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The interplay of free word order and pro-drop in incremental sentence processing: Neurophysiological evidence from Japanese

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Contents

Introduction: Challenges for incremental sentence processing

One of the most fundamental properties of language comprehension is that it proceeds incrementally. Thus, every incoming input item is integrated and interpreted as soon as it is encountered (e.g. Crocker, 1994; Stabler, 1994). Consequently, a substantial portion of psycholinguistic research has been devoted to exploring the nature and mechanisms of incremental processing and particularly to addressing the question of how interpretation can be maximized even in the face of ambiguous or incomplete input information.

While English is clearly the most extensively examined language in this regard, a particular challenge for incremental processing and for theoretical accounts of its (neuro)cognitive architecture is posed by the multitude of languages spoken in the world that deviate from English in various ways. In English, the order of the sentential constituents is relatively rigid and the main information carrier (the verb, which describes the event) is available quite early in the sentence, thus allowing for a rather straightforward incremental interpretation in the sense of "who is doing what to whom" at any point in a simple sentence on the basis of the early verb information and the linearization of the arguments.

Other languages than English, however, show a basic verb-final sentence structure and in addition may allow various possible linearizations and in some cases even the omission of sentential constituents. It is important to note that such deviances from an "English-style" sentence structure are by no means rare among the languages of the word. For example, an overview of the basic ordering of subject, object, and verb in the languages of the world (Table 1; from Haspelmath, Dryer, Gil, & Comrie, 2005, Chapter 81) reveals that only about one third of the world's languages has a basic SVO[1] word order like English, while more languages actu-

[1] Abbreviations used here and in the following: SVO, subject-verb-object; SOV, subject-object-verb; OSV, object-subject-verb

ally show a verb-final basic order, with SOV being the most common order overall. As in a verb-final sentence the verbal head (which describes the event) only occurs after all sentential arguments (which describe the participants of the event) have been encountered, incremental processing requires an interpretation and hierarchical integration of the pre-verbal arguments in the sense of “who is doing *something* to whom” / “who is acting upon whom” even before the information about what exactly is being “done” is encountered (i.e. “predicate-independent” comprehension; Bornkessel & Schlesewsky, 2006a; for evidence that sentences are interpreted incrementally even in such head-final languages, see, for example, Bader & Lasser, 1994; Kamide & Mitchell, 1999).

Incremental interpretation is further complicated if the order of the arguments is not as informative as it is in English, or if it is not granted that all participants of the described event are overtly expressed as arguments of the sentence. This is often the case cross-linguistically, as many languages of the world allow considerably more variation in the ordering of arguments than English does (e.g. *scrambling*; see Chapter 1.1), and many languages, unlike English, frequently allow sentential elements (e.g. subject pronouns) to be omitted altogether (i.e. *pro-drop*; see Chapter 1.2).

As language comprehension is based on cognitive and neural processes that are presumed to be largely independent of the individual language under consideration, a complete understanding of the (neuro)cognitive architecture of language compre-

Table 1: Order of subject, direct object and verb in the world’s languages (from Haspelmath et al., 2005, Chapter 81)

Word order	Number of languages
SOV	497
SVO	436
VSO	85
VOS	26
OVS	9
OSV	4
Ø	171
total	1228

Abbreviations used: SOV, subject-object-verb; SVO, object-subject-verb; VSO, verb-subject-object; VOS, verb-object-subject; OVS, object-verb-subject; OSV, object-subject-verb; Ø, no dominant order hension cannot be attained without a close examination of incremental sentence interpretation in such languages as the ones described above. That is, for adequately modelling sentence comprehension mechanisms in a cross-linguistically valid context, it is important to investigate the (neuro)cognitive processes underlying incremental comprehension in the face of word order variations and argument omission.

From this point of view, Japanese, the language employed in the empirical studies presented in this thesis, qualifies as a highly applicable language for the examination of incremental sentence processing. Since Japanese is a verb-final language allowing word order permutations as well as the omission of arguments, it offers numerous variations that a cross-linguistically valid account of online sentence comprehension needs to address. In this regard, it is – among other things – suited to examine the processes of incremental argument interpretation in the absence of verbal information, the processing of word order variations, and the inference of non-overt sentential information.

In Part I of this thesis, I will first give a brief description of the linguistic phenomena that were in the focus of the research summarized in this thesis (i.e. word order variations, Section 1.1, and argument omission, Section 1.2). After introducing the neurocognitive method employed in the empirical part of the thesis (i.e. event-related potentials, Chapter 2), I will present previous behavioral and neurocognitive evidence as well as theoretical accounts of the processing of these linguistic variations (Chapter 3). Hereafter, the usefulness of the Japanese language as an ideal test case for answering several of the remaining open questions will be derived (Chapter 4). Part II of the thesis will comprise four ERP experiments investigating incremental sentence interpretation in Japanese, with Experiments 1 and 2 (Chapters 5 and 6) focusing on the processing of permuted word orders and Experiments 3 and 4 (Chapters 7 and 8) focusing on the processing of sentences with omitted arguments.[2] The findings of Experiments 1 to 4 will be conclusively discussed in Part III, which will comprise summaries of the observed ERP effects as well as suggestions for future research arising from these findings (Chapter 9), and implications of the observed results for models of incremental sentence processing (Chapter 10).

[2]The results of Experiments 1 and 2 correspond to those reported in Wolff, Schlesewsky, Hirotani, & Bornkessel-Schlesewsky (2008).

Part I

Theoretical and empirical background

Chapter 1

Key linguistic concepts

In incremental sentence processing, some sentence structures present a greater challenge than others. Examples include sentence structures with word order variations, omitted arguments, multiple center embeddings, and many more. Two of these linguistic phenomena were in the focus of the research summarized in this thesis: permuted word orders (specifically scrambling) and pro-drop (argument omission). In the following, I will give a brief introduction to these two linguistic concepts.

1.1 Free word order and scrambling

As mentioned in the Introduction, the language most extensively examined in the language processing literature – English – has a relatively fixed SVO word order (with minor exceptions such as object relative clauses requiring an OSV order). Thus, in English, a sentence like *Peter helped the teacher* can only mean that Peter is the helper and the teacher is the person being helped and not the other way around. By contrast, many of the world's languages, e.g. German, Polish, Czech, Turkish, Persian, Arabic, Russian, Hindi, and Japanese, allow various possible linearizations of the words within a sentence. This availability of flexible word order in a language should, however, not be mistaken for the absence of a dominant word order (recall from Table 1 that less than 10% of the world's languages show no dominant word order at all). By contrast, most languages allowing word order variations clearly have one canonical, or basic, word order (e.g. SOV in German and Japanese, and SVO in Czech and Russian), but permit the order of sentence constituents to vary. A deviation from the basic word order is usually called a *marked* word order, as it is less "natural" and less frequent than the basic order.[3] Of course, word order does not necessarily only refer to the ordering of the subject, object, and verb of a sentence. For instance, it can also focus on the ordering of nouns and their modifiers (e.g. adjectives or relative clauses) or of subordinate clauses and the corresponding subordinating adverbs (for a comprehensive list, see Haspelmath et al., 2005, Section F: Word Order).

In the following, I want to address one particular variant of word order variation called *scrambling*. When the term scrambling was first coined by Ross (1967), it was used to describe a stylistic rule involving all syntactically optional and semantically vacuous reorderings of sentence constituents involving movement. Here, syntactic optionality describes the proposition that scrambling is not necessary to render a sentence grammatical, while semantic vacuity indicates that the reordering involved in scrambling has no semantic import (i.e. the meaning of a scrambled sentence is identical to the meaning of its unscrambled counterpart). Since then, scrambling has been subject to much (and not yet resolved) debate with regard to which features make scrambling availabe in a language and which syntactic, semantic, and discourse related properties can be ascribed to scrambling (for an overview, see Karimi, 2008).

Independently of the analysis given to scrambling, however, most authors seem to agree that prototypical instances of scrambling can be found in Japanese, the language employed in the empirical studies presented in this thesis, and in German, another verb-final language that has received much attention in the theoretical linguistic literature on scrambling (e.g. Bayer & Kornfilt, 1994; Fanselow, 1990, 2003; Grewendorf & Sabel, 1999; Haider & Rosengren, 2003; Müller, 1999; Webelhuth, 1989) as well as in research concerned with the processing of scrambling (see Section 3.1). Below, two examples of scrambled sentences in Japanese (1) and German (2) are given. Both examples show the clause-internal reordering of the object from its canonical position following the subject (SOV, a) to a position preceding the subject (OSV, b).[4]

[3] Haspelmath (2006) provides a thorough discussion of the various senses in which the term *markedness* has been used in the linguistic literature. He points out that markedness has been variably defined as an issue of complexity, difficulty, or abnormality, with little overlap between the different definitions. As an alternative, he proposes that most structural asymmetries described in terms of markedness could be better and more straightforwardly explained in terms of frequency of use (especially regarding syntactic patterns and morphosyntactic categories).

[4] Japanese (but not German) also allows so-called long-distance scrambling in which a scrambled argument can cross clause boundaries and which has distinct pragmatic motivations. As the focus of the research summarized in this thesis was on clause-bound scrambling, however, the examples given here are restricted to instances of this scrambling type.

(1) Scrambling in Japanese[5]

(a)

Hanji-ga	*daijin-o*	*maneita.*
judge-NOM	minister-ACC	invited

‘The judge invited the minister.’

(b)

Daijin-o	*hanji-ga*	*maneita.*
minister-ACC	judge-NOM	invited

‘The judge invited the minister.’

(2) Scrambling in German

(a)

(Ich	*glaube,)*	*...*	*dass*	|	*der*	*Richter*	*den*	*Minister*	|
(I	think)	...	that	|	[the	judge]$_{NOM}$	[the	minister]$_{ACC}$	|
eingeladen	*hat.*								
invited	has								

‘(I think) ... that the judge invited the minister.’

(b)

(Ich	*glaube,)*	*...*	*dass*	|	*den*	*Minister*	*der*	*Richter*	|
(I	think)	...	that	|	[the	minister]$_{ACC}$	[the	judge]$_{NOM}$	|
eingeladen	*hat.*								
invited	has								

‘(I think) ... that the judge invited the minister.’

With regard to the pragmatics of scrambling (i.e. the usage of scrambling in a specific context), it is of interest which discourse-based factors motivate scrambling, or in other words, under which contextual circumstances scrambled word orders such as (1b) and (2b) can be uttered felicitously (i.e. appropriately with respect to the situation; see Austin, 1962). In this regard, it has often been claimed in the literature that scrambled word orders are felicitous when the scrambled argument has already been mentioned in the preceding context, i.e. when it is “old” or “given” (e.g. Fanselow, 2003; Haider & Rosengren, 2003; Ishihara, 2001; Lenerz, 1977; Yokoyama, 1986). This would, for example, be the case if a sentence such as (2b) was preceded by a question introducing the initial object, like *Wer hat den Minister eingeladen?* (“Who invited the minister?”). This relation between scrambling and givenness can be attributed to the so-called *given-before-new principle* which states that in human languages (or at least in such natural languages in which the subject precedes the verb) old information tends to occur before new information (e.g. Halliday, 1967; see also Birner & Ward, 2004; Erteschik-Shir, 2007).[6] In addition, scrambled word

[5] Abbreviations used in the linguistic examples here and in the remainder of this thesis: NOM, nominative; ACC, accusative; DAT, dative; AMB, ambiguous; TOP, topic; Q, question particle; 1P, first-person; 3P, third-person; SG, singular; PL, plural; COMP, complementizer.

[6] Note that speakers of Japanese, however, have several syntactic options to distinguish old from new information in an utterance. As an alternative to placing the old information in the beginning of the utterance, old information that is recoverable from the context can also be omitted from the sentence altogether in languages like Japanese, leaving only new information to be expressed overtly (see 1.2).

orders also seem to be licensed in contexts allowing a contrastive reading, i.e. if the context provides several object alternatives and requires only one of them to be selected and thereby contrasted against the other (Choi, 1999; Hirotani, 2005; Jakobs, 1997; see also Bornkessel & Schlesewsky, 2006b). This would be the case if a sentence such as (2b) was preceded by a sentence like *Der Minister und der Abgeordnete wurden beide zur Feier eingeladen* ("Both the minister and the congressman were invited to the party").

It is important to note that the existence of pragmatic circumstances licensing scrambled structures is not incompatible with an interpretation of scrambling as a syntactically optional variation, as has been suggested by Ross (1967) and maintained by many other authors (e.g. Bošković & Takahashi, 1998; Fanselow, 2001; Fukui, 1993; Haider & Rosengren, 2003; Saito, 1989; among others). Under such an assumption, scrambling can be distinguished from syntactically afforded word order variations like those involved in the formation of wh-questions in many languages, as in such cases the reordering is necessary to render the sentence structure grammatical (for an introduction to wh-movement, see Cheng & Corver, 2006). Most accounts (but not all; for a counter-example, see Van Gelderen, 2003) furthermore agree that scrambling is different from topicalization, for reasons which vary depending on the linguistic approach and the language under consideration (e.g. Saito, 1985, and Bošković, in press, for Japanese; Haider & Rosengren, 2003, and Rambow, 1993, for German).

In German, the distinction between scrambling on the one hand and topicalization / wh-question formation on the other hand concurs with a distinction on the clause structural level (Rambow, 1993). In this regard, it is important to distinguish two different regions of the German clause: the *prefield* ("Vorfeld") and the *middlefield* ("Mittelfeld"). The prefield comprises the clause-initial position (preceding the finite verb in second position in a main clause) and can contain exactly one syntactic constituent. This constituent can be any element of the clause (e.g. an argument, an adjunct or the non-finite verb). The middlefield, by contrast, is a clause-medial region which is delimited to the left by the finite verb in second position (in main clauses) or by a complementizer (in subordinate clauses) and to the right by a clause-final non-finite verb or a verbal particle (e.g. *up* in the verb *to ring up*). In contrast to the prefield, the middlefield can contain several syntactic constituents. Crucially, while scrambling describes the movement of any number of constituents (prototypically arguments, cf. Haider & Rosengren, 2003) within the middlefield, topicalization and wh-question formation describe the movement of a single constituent into the prefield. This constituent can be an argument, an adjunct, or a non-finite verb in the case of topicalization, or the wh-phrase in the case of wh-question formation. A comparison of Examples (2)–(4) illustrates this distinction (vertical bars indicate the left and right edges of the middlefield in (2) and of the prefield in (3) and (4)); and the neurocognitive findings reported in Section 3.1.3 will lend it further support.

(3) Topicalization in German

<table>
<tr><td>|</td><td>Den</td><td>Minister</td><td>|</td><td>hat</td><td>der</td><td>Richter</td><td>eingeladen.</td></tr>
<tr><td>|</td><td>[the</td><td>minister]$_{ACC}$</td><td>|</td><td>has</td><td>[the</td><td>judge]$_{NOM}$</td><td>invited</td></tr>
</table>

‘Speaking of the minister, the judge invited him.’

(4) Wh-question in German

<table>
<tr><td>|</td><td>Wen</td><td>|</td><td>hat</td><td>der</td><td>Richter</td><td>eingeladen?</td></tr>
<tr><td>|</td><td>who$_{ACC}$</td><td>|</td><td>has</td><td>[the</td><td>judge]$_{NOM}$</td><td>invited</td></tr>
</table>

‘Whom did the judge invite?’

While Japanese clauses are not divided into prefield and middlefield, a distinction between scrambling and topicalization is still feasible (at least in part) thanks to the topic-marker *wa* that is carried by all topicalized elements in Japanese (5). While such *wa*-marked elements are ambiguous as they can involve either topicalization alone or topicalization *and* scrambling (Saito, 1985), a reordered element *without* a topic marker can be considered as unambiguously scrambled. Wh-phrases, on the other hand, replace noun phrases in the same position in Japanese (6); that is, Japanese is a so-called *wh-in-situ* language. Thus, no movement transformation equivalent to wh-movement in languages like German or English is necessary to render wh-questions grammatical in Japanese (cf. Tsujimura, 2006).

(5) Topicalization in Japanese

Daijin-wa	*hanji-ga*	*maneita.*
minister-TOP	judge-NOM	invited

‘Speaking of the minister, the judge invited him.’

(6) Wh-question in Japanese

Hanji-ga	*dare-o*	*maneita*	*ka.*
judge-NOM	who-ACC	invited	Q

‘Whom did the judge invite?’

1.1.1 Assumed representations underlying scrambling

The syntactic representations assumed to be involved in scrambled structures crucially depend on the kind of analysis adopted for the scrambling operation. In this respect, it is important to distinguish accounts that attribute scrambling to movement from those that do not assume any movement operation to be involved in scrambling.

If, as is assumed in Chomskyan generative theories of grammar like Government and Binding (GB; see Haegeman, 1994, for an introduction), an object-initial order is derived by movement of the object from its base position (following the subject) to a position preceding the subject, the representation of the scrambled structure involves the generation of a *trace* in the object's base position (e.g. after *hanji-ga* in Example 1). The trace ensures the correct interpretation of the arguments in the sense of "who is doing what to whom" and can be described as a movement-generated form of an *empty category*, i.e. a syntactic element without any phonological content. The object is linked to its trace via a so-called *chain* (with the scrambled element in the head position and the trace in the foot position of the chain).

While the concept of movement is highly popular in the scrambling literature, there are also alternative accounts that reject the notion of movement in scrambling. On the one hand, some (primarily Minimalist) accounts of scrambling propose that scrambled word orders are directly base-generated in their surface position (e.g. Bošković & Takahashi, 1998). These accounts of scrambling are still couched within a theory based on syntactic movement operations (i.e. the Minimalist Program, MP; Chomsky, 1995), but state that such movement is not involved in the generation of scrambled structures.[7] Consequently, such accounts assume no occurrence of traces in scrambled structures.

A more radical diversion from movement-based explanations is evident in theories that reject syntactic movement operations altogether. In the early 1980s, some authors suggested that all scrambling languages are non-configurational, i.e. that they have a flat clause structure (e.g. Farmer, 1980, and Hale, 1980, for Japanese; Haider, 1989, for German; but see Saito, 1985, and Bayer & Kornfilt, 1994, for counter-evidence). In such a structure, the order of the subject and the object of a

[7] The ideas put forward in MP (Chomsky, 1995) turned out to be incompatible with Ross' (1967) original definition of scrambling as syntactically optional movement, since in MP every movement operation is by definition obligatory. As a result, minimalist approaches to scrambling either viewed scrambling as obligatory movement leaving a trace (e.g. Miyagawa, 1997, 2003), or concluded that scrambling is indeed optional but does not involve any syntactic movement operation, as described above.

sentence is considered irrelevant, as subject and object are represented symmetrically at the same level instead of in a configurational hierarchy.

