs we used have a high degree of transitivity: 94% of the 136 sentences were judged to be better with a direct object.

the previous sentence, the other half had not. Participants responded to this task by pressing the green '*yes*'- or red '*no*'-button of the push-button box. The presentation of the stimuli and the measuring of the reaction times were controlled by the NESU software package (Baumann et al. 1993).

The test sentences were presented in a sequence of 6 segments. The first four segments consisted of the subject of the first main clause (segment 1), the VP of the main clause (segment 2), the conjunction of the following second clause (segment 3), and the subject of the second clause (segment 4). Segments 5 and 6 contained the critical verbs and objects; (4) illustrates the segmentation for sentence (3c).

(4) a. Die Leiterin des Kochkurses bestimmt, daß Erika **die Dosen** **öffnet.**

segment 1 segm. 2 segm. 3 segm. 4 segm. 5 segm. 6

b. * Die Leiterin des Kochkurses bestimmt, daß Erika **öffnet** **die Dosen.**

segment 1 segm. 2 segm. 3 segm. 4 segm. 5 segm. 6

A written instruction with a detailed description of the task was given to the participants before the experiment. The experiment itself started with a short practice phase, familiarizing the participants with the procedure and the task.

Self-paced reading experiments have been found to produce an end-of-sentence effect, i.e. participants take longer to press the button in response to the final segment of a sentence than to the same stimulus occurring earlier in the sentence (Just et al. 1982, Just & Carpenter 1987). This might be attributed to wrap-up processes taking place at the ends of sentences. To reduce this effect, we collapsed the reading times for segments 5 and 6 by calculating, for each sentence, average reading times for both segments; that is the reading times for the critical verb and the object were added together and divided by 2. Mean object-verb reading times were then computed for each of the 20 participants. These means were entered into a repeated measures ANOVA with the factors *clause type* (main vs. embedded) and *word order* (SV_fO vs. SOV_f). Effects of grammaticality are expressed by the interaction of these two factors. For subsequent post-hoc testing matched *t*-tests were calculated.

The mean error-rate for the monitoring task was 5.9%, indicating that the participants attentively read the sentences. Extreme outliers in reading times were determined for each participant and condition separately and were eliminated from the data set. In this way, 6.5% of the data (124 of

1920 reading times) were excluded from the statistical analyses.

Results

Figure 1 presents the relevant mean object-verb reading times in ms for main and embedded clauses with correct and incorrect word order.

//INSERT FIG.1 ABOUT HERE//

The ANOVA revealed no significant main effect of clause type, $F(1,19) = 2.187$, $p = 0.156$, but a significant main effect of word order, $F(1,19) = 9.678$, $p = 0.006$. Moreover, there was a significant effect of ungrammaticality indicated by the significant interaction of clause type × word order, $F(1,19) = 10.031$, $p = 0.005$.

A comparison of the mean object-verb reading times for main clauses with incorrect SOV_f (376 ms) and correct SV_fO order (331 ms) yielded a significant slowing down in reading times for main clauses with the incorrect SOV_f word order, $t(19) = -4.263$, $p = 0.000$. A comparable effect, however, could not be observed for embedded clauses. Object-verb reading times for embedded clauses with correct SOV_f (347 ms) and incorrect SV_fO word order (343 ms) did not differ significantly, $t(19) = 0.397$, $p = 0.696$. A direct comparison of the reading times for SV_fO word order in main and embedded clauses yielded no significant difference (main clause SV_fO: 331 ms, embedded clause SV_fO: 343 ms, $t(19) = -1.487$, $p = 0.153$). Reading times for incorrect SOV_f main clauses, however, were significantly slower than reading times for embedded clauses with SOV_f word order (main clause SOV_f: 376 ms, embedded clause SOV_f: 347 ms, $t(19) = 3.194$, $p = 0.005$), thus giving rise to an ungrammaticality effect. Finally, a direct effect of word order can be seen in ungrammatical sentences. Object-verb reading times for main clauses with ungrammatical SOV_f order were significantly slower than reading times for embedded clauses with ungrammatical SV_fO order, $t(19) = 4.179$, $p = 0.001$.

Discussion

We found that embedded clauses with ungrammatical SV_fO word order did not produce longer reading times compared to embedded clauses with correct SOV_f order and main clauses with correct SV_fO word order. By contrast, reading times for main clauses with ungrammatical SOV_f were significantly slower compared to grammatical SV_fO in main clauses and grammatical SOV_f in embedded clauses. Thus there was a significant increase in reading times for ungrammatical SOV_f

in main clauses (compared to the grammatical SV_fO order), but there is no corresponding effect of ungrammaticality for incorrect SV_fO in embedded clauses (compared to the grammatical SOV_f). The observed interaction of ungrammaticality with clause type and word order indicates a local/temporal preference for parsing finite verbs in second position, immediately after the subject and before the object. In the case of ungrammatical (SOV_f) main clauses, the longer reading times (compared to the corresponding grammatical sentences) can be attributed to the violation of this order preference, in addition, of course, to the ungrammaticality of SOV_f in main clauses. In ungrammatical embedded clauses, on the other hand, the SV_fO order preference has not been violated, and these sentences did not produce longer reading times than the correct ones, even though they were ungrammatical. Thus it seems as if in this case the effect of ungrammaticality (which should lead to longer reading times) is cancelled out by the fact that an SOV_f pattern was replaced by SV_fO which made it possible to parse the finite verb at its preferred post-subject position. Taken together, the results of this experiment suggest that there is a preference for SV_fO in reading German sentences. This effect can even be seen in ungrammatical sentences.

EVENT-RELATED BRAIN POTENTIALS AND GERMAN VERB PLACEMENT

In this section, we will describe the results of two experiments (and a third control experiment) to further investigate the role of word order in on-line sentence processing. In these experiments, we made use of event-related brain potentials (ERPs). ERPs consist of a series of positive and negative voltage changes in the ongoing electroencephalogram that are recorded from the intact human scalp while the participant is performing some task, such as reading a sentence (Hillyard & Picton 1987, Kutas & Van Petten 1994, Osterhout 1997). Unlike reaction time measures that are punctuate, ERPs provide the advantage of a continuous recording which makes them particularly useful for the investigation of the temporal organization of linguistic processing. Moreover, ERPs are multidimensional in nature, i.e. they can vary in polarity, amplitude, latency, and topographical distribution.

ERPs and sentence processing

In previous studies, two different ERP responses have been attributed to syntactic processing. First, an early negative-going wave was reported approximately overlapping in time with the semantic N400 component (i.e. between 300 and 500 ms after stimulus onset), but showing a different topographical distribution. While the semantic N400 had a centroparietal distribution, the 'syntactic negativity' showed a more anterior distribution (sometimes larger over the left than over the right

hemisphere) (Osterhout 1997: 497). This anterior negativity has been found in a variety of experimental circumstances, for example, as a response to phrase structure violations (e.g. Neville et al. 1991), to morphosyntactic incongruencies (Coulson et al. 1998; Münte et al. 1998) and also to overregularization errors in irregular verbs or nouns (Penke et al. 1997, Weyerts et al. 1997). Anterior negativities have also been observed for infrequent but grammatically well-formed syntactic structures, such as in the study by Ostrosky-Solis et al. (1996) on SVO versus OVS sentences in Spanish in which they found an anterior negativity for the less common OVS order compared to SVO.

A second ERP response to syntactic processing is a late centroparietal positive-going wave with a duration of several hundred milliseconds, alternately labeled the P600 (Osterhout & Holcomb 1992) or the syntactic positive shift (Hagoort et al. 1993). P600 effects have been elicited by phrase structure violations (Hagoort et al. 1993, Neville et al. 1991), by subjacency violations (Neville et al. 1991; McKinnon & Osterhout 1996) and by subject-verb agreement violations (Hagoort et al. 1993). Moreover, P600 effects have been described for temporarily ambiguous so-called garden-path sentences (e.g. Osterhout et al. 1994).

The exact functional properties of the anterior negativity and the P600 are still controversial. In addition to the circumstances mentioned above, anterior negativities have also been found for perfectly grammatical object wh-questions compared to subject wh-questions (Kluender & Münte 1998), an effect that has been interpreted to reflect the greater working memory load associated with keeping the filler (= the displaced object) active for longer. Consequently, different theoretical accounts have been offered regarding the anterior negativity; see Friederici (1999), Coulson et al. (1998) for review. Recently, it has been suggested that probably two (or more) components with a similar, albeit not identical, topography might account for the discrepancies in the literature; see Kluender & Münte (1998). Likewise, while the P600 has been interpreted to reflect processes of syntactic reanalysis (see e.g. Friederici & Mecklinger 1996, Gunter et al. 1997; Hahne & Friederici 1999)[6], other authors have argued that the P600 might be an instance of the P300 family of late positive components that vary as a function of stimulus probability and saliency manipulations and occurs in linguistic and non-linguistic contexts (Coulson et al. 1998, Münte et al. 1998).

The present study does not aim to resolve the controversy of whether anterior negativities are specific to sentence processing or reflect working memory processes in more general terms and the

[6] In addition to the P600 and the anterior negativity, Hahne & Friederici (1999) identified a third ERP effect, which has a latency of about 100 to 300 ms and which they call ELAN (= early left anterior negativity). Hahne & Friederici suggest that the ELAN reflects highly automatic first-pass parsing processes while the P600 reflects more controlled second-pass parsing processes.

question of whether or not the P600 is specific to language. Instead, the purpose of the ERP experiments to be reported below is to determine word order preferences in on-line sentence comprehension.

EXPERIMENT 2: ERPs AND THE PLACEMENT OF FINITE VERBS

In experiment 1, we found an effect of word order in self-paced reading of German sentences: ungrammatical SOV_f sentences produced longer reading times than the corresponding grammatical SV_fO sentences, while ungrammatical SV_fO sentences did not produce longer reading times than the corresponding grammatical SOV_f sentences. This finding is compatible with an SV_fO order preference in German. Note, however, that a self-paced reading experiment does not provide an on-line record of the mental processes occurring *while* the parser is reading a particular segment, e.g. a finite verb. This is because in this task response times are measured at the end of each stimulus. In order to get more direct access to the way finite verbs are processed in the different word orders, further experimentation is required.

For the present experiment, we made use of the same kinds of experimental sentences as in experiment 1, i.e. SV_fO versus SOV_f word order patterns in main and embedded clauses[7]. An example stimulus set is shown in (5); the complete set of experimental sentences is in the appendix.

(5) a. Main clause with correct SV_fO word order
Es ist Ostern, und die trauernde Witwe *opfert Kerzen*
'It is Easter time, and the mourning widow sacrifices candles.'

b. Main clause with incorrect SOV_f word order
*Es ist Ostern, und die trauernde Witwe *Kerzen opfert*.
'It is Easter time, and the mourning widow candles sacrifices.'

c. Embedded clause with correct SOV_f word order
Der Priester sieht, daß der fromme Novize *Kerzen opfert.*
'The priest sees that the pious novice candles sacrifices.'

d. Embedded clause with incorrect SV_fO word order
*Der Priester sieht, daß der fromme Novize *opfert Kerzen*.

[7] To allow for a direct comparison of the ERPs to nouns and verbs, in the present experiment we used (grammatically well-formed) bare plural nouns as direct objects; this was different in experiment 1. Moreover, to obtain a better signal-to-noise ratio for analyzing the ERPs, there were 68 sentences per condition in the present experiment, in contrast to 12 experimental sentences per condition in experiment 1.

’The priest sees that the pious novice sacrifices candles.’

We can make two predictions for the present experiment. First, we expect to find an ERP effect of ungrammaticality caused by word-order violations, similar to those seen in other ERP studies using the ERP violation paradigm. Thus, the ungrammatical sentences in (5b) and (5d) should elicit a larger anterior negativity and/or P600 than the corresponding grammatical sentences. Furthermore, following from the observed SV_fO preference in experiment 1, we expect in the present experiment, a larger anterior negativity and/or P600 in cases in which this SV_fO order preference is violated. To test this, we will collapse the ERP waveforms to the critical elements of clause types (5a) and (5d) and compare them with the corresponding ERPs for clause types (5b) and (5c). In this way, the potential role of word order can be isolated while keeping other properties of the sentences constant. We will further test this prediction by comparing ERPs to ungrammatical SOV_f in main clauses with ERPs to ungrammatical SV_fO in embedded clauses. If there is an SV_fO order preference in German, then sentence type (5b) should evoke a larger anterior negativity and/or a larger P600 than (5d).

METHODS

Participants

Twenty-two monolingual native German speakers (age range 21-28, mean = 23.4 years; 13 women, 9 men) were paid to participate in the experiment. All of them were right-handed by self-report. The data from three participants had to be discarded due to movement-related artifacts present in the EEG. The remaining 19 participants had a mean age of 23.2 years (range 21-28; 11 women, 8 men). All participants had normal or corrected-to-normal vision. They had no history of reading difficulties and no neurological disorders.