A modern theory making similar assumptions with regard to the syntactic structure of sentences in general (that is, independent of whether the language provides scrambling or not) is the Role and Reference Grammar (RRG) proposed by Van Valin & LaPolla (1997) (see also Foley & Van Valin, 1984; Van Valin, 2005). This linguistic theory is motivated by the immense diversity in grammatical systems occurring across the world's languages, and focuses on the interaction of syntax, semantics, and pragmatics in describing these typologically diverse grammatical systems. Furthermore, the theory seeks validation through its compatibility with language processing and language acquisition models (see Section 3.1.4 for a neurocognitive model of language processing implementing RRG-based representations). According to RRG, there is only a single syntactic representation for a sentence, and this representation corresponds to the actual form of the sentence. This syntactic representation (which is composed of lexically stored, non-hierarchical *syntactic templates*) is mapped directly (i.e. without intermediate levels of syntactic representation) to the semantic representation via a linking algorithm. In contrast to movement-based accounts like GB and MP, RRG thus does not assume that asymmetries between subjects and objects result from a hierarchical syntactic structure, nor does it allow any movement operations. Consequently, empty categories like traces are ruled out in RRG, and scrambled structures are not considered to involve syntactically more complex representations than their unscrambled counterparts. Instead, increased "markedness" in scrambled structures can be derived from the linking between the syntactic and the semantic representation of the clause, where in scrambled sentences the less prominent generalized semantic role (the *undergoer*) needs to be assigned before the more prominent generalized semantic role (the *actor*). These two generalized semantic roles, or *macroroles*, are abstractions over individual *thematic roles* (cf., for example, Grimshaw, 1990; Gruber, 1965; Jackendoff, 1972) like *agent*, *patient*, *recipient*, *experiencer*, *theme* and others, and stand in a hierarchical relation. The argument of a sentence that is most agent-like will be the actor and the argument that is most patient-like will be the undergoer. Thereby, the macroroles defined in RRG are comparable to the concept of *proto-roles* (Dowty, 1991; Primus, 1999) which makes a similar distinction between *proto-agents* and *proto-patients*.

1.2 Pro-drop

While the term *scrambling* is generally used to describe a syntactic variation occurring in specific sentences, the linguistic term *pro-drop* (from “pronoun-dropping”) is more often referred to as a language-describing feature (or *parameter*; Chomsky, 1981). Accordingly, the languages of the world can be divided into languages having this feature ([+pro-drop] or pro-drop languages) or not having it ([−pro-drop] or non-pro-drop languages). In this regard, a pro-drop language is defined as a language that does not require an overt subject and/or object in a sentence to render it grammatical. Pro-drop languages include, for example, Italian, Spanish, Czech, Arabic, Hindi, Chinese, and Japanese, while English, French, Swedish, Dutch, and German are typically considered non-pro-drop languages (see Haspelmath et al., 2005, Chapter 101).

The linguistic phenomenon of pro-drop has been primarily discussed with regard to the question of which languages allow pro-drop and which further features these languages might have in common. When the term was originally coined by Chomsky (1981), a pro-drop language was defined as a language in which (along with other features[8]) the subject of a sentence does not need to be expressed overtly to render the sentence grammatical. In his definition, Chomsky (1981) therefore only addressed a sub-class of the pro-drop languages (namely the now so-called *null-subject* languages) while explicitly excluding other pro-drop languages like Japanese, in which not only the subject, but also the object can be omitted from a sentence. The availability of pro-drop was initially assumed to depend on rich person and number agreement between the verb and the (omitted) subject, as this property allows the recovery of the omitted subject from the agreement inflection on the verb (Rizzi, 1982). Below, (7) shows an example from Italian, in which the agreement information on the verb (first person, singular) allows the recovery of the first-person singular personal pronoun (“I”) as the subject of the sentence.

(7) Pro-drop in Italian; first person agreement

Invitavo *Maria.*
invited$_{1P.SG}$ Maria
‘[I] invited Maria.’

[8]Besides the permission of null-subjects, Chomsky (1981) subsumed the following features under the pro-drop parameter: free inversion of subject and verb, a lack of pleonastic subjects (also called dummy subjects; e.g. *It* in *It is raining*), and a lack of the that-trace effect (i.e. the phenomenon that the subject of a complement clause cannot be extracted to the main clause from a position directly following the complementizer).

However, while the dependency of the pro-drop feature on rich agreement is a very attractive theory that can successfully describe most European languages (for example distinguishing the pro-drop languages Italian and Spanish from the non-pro-drop languages English and Swedish), it fails to account for the distribution of the parameter in *all* of the world's languages. For example, an agreement-based restriction on the pro-drop feature cannot readily explain why a language like German, which does have rich subject-verb agreement, nevertheless does not allow sentences without an overt subject (but see Müller, 2006, for a diverging view on the German verb morphology). Furthermore, an agreement-based distribution of the pro-drop feature cannot account for languages like Chinese or Japanese (8), which do not exhibit any agreement between the subject and the verb but nonetheless allow subjects (and objects) to be omitted (e.g. Huang, 1984; Neeleman & Szendroi, 2005).

(8) Pro-drop in Japanese
Hanako-o *maneita.*
Hanako-ACC invited
'[ ] invited Hanako.'

While numerous other syntactic features have been discussed as potential correlates of the pro-drop feature, among them basic word order, word order flexibility, morphological uniformity, and morphological complexity (for an overview, see Geeslin, 1999), it has been difficult to find a syntactic feature that can fully derive the distribution of the pro-drop parameter across the world's languages. While some authors suggest different types of pro-drop languages as a consequence (e.g. Neeleman & Szendroi, 2005, who suggest one type of pro-drop which is conditioned by rich agreement and one type which is conditioned by agglutinative pronoun morphology), others come to the conclusion that a purely syntactic factor determining the availability of pro-drop in a language might not exist (e.g. Geeslin, 1999, who views "discourse factors" as a possible non-syntactic basis of the distribution of the pro-drop parameter, albeit without further specifying these factors). An interesting proposition is made by Huang (1984) who suggests a distinction between "medium" languages which have rich subject-verb-agreement and allow only subject pronouns to be omitted, and "cool" languages like Japanese and Chinese that allow subject pronouns as well as *topics* (i.e. what the sentence is "about"; including topicalized subjects *and* topicalized objects as in (5) above) to be omitted.[9]

A closely related issue with regard to the phenomenon of pro-drop is not so much concerned with the differentiation of pro-drop and non-pro-drop languages

[9]The third category, "hot" languages, comprises languages like English that generally do not allow any argument omission.

but rather focuses on the question which linguistic circumstances license (or even necessitate) the omission of arguments from specific sentences *within* a pro-drop language. While the distribution of pro-drop across the world's languages is a matter of language *typology* (and, in the GB framework, of parameter setting), the licensing conditions of pro-drop within a pro-drop language are a question of pragmatics, i.e. the study of language *use*.[10] Even in a pro-drop language, the subject and/or object is not omitted from *every* sentence. This raises the question in which cases the omission of arguments from a sentence is felicitous in such a language, and in which cases it is not. Several answers have been given to this question. On the one hand, as pointed out above, languages with rich inflectional verb morphology allow grammatical features of the subject to be recovered from the agreement information on the verb (7). However, even in an inflectionally rich language like Italian, not every verb inflection is equally informative. In this regard it is important to differentiate between two levels of information potentially provided by the verb inflection: syntactic information and non-syntactic (referential) information. For illustration, compare the Italian example in (7) to the following Italian sentence:

(9) Pro-drop in Italian; third-person agreement

Invitava *Maria.*
invited$_{3P.SG}$ Maria
'[He/she] invited Maria.'

In (9), the verb provides the syntactic information that the omitted subject is the third-person singular pronoun (i.e. "he/she"), just as in (7) it provides the syntactic information that the omitted subject is the first-person singular pronoun ("I"). With regard to the non-syntactic information, on the other hand, the two examples differ substantially. While the referent responsible for the action (i.e. the inviter) is clearly identifiable as the *speaker* (i.e. the person who uttered or wrote the sentence) in (7), the respective referent is still largely unclear in (9), where the only available information is that the omitted referent is a single person (singular agreement) who is neither the *speaker* nor the *addressee* of the sentence (third-person agreement). Due to this lack of information, sentences such as (9) are not felicitous if they are uttered "out of the blue". Based on such examples, it can be concluded that if the referential content of the omitted argument cannot be fully recovered from the agreement inflection on the verb, it must be recoverable from the context

[10] This question is also closely related to an issue arising in the area of language processing, namely how sentences are interpreted by the hearer or reader when not all referents are overtly present in the sentence (see Section 3.2).

in which the sentence is uttered. In other words, the context needs to provide a referent for the omitted argument (e.g. Goldberg, 2006). While (9) is for example not licensed when it is uttered without an appropriate context, it is considered felicitous when it is preceded by another sentence like *Luigi darà una festa sabato prossimo* ("Luigi will throw a party next Saturday"). From this linguistic context, Luigi can be recovered as the referent of the omitted argument, meaning that it was Luigi who invited Maria.[11] Note, however, that a licensing context does not need to be *linguistic* in nature; alternatively the speaker of (9) could for example point at a person present in the spatial context of himself and the addressee (i.e. make a *deictic* gesture) while uttering the sentence, indicating that this person is the one who invited Maria.

In a language like Japanese, in which no agreement information on the verb is available, the case is slightly different. Here, the verb is uninformative with regard to *both* information levels, i.e. the omitted subject pronoun in (8) could be any Japanese pronoun (for example, *watashi*, "I"; *anata*, "you"; *karera*, "they"). Consequently, the referent of an omitted argument in Japanese always has to be recovered from the context. However, a preceding linguistic context is not always necessary to license a sentence with a dropped argument (at least if the omitted argument is the subject of the sentence). This is due to the fact that two discourse referents are always given when a sentence is uttered, namely the speaker and the addressee of the sentence, as these two referents are always present in the situational context of an utterance (cf., for example, Chafe, 1976; Prince, 1981). Therefore, just like (7) in Italian, a sentence like (8) in Japanese is licensed even if it is uttered without a preceding linguistic context. In this case, the speaker will be recovered as the referent of the omitted subject in declarative sentences, while the addressee will be recovered as the referent of the omitted subject in interrogative sentences (Martin, 2003). On the other hand, if the sentence is for example preceded by a linguistic context including another referent (e.g. *Doyoubi-ni Taroo-wa paatii-o shimasu*, "Taroo will throw a party next Saturday"), this referent (Taroo) will be recovered as the referent of the omitted argument. In some analyses (e.g. Huang, 1984; see above), this case would not be considered an instance of pro-drop (in the sense of the omission of a subject

[11] The restriction on the usage of pro-drop described here is comparable to the restriction on the usage of pronouns in non-pro-drop languages. In German, for example, sentences with first or second person pronouns like *Ich habe Maria eingeladen* ("I invited Maria") do not need a licensing context, whereas a sentence with a third person pronoun like *Er hat Maria eingeladen* ("He invited Maria") is not licensed unless it is uttered in a context providing information about the referent of the pronoun "he", for example by including or implying an *antecedent* for the pronoun in the preceding sentence (e.g. Sanford, Garrod, Lucas, & Henderson, 1983).

pronoun) but as an example of *topic-drop*, with Taroo constituting the overt topic of the first sentence and the phonologically null topic of the second sentence.

To summarize, the usage of pro-drop is felicitous in a pro-drop language if the referent of the omitted argument is recoverable, be it from agreement information on the verb, or from the linguistic or extra-linguistic context in which the sentence is uttered. Actually, the recoverability of a referent can be considered not only to license the omission of an argument referring to an already given entity, but to even *require* its omission. Thus, while the repetition of a given referent in a pro-drop language would not render an utterance ungrammatical in syntactic terms, it would still be infelicitous in pragmatic terms. Goldberg (2006) traces these restrictions on the usage of pro-drop back to Grice's (1975) conversational maxim of quantity, which states that an utterance should be as informative as required (cf. no argument omission without recoverability of the referent) and not more informative than required (cf. no full noun phrases when the referent can be recovered).

1.2.1 Assumed representations underlying pro-drop

The representations assumed to be involved in pro-drop sentences strongly depend on the underlying linguistic theory. Again, it is important to differentiate between generative, movement-based theories of grammar and such theories that reject such notions as movement and empty categories. Generative theories of grammar like GB (see Haegeman, 1994) assume a so-called *pro* in the position of the omitted argument. A pro is an empty category like the traces assumed to be involved in scrambling, with the difference that a trace refers to an empty category that is the result of a movement operation while a pro indicates an empty category that is base-generated in its position. Thus, if a sentence is lacking an overt subject or object, these arguments are nevertheless assumed to be represented in the syntactic structure as a pro. The pro – like the trace in scrambled sentences – is required in generative grammars to allow for the correct interpretation of pro-drop sentences in the sense of "who is doing what to whom". In this regard, Chomsky (1982) describes pros as the null counterparts of overt pronouns, with very similar referential properties (i.e. both pros and overt pronouns refer to given referents which will be drawn on for the interpretation of the sentence). According to this view, thus, the respective pronouns are in fact included in the syntactic representations of pro-drop sentences, albeit not phonologically realized. In the case of Huang's (1984) topic-drop analysis, however, the syntactic representation of a sentence with an omitted subject or object would include a phonologically empty topic in the sentence-initial topic position instead of an empty pronoun in the subject or object position.

Grammar theories like RRG (Foley & Van Valin, 1984; Van Valin, 2005; Van Valin & LaPolla, 1997), on the other hand, which reject the notion of empty categories, do not assume phonologically null arguments like pros in the syntactic structure of pro-drop sentences. For languages with agreement between subject and verb, Van Valin & LaPolla (1997) suggested that the agreement inflection on the verb can be analyzed as an argument and thus can fill the subject position in sentences with an omitted subject. A comparable view can also be found in Lexical Functional Grammar (for an introduction, see Bresnan, 2001). For languages like Japanese which lack subject-verb agreement and allow the omission of objects as well as subjects, however, such an explanation would not hold. Therefore, Van Valin (2005) proposed that the interpretation of pro-drop sentences in such languages is made possible by a direct linking between the thematic roles encoded in the semantic representation of the sentence and the referents encoded in its discourse representation. The pragmatic discourse representation constitutes the third level of representation in RRG, besides the syntactic and the semantic representation, and includes the referents and propositions expressed in the sentence under consideration and the preceding linguistic context, i.e. in the entire discourse. Thereby, the inclusion of null pronouns in the syntactic representation of the sentence, which is inevitable for the sentence interpretation in movement-based theories of grammar, is obviated in RRG.

Chapter 2

Event-related brain potentials

Before turning to the presentation of previous findings on the processing of word order variations and pro-drop, I will introduce an experimental method that has been employed extensively in the research of human information processing and is specifically suited for examining the processes involved in language comprehension: the ERP (event-related potential) method. Due to its unique characteristics as a tool of language comprehension research (see below), this neurocognitive method was also employed to acquire the data presented in Part II of this thesis.[12]

The processes involved in the comprehension of language (ranging from the identification of single phonemes to the integration of syntactic, semantic, prosodic and contextual information) are known to take place remarkably fast. ERPs provide a temporal resolution in the millisecond range, thus constituting an excellent instrument for capturing the neural correlates of these processes in real-time. Thus, while other, "slower", neurocognitive methods like PET and fMRI are useful instruments in localizing brain regions that are active during language processing, ERPs can provide valuable insights especially with regard to the timing and ordering of these activations (cf. Birbaumer & Schmidt, 1990; Osterhout & Holcomb, 1995). A further advantage, especially in comparison with behavioral psycholinguistic measures like reaction times, is that ERPs are not only able to show *quantitative* effects (comparable to longer reaction times for certain experimental manipulations) but can also uncover *qualitative* distinctions between different experimental manipulations along a number of dimensions (Kotz, Herrmann, & Frisch, 2009). In the following, I will first give a brief overview of the electrophysiological basis of ERPs, the EEG (electroencephalogram; Section 2.1). After that, I will describe how ERPs are extracted

[12] Other relevant neurocognitive and behavioral methods employed in psycholinguistic research will be described, along with the results they yielded with respect to the processing of word order variations and pro-drop sentences, in Chapter 3.

from the EEG and discuss their application in the field of language comprehension research (Section 2.2).

2.1 The EEG method

Event-related potentials are based on the EEG, a summation of post-synaptic potentials from a large number of cortical neurons, which are recorded with electrodes placed on the scalp. The resulting scalp-recorded EEG signal oscillates at multiple frequencies (between 0 and 100 Hz; Birbaumer & Schmidt, 1990) which are associated with different states of brain functioning. The term *electroencephalogram* (originally "Elektrenkephalogramm") was coined in 1929 by Hans Berger who was the first scientist to develop a non-invasive method for recording electrical activity originating from the human brain by placing electrodes on the scalp (Berger, 1929). After initially being primarily employed in clinical settings (e.g. in the evaluation of seizure disorders, tumors, or head injuries), the EEG has by now developed into one of the most important experimental instruments of psychological research, as it provides an excellent opportunity to investigate the neural correlates of mental activity. For a more detailed survey of the history of the EEG, see Niedermeyer (2005).

2.1.1 The generation of the human EEG

The primary source of the electrical activity measured in the EEG lies in the *excitatory* and *inhibitory postsynaptic potentials* (EPSPs and IPSPs, respectively) generated in neurons as a result of receptor-mediated synaptic stimulation by other neurons. These postsynaptic potentials generate electrical currents flowing along the neuron's cell membranes in the intra- and extracellular space between the position where the synaptic input is received (usually a dendrite) and more distant sections of the neuron (e.g. the soma). Under certain conditions, the scalp EEG can detect the extracellular portion of these currents in the form of changing voltage differences between at least two electrodes placed on the scalp. For this purpose, a sufficient number of neurons (at least 10,000; Birbaumer & Schmidt, 1990) needs to be activated synchronously, as the electrical current produced by one neuron is far to weak to elicit measurable voltage changes on the scalp surface. Furthermore, these neurons (or more precisely, their dendrites) must be aligned in parallel to avoid currents running in different directions cancelling each other out in the summation, and they must be aligned vertically to the cranial surface so that the electrical current flowing along their membranes forms an *open field* (or *dipole*) in the extracellular

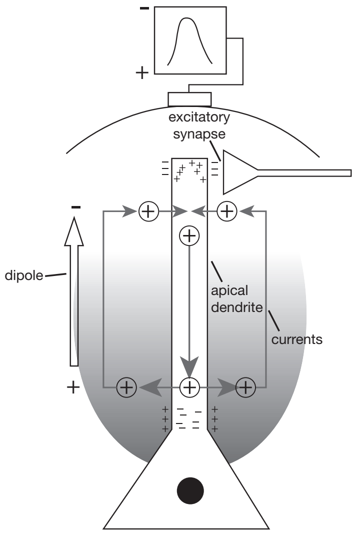

Figure 2.1: Schematic illustration of the formation of an extracellular dipole by a pyramidal cell in the cortex (adapted from Kirschstein, 2008). Intra- and extracellular currents are illustrated by arrows; positive and negative voltages are represented by plus and minus signs, respectively. In the scalp-recorded potential, negativity is plotted upwards.

space which can be picked up by the electrodes placed on the scalp.

Due to these restrictions, the major contribution to the electrical activity measured in the EEG stems from the pyramidal cells of the neocortex, or more precisely, from the pyramidal cells situated in the surfaces of the cortical gyri (and to a lesser degree those in the bases of the cortical sulci), which are aligned in parallel, with their apical dendrites expanding in the higher cortical layers and thus closer to the cranial surface and their somata located in the lower cortical layers further removed from the surface. Fig. 2.1 illustrates the formation of a dipole resulting from an EPSP in such a pyramidal cell and the resulting voltage change recorded at the scalp surface if a sufficient number of adjacent pyramidal cells were stimulated in the same way.[13] By contrast, instances of neuronal activity originating in differently organized areas of the brain (e.g. in pyramidal cells in the walls of the sulci, in cortical stellar cells and especially in subcortical neuron assemblies) are not captured by the EEG. An elaborate introduction into the physiology and underlying physics of the EEG can be found in Kutas & Dale (1997) or Nunez & Srinivasan (2006).

[13]Note that the polarity of the surface EEG per se is not automatically an indicator of whether it is caused by excitatory or by inhibitory synaptic activation of the pyramidal cells. This is due to the fact that (summed) EPSPs and IPSPs will be reflected in the scalp-recorded EEG with *inverse* polarities if the synaptic stimulation occurs at synapses further from the scalp (i.e. in a section of the apical dendrite closer to the soma). Thus, a negative scalp polarity can stem either from EPSPs originating close to the surface or from IPSPs originating distant from the scalp (and vice versa for positive scalp polarities; see Kirschstein, 2008). However, as Birbaumer & Schmidt (1990) point

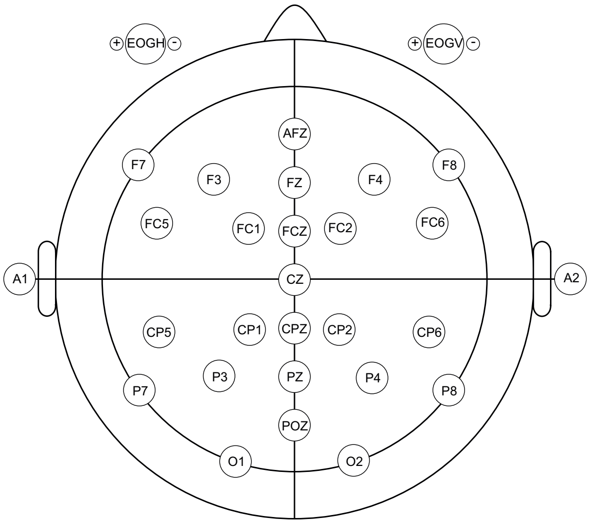

Figure 2.2: 24 channel electrode configuration employed in Experiments 1 to 4 of this thesis. Electrode positions are labelled according to adjacent brain areas: F (frontal), FC (fronto-central), C (central), CP (centro-parietal), P (parietal), O (occipital). The electrodes placed on the midline are coded with a z (zero), even numbers refer to right hemisphere electrodes, and odd numbers refer to left hemisphere electrodes. The additional scalp electrode AFz served as ground electrode; the mastoid electrodes A1 and A2 served as reference.

2.1.2 Issues in recording the EEG

While it is generally possible to measure an EEG with only two electrodes placed on different positions of the head, considerably more electrodes are usually attached to the scalp in psychological research paradigms. The arrangement of these electrodes on the head usually follows the internationally standardized *10-20 system* recommended by the American Electroencephalographic Society (Sharbrough, Chatrian, Lesser, Lüders, Nuwer, & Picton, 1991; based on Jasper, 1958), which also served as a basis for the electrode configuration employed in the EEG experiments described in this thesis. Following this guideline, the electrodes are placed at positions in relative distances with regard to specific anatomical landmarks (e.g. at 10% or 20% intervals of the distance between nasion and inion). The electrode configuration employed in the EEG experiments of this thesis is illustrated in Fig. 2.2.

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out (see also Witte, Hagemann, & Haueisen, 2006), most of the neuronal activity measured in the EEG is considered to stem from excitatory synapses, with higher layer activation thus leading to a negative scalp polarity (as illustrated in Fig. 2.1) and lower layer activation resulting in a positive scalp polarity.

As the scalp EEG is always measured in the form of voltage differences between two electrode positions, each electrode of interest requires a so-called *reference* for calculating this difference. There are several options with regard to the choice of reference which strongly influence the shape of the resulting EEG signal. The most popular (though not undisputed) choice in psychological research is an *inactive* reference which is supposed to record no (or only little) brain activity, for example the nose or the mastoids. If one of the mastoids is chosen as reference (as in the current experiments), the EEG signal can later be rereferenced to the *linked mastoids* (i.e. to an average of the potentials recorded at the left and the right mastoid) to avoid topographical distortions caused, for example, by unilateral external artifacts. Alternatively, it is possible to chose one of the *active* electrodes on the scalp (e.g. Cz) as a common reference with the disadvantage that similar activity recorded close to this electrode will be cancelled out in the difference calculation. Finally, the *average* voltage of all active electrodes can be calculated and used as reference. This variant, however, should not be employed unless all of the scalp activity can be captured in the EEG which requires a sufficiently high number of electrodes (128 or more; Nunez & Srinivasan, 2006).[14]

In a next step, the voltage differences recorded by the scalp electrodes are amplified (typically by a factor around 10,000, and in the process often filtering out EEG frequencies that are not of interest), and nowadays typically digitized (in psycholinguistic experiments usually with a sampling rate of 250 Hz) and fed into a computer, thereby permitting further manipulations of the signal like rereferencing (see above), the offline application of further filters (see Section 2.2.2), and the calculation of event-related potentials (ERPs; see below).

2.2 Event-related potentials

The brain activity captured with the EEG can be divided into *spontaneous*, stimulus-independent potentials, which are mainly of interest in clinical applications of the method, and *event-related* potentials (ERPs), which reflect brain responses to internal or external events and are of particular interest for cognitive neuroscientists. In addition to the brain's spontaneous activity and responses to external or internal

[14] An alternative to referential montages that is employed more often in clinical settings than in psychological research is provided by *bipolar* montages in which each electrode is referenced to one of its neighbors instead of to a fixed reference that is the same for all electrodes. While bipolar recording provides a better spatial resolution than referential recording, its disadvantage lies in a strong attenuation of synchronous voltage changes that are more widely distributed across the scalp (Hoppe, 2006).

stimulation, the EEG can also reflect electrical activity not originating in the brain. The latter kind of electrical activity, also called *artifacts*, can stem, for example, from muscular activity, cardiac activity, skin conductance fluctuations, or technical interference.

2.2.1 Extracting ERPs from the EEG

Since the event-related brain potentials tend to have much lower amplitudes (1–30 microvolts) than the spontaneous activity of the brain (up to 200 microvolts; Birbaumer & Schmidt, 1990), they cannot be visually detected in the EEG recorded following any single stimulus. To make ERPs visible, the experimental stimulus of interest is therefore presented repeatedly and the EEG signal is averaged relative to a fixed time point in the presentation of each stimulus (for example the onset). By time-locking the EEG to the external event, the signal-to-noise ratio is raised, as the signal (the response to the event) is assumed to remain similar across repetitions, while the noise (the spontaneous EEG and non-brain related artifacts) vary independently of stimulus presentation and thus are cancelled out in the average. As a result, the neuronal response to the experimental stimulus, the ERP, can be isolated from the uncorrelated spontaneous brain activity and possible external noise caused by artifacts (Coles & Rugg, 1995; see Fig. 2.3 for illustration).[15] In a typical ERP experiment, the resulting *single-subject averages* are further averaged across a group of approximately 20 participants to level out potential interindividual differences, resulting in one *grand-average* ERP response for each experimental condition.

2.2.2 Issues in the averaging process

Most commonly, the EEG signal is averaged relative to a *baseline* (e.g. the average voltage recorded in the 100 or 200 milliseconds before stimulus onset) to counteract slow drifts which occur in the course of experiments and can lead to stimulus-independent differences between conditions. In applying a baseline correction, this is prevented by cancelling out any differences that might exist between experimental conditions before stimulus onset. However, the application of such a baseline

[15] A special kind of artifact is caused by eye movements and blinks. These artifacts might not be cancelled out in the averaging process and cannot be filtered out as they occur at the same frequencies as ERP features of interest (see Section 2.2.2). Therefore, participants are usually instructed to keep their eyes still and avoid blinking during the critical periods of stimulus presentation. If eye movements or blinks still occur in the EEG, the contribution of the respective artifact to the EEG signal needs to be estimated and removed (e.g. Berg & Scherg, 1994), or the respective EEG epoch needs to be excluded altogether before averaging.

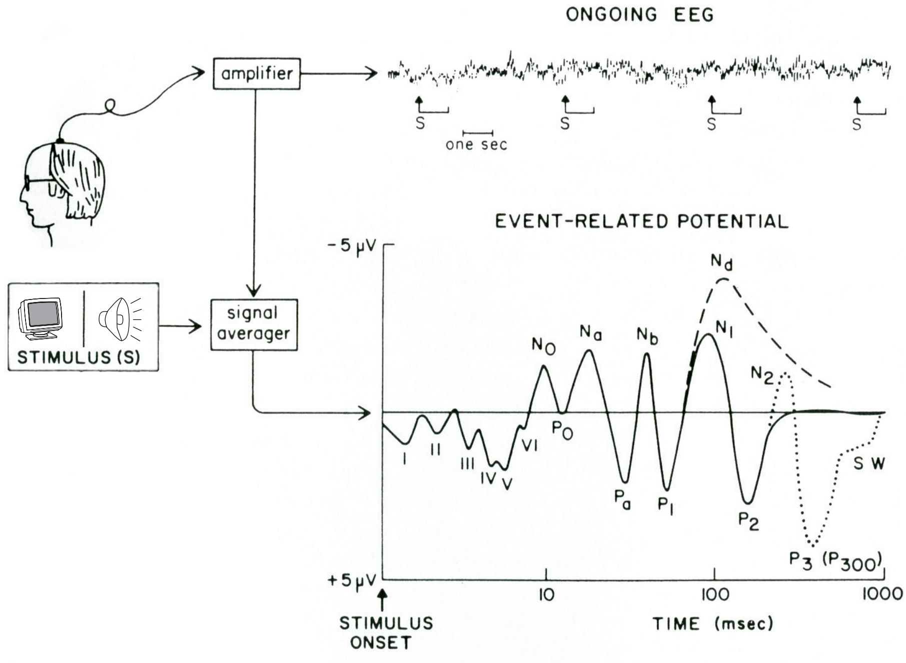

Figure 2.3: Illustration of the ERP averaging procedure; adapted from Coles & Rugg (1995).

correction can lead to a distortion of the critical ERP epochs as other signal differences generated by pre-stimulus activity can continue into the baseline interval. This issue arises particularly when presenting acoustically unaltered auditory language materials, because here the stimulus materials by definition cannot be fully identical before critical word onset. Furthermore, Woldorff (1993) pointed to the same problem in the context of short interstimulus intervals (ISIs) which result in an overlap between the ERP responses to successive stimuli. In language comprehension experiments, ISIs are often short and the stimulus materials preceding a stimulus of interest are frequently not identical between conditions, thus rendering baseline related averages particularly susceptible to such distortions (for further evidence that stimulus-induced ERP effects are not independent of EEG activity in the pre-stimulus interval, see, for example, Barry, Rushby, Smith, Clarke, & Croft, 2006; Basar, 1998; Makeig, Westerfield, Jung, Enghoff, Townsend, Courchesne, & Sejnowski, 2002).

In such cases, the offline application of a specific filter before averaging the EEG signal provides an effective alternative to baseline corrections. The frequency settings of such a filter can be defined such that it excludes the slow drifts mentioned above, while being sufficiently broad to include the relevant language related ERP activity (which typically lies in a range from approximately 0.5 to 5 Hz; cf. Roehm, Winkler, Swaab, & Klimesch, 2002). As a consequence, such a filter essentially has a similar effect to a baseline under "ideal" circumstances (i.e. circumstances in which the baseline only serves to remove differences due to drifts), while at the same time avoiding a distortion of the post-stimulus ERPs that might result from transient differences between conditions in the pre-stimulus baseline interval.

2.2.3 ERP components

An averaged ERP response is characterized by a sequence of waves (see bottom half of Fig. 2.3) which are understood to reflect distinct neurophysiological and psychological processes and are often (but not uncontroversially) called *components*. Components occurring within the first 100 milliseconds of an ERP are often called *exogenous* or *sensory* components and typically vary depending on physical characteristics of a presented external stimulus. Later components are usually called *endogenous* or *cognitive* components. These latter components can be induced by external stimulation as well as internal events and reflect cognitive processing required by the event.

Descriptively, ERP components can be characterized by three parameters: *polarity* (negative vs. positive voltage deflection from a baseline or a control condition), *latency* (time elapsed between the onset of the critical stimulus and the peak of the deflection), and *topography* (the position of the electrodes at which the effect occurs). With regard to the topography, it is important to note that the localization of the electrodes showing the signal should not be confused with the cortical areas in which the signal originated. This lack of correspondence is due to the poor spatial resolution of the EEG signal. While the so-called *forward problem*, which is concerned with the scalp distribution resulting from a given set of dipole generators in the brain, can be unambiguously answered, the *inverse problem* is not as easily solved. For every given surface distribution of activity, there is a theoretically infinite number of potentially underlying dipole configurations. Furthermore, other possibly activated generators will not be represented in the scalp-recorded activity at all (see Section 2.1.1). As a result, the scalp-recorded EEG does not allow the localization of its underlying source (or sources). While mathematical models addressing this problem do exist (for an overview, see Luck, 2005, Chapter 7), their solutions always remain non-unique approximations.

Component nomenclature is often based on the physiological characteristics described above, especially on polarity and latency, like in the P300 (Sutton, Braren, Zubin, & John, 1965) which describes a positive deflection (P) peaking at approximately 300 ms after stimulus onset. Some component denominations rely more heavily on the topography of the signal, like the LAN (e.g. Gunter, Friederici, & Schriefers, 2000) which describes a negativity (N) with a left-anterior (LA) distribution. In addition to this signal-based type of nomenclature, some components have been named based on the psychological process that they are assumed to reflect. For example, the *Bereitschaftspotential* (“readiness potential”; Kornhuber & Deecke, 1965) is a positive deflection assumed to indicate the preparation of voluntary movements. In addition, the signal-based labels are often also used to describe ERP components with quite divergent actual characteristics but an assumedly comparable functional basis. For example, negativities that are affected by semantic manipulations are frequently called N400 (Kutas & Hillyard, 1980), even if their actual latencies may diverge from 400 ms (see below).

2.2.4 Issues in interpreting language related ERP components

The issue of identifying and naming ERP components is closely related to the problem of finding functional interpretations for the observed components. The usual approach to finding such interpretations is to present stimuli of at least two experimental conditions differing with regard to an assumed underlying cognitive process (e.g. lexical access), and to attribute the ERP component differentiating between the conditions to said underlying process. However, as Coles & Rugg (1995) point out, this approach is only reasonable under the assumption of *pure insertion*, that is, the “assumption that one can create two conditions in such a way that the conditions differ only in the process of interest and are equivalent with respect to all other processes” (Coles & Rugg, 1995; p. 11).

Especially in the field of language comprehension, however, it is often difficult to meet this demand. As mentioned above, language comprehension always involves the execution and integration of a multitude of cognitive processes. Thus, especially when studied in a sentential context, it is not easy to manipulate one level of the comprehension process in isolation without affecting any of the other levels. For instance, a syntactic violation (like in *The broker hoped to sell the stock was sent to jail*; Osterhout & Holcomb, 1992) often renders the sentence not only ungrammatical but also less interpretable than its syntactically correct counterpart, thus also affecting the semantic level of sentence processing.[16] The difficulty in isolating the cognitive processes underlying sentence comprehension is thereby somewhat comparable to the inverse problem in source localization described above. Just as a given scalp-recorded EEG does not allow the researcher to uniquely infer the anatomical sources generating the signal, a given ERP component cannot be automatically attributed to a unique underlying cognitive process.

Consequently, the cognitive functions underlying certain language related ERP components are an issue of ongoing research and debate, which leads to a continuous revision and refinement of the knowledge about said components. A case in point is the N400, a negative deflection occurring between approximately 300 and 500 ms post word onset and peaking at around 400 ms, which usually is largest over centro-parietal electrode sites.[17] The N400 is a component that has typically been associated with aspects of semantic processing, as an increased N400 has repeatedly been observed in response to semantic anomalies like contextually inappropriate words (Kutas & Hillyard, 1980) or non-words (Bentin, 1987), while the component usually shows a reduced amplitude in primed (Bentin, McCarthy, & Wood, 1985), repeated (Van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991), highly frequent (Van Petten & Kutas, 1990), or contextually highly expected words (i.e. words with a high *cloze probability*; Kutas & Hillyard, 1984).

The exact cognitive processes underlying the N400, however, are far from clear. On the one hand, the component was variously claimed to be indicative of automatic spreading activation influencing lexical access or of post-lexical processes of language comprehension (for an overview, see Osterhout & Holcomb, 1995). On the other hand, studies employing picture stimuli instead of / in combination with verbal material (e.g. Nigam, Hoffman, & Simons, 1992) demonstrated that the N400 might be a measure of general, that is *amodal*, semantic expectation that is not confined to purely linguistic stimuli. More recently, the N400 has also been found in

[16] In addition, such an approach is further complicated by the conceptualization and classification of these different processing levels, which can vary widely and is strongly dependent on the underlying theory. Thus, one and the same experimental comparison can represent the manipulation of one level of sentence processing in the framework of one theoretical approach, while being an instance of the manipulation of another level against the background of a different theory.