Materials

There were 272 experimental sentences, each consisting of two clauses, 136 sentences were combinations of two main clauses and 136 sentences consisted of a main clause followed by an embedded clause. The critical final clauses in both conditions were presented with correct or incorrect word order. Ungrammatical main clauses were constructed by shifting the finite verb to clause-final position, while ungrammatical embedded clauses were constructed by placing the finite verb immediately after the subject, leaving all other parts of the sentence unchanged. Each experimental sentence consisted of nine words, of which the last two words of the second clause,

i.e. the finite verb and the direct object, were critical. These elements (shown in italics in (5)) were matched according to their frequency of occurrence and their syllable structure. The mean frequency was 6.9 per million for nouns and 7.7 per million for verbs according to the CELEX database (Baayen et al. 1993) and all nouns and verbs were bisyllabic. All nouns were either mass nouns or plural forms and were presented without a determiner. All verbs appeared in the third person singular form. Furthermore, only highly transitive verbs were used (see footnote 5). In addition to the 272 experimental sentences, there were 320 filler sentences representing a range of different constructions[8], resulting in a total stimulus set of 592 sentences.

Procedure

The 592 sentences were presented in 74 blocks of 8 sentences. Each block was followed by an additional 'test' sentence presented in red color. The participants' task was to decide for these 'test' sentences, whether or not these test sentences were an identical repetition of one of the preceding 8 sentences. Participants responded to these sentences by pressing a button with their right or left index finger. The whole scenario of 666 sentences was presented in 10 segments with short breaks of 1-2 minutes between each block. Four different scenarios were generated, so that the order of presentation for the four critical conditions could be counterbalanced across participants.

Sentences were presented one word at a time in yellow letters (or red for the 'test' sentences) against a blue background. The critical words subtended a vertical angle of approximately 1.3° and a maximum horizontal of 2.8°. Each word was presented for a duration of 300 ms with an inter-stimulus interval of 200 ms. The interval between two sentences was 2.7 s.

Recordings

The EEG was recorded from the scalp using tin electrodes embedded in an electrode cap and located at 29 standard sites according to the International 10/20 system (Jasper 1958; Fp1/Fp2, F7/F8, F3/F4, Fz, T3/T4, C1/C2, C3/C4, Cz, T5/T6, P3/P4, Pz, O1/O2) and to the electrode placement nomenclature guidelines of the American EEG society (1991; Fc1/Fc2, Fc5/Fc6, Cp1/Cp2, Cp5/Cp6). Each electrode was referred offline to an averaged common reference placed at both earlobes. Eye movements were monitored with electrodes placed at the outer canthus of the left eye and the infra-orbital ridge of the right eye. All channels were amplified with a bandpass

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[8] Most of the filler sentences were simple main clauses in $SV_f(X)$ or XV_fS order; in addition, there were 12 filler sentences, each consisting of a main clause (in SV_f or XV_fS order) and an embedded clause, half of which appeared in (ungrammatical) SV_fO order and half of which had the correct SOV_f order.

from 0.01 to 64 Hz, digitized with 8 ms resolution. When base-to-peak EOG amplitude exceeded 50 μV, when amplifier saturation occurred, or when the baseline shift of the EEG exceeded 200μV, trials were automatically excluded from the averages. ERPs were obtained separately for each electrode site and each stimulus condition for 2048 ms starting 200 ms prior to the presentation of the stimulus. The waveforms were quantified by measuring the mean amplitude in consecutive latency windows. The data from these measures were subjected to repeated measures ANOVAs. Reported *p*-values were Greenhouse-Geisser corrected for inhomogeneities of covariance whenever applicable. Reported are the uncorrected degrees of freedom, epsilon value, and probability level following correction.

Results

The distracter task in which participants had to monitor the experimental sentences for identity/non-identity of a 'test' sentence was performed with relatively high accuracy and will not be discussed further. The mean rates of 'hits', i.e. correct responses to identical sentences was 79.4%, and the mean rates of 'rejections', i.e. correct responses to non-identical sentences was 86.5%.

Figures 2, 4 and 5 present grand average ERP waveforms time-locked to the penultimate word in each sentence, i.e. the point from which the sentences started to differ with respect to verb placement and grammaticality. Figure 2 shows the results for SV_fO versus SOV_f word order. The left column of Figure 2 presents a comparison of sentence types (5a)/(5d) versus (5b)/(5c). The right column presents a breakdown for both main and embedded clauses.

// INSERT FIGURE 2 AND 3 ABOUT HERE //

In the left column of Figure 2, ERPs begin to diverge at approximately 300 ms poststimulus with a larger negativity for the SOV_f word order. This difference was maximal over frontocentral sites as can be seen more clearly from the illustration given in Figure 3. The right column of Figure 2 shows that the larger negativity for the SOV_f order was present in both main and embedded clauses from 300-500 ms, even under circumstances (i.e. in embedded clauses) in which SOV_f is the order required by the grammar of German.

As is evident from Figure 4, effects of ungrammaticality occurred later, namely between 700 and 1000 ms poststimulus. In this time region a large P600 with a centroparietal maximum was found for incorrect SOV_f order, i.e. for SOV_f in main clauses (Figure 4, left panel). By contrast, incorrect SV_fO order elicited only a very small P600 with a parietal maximum (Figure 4, right panel).

// INSERT FIGURE 4 ABOUT HERE //

Finally, beginning at approximately 1000 ms a further ERP difference was observed for SOV_f vs.

SV_fO word order, which is illustrated in Figure 5 for midline electrode sites. A negative shift was found for SOV_f sentences that was maximal for embedded clauses in which SOV_f was the correct word order.

// INSERT FIGURE 5 ABOUT HERE //

To assess the reliability of these ERP differences, a repeated measures ANOVA of the mean amplitude of waveforms was conducted in the following four consecutive latency windows: 300-500 ms, 500-700 ms, 700-1000 ms, and 1000-1800 ms. Separate ANOVAs were computed for midline (Fz, Cz, Pz) and parasagittal sites (F3/4, Fc1/2, Fc5/6, Cp1/2, Cp5/6, P3/4). ANOVAs were computed including the factors *clause type* (main vs. embedded) and *word order* (SOV_f vs. SV_fO). Recall, that in German, SOV_f is the correct word order in embedded clauses, but the incorrect word order in main clauses, while SV_fO is correct in main clauses and incorrect in embedded clauses. Thus, effects of correct versus incorrect word order would appear as an interaction between the factors clause type and word order. Furthermore, topographical factors were included in the ANOVAs, the factor *position* (anterior vs. central vs. posterior) for midline sites and the factors *hemisphere* (left vs. right) and *position* (anterior vs. posterior) for parasagittal sites. In case of significant interactions between clause type and word order, the overall ANOVA was followed by relevant post-hoc comparisons.

<u>300-500 ms.</u> While there was no reliable main effect of clause type, there was a significant main effect of word order at midline sites ($F(1,18)=13.21$, $p<0.002$) and at parasagittal sites ($F(1,18)=9.47$, $p<0.007$) with a larger negativity for SOV_f than for SV_fO sentences (midline: -1.44μV vs. 0.11μV; parasagittal: -1.16μV vs. 0.01μV; see also Figure 2). The negativity for SOV_f compared to SV_fO word order was largest over frontocentral electrode sites and rather small over parietal sites, as can be seen from the graphs in Figure 3. Furthermore, significant interactions were found between clause type and the anterior/posterior factor (midline: $F(2,36)=4.05$, $ep=0.85$, $p<0.03$; parasagittal: $F(1,18)=4.55$, $p<0.05$), reflecting a slightly larger positivity for embedded clauses than for main clauses at posterior sites (midline: -0.44μV vs. -0.96μV; parasagittal: -0.38μV vs. -0.77μV).

<u>500-700 ms.</u> In this time window, namely 500 ms after the beginning of the penultimate word, the last word was presented. As expected, neither significant main effects nor any reliable interaction with the factors clause type or word order were observed.

<u>700-1000 ms.</u> The overall ANOVA revealed no main effect. However, there was a significant interaction between clause type and word order at midline and parasagittal sites (midline: $F(1,18)=8.45$, $p<0.01$; parasagittal: $F(1,18)=5.12$, $p<0.04$). This interaction reflects an effect of

incorrect word order: In main clauses, ERPs for incorrect SOV_f word order were associated with a larger positivity compared to the correct SV_fO order and in embedded clauses, the incorrect SV_fO order revealed a larger positivity than the correct SOV_f order. Thus, incorrect word order is reflected in a P600 effect. To further elucidate this effect, separate ANOVAs were performed for SOV_f and SV_fO clauses (Figure 4). For SOV_f clauses, a significant P600 for incorrect word order was observed over midline ($F(1,18)=6.52$, $p<0.02$) and parasagittal sites ($F(1,18)=5.05$, $p<0.04$), while for SV_fO clauses, no main effect of incorrectness was found. There was only a marginal trend for an incorrectness by site interaction over midline sites ($F(2,36)=2.08$, $p=0.14$), reflecting the fact that the P600 was largest over the parietal site Pz.

1000-1800 ms. In this latency window, the overall ANOVA revealed a main effect of word order, which was significant at midline sites only ($F(1,18)=6.38$, $p < 0.03$), reflecting a long-lasting negative shift for SOV_f sentences compared to SV_fO sentences.

DISCUSSION: ERP EFFECTS AND FINITE VERB PLACEMENT

Explaining the anterior negativity

We found an electrophysiological distinction between the processing of SV_fO and SOV_f in the online comprehension of German sentences. Between 300 and 500 ms poststimulus, the SOV_f word order was associated with a larger negativity compared to SV_fO word order, which was most pronounced over fronto-central electrode sites. Both in terms of its timing and its distribution this waveform can be taken to be an instance of the anterior negativity that was found in previous studies. Recall that anterior negativities are elicited by morpho-syntactic violations of different kinds, and by other constructions that require extra parsing effort compared to a control condition. Interestingly, in our study the anterior negativity elicited by SOV_f sentences did not only occur in main clauses (in which SOV_f is ungrammatical) but also in embedded clauses where SOV_f is the correct word order.

These results support the hypothesis of an SV_fO order preference in on-line sentence comprehension. It seems that after having processed an IP-initial subject, the parser expects to get a finite verb in German and that SOV_f sentences with clause-final finite verbs require some extra parsing effort, hence the anterior negativity in these cases. One possibility of explaining this finding is in terms of Gibson's (1998) 'Syntactic Prediction Locality Theory', in which processing costs are determined by calculating the integration and the memory costs for each new word in a parse. Following Gibson, memory cost and integration cost are strongly influenced by locality. The longer a predicted constituent must be kept in memory before the prediction is satisfied, the higher the

memory cost, and the greater the distance between an incoming word and the most local head or dependent to which it attaches, the greater the integration cost. In our stimulus materials, the first NP the parser encounters is the subject NP. This applies to both SOV_f and SV_fO sentences. Note also that in the grammar of German, the subject is closely related to verb finiteness, as is reflected by case marking and subject-verb agreement. Thus it is conceivable that once the subject NP is processed, the parser predicts a finite verbal element, i.e. I(nfl) or T(ense) or Agr, by virtue of the head-dependent relationship between the subject and the finite verb within IP. In other words, given the syntactic relationship between the subject and the finite verb, the subject NP can be taken to be the constructor of an IP/AgrP in German, the head of which is the finite verb. Such a syntactic prediction will be made for all our experimental sentences. The important difference between SV_fO and SOV_f sentences is, however, that only in the former the finite verb and the subject are immediately adjacent. This may lead to higher memory costs for SOV_f sentences. In such sentences, a finite verb is predicted once the subject is encountered, and this needs to be retained in working memory while the object is processed. In an SV_fO structure, by contrast, the finite verb is also predicted at the subject, but it does not have to be retained in memory until the end of the clause, as is the case in an SOV_f sentence. Thus, SV_fO structures are likely to consume less memory space than SOV_f structures, all other things being equal. According to this account, the observed anterior negativity reflects an order preference for *finite* verbs in the on-line comprehension of German sentences.

Before accepting this conclusion, however, we need to consider the possibility that the anterior negativity is caused by other factors or other sources of information that might be accessible to the parser. First, we cannot be sure whether the SV_fO preference found in experiments 1 and 2 is due to the lexical-semantic contents of verbs or to their grammatical properties. It is true that the critical verbal elements were clearly marked as finite verbs, through person and number endings, but they were also main verbs with lexical-semantic content. Thus the order preference could be due to the verb's lexical-semantic properties, rather than to its finiteness features. In particular, one might attribute the greater workload for SOV_f sentences (compared to SV_fO) to the fact that in the former the thematic verb is encountered later in the clause, causing a higher degree of temporal ambiguity. In an SOV_f clause, the parser is confronted with two consecutive NPs which might be case-ambiguous[9]. Given the subject-first preference reported in previous studies, the parser might interpret a clause-initial case-ambiguous NP as a subject, but in SOV_f order this can only be

[9] Note that as shown in the appendix, the subject was case-ambiguous in 68 out of 136 experimental sentences in experiment 2 and that the objects were bare (plural) nouns which do

confirmed upon encountering the verb at the end of the clause, while in an SV_fO sentence the confirmation provided by the verb comes sooner, and this difference may have caused the ERP effect.

Another potentially influencing factor for the SV_fO preference might be that all our critical sentences were preceded by a main clause, most of which had SV_fO order. It is possible that this biased subjects towards SV_fO order for the second clause.

The frequency distribution of verb-placement patterns in German usage might be another relevant factor. Recall from above that in the frequency counts that were available to us, 74% of the sentences had a finite verb in second (or first) and only 26% in clause-final position. This asymmetry may be a source of bias towards SV_fO as opposed to SOV_f.

Finally, recall that in experiment 2 we directly compared ERPs to nouns (at the object positions) with those of verbs, and one might argue that the observed ERP effects reflect word class differences rather than differences in sentence structure.

Other ERP effects

With respect to the role of grammatical well-formedness, we found a positive-going wave with a latency of 700 to 1000 ms poststimulus for ungrammatical sentences compared to the corresponding grammatical ones. This ERP positivity could be identified as a P600 effect, a component that many previous ERP studies have found as a response to syntactic violations. It is important to note, however, that the P600 effect was larger and statistically reliable only for ungrammatical SOV_f. Previous ERP studies indicate that the P600 amplitude varies as a function of the severity of the syntactic anomaly (see e.g. Osterhout et al. 1994, Osterhout 1997: 496). Our results are compatible with this interpretation and provide further support for an SV_fO order preference in German sentence comprehension. This is because two factors contribute to the syntactic anomaly of SOV_f in main clauses: (i) SOV_f is ungrammatical in main clauses, and (ii) the finite verb cannot be parsed in its preferred position immediately after the subject. By contrast, an embedded clause in SV_fO order does not violate the preferred order of subject and finite verb, even though it is ungrammatical. This difference may account for the larger and more widespread P600 in the former case.

In addition to the effects of word order and ungrammaticality, ERP differences between main and embedded clauses were found, but these were restricted to parietal brain regions. Between 300 and 500 ms, a larger positivity was observed for embedded clauses compared to main clauses. This effect was independent of word order and was probably caused by different sets of conjunctions that

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not have any surface case marking.

either introduced main or embedded clauses. Processing of these conjunctions may have lead to specific expectations about clause types, which was reflected in the observed parietal ERP difference.

Finally, a late negative shift was observed for SOV_f sentences relative to SV_fO sentences beginning at 1000 ms and lasting until the end of the recording epoch (see Figure 5). This waveform seems to reflect processes associated with sentence closure. Note that SV_fO sentences such as (5a) do not need to end after the direct object. In an SOV_f structure, on the other hand, the position of the finite verb after the direct object marks a clause boundary. It is likely that the late negative shift reflects this difference.

To further examine verb-placement preferences and to assess some of the potentially influencing factors mentioned above, we performed two additional ERP experiments, one on sentences with auxiliaries (experiment 3), and one comparing ERPs to the critical nouns and verbs of experiment 2 in which these items were presented in isolation without syntactic context (experiment 4).

EXPERIMENT 3: ERPs AND THE PLACEMENT OF AUXILIARIES

The main purpose of this experiment is to examine whether the observed order preference for finite verbs generalizes to auxiliaries. Auxiliaries are grammatical function words without much lexical-semantic content. They are, however, marked for finiteness in much the same way as main lexical verbs. Hence, if the order preference in experiments 1 and 2 is caused by the verb's finiteness features, we expect there to be similar ERP effects for finite main verbs and finite auxiliaries, for example, an anterior negativity for S-O-V-AUX (compared to S-AUX...-V). If, on the other hand, the advantage of the SV_fO order in our previous experiments is due to the position of the *thematic* verb, in the present experiment there should be no difference between the two word orders (S-O-V-AUX versus S-AUX...-V), since in both of them the thematic verb follows all arguments. Thus, if the S-O-V order causes a temporal ambiguity (due to the late arrival of the thematic verb), it should do so in both conditions of the present experiment.

Methods and materials

Sixteen native speakers of German participated in this experiment (age range 20-34, mean = 25.4 years; 9 women, 7 men). All of them were right-handed and had normal or corrected-to-normal vision. Critical stimuli were 66 pairs of complex sentences consisting of a main clause followed by an embedded clause. Embedded clauses were presented either with grammatical S-O-V-AUX or ungrammatical S-AUX-O-V word order. The complete set of experimental sentences is shownin the

appendix; (6) provides an example.

(6) a. Embedded clauses in correct S-O-V-AUX order

Der grüne Politiker verspricht, daß der Naturschutz *den* Wald retten wird.

'The green politician promises that the nature conservation the forest save will'

(='The green politician promises that nature conservation will save the forest'

b. Embedded clauses in incorrect S-AUX-O-V order

*Der grüne Politiker verspricht, daß der Naturschutz *wird* den Wald retten.

All the grammatically well-formed embedded clauses had a parallel structure, a complementizer followed by the subject and the object, and at the end a main verb in a non-finite form followed by an auxiliary. In the ungrammatical sentences, the auxiliary appeared immediately after the subject, as shown in (6b), leaving the rest of the sentence untouched. Each embedded clause consisted of seven words, where the words given in italics in (6) were critical for the ERP measurements; in grammatical S...AUX sentences, the critical word was either a definite article (as shown in (6)) or a possessive pronoun (*sein* 'his'), and in ungrammatical S-AUX... sentences, the critical word was an auxiliary (*hat* 'have-3rd-sg.pres.' or *wird* 'will-3rd-sg.pres.').

There were 132 experimental sentences to which 268 filler sentences were added, the latter were taken from the same pool as in experiment 2. In most experimental sentences, subjects and objects are distinguishable in terms of case marking[10]. Note also that the proportions of verb-final and verb-second placements in the experimental sentences were similar: 66 sentences had the finite verb in final and 66 in second position. Of the main clauses that preceded the experimental sentences, half were simple Subj+V_f constructions (see e.g. 2, 3, 7, 8, 12, etc.), while in the other half an additional element followed the finite verb leaving the verb in second position (e.g. 1, 4, 5, 6, etc.).

The sentences were presented in 50 blocks of 8 sentences, and each block was followed by an additional 'test' sentence presented in red color. As in experiment 2, participants had to judge (by a right or left button press) whether or not these 'test' sentences were an identical repetition of one of the preceding sentences. The whole scenario was presented in 7 blocks with short breaks of 1-2 minutes between each block. Two different scenarios were generated, so that the order of presentation for both critical conditions could be counterbalanced across participants. Presentation rate and inter-stimulus interval were the same as in experiment 2.

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[10] There were only 23 sentences in each condition that were case-ambiguous (see sentences 3, 4, 8, 9, 11, 20, 21, 22, 24, 25, 28, 30, 32, 34, 36, 40, 42, 43, 44, 49, 60, 64, 66).

EEG recording and electrode placement was the same as in experiment 2 with the exception that the digitization rate was 4 ms here[11]. ERPs were obtained separately for each electrode site and each stimulus condition for 1024 ms starting 100 ms prior to the presentation of the stimulus. Statistical results of the observed ERP effects were obtained separately for the following consecutive time windows: 150-300 ms, 300-400 ms, 400-500 ms, 500-650 ms and 650-800 ms. Separate ANOVAs were computed for midline sites and for selected parasagittal sites including the factor *word order* (S...AUX vs. S-AUX...) and for parasagittal sites also including the factors *hemisphere* (left vs. right) and *position* (anterior vs. posterior). Reported *p*-values were Greenhouse-Geisser corrected for inhomogeneities of covariance whenever applicable. Reported are the uncorrected degrees of freedom, epsilon value, and probability level following correction.

Results

The behavioral results are similar to those of experiment 2. Participants responded to the distracter task with reasonable levels of accuracy, 78% correct responses to identical sentences and 87.3% correct responses to non-identical ones.

// INSERT FIGURE 6 ABOUT HERE //

The main ERP results are shown in Figure 6. Grand average ERPs were timelocked to the presentation of the critical word in each embedded clause; this was either a determiner introducing the object in a grammatical S...AUX clause (= dotted line) or an auxiliary in an ungrammatical S-AUX... sentence (= solid line). As can be seen from Figure 6, ERP waveforms begin to diverge at about 150 ms poststimulus with a larger negativity for the (grammatical) S...AUX sentence compared to the (ungrammatical) S-AUX... sentence. This early negativity was maximal over frontocentral electrode sites and lasted until about 300 ms poststimulus. From 400 ms to approximately 650 ms poststimulus, there was another ERP difference between ungrammatical S-AUX... and grammatical S...AUX with the former being more positive; this difference, however, is likely to be influenced by the presentation of the next word (see discussion below).

Statistically, in the 150-300 ms time window, both the ANOVA for midline sites and the ANOVA for parasagittal sites revealed a significant main effect of word order with a larger negativity for the correct S...AUX order compared to the incorrect S-AUX... order ($F(1,15)=10.43$, $p<0.01$ and $F(1,15)=10.44$, $p<0.01$, respectively). For parasagittal sites, a significant word order by electrode sites interaction was also found ($F(2,30)=4.68$, $ep=0.77$, $p<0.02$). Post-hoc comparisons of mean

[11] Due to the design of the experiment, the recording epoch in experiment was half as long as in experiment 2. We were therefore able to digitize the biosignals with a better resolution in

amplitudes showed that the difference between conditions was maximal over the right fronto-central electrode Fc2 (S...AUX minus S-AUX... = 1.5μV). In the 300-400 ms time window, there were no significant main effects and no reliable interactions. In the 400-500 ms time window, there was no main effect of word order, but a significant interaction between the factors *word order* and *position* ($F(1,15)=9.41$, $p<0.01$) with a larger negativity for S...AUX compared to S-AUX... that was maximal over frontal sites. Over midline sites the interaction between *word order* and *electrode sites* was marginally significant ($F(2,30)=4.31$, $ep=0.63$, $p=0.05$). In the 500-650 ms time window, there was a main effect of *word order*, both for midline and parasagittal sites with a larger negativity for S...AUX compared to S-AUX... ($F(1,15) = 6.9$, $p < 0.02$ and $F(1,15) = 7.28$, $p < 0.02$). This effect was widely distributed. No significant interaction between *word order* and *electrode sites* were found. Finally, in the 650-800 ms time window, no main effect of word order was found, but a significant interaction between *word order* and *position* ($F(1,15) = 5.03$, $p < 0.05$) with a larger negativity for S...AUX (compared to S-AUX...), which was maximal over centro-parietal sites.

DISCUSSION: ERP EFFECTS AND THE PLACEMENT OF AUXILIARIES

The most important result from this experiment is that ERPs timelocked to the determiner of the object NP in S...AUX clauses were more negative-going than ERPs timelocked to the auxiliary in S-AUX... clauses. The difference between S...AUX and S-AUX... clauses occurred between 150 and 300 ms poststimulus and was maximal over frontocentral electrode sites. In terms of its polarity and its topographical distribution, the present ERP effect is similar to the anterior negativity found in experiment 2 as a response to SOV_f sentences.

The common property that is shared by the verbal elements used in experiments 2 and 3 is the grammatical feature 'finiteness'. In both experiments, direct objects in second position yielded larger anterior negativities than finite verbs in second position. This finding suggests that the order preference in German sentence comprehension depends upon a purely structural property, namely on whether the verbal element is marked as finite. The alternative possibility, that SOV_f (due to the late occurrence of the thematic verb) results in a higher degree of temporal ambiguity than SV_fO and is therefore dispreferred, can be ruled out, since in the present experiment the thematic verbs all appeared in the same position, namely at the end of the clause after their subjects and objects. We conclude that there is a general S-[+Fin]-O order preference which holds for finite forms of lexical verbs and (finite) auxiliaries.

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experiment 3 (i.e. 4 ms compared to 8 ms in experiment 2).

With respect to the other factors mentioned in the previous discussion, consider first the possibility that the disadvantage of the SOV_f order is due to case ambiguities in the experimental materials. Even though the present experiment does not completely rule out this possibility, we do not believe it is very likely, for the following reason. Experiment 3 contained a smaller percentage of case-ambiguous experimental sentences than experiment 2. Thus, any ERP effect in experiment 2 that is ascribed to case ambiguities should be reduced or absent in experiment 3. The crucial anterior negativity, however, is present in both experiments and is therefore unlikely to be caused by case ambiguities[12]. Another potentially influencing factor is word-order frequencies. In particular, the high frequency of finite verbs in second position in German usage and the corresponding overall preponderance of V_f-second patterns in the materials presented to subjects may have contributed to the observed preference. It is true that the experimental sentences in experiment 3 were carefully counterbalanced with respect to verb placement and that the SV_fO order, shown for half of them, was ungrammatical. Yet, most of the filler sentences (see footnote 8) had verb-second order, and these may have biased participants against the verb-final order. Moreover, even though the main clauses that preceded the experimental clauses were more variable in form than those in experiments 1 and 2, and half of the main clauses were simple Subj+V_f constructions in which verb-final and verb-second positions are indistinguishable, it is still the case that *all* of the clauses that preceded the experimental clauses were main clauses, and main clauses require a finite verb in second position. Hence, despite the precautions that were taken in the design of the experimental materials, the possibility that word-order frequencies are a contributing factor for the observed order preference cannot be ruled out. Further studies will be needed to determine whether or not this is the case.

It should also be noted that in the present experiment the negativity occurred earlier than in experiment 2. This latency difference can be attributed to the different materials used in the two experiments. Experiment 2 made use of content words and experiment 3 of function words. The latter are more frequent, monosyllabic and in general much shorter than the content words used in experiment 2. It is likely that these properties of function words are responsible for the relatively

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[12] To assess the role of case ambiguity, we considered the possibility of re-computing ERP averages for just those sentences without any case ambiguities. Unfortunately, this would have left us with a sample of 43 sentences per condition, of which another 30% would be lost due to artifacts. However, 30 artifact-free trials have been recommended as an absolute minimum for effect sizes of 2-3 µV (Münte et al. 2000). In our case, the resulting number of trials per condition would have been too low in view of the size of the experimental effect (approx. 1 µV).

short latency of the negative component found in the present experiment. In addition, we found an ERP difference in the 400-650 ms time window between ungrammatical S-AUX... and grammatical S...AUX. This difference is likely to be influenced by the presentation of the word following the critical items, which appeared 500 ms later. These postcritical words were radically different in both conditions, a content word (i.e. a noun) in the S...AUX condition and a function word (i.e. a determiner) in the S-AUX... condition. It is therefore possible that this later effect is elicited by processing differences between content and function words. This interpretation is compatible with results from previous ERP studies indicating that content words produce larger N400 effects than function words (e.g. Münte et al. 2001).