[17] Note that depending on the experimental environment, the onset as well as the distribution of the N400 can vary: In auditory ERP experiments using natural connected speech, the N400 has been observed with an onset as early as 50 ms post word onset, which is usually attributed to speech cues like coarticulation and prosody that are available before the onset of the critical word (Holcomb & Neville, 1991; see also Marslen-Wilson, 1987). Furthermore, N400 effects have been shown to have a centro-parietal maximum when the critical words are presented visually, but a more widely-spread distribution in the case of auditory presentation (e.g. Domalski, Smith, & Halgren, 1991; for a more general discussion, see Kutas & Federmeier, 2000).

experimental contexts that manipulated syntactic rather than semantic aspects of the linguistic stimuli. For example, N400 effects have been observed in grammatical function reanalyses (Bornkessel, McElree, Schlesewsky, & Friederici, 2004c; Haupt, 2008; Leuckefeld, 2005) and for unambiguous subject-before-object word orders in comparison to object-before-subject word orders (Bornkessel, Fiebach, & Friederici, 2004a; a more detailed account of the latter will be given in Section 3.1.3). Thus, the status of the N400 component as an unequivocal index of purely lexical-semantic processing cannot be upheld.

A similar situation can be observed with regard to the P600 (Osterhout & Holcomb, 1992; alternatively termed SPS, syntactic positive shift, by Hagoort, Brown, & Groothusen, 1993), a centro-parietally distributed positive deflection between approximately 500 and 1000 ms post stimulus onset typically peaking at around 600 ms (though latency and topography can vary here, too; cf. Footnote 17, and see Osterhout & Holcomb, 1993, for an example of an earlier onset of the component). This component has long been described as an indicator of syntactic processing, as it has been observed as a response to syntactic violations (Friederici, Hahne, & Mecklinger, 1996; Hagoort & Brown, 2000; Osterhout & Holcomb, 1992, 1993), syntactic ambiguity (Frisch, Schlesewsky, Saddy, & Alpermann, 2002), dispreferred disambiguations in syntactic garden-path sentences (Friederici et al., 1996; Mecklinger, Schriefers, Steinhauer, & Friederici, 1995; Osterhout & Holcomb, 1992, 1993; Osterhout, Holcomb, & Swinney, 1994), and syntactic complexity (Kaan, Harris, Gibson, & Holcomb, 2000).

However, even though an immense corpus of neurophysiological data supports a close association between the P600 and a syntactic level of linguistic processing, the occurrence of the component does not seem to be restricted to manipulations in the syntactic domain. For instance, P600-like components have also been reported in response to orthographic violations (Münte, Heinze, Matzke, Wieringa, & Johannes, 1998) or been claimed to reflect the integration of new referents into a discourse model (Burkhardt, 2006, 2007b; Kaan & Swaab, 2003; see Section 3.2.2 for a more detailed description). Furthermore, a series of ERP studies that recently gained a great deal of attention reported so-called "semantic P600" effects (e.g. Hoeks, Stowe, & Doedens, 2004; Kim & Osterhout, 2005; Kolk, Chwilla, Van Herten, & Oor, 2003; Kuperberg, Sitnikova, Caplan, & Holcomb, 2003). In these studies, P600 effects were observed in response to (non-lexical) semantic anomalies at the sentence level in the absence of any syntactic violation, syntactic ambiguity or syntactic complexity (e.g. in response to so-called "semantic reversal anomalies" as in *The hearty meal was devouring the kids*; Kim & Osterhout, 2005). Crucially, while the exact cognitive processes responsible for these P600 effects are still debated (cf. Kuperberg, 2007, and Bornkessel-Schlesewsky & Schlesewsky, 2008), there is wide agreement that they are not purely syntactic in nature, thereby conflicting with a simple 1:1 mapping between the P600 component and one single underlying cognitive process.

To conclude, a variety of recent studies seem to suggest that the highly intriguing dichotomy that regards semantic processes as reflected in the N400 component and syntactic processes as responsible for the P600 effect (e.g. Hagoort et al., 1993) cannot be straightforwardly upheld anymore (Kutas, Van Petten, & Kluender, 2006). More generally, this implies that the assumption of a 1:1 correspondence between any particular ERP component and one unitary underlying cognitive function should not be considered as a given basis for conducting neuropsychological research, especially in the field of neurolinguistics. Thus, even though there may be a high correlation between certain ERP components and certain cognitive processes, the evidence reported above shows that it does not justify the use of ERP components as diagnostic tools for "detecting" these processes (e.g. by considering the N400 as an indicator of exclusively semantic processing or by concluding from the emergence of a P600 that a syntactic process must necessarily be involved; cf. Osterhout & Holcomb, 1995, for a similar view). Ongoing research employing ever new interesting linguistic manipulations, on the other hand, continues to provide valuable insights leading to an increasingly detailed picture of the cognitive functions underlying each particular ERP component. A comprehensive review of the most prominent language-relevant ERP components currently under discussion can be found in Kutas et al. (2006). The ERP components that are relevant for the current thesis as electrophysiological correlates of the processing of word order variations and pro-drop sentences will be discussed more thoroughly in the next chapter, along with other neurocognitive and behavioral findings regarding the processing of these structures.

Chapter 3

The processing of word order variations and pro-drop: Previous evidence and theoretical approaches

The aim of this chapter is to provide an overview of the relevant psycholinguistic and neurolinguistic literature on the processing of the two linguistic phenomena in the focus of this thesis, word order variations (Section 3.1) and pro-drop (Section 3.2). For each of these linguistic structures, the available empirical evidence and psycholinguistic as well as neurolinguistic theoretical approaches will be discussed.

3.1 Word order variations

With regard to the processing of word order variations, I will first discuss behavioral evidence for increased processing costs in object-before-subject word orders (Section 3.1.1). Then I will introduce a selection of theoretical approaches that attempt to account for the processing difficulty in object-initial structures (Section 3.1.2), before turning to an overview of the neurolinguistic literature on the processing of word order variations (Section 3.1.3) and a model of sentence processing that attempts to derive the distribution of the different neurcognitive markers of word order processing cross-linguistically (Section 3.1.4).

3.1.1 Behavioral evidence

In psycholinguistic studies of word order processing, various behavioral measures like acceptability judgements, reading times, and reaction times in several kinds of tasks have pointed to increased processing costs for object-initial structures. In this regard, word order variations were first and foremost examined in temporarily ambiguous sentences which were alternatively disambiguated towards a subject-before-object or an object-before-subject reading. Therefore, before turning to the processing of object-initiality in unambiguous structures, which is in the focus of this thesis, I will give a short overview of the literature on object-initiality costs in locally ambiguous sentences.

The subject preference in locally ambiguous sentences

Local subject-object ambiguities can for example result from ambiguous relative pronouns (e.g. *that* in English, or *die* in German)[18] or from ambiguous wh-phrases as in (10); and in languages with free word order, local ambiguity can also arise due to ambiguous case marking on the arguments as in (11) and (12). In all examples given below, the initial argument is fully ambiguous with respect to case and, thereby, grammatical function. In (10a), the plural verb form disambiguates the sentence towards a subject-before-object order, while the singular verb form in (10b) forces an object-before-subject reading. In (11), the disambiguating information is not available until the position of the second, case marked, argument. At that position, the accusative marking in (11a) disambiguates the sentence towards a subject-before-object reading, while the nominative marking in (11b) signals an object-before-subject order. In (12), both arguments are encountered before the verb is reached, and both are fully ambiguous with respect to case and grammatical function. Here, the disambiguation towards a subject-before-object reading (12a) or an object-before-subject reading (12b) is accomplished by the singular or plural agreement information on the finite verb.

[18] In the psycholinguistic literature, there is an extensive corpus of research on the processing of locally ambiguous relative clauses in a great variety of languages. Here, increased processing costs arise when a clause-initial relative pronoun (e.g. the English *that* in *The reporter that...*) is disambiguated towards an object reading (e.g. King & Just, 1991, for English; Frazier, 1987, for Dutch; Schriefers, Friederici, & Kühn, 1995, for German; see also Miyamoto & Nakamura, 2003, for Japanese), indicating a preference for subject-before-object orders. However, as relative clauses modify arguments of the superordinate main clause (i.e. their *head nouns*), and as these across-clause boundary dependencies produce an additional level of complexity in comparison to the simple clauses that are in the focus of this thesis, they will not be discussed in any more detail here. Similarly, the processing of complex across-boundary long-distance scrambling, which is possible in Japanese (cf. Footnote 4), is beyond the scope of this thesis and will thus not be discussed here.

(10) Locally ambiguous word order permutation in Dutch wh-questions (from Frazier & Flores d'Arcais, 1989)

(a)

Welke	*arbeiders*	*hebben*	*de*	*voorman*	*geprezen?*
[which	workers]$_{AMB.PL}$	have$_{PL}$	the	foreman	praised

'Which workers have praised the foreman?'

(b)

Welke	*arbeiders*	*heeft*	*de*	*voorman*	*geprezen?*
[which	workers]$_{AMB.PL}$	has$_{SG}$	the	foreman	praised

'Which workers has the foreman praised?'

(11) Locally ambiguous word order permutation with object in the German prefield (topicalization; from Hemforth, 1993)

(a)

Die	*kluge*	*Tante*	*besucht*	*den*	*kleinen*	*Jungen.*
[the	clever	aunt]$_{AMB}$	visits	[the	little	boy]$_{ACC}$

'The clever aunt visits the little boy.'

(b)

Die	*kluge*	*Tante*	*besucht*	*der*	*kleine*	*Junge.*
[the	clever	aunt]$_{AMB}$	visits	[the	little	boy]$_{NOM}$

'The little boy visits the clever aunt.'

(12) Locally ambiguous word order permutation within the German middlefield (scrambling; from Bader & Meng, 1999)

(a)

... dass	*die*	*neue*	*Lehrerin*	*einige*	*der*	*Kollegen*	
... dass	[the	new	teacher]$_{AMB.SG}$	[some	of the	colleagues]$_{AMB.PL}$	
angerufen	*hat.*						
phoned	has$_{SG}$						

'... that the new teacher phoned some of the colleagues.'

(b)

... dass	*die*	*neue*	*Lehrerin*	*einige*	*der*	*Kollegen*	
... dass	[the	new	teacher]$_{AMB.SG}$	[some	of the	colleagues]$_{AMB.PL}$	
angerufen	*haben.*						
phoned	have$_{PL}$						

'... that some of the colleagues phoned the new teacher.'

In such cases of local grammatical function ambiguity, the processing system generally shows a preference to analyze the ambiguous initial argument as the subject rather than the object of the sentence. This tendency, which has been dubbed the *subject preference*, has been observed in many European languages like Dutch (e.g. Frazier & Flores d'Arcais, 1989), Italian (e.g. De Vincenzi, 1991), and German (e.g. Schlesewsky, Fanselow, Kliegl, & Krems, 2000) and is reflected in increased processing costs for the object-initial disambiguation in a variety of behavioral measures.

For example, Frazier & Flores d'Arcais (1989) employed wh-questions such as (10) in a speeded grammaticality judgement task (for a short description of the major

Table 3.1: Major behavioral methods employed to examine the comprehension of word order variations

Method	Description
SGJ	In the speeded grammaticality judgement task, grammatical and ungrammatical sentences are presented on the screen in a word by word manner. The words are presented in rapid succession and participants are instructed to judge the grammaticality of the sentences immediately after the presentation of the last word.
SPR	In self-paced reading (for an introduction, see Haberlandt, 1994), sentences are presented in a segmented manner (e.g. word by word), with each new segment either being presented alone at the center of the screen (stationary window technique) or gradually completing the sentence across the screen (moving window technique). Participants control the presentation rate by pressing a button each time they want to read the next segment. It is assumed that differences in processing demands at a particular sentence segment are reflected in differential reading times at the position of the respective segment (cf. Just & Carpenter, 1980). In one particular variant of the paradigm (Strube et al., 1988; see also Hemforth, 1993), two buttons are provided, and the button press response further serves to indicate a decision that participants make after reading every segment (e.g. regarding the acceptability of the sentence segments encountered so far; also known as the "stop making sense" task).
ET	In an eye-tracking paradigm, sentences are presented on the screen as a whole. Participants' eye movements and fixations are recorded with an infrared camera while they read the sentence. Many different measures can be extracted from the recorded signal, including the duration of the first fixation on a target word, the number and duration of regressions (i.e. movements back to previous words of the sentence) originating from the target word or ending at the target word, and the cumulated fixation time (also called total gaze time) for the target word including regressions to it. As in the self-paced reading time paradigm, the interpretation of eye-tracking data is closely tied to the assumption that a fixated element is also a currently processed element (cf. Just & Carpenter, 1980). As there is, however, no 1:1 correlation between the different measures and at the same time no clear evidence pointing to the superiority of one single measure over the others regarding its relationship with underlying cognitive processes, eye-tracking studies usually examine and discuss a variety of different eye-tracking measures at once (for an introduction and critical evaluation of the method as well as a comprehensive review of the eye-tracking research in reading and other information processing tasks, see Rayner, 1998; for more details with regard to eye-tracking research on syntactic processing, see Clifton et al., 2007).
ME	Magnitude estimation is considered a highly reliable non-speeded method for gathering acceptability judgements (cf. Bard et al., 1996; Cowart, 1997). The technique is derived from a method originally developed in the field of psychophysics (Stevens, 1975). Participants are instructed to estimate the acceptability (comparable to psychophysical magnitude) of linguistic stimuli by assigning values proportional to the perceived acceptability, either by giving a numeric judgement in the range of decimal numbers or by drawing a line with a length proportional to the perceived acceptability.

Abbreviations used: SGJ, speeded grammaticality judgement; SPR, self-paced reading; ET, eye-tracking; ME, magnitude estimation behavioral paradigms, see Table 3.1). For object-before-subject orders (10b), they observed more errors as well as longer reaction times than for subject-before-object orders (10a).

Hemforth (1993; see also Hemforth, Konieczny, & Strube, 1993) employed locally ambiguous declarative main clauses such as (11) in a number of behavioral tasks. Her results provided strong evidence for a subject preference in German: The object-initial orders (11b) were rated less acceptable in an offline acceptability questionnaire and yielded longer reading times at the disambiguating position in a self-paced reading experiment. Similarly, self-paced reading measures were able to provide evidence for a subject preference in locally ambiguous German wh-questions (Schlesewsky et al., 2000).

Employing a speeded grammaticality judgement task, Bader & Meng (1999) examined the subject preference in locally ambiguous scrambled sentences like the ones in (12) as well as in other verb-final German structures (including embedded wh-questions, subordinate clauses with pronouns, and relative clauses). Regardless of the specific sentence type, object-initial disambiguations (e.g. in the scrambled word order in 12b) led to decreased accuracies and increased reaction times in the judgement task, thus pointing towards a preference of the processing system for a subject-before-object analysis of ambiguous arguments in the German middlefield.

Taken together, the preferred analysis in the face of local ambiguity, as indicated by the increased processing costs for sentences that are disambiguated towards an object-initial structure, reflects a preference for canonical argument orders over object-initial orders. A processing disadvantage for object-initial orders is however not only measurable in ambiguous contexts but can also be observed in unambiguous sentences. Thus, even an initial argument which is unambiguously marked as an object (and can therefore not lead to an initial misinterpretation affording a subsequent reanalysis) can engender increased processing costs in comparison to an initial unambiguously marked subject. Free word order languages with overt case marking, like German and Japanese, are especially suited for the examination of such costs.

Object-initiality costs in unambiguous sentences

With regard to the processing of German, several psycholinguistic studies provide evidence for increased processing costs associated with objects encountered in the prefield (i.e. topicalized objects or wh-objects; cf. Examples 3 and 4) as well as in the middlefield (i.e. in scrambling; cf. Example 2; for a detailed differentiation between the clausal regions, see Section 1.1).

Hemforth (1993; see also Hemforth et al., 1993) examined declarative main clauses that had an identical structure to the ones in (11), but featured an unambiguously case marked initial argument in the prefield, as in (13).

(13) Word order permutation with object in the German prefield (topicalization; from Hemforth, 1993)

(a)

Der	*kluge*	*Onkel*	*besucht*	*den*	*kleinen*	*Jungen.*
[the	clever	uncle]$_{NOM}$	visits	[the	little	boy]$_{ACC}$

'The clever uncle visits the little boy.'

(b)

Den	*klugen*	*Onkel*	*besucht*	*der*	*kleine*	*Junge.*
[the	clever	uncle]$_{ACC}$	visits	[the	little	boy]$_{NOM}$

'The little boy visits the clever uncle.'

For the object-initial sentences (13b), Hemforth (1993) found a trend towards reduced acceptability ratings in a questionnaire study as well as increased reading times at the positions of the first noun and the following verb in several self-paced reading experiments. Similarly, Fanselow, Kliegl, & Schlesewsky (1999) reported several experiments yielding increased reading times for unambiguous object-initial wh-questions such as as (14b) in comparison to subject-initial questions (14a). The reading time difference arose at the position of the clause-initial wh-phrase and persisted across the two adverbial phrases.

(14) Word order permutation with object in the German prefield (wh-questions; from Fanselow et al., 1999)

(a)

…	*wer*	*vermutlich*	*glücklicherweise*	*den*	*Mann*	*erkannte.*
…	who$_{NOM}$	presumably	fortunately	[the	man]$_{ACC}$	recognized

'… who presumably and fortunately recognized the man.'

(b)

…	*wen*	*vermutlich*	*glücklicherweise*	*der*	*Mann*	*erkannte.*
…	who$_{ACC}$	presumably	fortunately	[the	man]$_{NOM}$	recognized

'… who the man presumably and fortunately recognized.'

Just like the objects in the prefield in Hemforth et al.'s and Fanselow et al.'s experiments, initial objects in the German middlefield (i.e. scrambled objects) have also been shown to engender increased processing costs. Keller (2000a; see also Keller, 2000b) included unambiguous sentences like the ones in (15) in a questionnaire asking participants to judge the sentence acceptability by means of magnitude estimation.

(15) Word order permutation within the German middlefield (scrambling; from Keller, 2000a)

(a)	*Maria*	*glaubt,*	*dass*	*der*	*Vater*	*den*	*Wagen*	*kauft.*
	Maria	believes	that	[the	father]$_{NOM}$	[the	car]$_{ACC}$	buys
(b)	*Maria*	*glaubt,*	*dass*	*den*	*Wagen*	*der*	*Vater*	*kauft.*
	Maria	believes	that	[the	car]$_{ACC}$	[the	father]$_{NOM}$	buys

'Maria believes that the father will buy the car.'