EXPERIMENT 4: ERPs FOR NOUNS AND VERBS

The purpose of this experiment is to test whether the anterior negativity for SOV_f (compared to SV_fO) in experiment 2 could be due to lexical differences between nouns and verbs, rather than (as we have suggested) to differences in syntactic structure. The lexical interpretation of the ERP difference is a plausible account, since in experiment 2 we directly compared ERPs to bare nouns (in object position) with those to simple verbs. We therefore re-tested all the critical nouns and verbs that were used in experiment 2 in an additional lexical decision experiment in which the critical words were presented together with pseudo-words in a simple word list. If the lexical interpretation of the results of experiment 2 was correct, we would expect that in this experiment (which does not require any kind of syntactic processing), nouns elicit an anterior negativity when compared to verbs.

Methods and materials

Eighteen native speakers of German participated in this experiment. The data of five of them had to be discarded due to too many EEG recording artifacts. The remaining 13 participants were 8 women and 5 men (age range 21-27, mean = 22,3 years). Stimuli were the critical words used in experiment 2 (i.e. 68 plural forms of nouns and 68 verbs in 3rd person singular form) together with 50 pseudo-words. The participants were required to perform a word/non-word (lexical) decision task. All words and pseudo-words were randomly ordered making sure that not more than three pseudo-words were following each other. Eight lists with different orders of stimuli were created, that were distributed across subjects. The stimuli were presented word by word for a duration of 300 ms. with an inter-stimulus interval of 1000 ms. EEG recording and electrode placement was the same as in experiments 2 and 3. Digitization rate was 4 ms. ERPs were obtained separately for each

electrode site and each stimulus condition for 1024 ms starting 100 ms prior to the presentation of the stimulus.

Results

Reaction times for nouns and verbs were very similar, both overall (i.e. for correct and incorrect responses) and for correct responses only. Reaction times for nouns were slightly faster, but this difference was statistically not significant. Error scores were also similar for verbs and nouns (14.2% for verbs and 14.3% for nouns).

// INSERT FIG. 7 ABOUT HERE //

The ERP waveforms in Figure 8 show a slightly larger N400 effect for verbs compared to nouns, which was significant from 350-420 ms poststimulus ($F(1,12)=5.13$, $p<0.05$) over midline and parasagittal electrode sites. This N400 effect was widely distributed. There was no interaction between the factors of word class and electrode sites.

// INSERT FIGURE 8 ABOUT HERE //

We found that in a simple lexical decision task ERPs for verbs were more negative-going than those for nouns. This is contrast to what was found in experiment 2 in which the nouns (appearing in the second position of SOV_f sentences) elicited a more negative-going waveform than the verbs (appearing in the same position in SV_fO sentences). We conclude that the anterior negativity found in experiment 2 cannot be attributed to lexical differences between nouns and verbs.

GENERAL DISCUSSION

The present study produced results from three experiments indicating that word order influences the way in which syntactic representations are constructed during on-line sentence comprehension. Our focus was on the position of finite verbs in relation to subjects and objects in German, a language that allows for different surface positions of finite verbs. We found that SV_fO word order is preferred over SOV_f in on-line sentence comprehension.

In experiment 1, sentences with ungrammatical word order produced longer reading times compared to grammatical word order, but this was only the case for (ungrammatical) SOV_f sentences. For (ungrammatical) SV_fO sentences, no significant reading-time differences were found (compared to grammatical SOV_f sentences). These results indicate that the SV_fO word order has a facilitating effect on reading times.

In experiment 2, ERPs showed an early anterior negativity for SOV_f sentences (compared to sentences in SV_fO word order), and this occurred even for grammatically well-formed SOV_f

sentences. Effects of ungrammaticality occurred later, between 700 and 1000 ms poststimulus. An additional control experiment was performed (experiment 4) to show that the ERP effect for SOV_f sentences is unlikely to be due to lexical differences.

In experiment 3, we elicited ERPs to sentences containing auxiliaries and non-finite main verbs (instead of the finite lexical verbs used in experiments 1 and 2). An anterior negativity for S...AUX (compared to S-AUX...) was found, similar to experiment 2. This finding confirms the SV_fO order preference found in experiment 1 and 2, showing that it is caused by the position of the *finite* verbal element, rather than by a verb's lexical-semantic content or argument structure.

Several factors may have contributed to the observed SV_fO order preference; see discussion in 5.2.3 and 5.3.3. We have specifically argued for a processing explanation. Assuming that all obligatory syntactic predictions that are made in the left-to-right parse of a sentence increase processing costs (Gibson 1998), and that in the grammar of German there is a close syntactic relationship between the subject and the finite verb, we argued that in parsing a German sentence, a subject may serve as an obligatory predictor for a finite verb and its corresponding phrasal projection (IP or AgrP). This means that when the first argument the parser receives in a sentence is a subject NP, it predicts a finite verb. This prediction is made for all the experimental sentences we tested, since they all have initial subjects. However, while in an SV_fO structure, the subject and the finite verb are adjacent, and thus optimal in terms of processing costs, in SOV_f order, the predicted finite verb occurs at the end of the clause. The intervening material (i.e. the object) between the point at which the prediction is made and the point at which it is satisfied may therefore lead to higher parsing efforts for SOV_f sentences, particularly extra memory costs, and hence the ERP effects and the longer reading times we found in our experiments.

The findings from our experiments raise the question of whether the SV_fO order preference reflects specific aspects of on-line comprehension, or whether it has any general significance. Consider, for example, evidence from child language. Several acquisition studies have shown that the verb-second construction of German is acquired early and is not affected in developmental language impairments. Thus, in early stages of the acquisition of German, finite verbs are almost always placed in second or first position, i.e. before objects (see Clahsen & Penke 1992, Boser et al. 1992, Poeppel & Wexler 1993) It has also been shown that children with Specific Language Impairment produce fewer finite verb forms than unimpaired control subjects and make inflectional errors, but that the finite verb forms they use are correctly placed in second or first position (Clahsen et al. 1997). Thus, SLI children are capable of discovering the placement properties of finite verbs in German main clauses, despite their impairment in forming correctly inflected finite verbs. Acquired

language disorders such as Broca's aphasia show the same picture. German-speaking Broca's aphasics often produce root infinitives, i.e. main clauses in which a finite verb form is replaced by a nonfinite form such as an infinitive or participle, and these nonfinite verb forms are generally placed clause-finally (as required by German, see Penke 1998). However, when the aphasics produce finite verb forms, these are (correctly) placed in second or first position. Penke (2001) found, for example, that out of 615 finite verbs produced by 4 German-speaking Broca's aphasics, 607 cases (= 99%) were correctly placed in second or first position (for similar data see Kolk & Heeschen 1992). These findings show that the (S)V_fO order is not only preferred in comprehension but that it is also early in child language acquisition, and not affected in developmental language disorders or in aphasia.

Extending the question of word order preferences further, we may wonder to what extent the observed preference of processing finite verbs immediately after the subject applies to other languages. With respect to this, we note an interesting left-right asymmetry in finite verb placement across languages. It has been observed (see e.g. Steele 1975, Steele et al. 1981) that many languages permit a construction with a finite verbal element (i.e. an auxiliary or a finite lexical verb) in clause-initial or second position. Such a construction is found in languages that are otherwise completely unrelated, for example the continental Germanic languages, Warlpiri, Luiseño, Vata and Gbadi (Koopman 1984). The V2 construction for finite verbs is found in head-initial languages with basic VO order (e.g. in the Scandinavian languages) and in SOV languages such as Dutch and German. Interestingly, the reverse possibility, i.e. head-initial languages with basic VO order that place finite verbs clause-finally, seems to be extremely rare cross-linguistically. One might attribute the prevalence of the V2/V1 construction to the fact that finite verbal elements provide crucial structural information for the construction of clause-level syntactic units, and to the close syntactic relation between the finite verb forms with the subject. Hence, the V2-construction for finite verbs might be beneficial in the left-to-right parsing of a sentence.

Even for a consistently head-final language such as Japanese we can see ramifications of the order preference for finite verbs. Hawkins (1994) observed that in written Japanese texts there is a clear preference for short direct objects, while there is no such preference for subjects. The reverse distribution of syntactic weight is found in head-initial languages such as English, subjects tend to be short and direct objects may be long and syntactically heavy. This asymmetry can be explained in terms of the order preference for finite verbs along with grammatical differences between head-final and head-initial languages. Clearly, the predictions made by the parser during on-going processing depend crucially on the grammar of the particular language. Thus, in Japanese a finite

verb is constructed at the right periphery, whereas in English it is constructed at the left periphery. Suppose, however, that the order preference applies in both cases, such that upon encountering a subject NP the parser predicts (= expects) a finite verb. Then, it might be advantageous to minimize the distance between the subject, respectively the subject case suffix *-ga*, and the finite verb, and in an SOV language like Japanese this means having short direct objects. In an SVO language, however, the finite verb and the subject are adjacent anyway, and hence there is no corresponding constraint on direct objects.

CONCLUSION

Our results suggest that native speakers of German have a preference for processing finite verbs in second position, i.e. immediately after the subject and before the object, rather than at the end of the clause. We explained the experimental difference between SV_fO and SOV_f in terms of differences in processing costs.

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FIGURE CAPTIONS

Figure 1: Experiment 1. Mean reading times in ms for the critical objects and verbs in the four experimental conditions.

Figure 2: Experiment 2. ERP effects of word order. *Left column*: Grand average ERPs from 19 selected electrodes to SV_fO word order (solid line) and SOV_f word order (dotted line) collapsed over main and embedded clauses, i.e. over correct and incorrect conditions. Each tick represents 100 ms. Negative voltage is plotted up. ERPs associated with SOV_f word order showed a larger negativity compared to ERPs associated with SV_fO word order, mainly between 300 and 500 ms poststimulus with a fronto-central maximum. *Right column*: SV_fO and SOV_f differences displayed separately for main clauses (upper panel) and embedded clauses (lower panel) over the frontal electrode Fz.

Figure 3: Experiment 2. ERP effects of word order. Illustration of the scalp distribution of the negative effect associated with SOV_f word order: depicted are the mean differences between SV_fO and SOV_f word order in the 300-500 ms time window (aligned for the prestimulus baseline -200 to 0 ms). LH, left hemisphere, RH, right hemisphere. The negative effect has a frontocentral maximum.

Figure 4: Experiment 2. ERP effects of ungrammaticality. Grand average ERPs associated with correct word order (solid line) and incorrect word order (dotted line), illustrated separately for SOV_f word order (left column) and SV_fO word order (right column). Displayed are ERP effects over the three midline electrodes Fz, Cz, and Pz for a duration of 1200 ms. ERP effects of ungrammaticality, reflected in a larger positivity between 700-1000 ms poststimulus, can be seen for incorrect SOV_f compared to correct SOV_f word order, while this effect was small and marginal significant only over the parietal site Pz for incorrect SV_fO compared to correct SV_fO word order.

Figure 5: Experiment 2. Grand average ERPs for all four conditions. Illustrated are ERP effects over the midline electrodes Fz, Cz and Pz for a duration of 1800 ms.

Figure 6: Experiment 3. ERP effects of word order. ERPs were timelocked to the correct determiner (dotted line) and to the incorrect auxiliary (solid line) in embedded clauses. Displayed are the effects from 19 selected channels.

Figure 7: Experiment 4. Lexical decision times in ms for verbs versus nouns for all responses and for correct responses only.

Figure 8: Experiment 4. Grand average ERPs from 19 selected electrodes to verbs (solid line) versus nouns (dotted line) presented in a word list.

APPENDIX

Sentences presented in Experiment 1

The subscript 'S(ubject)' indicates that a DP is unambiguously case-marked (= nominative); this holds for masculine singular DPs.

1a. Der Tischler verlangt, dass [der Lehrling]$_S$ die Bretter stapelt.
(= The carpenter demands that the apprentice stacks the boards.)

1b. Peter stellt Regale auf, und [der Gehilfe]$_S$ stapelt die Bretter.
(= Peter is putting up shelves and the assistant is stacking the boards.)

2a. Die Leiterin des Kochkurses bestimmt, dass Erika die Dosen öffnet.
(= The lady in charge of the cookery course selects Erika to open the cans.)

2b. Hans facht das Lagerfeuer an, und Paul öffnet die Dosen.
(= Hans is fanning the camp fire and Paul is opening the cans.)

3a. Der nahende Gerichtstermin erfordert, dass [der Anwalt]$_S$ die Akten ordnet.
(= The imminent day of hearing makes it necessary for the lawyer to arrange the files.)

3b. Der Notar diktiert Schriftsätze, und die Sekretärin ordnet die Akten.
(= The notary is dictating statements and the (female) secretary is arranging the files.)

4a. Die frechen Elstern bemerken, dass das Mädchen die Spatzen füttert.
(= The cheeky magpies notice that the girl is feeding the sparrows.)

4b. Vater hängt den Meisenring auf, und Mutter füttert die Spatzen.
(= Dad is hangig up the (circular) tit food and mum is feeding the sparrows.)

5a. An Silvester bitten die Kinder, dass Vater die Kracher zündet.
(= On New Year's Eve the children ask their father to fire the bangers.)

5b. Das neue Jahr beginnt, und die Menge zündet die Kracher.
(= The new year begins and the crowd are firing the bangers.)

6a. Die Gemeinde bezahlt dafür, dass [der Hirte]$_S$ die Schafe hütet.
(= The municipality pays the herdsman to tend the sheep.)

6b. Der Schaefer trinkt Tee, und [der Hund]$_S$ hütet die Schafe.
(= The shepherd is drinking tea and the dog is watching the sheep.)

7a. Der Landwirt erkundigt sich, ob die Maschine die Rüben erntet.
(= The farmer inquires whether the machine harvests (the) turnips.)

7b. Der Herbst ist gekommen, und [der Bauer]$_S$ erntet die Rüben.
(= Autumn has come and the farmer is harvesting turnips.)

8a. Der Feldwebel empfiehlt, dass [der Rekrut]$_S$ die Stiefel säubert.

(= The sergeant advises the recruit to clean his boots.)

8b. Ein Appell steht an, und [der Soldat]$_S$ säubert die Stiefel.

(= A roll call is on the agenda and the recruit is cleaning his boots.)

9a. Es ist interessant, dass die Königin die Ritter adelt.

(= It is interesting that the queen raises the knights to peerage.)

9b. Die Zuschauer sind begeistert, denn [der Koenig]$_S$ adelt die Ritter.

(= The audience are enthusiastic, for the king raises the knights to peerage.)

10a. Die Kundin bewundert, wie die Floristin die Sträuße bindet.

(= The (female) customer admires the way the (female) florist arranges the bouquets.)

10b. Es ist Valentinstag, und [der Blumenhändler]$_S$ bindet die Sträuße.

(= It is Valentine's Day and the florist is arranging the bouquets.)

11a. Es wird höchste Zeit, dass [der Naturschutz]$_S$ die Wälder rettet.

(= It is high time nature conservation(ists) saved the forests.)

11b. Auch Deine Spende ist nützlich, denn Greenpeace rettet die Wälder.

(= Also your donation is useful, for Greenpeace saves the forests.)

12a. Im Stahlwerk wird erwartet, dass [der Azubi]$_S$ die Drähte wickelt.

(= In the steel mill it is expected that the trainee winds the wires.)

12b. Heinz bereitet Rollen vor, und [der Gehilfe]$_S$ wickelt die Drähte.

(= Heinz is preparing coils and the assistant is winding the wires.)

Sentences presented in Experiment 2

1a. Die Äbtissin beschwert sich, daß [der Lausbub]$_S$ Nonnen ärgert.

(= The abbess complains about the naughty boy annoying (some) nuns.)

1b. Manche schwatzen im Kloster, und dieses Verhalten ärgert Nonnen.

(= Some people are chatting in the monastery and this behaviour annoys (some) nuns.)

2a. Der Tischler verlangt, daß [sein neuer Lehrling]$_S$ Bretter stapelt.

(= The carpenter demands that his new apprentice should stack boards.)

2b. Peter stellt Regale auf, und [sein Gehilfe]$_S$ stapelt Bretter.

(= Peter is putting up shelves and his assistant is stacking boards.)

3a. Die Versicherung lebt davon, daß [der Mensch]$_S$ Brände fürchtet.

(= The insurance company lives off the fact that man fears fire.)

3b. Menschen beherrschen das Feuer, aber ein Tier fürchtet Brände.

(= Human beings control fire, but an animal fears fire(s).)

4a. Die Leiterin des Kochkurses bestimmt, daß Erika Dosen öffnet.

(= The lady in charge of the cookery course selects Erika to open cans.)

4b. Hans facht das Lagerfeuer an, und Paul öffnet Dosen.

(= Hans is fanning the camp fire and Paul is opening cans.)

5a. Der Meister begutachtet kritisch, wie die Frisöse Locken kräuselt.

(= The master is critically examining how the (female) hairdresser is frizzing curls.)

5b. Die Friseuse schneidet Haare, und ihre Kollegin kräuselt Locken.

(= The (female) hairdresser is cutting hair and her (female) colleague is frizzing curls.)

6a. Neugierig fotografieren die Touristen, wie [der Fischer]$_S$ Austern züchtet.

(= The tourists are curiously taking photographs of how the fisherman breeds oysters.)

6b. Die Perlenpreise steigen, und [der geschäftstüchtige Fischer]$_S$ züchtet Austern.

(= The price of pearls is rising and the smart fisherman breeds oysters.)

7a. Der Kapitän zeigt achtern, wie [ein Seemann]$_S$ Taue knotet.

(= The captain points to the back of the boat to show how a sailor is tying ropes.)

7b. Der Smutje schält Kartoffeln, und [der Schiffsjunge]$_S$ knotet Taue.

(= The ship's cook is pealing potatoes and the ship's boy is tying ropes.)

8a. Der nahende Gerichtstermin erfordert, daß [der Anwalt]$_S$ Akten ordnet.

(= The imminent day of hearing makes it necessary for the lawyer to arrange files.)

8b. Der Notar diktiert Schriftsätze, und seine Sekretärin ordnet Akten.

(= The notary is dictating statements and the (female) secretary is arranging files.)

9a. Der Kommandant befürchtet, daß das feindliche Schiff Salven feuert.

(= The commander fears that the enemy boat will fire volleys.)

9b. Die Königin empfängt Staatsbesuch, und die Ehrengarde feuert Salven.

(= The queen is receiving state visitors and the guards of honour are firing volleys.)

10a. Der Biologe fand heraus, daß [der Elefant]$_S$ Herden bildet.

(= The biologist discovered that elefants form herds.)

10b. Der Leopard jagt allein und [der Löwe]$_S$ bildet Herden.

(= Leopards hunt on their own and lions form herds.)

11a. Es ist kein Wunder, daß [ein Verbrecher]$_S$ Morde leugnet.

(= It is no wonder that a criminal denies murder(s).)

11b. Er gesteht die Einbrüche, aber [der Täter]$_S$ leugnet Morde.

(= He confesses the burglaries, but the culprit denies murder(s).)

12a. Der Redakteur wartet gespannt, ob seine Quelle Stories liefert.

(= The editor is waiting curiously whether his new source/informant will supply stories.)

12b. Das Fernsehen produziert Träume, und die Realität liefert Stories.

(= Television produces dreams and reality supplies stories.)

13a. Don Quichotte ist entsetzt, daß Sancho Pansa Esel sattelt.

(= Don Quichotte is appalled by the fact that Sancho Pansa is saddling donkeys.)

13b. Die Expedition beginnt gleich, und [der Führer]$_S$ sattelt Esel.

(= The expedition is about to start and the guide is saddling donkeys.)

14a. Die Visagistin ist verärgert, daß die Fotografin Nasen pudert.

(= The makeup artist is angry about the fact that the (female) photographer is powdering noses.)

14b. Schauspieler proben ihre Texte, und [der Visagist]$_S$ pudert Nasen.

(= Actors are rehearsing their texts an the makeup artist is powdering noses.)

15a. Eine Demokratie macht möglich, daß [jeder Bürger]$_S$ Rechte fordert.

(= A democracy makes it possible for every citizen to claim rights.)

15b. Der Tarifstreit ist entbrannt, und die Gewerkschaft fordert Rechte.

(= The wage dispute is kindled and the union is claiming rights.)

16a. Der Polier tobt, daß [ein weiblicher Lehrling]$_S$ Zement schaufelt.

(= The foreman is in a rage because a female apprentice is shovelling cement.)

16b. Die Mischmaschine läuft schon, und [der Bauarbeiter]$_S$ schaufelt Zement.

(= The cement mixer is already running and the construction worker is shovelling cement.)

17a. Der kanadische Winter erfordert, daß [der Trapper]$_S$ Brennholz spaltet.

(= The Canadian winter makes it necessary for the trapper to chop fire wood.)

17b. Der Winter ist hart, und [der Knecht]$_S$ spaltet Brennholz.

(= The winter is hard and the serf chops fire wood.)

18a. Der Kirchgänger glaubt fest, daß [der Messbesuch]$_S$ Sünder bessert.

(= The churchgoer firmly believes that attending the mess will reform sinners.)

18b. Der Sozialarbeiter bestreitet es, aber die Haftstrafe bessert Sünder.

(= The social worker disputes it, but prison sentences reform sinners.)

19a. Die Jäger warten gespannt, daß [der Hund]$_S$ Beute wittert.

(= The hunters cannot wait that the dog will scent (the) prey.)

19b. Hasen springen übers Feld, und [der Fuchs]$_S$ wittert Beute.

(= Rabbits are jumping over the field and the fox is scenting (the) prey.)

20a. Es ist sehr verwirrend, daß [der Spielführer]$_S$ Regeln ändert.

(= It is very confusing that the captain is changing (the) rules.)

20b. Die Spieler sind aufgebracht, denn [der Schiedsrichter]$_S$ ändert Regeln.

(= The players are upset, for the referee is changing (the) rules.)

21a. Es kommt selten vor, daß [ein Dummkopf]$_S$ Schätze findet.

(= It hardly ever happens that an idiot finds treasures.)

21b. Das Wrack ist gehoben, und [der Archäologe]$_S$ findet Schätze.

(= The wreck is raised and the archaeologist finds treasures.)

22a. Schumacher beobachtet kritisch, wie seine neue Crew Reifen wechselt.

(= Schuhmacher critically examines how his new crew are changing tyres.)

22b. Der Mechaniker überprüft Bremsbeläge, und [der Lehrling]$_S$ wechselt Reifen.

(= The mechanic is checking brake linings and the apprentice is changing tyres.)

23a. Im Werkkurs lernt man, wie [ein Buchbinder]$_S$ Pappe schneidet.

(= In the arts and crafts course one learns how a bookbinder cuts cardboard.)

23b. Die Klasse bastelt Lampions, und unsere Gruppe schneidet Pappe.

(= The class is making Chinese lanterns and our group is cutting cardboard.)

24a. Der Alarmplan sieht vor, daß [der Wachdienst]$_S$ Pforten sichert.

(= The emergency plan intends the guards to secure the gates.)

24b. Die Fenster sind vergittert, und die Alarmanlage sichert Pforten.

(= The windows are barred and the alarm secures the gates.)

25a. Der Anwalt ist dagegen, daß [dieser Geschworene]$_S$ Schurken richtet.

(= The lawyer does not want this member of the jury to judge rogues.)

25b. Die Volksseele fordert Selbstjustiz, aber das Gesetz richtet Schurken.

(= The public feeling calls for taking the law into one's own hands, but the law judges rogues.)

26a. Die Verkäuferin verspricht, daß die teure Strumpfhose Venen kräftigt.

(= The (female) shop-assistant promises that the expensive tights will strengthen veins.)

26b. Es schmeckt ziemlich schlecht, aber dieses Medikament kräftigt Venen.

(= It tastes rather bad, but this drug strengthens veins.)

27a. Die frechen Elstern bemerken, daß das Mädchen Spatzen füttert.

(= The cheeky magpies notice that the girl is feeding sparrows.)

27b. Vater hängt den Meisenring auf, und Mutter füttert Spatzen.

(= Dad is hanging up (circular) tit food and mum is feeding sparrows.)

28a. An Silvester bitten die Kinder, daß Vater Kracher zündet.

(= On New Year's Eve the children ask their father to fire bangers.)

28b. Das neue Jahr beginnt, und die Menge zündet Kracher.

(= The new year begins and the crowd are firing bangers.)

29a. Erich bemerkt nicht, daß seine aufopfernde Gattin Sakkos bürstet.

(= Erich does not notice that his self-sacrificing wife is brushing jackets.)

29b. Sie sind nicht schmutzig, aber die Haushälterin bürstet Sakkos.

(= They are not dirty, but the housekeeper is brushing jackets.)

30a. Der besorgte Arzt rät, daß [der Allergiker]$_S$ Käse meidet.

(= The worried doctor advised the allergy sufferer to avoid cheese.)

30b. Mein Bruder verabscheut Fleisch, und meine Schwester meidet Käse.

(= My brother despises meat and my sister avoids cheese.)

31a. Der Job erfordert es, daß [ein Moderator]$_S$ Sprüche sammelt.

(=The job requires (it) that a presenter collects maximes.)

31b. Ein Gedichtband ist geplant, und [der Poet]$_S$ sammelt Sprüche.

(= A book of poems is planned and the poet is collecting maximes.)

32a. Die Gemeinde bezahlt dafür, daß [der Hirte]$_S$ Schafe hütet.

(= The municipality pays the herdsman to tend sheep.)

32b. Der Schäfer trinkt Tee und [sein Hund]$_S$ hütet Schafe.

(= The shepherd is drinking tea and the dog is watching sheep.)

33a. Den Gast beeindruckt sehr, wie die Köchin Omeletts wendet.

(= The guest is very impressed by the way the (female) cook turns omelettes.)

33b. Der Italiener backt Pizza und [der Franzose]$_S$ wendet Omeletts.

(= The Italian man is baking pizza and the Frenchman is turning omelettes.)

34a. Jeder weiß, daß eine Erhöhung des Gehalts Schulden mindert.

(= Everyone knows that a salary increase will reduce debts.)

34b. Das Erbe ist groß, und seine Auszahlung mindert Schulden.

(= The inheritance is big and its payment will reduce debts.)