The scrambled object-subject-verb sentences (15b) were judged to be less acceptable than the canonical subject-object-verb sentences (15a). Keller (2000a) further demonstrated that the preference for subject-initial sentences can be influenced by pronominality and discourse factors like contextual givenness (see Section 1.1, for the licensing properties of specific linguistic contexts). Specifically, he found that the preference for the subject-initial order disappeared if the object was pronominalized (i.e. *ihn*, "it$_{ACC}$", instead of *den Wagen*) and that if the object was given in the preceding context (and the focus was on the new subject), the acceptability of the object-initial sentences was increased (e.g. following the question *Wer kauft den Wagen?*; "Who will buy the car?"). The influence of such a supporting context was especially strong if the object of the scrambled clause was pronominalized; in this case no acceptability difference was observable between the scrambled sentence with a pronominal object (*...dass ihn der Vater...*), the canonical word order with a pronominal object (*...dass der Vater ihn...*) and the canonical word order with full noun phrases (*...dass der Vater den Wagen...*). The influence of a licensing context on the processing of scrambled sentences was also evident in a self-paced reading study conducted by Meng, Bader, & Bayer (1999), who employed comparable subject- and object-initial sentences to the ones examined by Keller (2000a). The authors reported longer reading times at the sentence-final verb of object-before-subject sentences if they were preceded by a neutral context (like "What happened?") but no such processing disadvantage if they were preceded by a context introducing the the object.

Pechmann, Uszkoreit, Engelkamp, & Zerbst (1994; see also Pechmann, Uszkoreit, Engelkamp, & Zerbst, 1996) examined German ditransitive clauses in which the order of the subject (S), indirect object (I), and direct object (O) was fully permuted in the middlefield, resulting in six different variants of each sentence, as exemplified in (16).

(16) Word order permutation within the German middlefield (scrambling; from Pechmann et al., 1994)

(SIOV) *Dann hat der Vater dem Säugling den Schnuller gegeben.*
then has [the father]$_{NOM}$ [the baby]$_{DAT}$ [the pacifier]$_{ACC}$ given

(SOIV) *Dann hat der Vater den Schnuller dem Säugling gegeben.*
then has [the father]$_{NOM}$ [the pacifier]$_{ACC}$ [the baby]$_{DAT}$ given

(ISOV) *Dann hat dem Säugling der Vater den Schnuller gegeben.*
then has [the baby]$_{DAT}$ [the father]$_{NOM}$ [the pacifier]$_{ACC}$ given

(OSIV) *Dann hat den Schnuller der Vater dem Säugling gegeben.*
then has [the pacifier]$_{ACC}$ [the father]$_{NOM}$ [the baby]$_{DAT}$ given

(IOSV) *Dann hat dem Säugling den Schnuller der Vater gegeben.*
then has [the baby]$_{DAT}$ [the pacifier]$_{ACC}$ [the father]$_{NOM}$ given

(OISV) *Dann hat den Schnuller dem Säugling der Vater gegeben.*
then has [the pacifier]$_{ACC}$ [the baby]$_{DAT}$ [the father]$_{NOM}$ given

'Then the father gave the pacifier to the baby.'

Employing this material, Pechmann et al. (1994) conducted a delayed articulation experiment and a rapid serial visual presentation (RSVP) experiment. In the delayed articulation task, sentences were presented on the screen as a whole and participants were instructed to encode each sentence for as long as necessary and then reproduce it after a short delay (cf. Ferreira, 1991). Pechmann et al. (1994) found increased encoding times for all scrambled orders (SOIV[19], ISOV, OSIV, IOSV, and OISV) in comparison to the canonical SIOV order (while articulation latencies did not differ between the six sentence types, with the exception of higher latencies for the IOSV order). In the RSVP paradigm, the sentences were presented phrase by phrase in rapid succession, with a presentation time of 150 milliseconds per segment. Participants were asked to repeat the sentences immediately afterwards as correctly as possible, and the measure of interest was the participants' reproduction performance for each segment (cf. Forster, 1970). Regarding the reproduction of the experimental sentences' noun phrases, Pechmann et al. (1994) found higher reproduction rates in the two subject-initial orders than in all object-initial orders. Furthermore, the data pattern suggested that the first argument of a sentence was easier to reproduce if it was the subject of the sentence, while the second and third argument of a sentence were easier to reproduce if they were the direct object of the

[19] Beside subject-object order variations, permutations of direct and indirect objects in the German middlefield can also be considered as a case of scrambling, and as Pechmann et al.'s data show, these variations can also induce increased processing costs. As the focus of the research summarized in this thesis was on the permutation of subjects and objects in (mono)transitive clauses, the further discussion will concentrate on this type of scrambling.

sentence. Finally, Pechmann et al. (1994) also examined the acceptability of the ditransitive clauses in a questionnaire study. For this purpose the multiply scrambled order OISV was replaced with the ungrammatical order OVIS (e.g. *Dann hat den Schnuller gegeben dem Säugling der Vater*) to provide a clearly unacceptable candidate for the negative end of the judgement scale. Crucially for present purposes, all orders in which one or more of the objects preceded the subject (i.e. the orders ISOV, OSIV, IOSV, and the ungrammatical OVIS) yielded reduced acceptability ratings in comparison to the subject-before-objects orders (SIOV and SOIV).

Altogether, the data from German thus strongly indicate increased processing costs for non-canonical word orders, even in the absence of grammatical function ambiguity. Further support for this assumption stems from psycholinguistic evidence on scrambled word orders in Japanese. For example, Mazuka, Itoh, & Kondo (2002) compared subject-before-object and object-before-subject sentences as in (17), alternatively with or without an embedded relative clause modifying the second argument (indicated by brackets).

(17) Word order permutation in Japanese (scrambling; from Mazuka et al., 2002)

(a)	*Mariko-ga*	*[soto-de*	*buranko-ni*	*notte-ita]*	*otooto-o*	*yonda.*
	Mariko-NOM	[outside	on a swing	swinging]	brother-ACC	called

'Mariko called the younger brother [who was swinging on a swing outside].'

(b)	*Mariko-o*	*[soto-de*	*buranko-ni*	*notte-ita]*	*otooto-ga*	*yonda.*
	Mariko-ACC	[outside	on a swing	swinging]	brother-NOM	called

'The younger brother [who was swinging on a swing outside] called Mariko.'

In two questionnaires, participants rated the scrambled orders (17b) as more difficult and as more misleading than the canonical sentences (17a). This effect was evident for both the simple sentences (without embedded relative clause) and the complex sentences (with embedded relative clause).[20] Furthermore, Mazuka et al. (2002) conducted an eye-tracking study and a self-paced reading experiment with the same stimulus material. The main finding from the eye-tracking study was that scrambled orders in both the simple and the complex sentences did not differ from canonical orders at the position of the accusative-marked first argument, but yielded increased total gaze times at the second argument position as well as more regressions

[20] The misleadingness effect can be attributed to the fact that, unlike the German examples above (14–16), the unambiguous case marking in Japanese does not prevent local structural ambiguity. As Mazuka et al. (2002) point out, the initial object in (17b) must not necessarily be interpreted as part of a scrambled sentence. Alternatively, the object could be part of a relative clause, or belong to a simple sentence with an omitted subject (i.e. a case of pro-drop; cf. Section 1.2 and Example 8; for a detailed discussion of these interpretational alternatives in Japanese, see Chapter 4).

originating from the second argument position. In the self-paced reading study, increased processing costs for the object-initial order were also evident at the position of the second argument, albeit only for the complex sentences. The latter result is also compatible with an earlier study by Yamashita (1997), who presented simple ditransitive sentences in a self-paced reading task, and did not observe any increase in reading times for scrambled word orders either. As Tamaoka et al. (2005) point out, however, participants are likely to develop a stable reading rhythm in the quite unnatural context of self-paced reading tasks, especially if the experimental sentences are short and not very complex. Therefore, self-paced reading times might not be an appropriate measure for examining scrambling in simple structures. Instead, Tamaoka et al. (2005) suggested employing a sentence-final semantic judgement task and using error rates and reaction times as measures of processing costs in simple sentences. For this, they presented each experimental sentence as a whole on a computer screen and instructed participants to judge as quickly as possible whether the sentence made sense. The critical sentences were simple transitive sentences as in (18) or simple ditransitive sentences as in (19). Sentences to be judged as nonsensical were constructed by applying semantic or syntactic violations.

(18) Word order permutation in Japanese transitive clauses (scrambling; from Tamaoka et al., 2005)

(a) *Tarou-ga* *Junko-o* *tasuketa.*
Tarou-NOM Junko-ACC helped

(b) *Junko-o* *Tarou-ga* *tasuketa.*
Junko-ACC Tarou-NOM helped

'Tarou helped Junko.'

(19) Word order permutation in Japanese ditransitive clauses (scrambling; from Tamaoka et al., 2005)

(a) *Kazuko-ga* *Tarou-ni* *hon-o* *kashita.*
Kazuko-NOM Tarou-DAT book-ACC lent

(b) *Hon-o* *Kazuko-ga* *Tarou-ni* *kashita.*
book-ACC Kazuko-NOM Tarou-DAT lent

'Kazuko lent a book to Tarou.'

In the sentence-final judgement task, participants showed a reduced accuracy as well as increased reaction times for the scrambled word orders (18b and 19b), with the reaction time effect being more severe in the ditransitive clauses than in the transitive clauses. Thus, unlike Yamashita (1997), Tamaoka et al. (2005) found increased processing costs for object-before-subject orders even in simple Japanese sentences, thereby supporting Mazuka et al.'s (2000) results achieved with offline questionnaire ratings and eye-tracking measures.

Taken together, the described behavioral evidence on the processing of word order variations, stemming from different languages, ambiguous as well as unambiguous sentences, and a variety of syntactic structures, strongly argues in favor of an increased difficulty in the processing of object-before-subject orders. The psychological processes underlying this processing disadvantage, however, are still far from clear. In the next Section, I will introduce some influential psycholinguistic accounts of word order processing that have been suggested in the literature on the basis of behavioral results such as the ones described above.

3.1.2 Prominent psycholinguistic accounts of word order processing

Many of the most prominent accounts of word order processing are based on the assumption that word order variations are caused by movement and that empty categories like traces are to some extent also *psychologically* real. Recall that according to movement-based theories of grammar, any argument which is removed from its base position leaves a trace in that position (cf. Section 1.1.1). On a processing level, the removed argument (usually called *filler* in a processing context) needs to be integrated with its trace (typically called *gap*) to arrive at an interpretation of the sentence.[21] In the following, I will begin by introducing a class of sentence comprehension models that strongly draw upon these assumptions in explaining increased processing difficulties, the so-called *filler-gap* accounts. Later in this section, I will describe an approach to sentence processing that attempts to integrate these structural assumptions with more general cognitive concepts such as working memory and capacity limitations. Finally, a class of models will be addressed that is primarily concerned with non-syntactic factors such as frequency, context, or plausibility, and their influence on sentence processing.

[21] It should be noted that not all psycholinguistic models of word order processing assume filler-gap dependencies. An example is the *Direct Association Hypothesis* (DAH) put forward by Pickering & Barry (1991). Based on results from English, Pickering & Barry (1991) proposed that increased processing costs at the position of the alleged gap can alternatively be derived from a direct association between the initial object and its subcategorizing verb (which occurs immediately prior to the gap position in English). As such a purely head-driven account can however not account for increased processing costs arising prior to the verb position in verb-final languages (e.g. Mazuka et al., 2002; see also the discussion of incremental processing in the Introduction), this account will not be discussed in greater detail here. For a neurolinguistic approach that does not assume any filler-gap dependencies but can nonetheless account for the processing of word order variations in verb-final languages, see Section 3.1.4.

Filler-gap accounts

One of the most influential accounts of this kind was proposed by Frazier (1987; see also Frazier & Flores d'Arcais, 1989) with the *Active Filler Strategy* (AFS). This account posits that the identification of a filler initiates the search for a gap, which is then created at the earliest possible point allowed by the grammar to avoid longer distance dependencies between the filler and its gap. In (10) above, for example, the ambiguous wh-phrase occurs in a non-argument position (the Dutch prefield) and is thus identified as a filler. Following the AFS, the processing system will assign the filler to the earliest possible gap in the sentence, i.e. the subject gap, which directly follows the verb and precedes the object gap. When the sentence turns out to be inconsistent with the resulting subject analysis of the initial argument, increased processing costs arise.[22] This approach to deriving the subject preference for initially ambiguous arguments can also account for the preferred subject interpretation of the topicalized initial argument *Die kluge Tante* in (11) and for the preferred subject analysis of case ambiguous relative pronouns (cf. Footnote 18).

However, the AFS only applies when an initial noun phrase can be identified as a filler; in other words, it makes predictions for cases in which movement has taken place and the processing system needs to decide in which position the movement has originated. By contrast, the model does not provide any predictions regarding processing decisions if an initial noun phrase is only potentially, but not necessarily, a filler, as is the case in (12). Crucially, while the clause-initial argument *die neue Lehrerin* needs to be analyzed as an object filler removed from its base position in the scrambled condition (12b), it can be analyzed as the unmoved subject occurring in its base position in the canonical condition (12a). Consequently, the initial argument cannot be unequivocally identified as a filler at the time it is first encountered, and thus does not fulfill the requirements for initiating the AFS mechanism.

A filler-gap based account overcoming these restrictions is the *Minimal Chain Principle* (MCP), which has been proposed by De Vincenzi (1991) as an extension

[22] Note that from a strictly incremental point of view, there seems to be a caveat in the way Frazier & Flores d'Arcais (1989) derive the subject preference in (10). According to the AFS, the subject preference should result from the integration of the filler with the first possible gap position being encountered. As the subject gap is encountered before the object gap, the filler is analyzed as a subject. Increased processing costs should arise if this analysis afterwards turns out to be incorrect, e.g. via verb agreement information. In (10), however, the disambiguating agreement information is already encountered before the subject gap position. A similar line of argumentation was also pursued by Schlesewsky et al. (2000), who observed increased reading times for object-initial structures at a position preceding the subject gap position at which the subject preference should arise according to the AFS. A modification of the AFS which assumes that the subject preference arises already at the position of the filler (via an immediate prediction of a subject gap) was proposed by Crocker (1994) in the *Active Trace Strategy* (ATS).

of the AFS. In case of an identified filler as in (10) and (11), the MCP makes similar predictions as the AFS: The filler will be assigned to the first possible gap position (i.e. the subject position), as this analysis contains the shortest distance between the filler and its gap. In addition, the MCP proposes that the processing system prefers minimal chains, that is, it prefers a non-movement analysis over a movement analysis if possible. Thereby, the MCP can derive the subject preference in sentences such as (12): The MCP predicts a preferred analysis of the initial argument *die neue Lehrerin* as a singleton chain (containing only the subject in its base position) instead of a chain with two members (containing the moved object and its trace position). When at the point of disambiguation the preferred analysis turns out to be incorrect in (12), increased processing costs are predicted as a consequence of the reanalysis from a singleton chain to a two-member chain.

A memory-based account of linguistic complexity

While the AFS and the MCP provide powerful mechanisms for resolving local subject-object ambiguities, they are in principle not laid out to derive increased processing costs in unambiguously case marked object-initial structures as in (13) to (19). An influential psycholinguistic theory that has been developed on the basis of such unambiguous cases of linguistic input is the *Syntactic Prediction Locality Theory* (SPLT) that was first suggested by Gibson (1998) and further developed into the *Dependency Locality Theory* (DLT; Gibson, 2000). In contrast to the AFS and the MCP, the SPLT/DLT was not designed as a theory of ambiguity resolution but is primarily concerned with the processing of linguistic complexity in unambiguous sentences (focussing on phenomena such as multiple center-embeddings of relative and complement clauses). It can, however, be employed to derive processing preferences in locally ambiguous sentences, as well. Furthermore, the SPLT/DLT attempts to consolidate linguistic concepts, such as filler-gap dependencies, with general psychological concepts, such as working memory load and limited processing capacity. Consequently, Gibson (1998) describes his theory as an extension or a possible psychological foundation for theories such as the AFS rather than as a concurring model with fundamentally incompatible assumptions.

According to the SPLT/DLT, two kinds of processing costs may arise in the course of sentence processing at the position of every incoming word: a *storage cost* component for making syntactic predictions and maintaining them in working memory until they are resolved, and an *integration cost* component for integrating new input elements into the existing syntactic structure and the given discourse. The storage cost component is primarily a function of the number of predicted elements (e.g. noun phrases, verbs, or empty categories like traces) that are necessary to complete the sentence in a grammatical manner. The integration cost component is a function of the complexity of the integration (e.g. whether or not it involves constructing a new discourse referent) and of the distance between the elements that are to be integrated. The distance is assumed to affect integration costs since the activation of an encountered element decays when subsequently encountered new input needs to be processed, thus making a reactivation for integration purposes increasingly difficult with growing distance between first encounter and integration point. Regarding the intervening input, distance is defined in terms of the number of new discourse referents occurring between the two sentence elements under consideration.

Based on these assumptions, Gibson (1998) derives object-initiality costs in unambiguous sentences such as the ones employed in (13) and (14) on the basis of the storage cost component: In the subject-initial case (13a, 14a), the sentence-initial subject engenders the prediction of a subject trace (as the wh-phrase is not in its base position) and a verb (as the sentence would otherwise not be grammatical), while in the object-initial condition (13b, 14b), an object trace, a verb and a subject are predicted (as the sentence would not be grammatical without an overt subject). Thus, the number of predictions that have to be made and maintained in working memory is higher in the object-initial condition. In the case of scrambling, in which the subject-initial counterpart does not involve any underlying movement operation (see above), the difference should be even more severe: In sentences such as (15) or the Japanese examples given above, an initial object (e.g. *den Wagen*) should lead to the prediction of a subject, an object trace following the subject, and a sentence-final verb, while an initial subject (e.g. *der Vater*) would only require the prediction of a verb. Thus, according to the SPLT/DLT, object-initial structures yield increased processing costs because they engender an increased working memory load (in the form of storage cost for the additional predictions) as compared to subject-initial structures. While Gibson (1998, 2000) himself does not go into details with regard to the integration cost component in unambiguous object-initial sentences, increased processing costs on this level can also be expected based on the SPLT/DLT assumptions, at least if empty categories are assumed.[23] After all, an initial object must be reactivated when its base position is encountered, i.e. when it can be integrated with the trace in its base position. An initial subject, on the other hand, either does not need to be integrated with an empty category at all (if it is not moved),

[23] As Gibson (1998) points out, the difference in the number of predictions (and therefore storage cost) between object-initial and subject-initial sentences persists even if no traces are assumed.

or it is integrated with its trace at an earlier point in the sentence (as the subject trace position precedes the object trace position). As the integration cost component is a function of the distance between the arguments that are to be integrated, higher integration costs should be encountered in object- than in subject-initial sentences. Thus, based on the SPLT/DLT, increased processing costs in object-initial structures can be derived on the basis of higher storage cost (more predictions) and higher integration cost (more integrations / integration across a longer distance).[24] Regarding the locus of the increased processing costs, the increased memory cost should be observable at the position of the initial object, i.e. the position where the syntactic predictions are made, and possibly at all following positions in which the additional predictions need to be maintained, while the increased integration cost should be observable at the position of the object trace, i.e. the position where the integration process takes place.