35a. Die Zoobesucher beobachten begeistert, wie [der Tierpfleger]$_S$ Affen kitzelt.

(= The visitors of the zoo enthusiastically observe how the (animal) keeper is tickling monkeys.)

35b. Der Tierpfleger ist weg, und das Kind kitzelt Affen.

(= The (animal) keeper is gone and the child is tickling monkeys.)

36a. Der Priester sieht, daß [der fromme Novize]$_S$ Kerzen opfert.

(= The priest sees that the pious novice is sacrificing candles.)

36b. Es ist Ostern, und die trauernde Witwe opfert Kerzen.

(= It is Easter and the mourning widow is sacrificing candles.)

37a. Der Anwalt überprüft, ob [sein fauler Gehilfe]$_S$ Schriften heftet.

(= The lawyer checks whether his lazy assistant is stapling documents.)

37b. Der Briefwechsel ist umfangreich und die Sekretärin heftet Schriften.

(= The correspondence is extensive and the (female) secretary is stapling documents.)

38a. Der Landwirt erkundigt sich, ob diese Maschine Rüben erntet.

(= The farmer inquires whether this machine harvests turnips.)

38b. Der Herbst ist gekommen, und [der Bauer]$_S$ erntet Rüben.

(= Autumn has come and the farmer is harvesting turnips.)

39a. Die Werbung verspricht, daß die neue Maschine Äcker ebnet.

(= Advertisements promise that the new machine is levelling fields.)

39b. Die Ernte ist eingefahren, und [der Bauer]$_S$ ebnet Äcker.

(= The crop is brought in and the farmer is levelling fields.)

40a. Die Fachpresse erwartet gespannt, wie Karl Lagerfeld Models kleidet.

(= The trade press is curiously awaiting how Karl Lagerfeld will dress models.)

40b. Ganz Paris steht Kopf, denn die Modewelt kleidet Models.

(= The whole of Paris is turned upside down, for the fashion world is dressing models.)

41a. Der Feldwebel befiehlt, daß [der neue Rekrut]$_S$ Stiefel säubert.

(= The sergeant commands the new recruit to clean boots.)

41b. Ein Appell steht an, und [der Soldat]$_S$ säubert Stiefel.

(= A roll call is on the agenda and the soldier is cleaning boots.)

42a. Vor dem Urlaub verlangen alle, daß Gisela Karten sendet.

(= Before the vacation everyone is demanding that Gisela should send cards.)

42b. Susanne wünscht sich Schmuck, und [ihr Ehemann]$_S$ sendet Karten.

(= Susanne is wishing for jewellery and her husband is sending cards.)

43a. Der Priester verkündet, daß das Jüngste Gericht Sünden ahndet.

(= The priest proclaims that the last judgement will avenge sins.)

43b. Das Paradies verheißt Erlösung, und die Hölle ahndet Sünden.

(= Paradise promises salvation and hell avenges sins.)

44a. Der kleine Junge fürchtet, daß [der Pfarrer]$_S$ Schwindler tadelt.

(= The little boy fears that the priest will reprimand swindlers.)

44b. Kleine Notlügen sind praktisch, aber die Kirche tadelt Schwindler.

(= Small white lies are practical, but the church reprimands swindlers.)

45a. Der Psychologe erklärt, wie ein kleines Kind Fabeln deutet.

(= The psychologist explains how a little child interprets fables.)

45b. Im Lehrplan steht Goethe, aber [unser Lehrer]$_S$ deutet Fabeln.

(= Goethe is in the curriculum, but our teacher interprets fables.)

46a. In Asien sahen wir, wie [ein Barbier]$_S$ Bärte zwirbelt.

(= In Asia we saw how a barber twists beards.)

46b. Es ist zwar altmodisch, aber [unser Frisör]$_S$ zwirbelt Bärte.

(= It is indeed old-fashioned, but our hairdresser twists beards.)

47a. Der barfüßige Landstreicher wartet, daß die Sonne Strümpfe trocknet.

(= The barefoot tramp waits for the sun to dry his socks.)

47b. Die Jeans bleiben feucht, aber die Maschine trocknet Strümpfe.

(= Jeans remain damp, but the machine dries socks.)

48a. Es ist interessant, daß die englische Königin Ritter adelt.

(= It is interesting that the British queen raises knights to peerage.)

48b. Die Zuschauer sind begeistert, denn [der König]$_S$ adelt Ritter.

(= The audience are enthusiastic, for the king is raising knights to peerage.)

49a. Die Kundin bewundert, wie die geschickte Floristin Sträuße bindet.

(= The (female) customer admires the way the skilful (female) florist arranges bouquets.)

49b. Es ist Valentinstag, und [der emsige Blumenhändler]$_S$ bindet Sträuße.

(= It is Valentine's Day and the industrious florist is arranging bouquets.)

50a. Die Bäuerin sieht wütend, daß [der Bauer]$_S$ Schnäpse testet.

(= The farmer's wife sees with fury that the farmer is trying spirits.)

50b. Im Brauhaus herrscht Stimmung, denn [der Minister]$_S$ testet Schnäpse.

(= In the brewery things are livened up, for the minister is trying spirits.)

51a. Es ist nicht erlaubt, daß [ein Polizist]$_S$ Füße fesselt.

(= A policeman is not permitted to tie feet.)

51b. Er knebelt alle Geiseln, und [sein Komplize]$_S$ fesselt Füße.

(= He is gagging all hostages and his accomplice is tying (their) feet.)

52a. Der Hausmeister kontrolliert, wie die neue Putzkolonne Böden scheuert.

(= The caretaker is controlling how the new cleaning crew are scrubbing (the) floor(s).)

52b. Der Frühjahrsputz steht an, und unsere Putzfrau scheuert Böden.

(= Spring cleaning is on the agenda and our (female) cleaner is scrubbing (the) floor(s).)

53a. Der Vertrag sieht vor, daß die Spedition Kisten lagert.

(= The contract determines that the haulage company is to store boxes.)

53b. Nirgends ist mehr Platz, aber meine Mutter lagert Kisten.

(= Nowhere is any space left, but my mother stores boxes.)

54a. Die Kinder schauen zu, wie [ihr Vater]$_S$ Pflaumen schüttelt.

(= The children are watching their father shaking plums.)

54b. Petra sammelt Äpfel auf, und [ihr Bruder]$_S$ schüttelt Pflaumen.

(= Petra is picking up apples and her brother is shaking plums.)

55a. Das Plakat zeigt, wie die alte Frau Schlangen häutet.

(= The poster shows how the old woman is sloughing off snakes.)

55b. Der Indianer raucht Pfeife, und seine Squaw häutet Schlangen.

(= The Indian is smoking (a) pipe and his squaw is sloughing off snakes.)

56a. Es wird höchste Zeit, daß [der Naturschutz]$_S$ Wälder rettet.

(= It is high time that nature conservation(ists) saved forests.)

56b. Auch deine Spende ist nützlich, denn Greenpeace rettet Wälder.

(= Also your donation is useful, for Greenpeace saves forests.)

57a. Der ständige Regen verhindert, daß die Hausfrau Wäsche klammert.

(= The constant rain prevents the housewife from hanging up washing.)

57b. Es ist sonniges Wetter, und die Haushälterin klammert Wäsche.

(= The weather is sunny and the housewife is hanging up washing.)

58a. Der König befiehlt hartherzig, daß [der Henker]$_S$ Diebe blendet.

(= The king hard-heartedly orders the henchman to blind thieves.)

58b. Der Sultan spricht Recht, und seine Wache blendet Diebe.

(= The sultan administers justice and his guard blinds thieves.)

59a. Die Gutsherrin ordnet an, daß die Zofe Laken faltet.

(= The lady of the manor orders the maid to fold sheets.)

59b. Die Wäsche ist gemangelt, und die Hausfrau faltet Laken.

(= The washing is mangled and the housewife is folding sheets.)

60a. Die Postbeamten wollen verhindern, daß eine Maschine Briefe stempelt.

(= The post office clerks want to prevent that a machine will stamp letters.)

60b. Es ist längst Dienstschluß, aber die Sekretärin stempelt Briefe.

(= It is long after hours, but the (female) secretary is stamping letters.)

61a. Der Psychologe verspricht, daß seine neue Therapie Ängste mildert.

(= The psychologist promises that his new therapy will alleviate fears.)

61b. Kleinkinder sind furchtsam, aber die mütterliche Stimme mildert Ängste.

(= Infants are timid, but their mother's voice alleviates fears.)

62a. Petra freut sich darüber, daß [ihr Sohn]$_S$ Hamster streichelt.

(= Petra is happy about the fact that her son is caressing hamsters.)

62b. Edgar mag Tiere gar nicht, aber Susi streichelt Hamster.

(= Edgar does not like animals at all, but Susi is caressing hamsters.)

63a. Jeder hier weiß, daß die kesse Sabine Witwer tröstet.

(= Everyone here knows that the pert Sabine consoles widowers.)

63b. Der Hinterbliebene betet oft, denn die Andacht tröstet Witwer.

(= The dependant often prays, for devotions give consolation to widowers.)

64a. Der Pfarrer erläutert uns, daß die Ehe Rückhalt bietet.

(= The priest is explaining to us that marriage gives support.)

64b. Jeder Mensch braucht Freunde, denn [ein Freund]$_S$ bietet Rückhalt.

(= Every human being needs friends, for a friend gives support.)

65a. Im Stahlwerk wird erwartet, daß [der Azubi]$_S$ Drähte wickelt.

(= In the steel mill it is expected that the trainee winds wires.)

65b. Heinz bereitet Rollen vor, und [sein Gehilfe]$_S$ wickelt Drähte.

(= Heinz is preparing coils and his assistant is winding wires.)

66a. Der Direktor verlangt, daß [der neue Dirigent]$_S$ Chöre leitet.

(= The director demands that the new conductor should be in charge of (some) choirs.)

66b. Dein Bruder ist Sänger, und [mein Bruder]$_S$ leitet Chöre.

(= Your brother is (a) singer and my brother is in charge of (some) choirs.)

67a. Amnesty International prangert an, daß die Regierung Sklaven knechtet.

(= Amnesty International condemn the government for subjugating slaves.)

67b. Das Königshaus ist angesehen, aber [der Kronprinz]$_S$ knechtet Sklaven.

(= The royal dynasty is respected, but the crown prince is subjugating slaves.)

68a. Man kann darauf vertrauen, daß [der Alarmknopf]$_S$ Feuer meldet.

(= One cannot trust the alarm (button) to give a warning against fire.)

68b. Nirgends ist Rauch, aber [dieser neue Apparat]$_S$ meldet Feuer.

(= There is no smoke anywhere, but this new device is giving a fire alarm.)

Sentences presented in Experiment 3

‘S(ubject)’ and ‘O(bject) indicate that a DP is unambiguously case-marked as nominative or accusative; this applies to masculine singular DPs.

1. Die Äbtissin beschwert sich, daß [der Lausbub]$_S$ die Nonne geärgert hat.
   (= The abbess complains that the naughty boy teased the nun.)
2. Der Tischler verlangt, daß [sein neuer Lehrling]$_S$ die Bretter stapeln wird.
   (= The joiner requires his new apprentice to stack the boards.)
3. Die Leiterin des Kochkurses bestimmt, daß Erika die Dosen öffnen wird.
   (= The leader of the cookery course decides that Heather will open the cans.)
4. Der Meister begutachtet kritisch, wie die Friseuse die Locken gekräuselt hat.
   (= The master examines critically how the hairdresser makes fizzy curls.)
5. Neugierig fotografieren die Touristen, wie [der Fischer]$_S$ die Austern gezüchtet hat.
   (=The tourists curiously take a photograph of how the fisherman bred the oysters.)
6. Der Kapitän zeigt achtern, wie [ein Seemann]$_S$ das Tau geknotet hat.
   (= The captain points to the back of the boat to show how a sailor tied the rope into a knot.)
7. Der nahende Gerichtstermin erfordert, daß [der Anwalt]$_S$ die Akten geordnet hat.
   (= The approaching date of the trial requires the advocate to get the files organized.)
8. Der Kommandant befürchtet, daß das feindliche Schiff die Salve feuern wird.
   (= The commanding officer fears that the hostile ship will fire the volley.)
9. Der Redakteur wartet gespannt, ob seine Quelle die Story liefern wird.
   (= The editor is waiting curiously as to whether his source will provide the story.)
10. Don Quichotte ist entsetzt, daß Sancho Pansa [den Esel]$_O$ gesattelt hat.
    (= Don Quichotte is horrified that Sancho Pansa has saddled the donkey.)
11. Die Visagistin ist verärgert, daß die Fotografin die Nase gepudert hat.
    (= The make-up artist is annoyed that the photographer has powdered the nose.)
12. Der Polier tobt, daß [ein weiblicher Lehrling]$_S$ [den Zement]$_O$ geschaufelt hat.
    (= The site foreman rages as a female apprentice has shoveled the cement.)
13. Der kanadische Winter erfordert, daß [der Trapper]$_S$ das Brennholz gespalten hat.
    (= The Canadian winter makes it necessary for the ranger to have chopped the firewood.)
14. Der Kirchgänger glaubt fest, daß [der Messbesuch]$_S$ [den Sünder]$_O$ bessern wird.
    (= The churchgoer firmly believes that visiting the mass will reform the sinner.)
15. Die Jäger warten gespannt, daß [der Hund]$_S$ die Beute wittern wird.
    (= The hunters are waiting curiously for the dog to scent the prey.)
16. Es ist sehr verwirrend, daß [der Spielführer]$_S$ die Regeln geändert hat.
    (= It is very confusing that the captain has changed the rules.)
17. Schumacher beobachtet kritisch, wie seine neue Crew [den Reifen]$_O$ gewechselt hat.

(= Schumacher is critically observing how his new crew has changed the tire.)

18. Der Alarmplan sieht vor, daß [der Wachdienst]$_S$ die Pforte sichern wird.
(= The alarm plan requires the security service to secure the gate.)

19. Der Anwalt ist dagegen, daß [dieser Geschworene]$_S$ [den Schurken]$_O$ richten wird.
(= The lawyer is opposed to this juror's decision to judge the villain.)

20. Die Verkäuferin verspricht, daß die teure Strumpfhose die Venen kräftigen wird.
(= The (female) shop-assistant promises that the expensive pants will strengthen the veins.)

21. Die frechen Elstern bemerken, daß das Mädchen die Spatzen gefüttert hat.
(= The cheeky magpies notice that the girl has fed the sparrows.)

22. Erich bemerkt nicht, daß seine aufopfernde Gattin das Sakko gebürstet hat.
(Eric doesn’t notice that his self-sacrificing wife has brushed the sports jacket.)

23. Die Gemeinde bezahlt dafür, daß [der Hirte]$_S$ die Schafe hüten wird.
(= The council is paying for the shepherd to look after the sheep.)

24. Den Gast beeindruckt sehr, wie die Köchin die Omeletts gewendet hat.
(= The guest is very impressed by the way the cook has turned over the pancakes.)

25. Jeder weiß, daß eine Erhöhung des Gehalts die Schulden mindern wird.
(= Everybody knows that a pay raise will reduce the debts.)

26. Die Zoobesucher beobachten begeistert, wie [der Tierpfleger]$_S$ [den Affen]$_O$ gekitzelt hat.
(= The zoo visitors enthusiastically observe the zoo-keeper tickling the monkey.'

27. Der Anwalt überprüft, ob [sein fauler Gehilfe]$_S$ die Schriften geheftet hat.
(= The lawyer is checking whether his lazy assistant has stapled the documents.)

28. Der Landwirt erkundigt sich, ob diese Maschine die Rüben geerntet hat.
(= The farmer is asking whether this machine has harvested the beets.)

29. Die Werbung verspricht, daß die neue Maschine [den Acker]$_O$ ebnen wird.
(= The advertisement promises that the new machine will level off the field.)

30. Die Fachpresse erwartet gespannt, wie Karl Lagerfeld die Models kleiden wird.
(= The specialist press are waiting curiously on how Karl Lagerfeld will dress the models.'

31. Der Feldwebel befiehlt, daß [der neue Rekrut]$_S$ die Stiefel säubern wird.
(= The sergeant is ordering the new recruit to clean the boots.)

32. Der Priester verkündet, daß das Jüngste Gericht die Sünden ahnden wird.
(= The priest is announcing that the Last Judgment will avenge the sins.)

33. Der kleine Junge fürchtet, daß [der Pfarrer]$_S$ [den Schwindler]$_O$ tadeln wird.
(= The little boy fears that the priest will tell off the swindler.)

34. Der Psychologe erklärt, wie ein kleines Kind die Fabel gedeutet hat.
(= The psychologist explains the way a small child has interpreted the fable.)
35. In Asien sahen wir, wie [ein Barbier]$_S$ den Bart gezwirbelt hat.
(= In Asia we saw how a barber was twisting the beard.)
36. Der barfüßige Landstreicher wartet, daß die Sonne die Strümpfe trocknen wird.
(= The barefooted hobo is waiting for the sun to dry the socks.)
37. Die Kundin bewundert, wie die geschickte Floristin [den Strauß]$_O$ gebunden hat.
(= The customer admires the way the skilful florist has made up the bouquet.)
38. Die Bäuerin sieht wütend, daß [der Bauer]$_S$ [den Schnaps]$_O$ getestet hat.
(= The (female) farmer sees angrily that the (male) farmer has tried the spirits.)
39. Der Hausmeister kontrolliert, wie die neue Putzkolonne [den Boden]$_O$ gescheuert hat.
(= The janitor is checking the way the new team of cleaners has scoured the floor.)
40. Der Vertrag sieht vor, daß die Spedition die Kisten lagern wird.
(= The contract requires the removal company to store the boxes.)
41. Die Kinder schauen zu, wie [ihr Vater]$_S$ die Pflaumen geschüttelt hat.
(= The children watch how their father has shaken the plums (off the tree).)
42. Das Plakat zeigt, wie die alte Frau die Schlange gehäutet hat.
(= The poster shows how the old woman has skinned the snake.)
43. Die Postbeamten wollen verhindern, daß eine Maschine die Briefe stempeln wird.
(= The post office staff want to prevent the letters being postmarked by a machine.)
44. Der Psychologe verspricht, daß seine neue Therapie die Ängste mildern wird.
(= The psychologist promises that his new therapy will reduce the fears.)
45. Petra freut sich darüber, daß [ihr Sohn]$_S$ [den Hamster]$_O$ gestreichelt hat.
(= Petra is pleased that her son has stroked the hamster.)
46. Jeder hier weiß, daß die kesse Sabine [den Witwer]$_O$ getröstet hat.
(= Here everybody knows that the cheeky Sabine has comforted the widower.)
47. Im Stahlwerk wird erwartet, daß [der Azubi]$_S$ die Drähte wickeln wird.
(=In the steelworks, it is expected that the trainee will wind up the wires.)
48. Der Direktor verlangt, daß [der neue Dirigent]$_S$ [den Chor]$_O$ leiten wird.
(= The manager requires the new conductor to lead the choir.)
49. Amnesty International prangert an, daß die Regierung die Sklaven geknechtet hat.
(= Amnesty International criticize that the government has oppressed the slaves.)
50. Man kann darauf vertrauen, daß [der Alarmknopf]$_S$ das Feuer melden wird.

(= One can rely on the alarm button reporting the fire.)

51. Eine alte Prophezeiung sagt, daß [der Mensch]$_S$ [den Brand]$_O$ fürchten wird.
(= An old prophecy says that humans will be afraid of the fire.)

52. Es ist zu erwarten, daß [der Verbrecher]$_S$ [den Mord]$_O$ leugnen wird.
(= It is to be expected that the criminal will deny the murder.)

53. Es ist zu befürchten, daß [jeder Bürger]$_S$ sein Recht fordern wird.
(= It is to be feared that every citizen will claim his rights.)

54. Es ist ziemlich unwahrscheinlich, daß [ein Dummkopf]$_S$ die Schätze finden wird.
(= It is rather unlikely that an idiot will find the treasures.)

55. Der Lehrling sieht zu, wie [der Buchbinder]$_S$ die Pappen geschnitten hat.
(= The apprentice watches the bookbinder cutting the cardboards.)

56. An Silvester erwarten die Kinder, daß Vater [den Kracher]$_O$ zünden wird.
(= On New Year's Eve, the children expect that (their) father will let off the firecrackers.)

57. Der besorgte Arzt hofft, daß [der Allergiker]$_S$ [den Käse]$_O$ meiden wird.
(=The worried doctor hopes that the person suffering from an allergy will avoid cheese.)

58. Die neue Chefin erwartet, daß [der Moderator]$_S$ die Sprüche gesammelt hat.
(= The new boss expects the presenter to collect the sayings.)

59. Der Priester erwartet, daß [der fromme Novize]$_S$ die Kerzen opfern wird.
(= The priest expects the pious novice to sacrifice the candles.)

60. Die Freunde hoffen wie immer, daß Gisela die Karten senden wird.
(= As always the friends are hoping that Gisela will send the postcards.)

61. Es ist interessant, wie die englische Königin [den Ritter]$_O$ geadelt hat.
(= It is interesting how the British Queen has ennobled the knight.)

62. Der bekannte Anwalt beanstandet, daß [der Polizist]$_S$ die Diebe gefesselt hat.
(= The well-known advocate queries the way the policeman tied up the thieves.)

63. Der grüne Politiker verspricht, daß [der Naturschutz]$_S$ [den Wald]$_O$ retten wird.
(= The green politician promises that nature conservation will save the forest.)

64. Der ständige Regen verhinderte, daß die Hausfrau die Wäsche geklammert hat.
(= The permanent rain prevented the housewife from being able to peg the laundry.)

65. Das rachsüchtige Volk erwartet, daß [der Henker]$_S$ [den Dieb]$_O$ blenden wird.
(= The vindictive people expect the hangman to blind the thief.)

66. Die Gutsherrin ist erstaunt, daß die Zofe das Laken gefaltet hat.
(= The lady of the manor is surprised that the lady's maid has folded up the sheet.)

Figure 1:

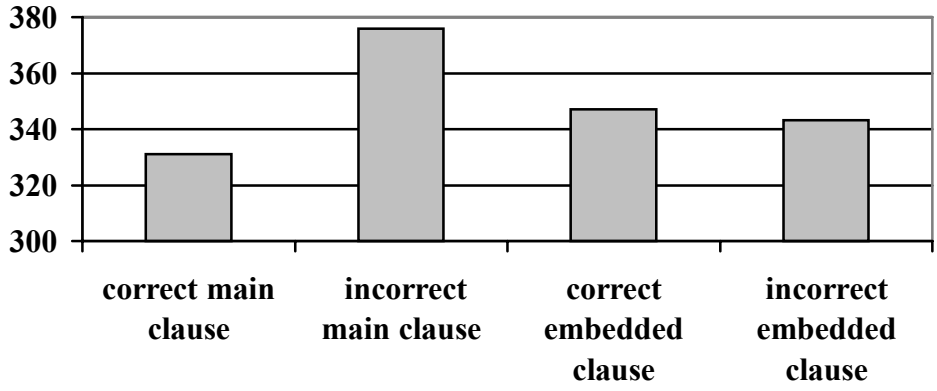
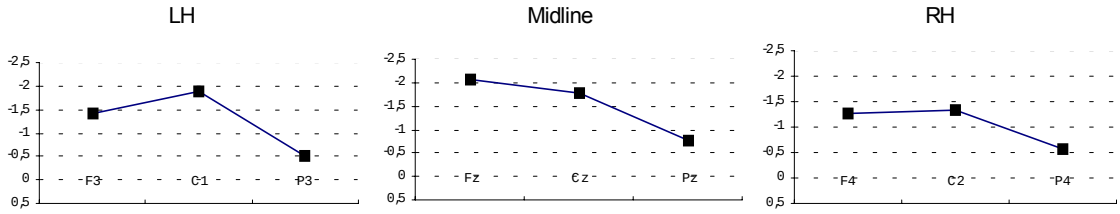

380
360
340
320
300
correct main clause
incorrect main clause
correct embedded clause
incorrect embedded clause

Figure 2:

Figure 3:

Main clauses



Embedded clauses

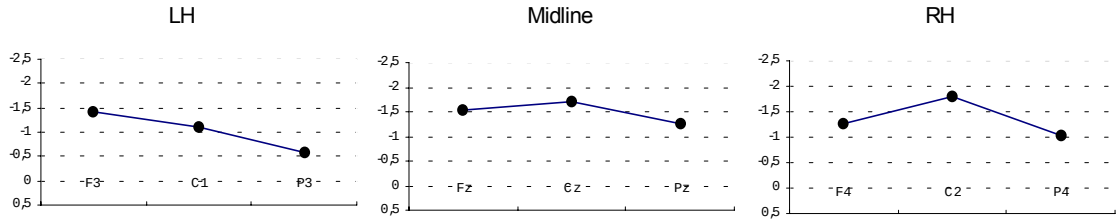


Figure 4:

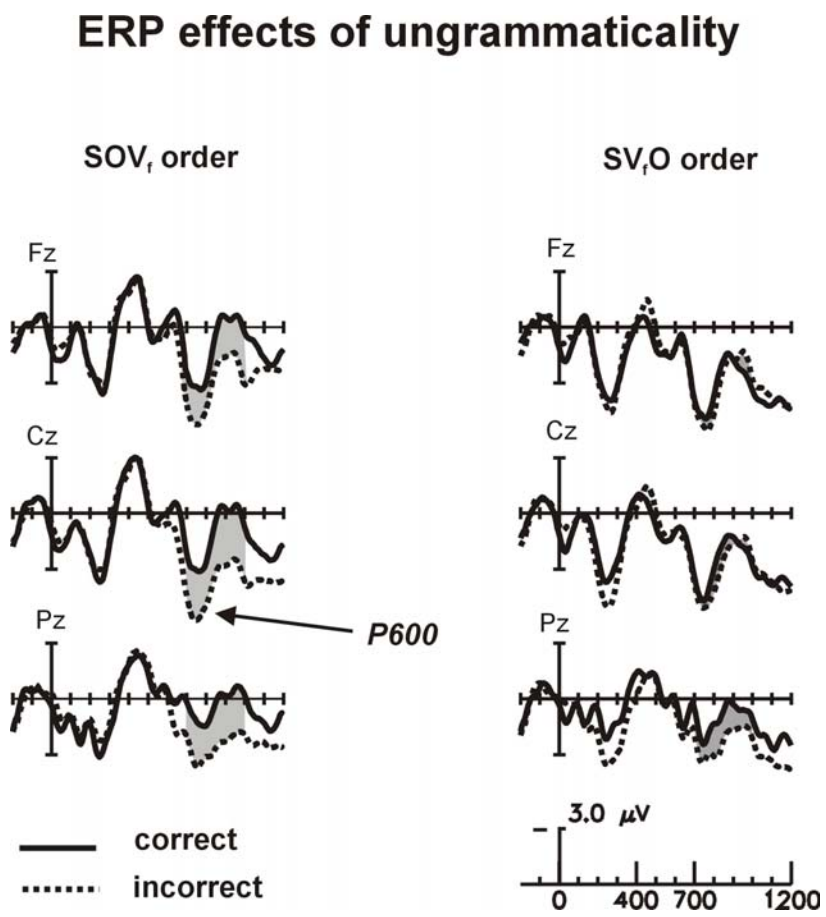

ERP effects of ungrammaticality
SOV$_f$ order
SV$_f$O order
Fz
Cz
Pz
P600
correct
incorrect
3.0 μV
0
400
700
1200