These predictions are compatible with the evidence for increased processing costs at the position of initial objects in German (Fanselow et al., 1999; Hemforth, 1993; Pechmann et al., 1994), which could be attributed to higher memory cost (more syntactic predictions). Note that such an account is particularly appealing in light of the reading time data reported above, since the additional predictions would need to be upheld in working memory until the predicted elements are encountered. This memory-based prediction is highly compatible with the reading time data reported by Fanselow et al. (1999) and Hemforth (1993), which both indicate a processing disadvantage for object-initial structures up to the point where the (predicted) subject is encountered. Based on the integration cost component, the SPLT / DLT might furthermore be able to account for the increased processing costs that the Japanese object-before-subject sentences in Mazuka et al.'s (2002) experiments showed at the presumed position of the object-trace, i.e. after the second argument.

The integration of non-syntactic information

The influence of non-syntactic factors such as plausibility or context information on sentence processing (e.g. Keller, 2000a; Meng et al., 1999; see above) is in the focus of so-called *interactive* or *constraint-based* theories (e.g. MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell, Tanenhaus, & Garnsey, 1994; Vosse & Kempen, 2000) which propose an immediate interaction of syntactic and non-syntactic information

[24] The subject preference in locally ambiguous sentences can simply be derived from these assumptions in the SPLT/DLT: In the face of local grammatical function ambiguity, the processing system will opt for a subject interpretation of an initial argument to avoid the increased working memory load in the form of additional storage costs engendered by the object-initial alternative.

at all levels of the comprehension process. These models are typically lexicalist in nature and assume that multiple alternative partial syntactic representations or *templates* are stored in the lexical entry of each word along with its semantic information. These templates encode possible syntactic frames for the word under consideration, along with various other kinds of information ranging from morphology to word categories, to grammatical functions and thematic roles (in nouns) or subcategorization frames and thematic grids (in verbs). In incremental sentence comprehension, especially in the case of ambiguous input information, all of these information types are taken into account to provide a preferred analysis of the sentence encountered thus far, via the selection of a template alternative and the integration of this template into the existing sentence structure. Crucially, the choice between different possible templates is co-determined by syntactic factors such as agreement or case morphology and non-syntactic factors such as discourse context, plausibility, and, most prominently, frequency of occurrence (cf. Jurafsky, 1996; Levy, 2005). Thus, just as in lexical ambiguity resolution the processing system selects the most frequent and most contextually appropriate sense of the ambiguous word, syntactic ambiguities are considered to be analyzed in favor of the most frequent and most contextually appropriate structure. Regarding the processing of word order variations, a subject-initial analysis might therefore be preferred due to the fact that it is the more frequent word order in basic SOV languages.

However, while such a correspondence between frequency and processing preferences seems to be evident more often than not, not all word order preferences can be related to differences in frequency. For instance, Kempen & Harbusch (2005) found a discrepancy between the pattern observed in the acceptability ratings surveyed by Keller (2000a) and the corpus frequency of the respective structures. Likewise, the increase in reading time that Fanselow et al. (1999) observed for object-initial wh-questions was evident even though wh-objects are not less frequent in German than wh-subjects. Thus, while it is beyond question that frequency of occurrence usually correlates with processing preferences, frequency alone does not seem to be able to derive the entire pattern of behavioral effects associated with the processing of word order variations.

With regard to the way in which non-syntactic information like frequency, plausibility, and discourse context affects sentence processing, interactive models (such as the constraint-based theories described above) are typically contrasted with so-called *modular* models. The latter include models such as the *Garden Path Theory* by Frazier (1978; Frazier & Fodor, 1978; Frazier & Rayner, 1982), in which the filler-gap based accounts described above are couched, or the neurocognitive model discussed in Section 3.1.4 below. When differentiating between the two classes of models, it is important to keep in mind that interactive models and modular models do not differ with respect to whether they acknowledge the influence of these information sources or not. By contrast, the influence of non-syntactic information on sentence processing has been demonstrated in numerous empirical studies and is generally undisputed. The crucial difference between interactive and modular models rather refers to the *point in time* at which non-syntactic information begins to interact with syntactic information. In constraint-based theories the interaction is immediate, with all information types being simultaneously taken into account for generating the syntactic structure. In modular models an initial analysis is computed based on syntactic information alone, while non-syntactic information types can only affect this initial "parse" in subsequent processing stages, possibly leading to reanalysis effects. Thus, while syntactic and non-syntactic information types do interact in both types of models, modular models differ from constraint-based models in that they assume at least one initial processing module that is based on purely syntactic information before the influence of non-syntactic information commences. Since the available behavioral data (e.g. the acceptability ratings reported by Keller, 2000a, or the sentence-final reading time data documented by Meng et al., 1999) only provide evidence for an interaction of syntactic and contextual information on a global sentence level, they remain largely inconclusive with regard to the timing of the non-syntactic impact on the processing of word order variations.

3.1.3 Neurocognitive evidence

An experimental method particularly useful for examining questions regarding the timing of specific processing aspects is constituted by event-related potentials. As described in Chapter 2, ERPs offer a high temporal resolution that is specifically suited for capturing cognitive processes in real time. Furthermore, due to the multidimensionality of the data (as ERP components can differ in latency, polarity, and topography), qualitatively different aspects of processing can be disentangled with this method even if they occur at the same position of the sentence and thus may lead to identical effects in behavioral measures (e.g. increased reading times). Since another high-resolution means for gaining insight into cognitive processes is provided by neuroanatomical measures, I will shortly introduce neuroanatomical correlates typically associated with the processing of word order variations before turning to a more detailed overview of the relevant ERP literature.

Neuroanatomical correlates of word order processing

The neuroanatomical method that has been employed most frequently in recent years for localizing higher cognitive processes in the brain is functional magnetic resonance imaging (fMRI). While the ERP method provides a high temporal resolution in the millisecond range but can only afford a poor spatial resolution (cf. Section 2.2.3), fMRI is a method with a poor temporal resolution which in return offers an excellent spatial resolution (in the millimeter range). The measure of interest in fMRI experiments is the BOLD (blood oxygenation level dependent) response (Ogawa, Lee, Kay, & Tank, 1990a; Ogawa, Lee, Nayak, & Glynn, 1990b), a particular modulation of the magnetic resonance (MR) signal that is thought to increase as a function of the increasing ratio of oxygenated to deoxygenated blood in regions of neural activity. For a comprehensive overview of the fMRI method, see, for example, the introduction provided by Buxton (2002).

In fMRI studies, word order permutations have been primarily associated with increased activation in the left inferior frontal gyrus (LIFG). For example, Röder, Stock, Neville, Bien, & Rösler (2002) examined unambiguous German sentences similar to the ones employed by Pechmann et al. (1994; cf. Example 16) and observed an increased activation for scrambled word orders in the pars opercularis (PO) and the pars triangularis (PT) of the LIFG (note that the two anatomical structures are often subsumed under the label "Broca's area"). Since then, the LIFG (especially the PO portion) has been confirmed as a highly sensitive area with regard to word order variations in numerous experiments (e.g. Bornkessel, Zysset, Friederici, von Cramon, & Schlesewsky, 2005; Friederici, Fiebach, Schlesewsky, Bornkessel, & von Cramon, 2006b; Grewe et al., 2005, 2006). Similar findings of increased LIFG activation for object-initial structures have also been reported in languages other than German (e.g. Ben-Shachar, Palti, & Grodzinsky, 2004, for Hebrew; Kinno, Kawamura, Shioda, & Sakai, 2008, for Japanese; Just, Carpenter, Keller, Eddy, & Thulborn, 1996, and Stromswold, Caplan, Alpert, & Rauch, 1996, for object relative clauses in English).

Furthermore, the same brain region has also shown increased activity for locally ambiguous object-initial sentences in comparison to sentences that are disambiguated towards a subject-initial reading (e.g. Bornkessel et al., 2005) and for locally ambiguous sentences per se, i.e. in comparison to unambiguous sentences (Bornkessel et al., 2005; see also Fiebach, Vos, & Friederici, 2004). Due to the poor temporal resolution of the fMRI method, however, it is virtually impossible to disentangle possible local effects of ambiguity, reanalysis, and global sentence complexity in the fMRI signal elicited by such sentences.

While there is general agreement that the LIFG displays a high sensitivity to word order variations, there is an ongoing debate about which aspect of permuted word orders is in particular responsible for this correlation. Approaches to the functional characterization of this brain region range from highly language-specific filler-gap based accounts centering on the number of movements and necessary trace integrations in a permuted structure (e.g. Grodzinsky, 2000; Grodzinsky & Friederici, 2006) to more general cognitive explanations like an increase in working memory load (e.g. Caplan, Alpert, Waters, & Olivieri, 2000; Fiebach, Schlesewsky, Lohmann, von Cramon, & Friederici, 2005; Kaan & Swaab, 2002).

Interestingly, initial objects encountered in the German prefield either seem to engender no activation difference in comparison to their subject-initial counterparts at all (Fiebach et al., 2005; for wh-objects), or are associated with an activation maximum in the PT rather than the PO portion of the LIFG (Bahlmann, Rodriguez-Fornells, Rotte, & Münte, 2007; for topicalized objects). Thus, in German, increased PO activation seems to be crucially tied to word order variations in the middlefield (cf. Bornkessel & Schlesewsky, 2006a). Additional fMRI findings point to the fact that at least with regard to the processing of unambiguous structures in the German middlefield, the PO portion of the LIFG is not only sensitive to the ordering of subjects and objects but also to other word order related factors like thematic roles, pronominality, or animacy (e.g. Bornkessel et al., 2005; Grewe et al., 2005, 2006).

Electrophysiological correlates of word order processing

The ERP literature on the processing of ambiguous and unambiguous word order permutations reveals a complex pattern of different components, indicating that several cognitive processes are involved in the processing of argument order variations. In the following, I will first present a short overview of ERP correlates of the subject-preference in locally ambiguous sentences, before turning to a more detailed discussion of the ERP data associated with the processing of unambiguous word order variations, which were in the focus of the experiments summarized in this thesis.

ERP indicators of the subject preference in locally ambiguous sentences The increased processing costs for disambiguations towards an object-initial order that are indicative of a subject preference in behavioral studies are also evident in ERP measures. Cross-linguistic data from a variety of languages show ERP effects speaking in favor of the subject-preference as a very robust, universal processing phenomenon (e.g. Frisch et al., 2002, for German; Lamers, 1996, for

Dutch; Penolazzi, De Vincenzi, Angrilli, & Job, 2005, for Italian; Casado, Martín-Loeches, Muñoz, & Fernández-Frías, 2005, for Spanish; Demiral, Schlesewsky, & Bornkessel-Schlesewsky, 2008, for Turkish; Wang, Schlesewsky, Bickel, & Bornkessel-Schlesewsky, in press, for Chinese). As in the behavioral experiments, the locus of the processing difficulty corresponds to the sentence position that disambiguates an initial ambiguous argument towards an object-reading, thus indicating reanalysis processes taking place at that position. However, unlike the clear (since one-dimensional) behavioral effects described above, the neurocognitive data pattern associated with the subject preference is not nearly as straightforward. Thus, the increased processing costs arising at the point of disambiguation have been demonstrated to correlate with a range of electrophysiological responses, depending upon the exact environment in which the reanalysis towards an object-initial structure becomes necessary. While in some experiments P600 effects were found in response to the dispreferred disambiguation (e.g. beim Graben, Schlesewsky, Saddy, & Kurths, 2000; Casado et al., 2005; Frisch et al., 2002; Lamers, 1996), others also reported early positivities (e.g. Demiral et al., 2008; Mecklinger et al., 1995, for German relative clause ambiguities; Penolazzi et al., 2005) or N400 like components (e.g. Bornkessel et al., 2004c; Haupt, 2008; Leuckefeld, 2005; Wang et al., in press) as correlates of the reanalysis. Furthermore, Frisch et al. (2002) also observed a P600 like effect at the position of the ambiguous initial argument in comparison to unambiguously case marked arguments. Crucially, the specific ERP components associated with grammatical function reanalyses in any given experiment seem to be dependent on the language and the specific sentence structure under consideration as well as on the exact point of disambiguation (for a detailed discussion, see Haupt, 2008).

Interestingly from a theoretical perspective, recent results from Turkish demonstrated a subject preference in a language which does not engender increased processing costs for initial objects. In a study by Demiral et al. (2008), unambiguously marked initial objects did not differ from initial subjects with regard to the electrophysiological response they elicited. Nonetheless, sentences with an ambiguously marked initial argument elicited an early positivity at the point of disambiguation towards an object-initial reading. These results pose a serious challenge for filler-gap based accounts like the AFS or the MCP as well as for memory-centered accounts such as the SPLT/DLT. Based on AFS/MCP assumptions, no subject preference should arise in Turkish since both a sentence-initial subject and a sentence-initial object can occur in their base position in Turkish. As a result, no filler-gap dependency is required in either of the two alternative readings of an ambiguous initial object. The SPLT/DLT, on the other hand, interprets the subject preference as a result of increased processing costs for initial objects, which the processing system attempts to avoid by adopting a subject analysis in the case of ambiguity. The fact that a subject preference can also be observed in the absence of increased processing costs for unambiguous initial objects, however, is strictly at odds with such an explanation. Instead, the findings from Turkish seem to indicate that the processing of word order variations might involve several kinds of cognitive processes operating at a number of distinct levels of sentence analysis.

Regarding the processing of unambiguous object-initial sentences, the pattern of observed ERP components is similarly heterogeneous. In particular, previous electrophysiological results have revealed three interesting observations: First, different types of word order permutations give rise to distinct ERP signatures. Second, there are circumstances under which object-initial orders do not engender a measurable increase in online processing cost at all. Third, there are cases in which the processing of the *canonical* word order seems to elicit increased processing costs. In the following, I will review the evidence for each of these points in turn.

Distinct ERP signatures for different types of unambiguous object-initial orders The vast majority of previous ERP results on the processing of unambiguous object-initial sentences stems from German. Like the reported findings on the processing of subject-object ambiguities, these findings suggest that the comprehension of word order permutations may not be supported by a single neural mechanism alone. As described in Section 1.1 and in Section 3.1.1 above, German permits a variety of different types of object-initial orders, with a particularly interesting distinction between the prefield and the middlefield of the sentence. Crucially, while behavioral results showed increased processing costs for initial objects in all sentential environments (e.g. Fanselow et al., 1999; Hemforth et al., 1993; Keller, 2000a; Meng et al., 1999; Pechmann et al., 1994; see above), initial objects show differential processing behavior in ERP studies, depending on whether they occur in the prefield (i.e. in topicalization or wh-questions) or in the middlefield (i.e. in scrambled sentences).

Initial objects that are encountered in the German prefield have been shown to engender sustained anterior negativities (SAN effects) in a number of ERP experiments. For example, Fiebach, Schlesewsky, & Friederici (2002) examined embedded wh-questions such as the ones in (20) and observed a left-lateralized SAN effect for the object-initial questions (20b) starting after the initial wh-object (at the position of *am Dienstag*) and lasting until the second argument (*der Doktor*) was encoun-

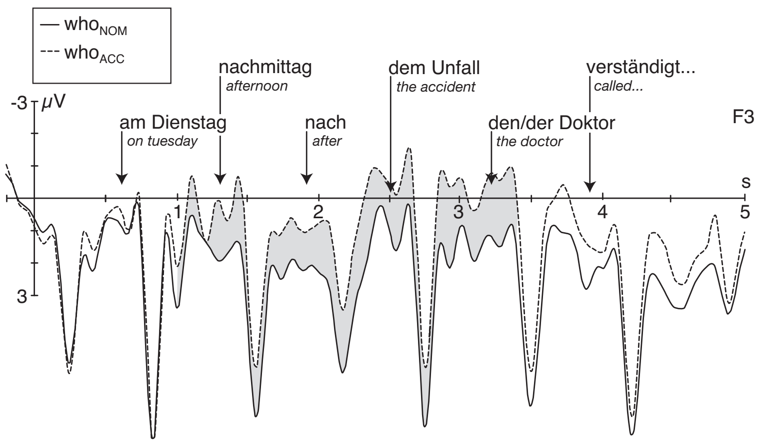

Figure 3.1: Sustained (left-)anterior negativity in response to initial objects in the German prefield (cf. Example 20; adapted from Fiebach et al., 2002).

tered (see Fig. 3.1). Similar effects were also observed for initial topicalized objects in declarative main clauses (Matzke, Mai, Nager, Rüsseler, & Münte, 2002). In addition, some studies also reported central to parietal positivities (P600 effects; see Fig. 3.2) for object-initial structures at the position of the second argument (Fiebach et al., 2002) or the clause-final verb (Felser, Clahsen, & Münte, 2003).

(20) Word order variation with object in the German prefield (wh-question; from Fiebach et al., 2002)

(a) *. . . wer am Dienstag nachmittag nach dem Unfall den*
. . . who$_{NOM}$ on Tuesday afternoon after the accident [the
Doktor verständigt hat.
doctor]$_{ACC}$ called has
'. . . who called the doctor on Tuesday afternoon after the accident.'

(b) *. . . wen am Dienstag nachmittag nach dem Unfall der*
. . . who$_{ACC}$ on Tuesday afternoon after the accident [the
Doktor verständigt hat.
doctor]$_{NOM}$ called has
'. . . who the doctor called on Tuesday afternoon after the accident.'