Figure 5:

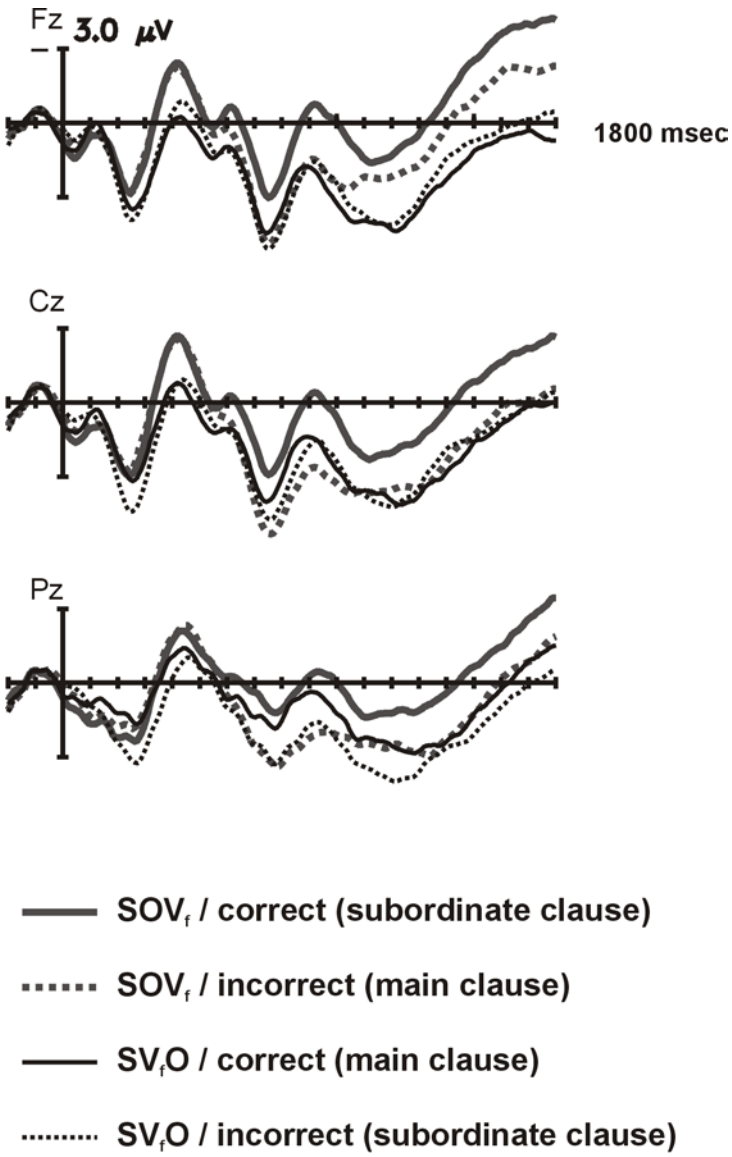

Fz
3.0 µV
1800 msec
Cz
Pz
SOV$_f$ / correct (subordinate clause)
SOV$_f$ / incorrect (main clause)
SV$_f$O / correct (main clause)
SV$_f$O / incorrect (subordinate clause)

Figure 6:

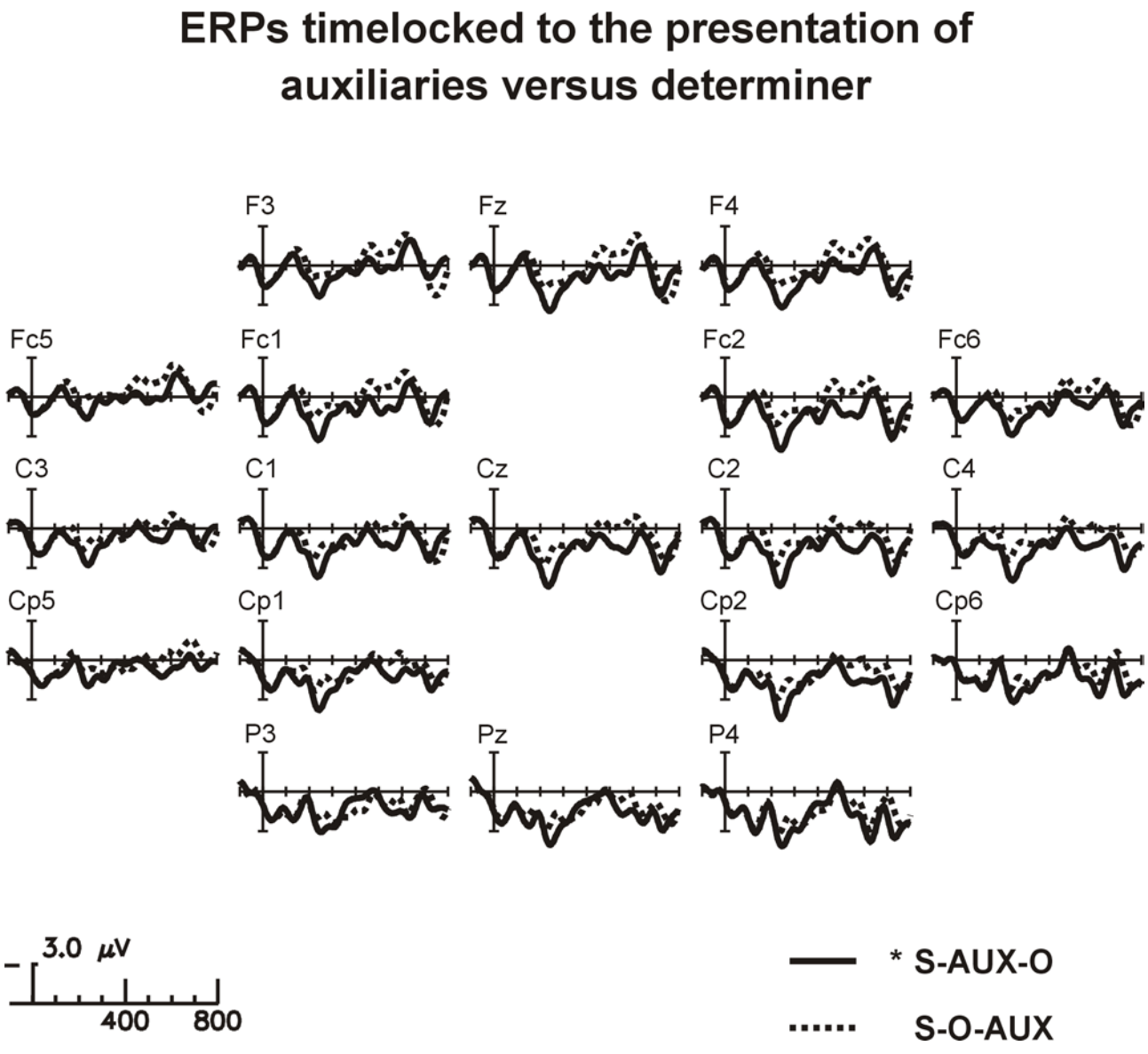

ERPs timelocked to the presentation of auxiliaries versus determiner
F3
Fz
F4
Fc5
Fc1
Fc2
Fc6
C3
C1
Cz
C2
C4
Cp5
Cp1
Cp2
Cp6
P3
Pz
P4
3.0 µV
400
800
* S-AUX-O
S-O-AUX

Figure 7:

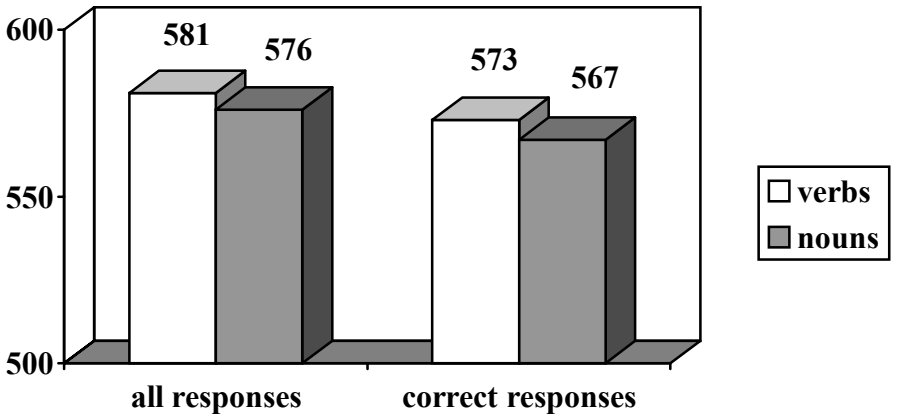
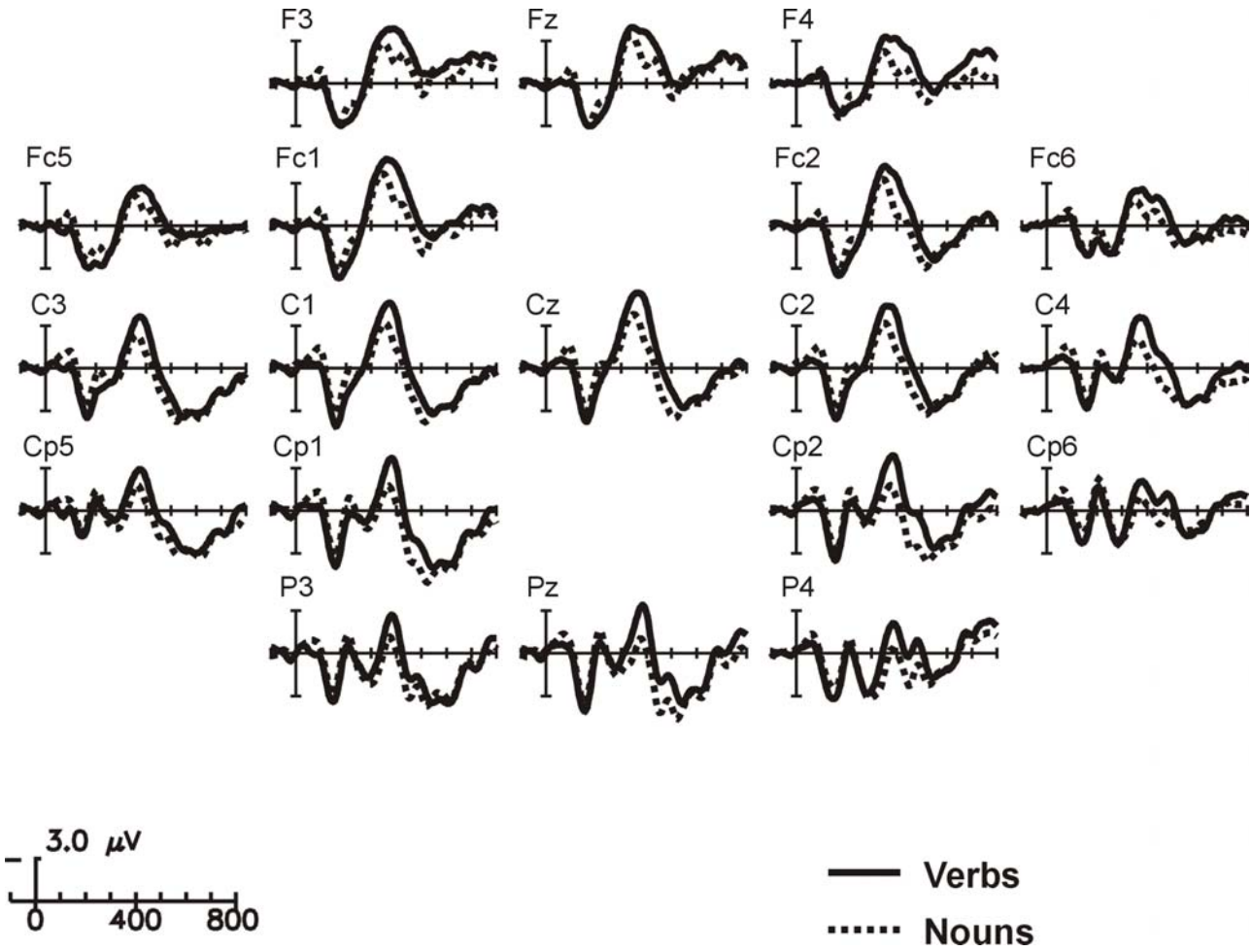

600
550
500
581
576
573
567
all responses
correct responses
verbs
nouns

Figure 8:


F3
Fz
F4
Fc5
Fc1
Fc2
Fc6
C3
C1
Cz
C2
C4
Cp5
Cp1
Cp2
Cp6
P3
Pz
P4
3.0 μV
0
400
800
Verbs
Nouns