The SAN effects in these structures were generally interpreted in terms of increased working memory load for object-initial structures, thus supporting working memory-based accounts like the SPLT / DLT which assume that in object-initial sentences the prediction of the subject (and possibly of the object trace) must be held active in working memory until the predicted elements are encountered. This

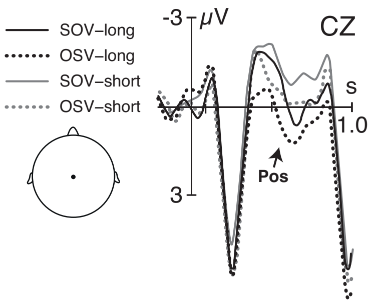

Figure 3.2: Parietal positivity in response to subjects following initial objects in the German prefield (cf. Example 20; adapted from Fiebach et al., 2002); long: long questions; short: short questions.

interpretation, which can be closely related to the memory-based explanation of the increased reading times observed by Fanselow et al. (1999) and Hemforth (1993) described earlier, is supported by two facts: First, the SAN effect in the study by Fiebach et al. (2002) interacted with working memory capacity, as determined on the basis of a reading span task.[25] Second, the effect disappeared if shorter sentences were presented (e.g. *wen am Dienstag der Doktor verständigt hat*), i.e. if the predicted elements were encountered shortly after the prediction was made, thus reducing the working memory load substantially.

The P600 effects were typically viewed as indexing the integration of the object, either at its trace position (Fiebach et al., 2002) or with its subcategorizing verb (Felser et al., 2003). Especially the trace integration interpretation of the P600 effects is highly compatible with filler-gap based accounts such as the AFS and the MCP, and also with the SPLT / DLT, at least if empty categories like traces are assumed. In this case, the P600 could be seen as a marker of the integration cost component proposed by the model (cf. Kaan et al., 2000, for a similar proposal based on results from English, a language in which increased integration costs at the position of the verb could in principle arise either from the integration of the dislocated object with the verb, as suggested by the authors, or with the immediately following object trace, as would be predicted by filler-gap based accounts).

[25] The reading span task, which was originally developed by Daneman & Carpenter (1980), is a frequently used tool to measure an individual's working memory capacity by combining processing and storage demands. In each trial of this task, participants are required to read a set of subsequent sentences out loud and afterwards recall the final word of each sentence. Typically, the number of sentences increases in the course of the test, so that the participants first have to store only two sentence-final words, then three, etc. The measure of interest is the reading span, which is defined as the maximal number of sentence-final words that a person can recall completely and in the correct order.

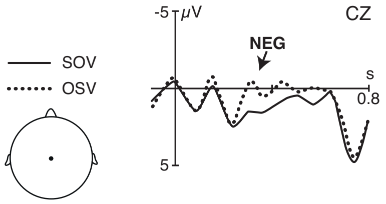

Figure 3.3: Scrambling negativity in response to initial objects in the German middlefield (cf. Example 21b; adapted from Bornkessel et al., 2002).

All in all, these findings for objects in the prefield in German are quite comparable to ERP results on the processing of long-distance dependencies in English (Phillips, Kazanina, & Abada, 2005) and Japanese (Hagiwara, Soshi, Ishihara, & Imanaka, 2007; Ueno & Kluender, 2003) which also revealed slow anterior negativities whenever an element needs to be kept active in working memory over a sufficiently long distance, and P600 effects when integrations are either more complex or have to be performed over a longer distance (though there is some debate with regard to which aspect of the integration process the P600 indexes and whether it is distance dependent or not; cf. Phillips et al., 2005).

In contrast to the findings for the German prefield, scrambled word orders, i.e. object-first orders in the middlefield, have been shown to engender a focal negativity between approximately 300 and 500 ms post onset of the initial object. This effect was first observed by Rösler, Pechmann, Streb, Röder, & Hennighausen (1998), who examined the processing of ditransitive sentences similar to the ones employed by Pechmann et al.(1994; cf. Example 16) and compared ERPs relative to the onset of the nominative, accusative and dative-marked determiners *der*, *den*, and *dem*. In various subsequent experiments (e.g. Bornkessel & Schlesewsky, 2006b; Bornkessel, Schlesewsky, & Friederici, 2002, 2003), the effect could also be replicated in response to complete object noun phrases such as *den Jäger* in the simple transitive sentences below (see Fig. 3.3).

(21) Word order variation in the German middlefield (scrambling; from Bornkessel et al., 2002)

(a) *... dass der Jäger den Gärtner besucht.*
... that [the hunter]$_{NOM}$ [the gardener]$_{ACC}$ visits
'... that the hunter visits the gardener.'

(b) *... dass den Jäger der Gärtner besucht.*
... that [the hunter]$_{ACC}$ [the gardener]$_{NOM}$ visits
'... that the gardener visits the hunter.'

While the effect was initially classified as a left-anterior negativity (LAN) by Rösler et al. (1998), it has subsequently occurred with a variety of diverging topographical distributions (from fronto-central to centro-parietal). Due to this deviation of its distribution from the classical distributions of the LAN (left-anterior) as well as the N400 (centro-parietal), the alternative term "scrambling negativity" (Schlesewsky, Bornkessel, & Frisch, 2003) has become established as a label for the effect. Here, I will also use this stimulus-driven label in order to avoid potentially unwarranted associations with either of the two more prominent negative components mentioned above.[26]

Regarding the interpretation of the scrambling negativity, it has been demonstrated that the scrambling negativity cannot be attributed to differences in frequency of occurrence (Bornkessel et al., 2002) or in working memory load (Schlesewsky et al., 2003) alone. A frequency-based interpretation does not seem to apply because under certain circumstances, initial dative-marked objects do not engender a scrambling negativity, even though – just like initial accusative-marked objects – they are considerably less frequent than initial nominative-marked subjects (Bornkessel et al., 2002; for more details see the next section). Similarly, the scrambling negativity cannot be interpreted in terms of increased working memory load (e.g. for the storage of a prediction) since initial object pronouns do not elicit the same effect (Schlesewsky et al., 2003; for more details see the next section), even though studies involving other types of object dislocation (e.g. Fiebach et al., 2002; Vos, Gunter, Schriefers, & Friederici, 2001) have shown comparable working memory demands for the processing of dislocated pronouns and full nouns.

Furthermore, contextual information does not seem to affect the behavior of the scrambling negativity. For example, Bornkessel et al. (2003) presented canonical and scrambled sentences comparable to the ones in (21) following questions which were either neutral (like "What happened?") or introduced the object of the target sentence (like "Who visited the hunter?"). While the latter kind of discourse context indisputably licenses scrambled word orders such as (21b) on theoretical grounds (e.g. Lenerz, 1977; cf. Section 1.1), and while this contextual licensing also seems to be reflected in a modulation of behavioral processing effects (e.g. Bader & Meng, 1999; Keller, 2000a; cf. Section 3.1.1), Bornkessel et al. (2003) observed no attenuation of the scrambling negativity in the licensing context. Likewise, contexts providing a contrastive reading for the scrambled sentence (cf. Section 1.1) also failed to alleviate the local processing costs induced by a scrambled object (Bornkessel & Schlesewsky, 2006b). Importantly, these results speak against an immediate inter-

[26]Note, however, that the use of the term "scrambling negativity" is not intended to imply that this effect necessarily warrants an independent component status (cf. Sections 2.2.3 and 2.2.4). Whether this is the case or not is beyond the scope of the present thesis.

action of syntactic and non-syntactic information sources upon the encounter of an initial object, thus providing a case of counterevidence against strongly interactive models of sentence processing (e.g. MacDonald et al., 1994; Trueswell et al., 1994).

Taken together with the feasible dissociation of the scrambling negativity from working memory- and frequency-based effects as described above, this lack of contextual influence on the scrambling negativity thus speaks against an interpretation of the scrambling negativity as a correlate of contextual inappropriateness, low surface frequency, or general cognitive demands like increased working memory load. As a result, the scrambling negativity has instead been described as an index of specifically syntactic processing costs for initial objects in the German middlefield (Bornkessel et al., 2002, 2003; Friederici, Schlesewsky, & Fiebach, 2003).

The clear divergence of the scrambling negativity from ERPs associated with the processing of initial objects in the German prefield (i.e. SAN effects indicative of working memory processes, and P600 effects usually attributed to integration operations; see above) thus suggests that an initial object does not invariably lead to the same kind of processing costs wherever it is encountered. Instead, several distinct levels of processing costs seem to be involved in the processing of permuted objects, with the precise properties of the clausal region in which the initial object is encountered being of crucial importance.

The absence of local processing costs for unambiguous initial objects
Some of the findings from the German middlefield suggest that the processing of an object-initial order not only depends upon the region of the clause in which the object is encountered, as described above, but also upon the properties of the object itself. More precisely, the findings attest to the fact that not all kinds of initial objects in the German middlefield engender increased local processing cost in the form of a scrambling negativity.

As shortly mentioned above, Schlesewsky et al. (2003) investigated the local processing costs elicited by word order variations in the middlefield with pronominal first arguments, such as in (22), and compared them to the effects elicited in scrambled sentences with non-pronominal first arguments (employing comparable stimulus materials to Rösler et al., 1998, and Pechmann et al., 1994; cf. Example 16, conditions SIOV, OSIV, and ISOV).

(22) Word order variation in the German middlefield (pronoun scrambling; from Schlesewsky et al., 2003)

(a) *Gestern hat er dem Sohn den Schnuller gegeben.*
yesterday has he$_{NOM}$ [the son]$_{DAT}$ [the pacifier]$_{ACC}$ given
'Yesterday, he gave the pacifier to the son.'

(b) *Gestern hat ihn der Vater dem Sohn gegeben.*
yesterday has it$_{ACC}$ [the father]$_{NOM}$ [the son]$_{DAT}$ given
'Yesterday, the father gave it to the son.'

(c) *Gestern hat ihm der Vater den Schnuller gegeben.*
yesterday has him$_{NOM}$ [the father]$_{NOM}$ [the pacifier]$_{ACC}$ given
'Yesterday, the father gave the pacifier to him.'

While Schlesewsky et al. (2003) could replicate the scrambling negativity observed by Rösler et al. (1998) for the determiners of initial non-pronominal objects, no such effect was observable for initial pronominal objects (i.e. *ihn* and *ihm*).

In another experiment, Bornkessel et al. (2002) compared the local processing costs engendered by scrambled structures involving accusative-marked objects, as in (21), and dative-marked objects, as in (23).

(23) Word order variation in the German middlefield (dative scrambling; from Bornkessel et al., 2002)

(a) ... *dass der Jäger dem Gärtner hilft.*
... that [the hunter]$_{NOM}$ [the gardener]$_{DAT}$ helps
'... that the hunter helps the gardener.'

(b) ... *dass dem Jäger der Gärtner hilft.*
... that [the hunter]$_{DAT}$ [the gardener]$_{NOM}$ helps
'... that the gardener helps the hunter.'

Behaviorally, both the accusative-before-nominative (21b) and the dative-before-nominative (23b) orders led to higher error rates and slower reaction times than their subject-initial counterparts (21a and 23a, respectively) in a comprehension task. With regard to the ERPs recorded at the initial argument position, however, Bornkessel et al. (2002) observed that, unlike the initial accusative objects (e.g. *den Jäger*), the initial dative objects (e.g. *dem Jäger*) did not engender a scrambling negativity. Interestingly, these results seem to be at odds with the findings reported by Rösler et al. (1998) and Schlesewsky et al. (2003), who observed a scrambling negativity for initial accusatives as well as initial datives in the middlefield of German sentences which superficially seem very similar to the ones in (23b). The authors however pointed out structural differences between the employed sentences that may serve to derive the apparent discrepancy between the results. More precisely, they argued that an initial dative-marked argument in sentences such as (23b) above is compatible with a passive continuation, while initial accusatives and the initial datives employed by Rösler et al. (1998) and Schlesewsky et al. (2003) are not. A detailed account of their argumentation couched within the framework of a neurocognitive model of sentence processing will be provided in Section 3.1.4.

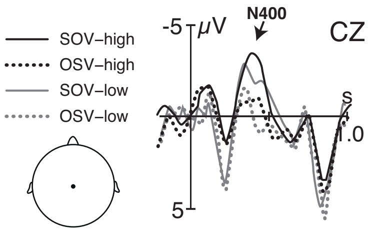

Figure 3.4: N400 effect in response to objects following initial subjects in canonical sentences in German (cf. Example 24; adapted from Bornkessel et al., 2004a); high: high-span readers; low: low-span readers.

Taken together, the findings reported in this section indicate that the scrambling negativity cannot be interpreted as a general marker of an object-first disadvantage in the German middlefield. Since this ERP effect was not observable in response to initial pronoun objects and (certain kinds of) initial dative objects in the middlefield, it seems that other properties of the scrambled objects (besides the sentence region they occur in) must be taken into account in an interpretation of the scrambling negativity.

Increased local processing costs for the canonical word order While all of the behavioral and electrophysiological results described so far unequivocally point to an increase in either global or local processing costs for *object*-initial sentences in comparison to their subject-initial counterparts, some findings seem to suggest increased local processing costs for the *canonical* subject-before-object order in comparison to its permuted counterpart. This somewhat surprising observation was first reported by Bornkessel et al. (2004a) for the processing of wh-questions like the ones in (24), which are syntactically highly comparable to the sentences employed by Fiebach et al. (2002; cf. Example 20).

(24) Word order variation with object in the German prefield (wh-question; from Bornkessel et al., 2004a)

(a) *... welcher Gärtner am Sonntag nachmittag hinter der Kirche den Jäger gesehen hat.*
... [which gardener]$_{NOM}$ on Sunday afternoon behind the church [the hunter]$_{ACC}$ seen has
'... which gardener saw the hunter behind the church on Sunday afternoon.'

(b) *... welchen Gärtner am Sonntag nachmittag hinter der Kirche der Jäger gesehen hat.*
... [which gardener]$_{ACC}$ on Sunday afternoon behind the church [the hunter]$_{NOM}$ seen has
'... which gardener the hunter saw behind the church on Sunday afternoon.'

At least for participants with a high reading span, Bornkessel et al. (2004a) replicated Fiebach et al.'s (2002) finding of a sustained left-anterior negativity following the presentation of the initial object and lasting throughout the subsequent prepositional phrases in (24b). At the position of the second argument, however, the authors observed a broadly distributed negativity between 350 and 500 ms (an N400) for (24a) vs. (24b), i.e. for the *canonical* subject-before-object order in comparison to the object-initial order (see Fig. 3.4). At first glance, this effect appears to be in conflict with the P600 effect observed at this position for object-before-subject sentences in the Fiebach et al. (2002) study. However, the authors point out that this is not necessarily the case. The ERP effect reported by Fiebach et al. (2002) was broadly distributed and occurred at 400 ms post onset of the second noun phrase (cf. Fig. 3.2). While Fiebach et al. (2002) interpreted the effect as a P600 for the object-before-subject order and attributed it to the integration of the object filler with its gap, Bornkessel et al. (2004a) argue that it could alternatively also be analyzed as an N400 for the subject-before-object order and offer a prediction-based explanation of the effect (for more details, see Section 3.1.4 below).

Both the observed data pattern regarding the scrambling negativity and the finding of increased processing costs for subject-before-object sentences in the form of an N400 are difficult to derive on the basis of the theoretical accounts encountered so far. As discussed above, the scrambling negativity cannot be accounted for in working memory terms or on the basis of frequency distributions, and it does not seem to be affected by non-syntactic contextual factors such as givenness, thus speaking against an immediate interaction of non-syntactic and syntactic factors in the generation of the component, as would be assumed by constraint-based models. The fact that the scrambling negativity only occurs in the German middlefield but not in the German prefield is similarly difficult to reconcile with filler-gap as well as working memory approaches since the mechanisms predicted by these accounts should apply to all initial objects in the same way. The finding of an N400 for the canonical word order is equally at odds with the theories described so far. Based on filler-gap theories (if they were adapted to apply also to unambiguous word order variations), increased processing costs for the *object-initial* order should arise at the respective position due to the integration of the moved object with its trace. Comparable predictions seem to arise from the SPLT/DLT, at least under the assumption of empty categories. In this case, increased integration costs would be predicted at the position of the gap, leading to increased processing costs for the object-initial structure at the position of the second noun phrase. If no empty categories are assumed, no difference would be predicted at the position of the second argument at all. In any case, increased processing costs for the *subject-initial* word order are not predicted in a memory-based account of sentence processing. Thus it seems that while the SAN effects engendered by long-distance dependencies may be well accounted for in terms of working memory and/or filler-gap mechanisms, the scrambling negativity and the N400 for canonical word orders warrant an independent interpretation. In the next Section, I will describe a recently developed model of sentence comprehension focusing specifically on word order phenomena and the diversity of ERP effects related with the processing of word order variations.

3.1.4 A neurolinguistic account of word order processing: The Extended Argument Dependency Model (eADM)

In the past decade, a number of influential neurocognitive models of sentence processing have been proposed in the literature. Unsurprisingly, the processing issues that were most controversially discussed in the psycholinguistic literature also featured prominently in the development of these neurocognitive accounts. As a result, some neurocognitive theories, like the *Neurocognitive Model of Auditory Language Comprehension* (Friederici, 1995, 2002), view sentence comprehension as a hierarchical process with a primacy of syntactic processing steps over non-syntactic processing, whereas other accounts argue that syntactic and non-syntactic information types interact immediately, e.g. the *Memory, Unification, and Control Model* (MUC; Hagoort, 2005), which can be considered a neurocognitive extension of Vosse and Kempen's (2000) constraint-based model. Others again suggest that sentence comprehension should be understood as a general cognitive process, involving mechanisms that do not differ from other domains of cognition (e.g. the *Declarative/Procedural Model*; Ullman, 2001, 2004).

While the above mentioned models offer valuable hypotheses about the processing mechanisms involved in various areas of sentence comprehension, the Extended Argument Dependency Model (eADM) developed by Bornkessel & Schlesewsky (2006a) is currently the only neurocognitive model with a specific focus on the incremental comprehension of word order variations. Furthermore, the model is primarily concerned with the *core constituents* of simple sentences, that is, the predicating verb and the sentential arguments required by it. While the processing mechanisms involved with more complex linguistic structures (like relative clauses or center embeddings) are in the focus of attention in various models of sentence comprehension, they are assumed to follow fundamentally different principles than the mechanisms involved in core constituent processing, and are therefore currently not addressed by the model. With regard to the processing of core constituents, the

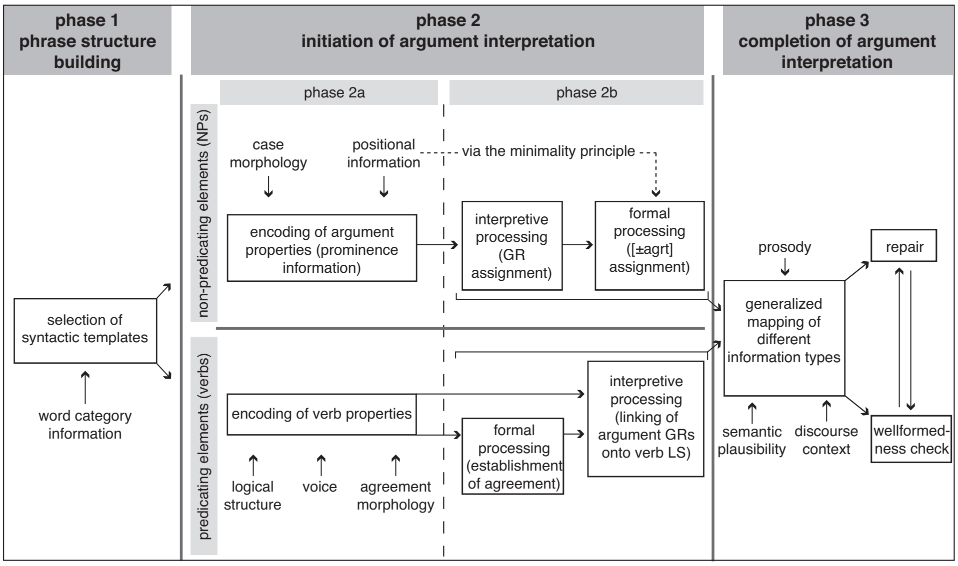

Figure 3.5: The architecture of the Extended Argument Dependency Model (adapted from Bornkessel & Schlesewsky, 2006a).

authors are particularly interested in the incremental interpretation of arguments in verb-final sentences, since free word order and verb-finality are very common among the world's languages (cf. the Introduction and Section 1.1), in fact much more common than the English-type fixed SVO order serving as a basis for most psycholinguistic theories to date. As the need to integrate sentential arguments with one another in the absence of verbal head information is thus – from a cross-linguistic perspective – the rule rather than the exception, the eADM aims at deriving cross-linguistic similarities and diversities as well as the intricate differences arising within single languages regarding the incremental processing of pre-verbal arguments. Since the eADM thus appears to be the only neurocognitive model to date that allows the derivation of concrete predictions for the processing of word order variations such as the ones in the center of this thesis, the following explanations will focus primarily on the assumptions of this approach and include references to other models when relevant.

The architecture of the eADM is laid out in Fig. 3.5. Like the Neurocognitive Model (Friederici, 2002), the eADM models sentence comprehension in three subsequent stages. Thus, as opposed to interactive accounts like the ones proposed by MacDonald et al. (1994), Trueswell et al. (1994), Vosse & Kempen (2000), or Ha-

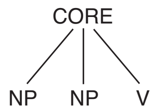

Figure 3.6: The phrase structure template selected for SOV and OSV structures in the core region of the German clause (adapted from Bornkessel & Schlesewsky, 2006a).

goort (2005), it assumes an initial processing stage which operates based on syntactic information alone.

Stage 1 The initial processing stage of the eADM is informed solely by word category information (such as *noun*, *adjective*, or *verb*) without taking other information types such as case or agreement into account. As an output, Stage 1 only provides a simple, non-hierarchical representation of the expected sentence structure by selecting a pre-stored phrase structure template that does not carry any relational information like grammatical functions (such as subject) or argument roles (such as actor). This implies that in the initial stage of processing, an object receives the same kind of analysis as a subject, both simply being encoded as noun phrases (NPs). On a sentence level, the phrase structure templates underlying subject- and object-initial sentences are therefore identical, too: Both *. . . der Jäger den Gärtner besucht* and *. . . den Jäger der Gärtner besucht* (cf. Example 21) are represented on the phrase-structural level in the form of an [NP–NP–verb] template (cf. Fig. 3.6). As you see, the templates only encode the number of arguments and the linear position of the arguments in relation to the verb. In contrast to the syntactic representations that are assumed in other modular accounts (e.g. Frazier, 1978; Friederici, 1995), the phrase structure templates in the eADM are not hierarchically structured and do not include any empty categories such as traces / gaps. As grammatical functions are not tied to specific argument base positions in these representations, word order variations do not need to be derived via movement operations on the phrase structural level (for similar assumptions in a theoretical linguistic model, see Role and Reference Grammar; Van Valin, 2005; Van Valin & LaPolla, 1997; cf. Section 1.1.1). As a consequence of this restriction of the Stage 1 output to strictly non-relational information, sentence interpretation in the sense of "who is doing what to whom" does not hinge upon the output of this first stage but on information processed in the second stage of sentence comprehension.

Stage 2 The second stage of sentence comprehension is the locus of *relational* processing and is subdivided into one pathway for non-predicates (mainly NPs) and one for predicates (mainly verbs). Furthermore, it consists of two sub-stages: Stage 2a, in which properties of the input are encoded, and Stage 2b, in which the actual relational processing takes place. Finally, Stage 2b is concerned with the computation of two types of relations: interpretive relations (i.e. answering the question of “who is doing what to whom”) and formal relations (i.e. assigning grammatical functions / agreement).

With regard to the interpretation of NPs, various types of *prominence information* are taken into consideration to determine the *generalized semantic role* (GR) of a currently processed argument, i.e. to determine whether the argument refers to the *actor* or the *undergoer* of the event being described. The GRs are in principle conceptualized as proposed in RRG, i.e. as abstractions over individual thematic roles. Furthermore, following Primus (1999), undergoers are considered to be hierarchically dependent on actors.[27] The relevant information sources for GR assignment can include, among others, positional information, morphological case marking, or animacy, and the assignment of GRs is determined by one or more of these information types, depending on the language under consideration. While interpretation is strongly guided by argument position in fixed word order languages like English, case morphology is the most salient information source in languages like German or Japanese.[28] Since in this way, argument interpretation can proceed independently from verb-based information, the interpretation of two pre-verbal arguments as in (21) results in a GR hierarchy between the two arguments, with the undergoer being hierarchically dependent on the actor.

[27]The notion of a dependency between undergoers/proto-patients and actors/proto-agents (Primus, 1999) builds upon the observation that undergoer arguments describe entities that are causally affected/experienced/possessed as part of the event being described. Since this implies the presence of a causer/experiencer/possessor, a general property of undergoers is that they are dependent on another argument (i.e. the actor). While such dependencies between actors and undergoers are not assumed in RRG, the notion is clearly incorporated in the eADM (Bornkessel & Schlesewsky, 2006a, p. 792).

[28]An example of a language in which animacy is the most salient information source in argument interpretation is provided by Fore, an Oceanic language in which both the sentences *wá yaga: aegúie* (“man pig kills”) and *yaga: wá aegúie* (“pig man kills”) can only ever mean that the man is the actor and the pig the undergoer since humans are higher on the animacy scale than animals (Scott, 1978; as cited in Bisang, 2006). In English, on the other hand, position clearly overrides animacy: Even if the sentence *The fence broke the man* does not make much sense semantically, no other interpretation is possible but that of the inanimate fence being the actor and the animate man being the undergoer. Similarly, animacy information is overridden by case morphology in German: Here, independently of the animacy information (and positional information), the interpretation solely hinges upon case marking (cf. *Den Mann zerbrach der Zaun*; “[the man]$_{ACC}$ broke [the fence]$_{NOM}$”). A psycholinguistic model with a particular focus on the interaction of different information sources (or *cues*) in language comprehension and their relative weights in different languages is the *Competition Model* (MacWhinney & Bates, 1989).

Besides the processing of interpretive relations (GRs), the second stage of argument processing also encompasses the processing of formal relations. In this regard, an agreement feature ([+agrt] or [–agrt]) is assigned to the currently processed argument, with [+agrt] meaning that the argument is the one that is expected to agree with the verb, e.g. in number or person morphology. In traditional linguistic terms, an argument holding [+agrt] is equivalent to the subject of the sentence, while arguments assigned [–agrt] are equivalent to objects.[29] The assignment of [±agrt] is based either on the previously computed GR information (if available) or on positional information (in the absence of sufficient prominence information for GR assignment; e.g. in case ambiguous sentences in German or Japanese[30]). Importantly, even though interpretive relations (GRs) and formal relations ([±agrt]) often coincide, a 1:1 correlation is usually not provided by natural languages (for a counter-example, consider passive sentences like *The fence was broken by the man*).

With regard to the interpretation of verbs, the second stage of the eADM incorporates the *linking* of the arguments encountered so far into the *logical structure* (LS) of the verb. The logical structure contains interpretive information about the type of event described by the verb, about the number of participants that the event requires, i.e. the transitivity of the described event, and about the hierarchical relationship holding between these event participants. For example, the LS of the verb *invite* describes a transitive activity event (i.e. requires two participants), resulting in the representation *do'(x,[invite'(y)])* with the hierarchically ordered participant roles *x* (the actor) and *y* (the undergoer). The linking between arguments and the verbal LS is accomplished based on the argument GRs (that is, the GR hierarchy, if more than one argument has already been encountered before the verb) and on verb properties such as the LS itself and voice (i.e. active / passive).

In languages with agreement morphology on the verb, the formal compatibility between the verb's agreement properties and the agreement features assigned to the previously processed argument(s) needs to be established as a prerequisite for the linking process. In other words, the verb needs to agree with the argument carrying [+agrt] (the subject) before interpretive processing can proceed. In languages without agreement morphology on the verb, like Japanese, this processing step is

[29] As cross-linguistic evidence shows that the notion of "subjecthood" is not universal in the world's languages, Bornkessel & Schlesewsky (2006a) preferred implementing the presumably less debatable notion of [±agrt] into the model. Since all of the languages under consideration in this thesis do have subjects, however, traditional grammatical function terms such as *subject* and *object* will be used interchangeably with [+agrt] and [–agrt], for ease of exposition.

[30] This part of the model is perceived to be primarily responsible for the emergence of the subject preference in free word order languages like German, since in the absence of GR information to the contrary, the argument in the first position will be assigned [+agrt], i.e. the subject function.

considered to be vacuously satisfied. If no arguments have been processed before the verb is encountered, the agreement establishment step is also vacuously fulfilled and predictions are in turn made for the upcoming arguments based on the LS of the verb.

Stage 3 The third processing stage in the eADM is perceived by the authors as the locus of integration between the output provided by Stage 2 and information from further domains such as semantic plausibility, discourse context, or frequency of occurrence. Recall that the late interaction with these factors does not mean to imply that such information types remain unprocessed until this point; rather they are presumably processed in parallel to the core processing steps of Stage 2 (a more detailed discussion of these parallel processes is provided in Bornkessel, 2002; Schlesewsky & Bornkessel, 2004; or Bornkessel-Schlesewsky & Schlesewsky, 2008). However, they are not assumed to modulate the processing of core relations during Stage 2 but are integrated with the Stage 2 output in the so-called *generalized mapping* step of Stage 3. A special case is constituted by prosodic information. While most prosodic information sources are assumed to be integrated with the Stage 2 output in the generalized mapping step as described above, the eADM acknowledges a potential earlier influence of intonational phrase boundary information. Based on data from German (Steinhauer, Alter, & Friederici, 1999), such prosodic boundary information is assumed to influence sentence processing as early as in the template selection processes of Stage 1. Following generalized mapping, the well-formedness of the encountered structure is evaluated and repair processes are initiated if necessary.

Besides the tripartite modular architecture of the model and the dissociation of phrase structure representation (non-hierarchical templates), interpretive relations (GRs, LS), and formal relations (agreement), the eADM is distinguished by two more characteristic properties. First, it is a truly incremental model, meaning that with every new input word and in each processing step the processing system strives to maximize interpretation regarding the entire sentence and thereby anticipate upcoming sentential input. Naturally, this implies that processing decisions need to be made even in the face of incomplete or ambiguous input information. Second, the eADM proposes a universal simplicity-based strategy guiding these processing decisions in the face of incomplete or ambiguous information.[31] This processing strategy has been termed *Minimality* by the authors and is defined it as in (25).

(25) Minimality (Bornkessel & Schlesewsky, 2006a; p. 790)
In the absence of explicit information to the contrary, the human language comprehension system assigns minimal structures. This entails that only required dependencies/relations are created.

In a similar spirit to Fodor and Inoue's meta-principle *Minimal Everything* (Fodor, 1998; Inoue & Fodor, 1995), Minimality is supposed to apply at all stages of processing and, thereby, to all levels of representation that are constructed. For present purposes, at least the following two levels and their interaction with the Minimality principle are important: the phrase structural level, which is associated with the selection of phrase structure templates in Stage 1, and the interpretive level, which is associated with the computation of interpretive relations in Stage 2 of the eADM. The application of the Minimality principle at the phrase structural level can be paraphrased as "always assume a minimal syntactic structure" (e.g. prefer phrase structure templates with one NP over those with two NPs), while its interpretive application can be expressed as "always assume a minimal event interpretation" (e.g. prefer intransitive event interpretations with only one participant over those with more participants).

The architecture of the eADM in concert with the application of the Minimality principle provides explanations for a great variety of neurophysiological and neuroanatomical effects observed in a multitude of languages and in connection with different types of syntactic violations, word order variations and local as well as global ambiguities. A comprehensive discussion of the entire evidence speaking in favor of the eADM would however go beyond the scope of this thesis (see Bornkessel & Schlesewsky, 2006a; for an overview). Here, the implementation of the eADM and the Minimality principle will be illustrated by applying them to the processing

[31] Interestingly, nearly every sentence occurring in natural languages is locally ambiguous, and often so at a number of levels at once. For instance, even an unambiguously case marked initial NP like *Der Mann...* ("[the man]$_{NOM}$..."), though not inducing a grammatical function ambiguity, is locally ambiguous on several other levels. For example, the sentence might turn out to have a one-argument phrase structure and describe an intransitive event, e.g. if it is continued with *schlief* ("slept"). Alternatively it might continue with a verb describing a transitive event and thus predicting a second argument in the phrase structure (e.g. *küsste*; "kissed"), or with a prepositional phrase modifying the first argument (e.g. *hinter der Tür*; "behind the door"), or with a much more complex continuation. Thus, local ambiguity is not restricted to perceptible cases such as grammatical function ambiguities, but also includes the (mostly unnoted) local equivocalities that occur in almost every sentence of natural languages.

of word order variations in grammatical, unambiguously case marked sentences like the ones in Examples (20) to (24).

Minimality in word order processing

In the following, the application of the two levels of Minimality will be discussed with regard to the processing of word order variations such as the ones described above. More specifically, I will explain how the application of the phrase structure level of Minimality can derive the behavior of the scrambling negativity, including its absence in response to objects in the prefield, initial pronouns, and some types of initial datives, and how the model may offer a possible way to account for the N400 effect observed in canonical subject-before-object orders on the basis of interpretive Minimality.

The scrambling negativity for initial objects in the middlefield Let us first consider the eADM's interpretation of the scrambling negativity, the ERP effect that has been observed repeatedly for initial (accusative) objects encountered in the German middlefield (e.g. Bornkessel & Schlesewsky, 2006b; Bornkessel et al., 2002, 2003; Rösler et al., 1998; Schlesewsky et al., 2003). As an example of such an initial object in the middlefield, consider the following sentence fragment (taken from Example 21 above).

(26) . . . *dass den Jäger . . .*
. . . that [the hunter]$_{ACC}$ . . .

Based on word category information (i.e. without taking into account case information), the processing mechanisms of Stage 1 identify *den Jäger* as an NP and select a minimal phrase structure template in accordance with the application of phrase structural Minimality. The most minimal possible (i.e. grammatical) phrase structure that can be assigned to the sentence at this moment is that of a one-argument subordinate clause, i.e. an [NP–V] template.[32] In Stage 2, prominence information (i.e. the case morphology of the NP) is processed for the purpose of GR assignment, and based on the accusative case marking the argument is assigned the undergoer role. With this output of the interpretive processing step in Stage 2, the following problem arises: Since the undergoer GR is hierarchically dependent on an actor GR (i.e. there cannot be an acted upon entity without another entity

[32] In the example employed here, the [NP–V] template may actually already be selected at the position of the complementizer *dass* and simply be upheld when the first NP is encountered and processed in Stage 1, as the categorical properties of the input (i.e., NP) match those required by the selected template.

responsible for the action; cf. Primus, 1999; Footnote 27), this analysis entails the assumption of an actor in the described event. As German does not allow arguments to be omitted from a sentence, the assumption of an actor in the event further implies the prediction of a second (subject) argument in the sentence structure. Therefore, the output of Stage 2 is no longer compatible with the minimal, (one-argument) phrase structure template selected in Stage 1. By contrast, a nominative case marking on the initial argument (*den Jäger*) does not engender such a problem: The nominative case marking leads to the assignment of the actor role, and (based on interpretive Minimality) an intransitive event interpretation is chosen.[33] Therefore, no second (undergoer) participant is anticipated in the event, and no second (object) argument is predicted in the phrase structure. Thus, the output of Stage 2 is compatible with the one-argument phrase structure template selected in Stage 1. In summary this means that the processing of an initial accusative-marked argument engenders a mismatch between the GR status of the argument and the previously established minimal phrase structure representation, resulting in a "violation" of Minimality at the phrase structure level. In terms of ERP measures, it is precisely this mismatch / violation that is assumed to be reflected in the scrambling negativity.

The absence of the scrambling negativity for objects in the prefield The fact that the scrambling negativity occurs only in response to initial objects in the German middlefield but not in the German prefield is explained in the eADM via the special structural position of elements in the German prefield. As previously mentioned in Section 1.1, the prefield can hold any type of constituent, including adverbs, verbs, and subject as well as object NPs, without necessarily resulting in a marked word order. In terms of the eADM, and in the terminology of RRG (Van Valin, 2005; Van Valin & LaPolla, 1997), NPs in the German prefield occupy a so called precore position (or "precore slot") which is associated with a specific type of phrase structure template (cf. Diedrichsen, 2008). More specifically, while an argument encountered in the middlefield leads to the selection of the most minimal available *core* template ([NP–V]; cf. Fig. 3.7A), elements encountered in the prefield are assumed to select only a [PreCore–Core] template for the clause (cf. Fig. 3.7B). If the initial element is a subject or an object, the PreCore part will be further specified as an NP based on the word category information. The Core part of the template will be further specified as soon as elements belonging to the core are

[33] Note that the assignment of a transitive event in the accusative-marked NP does not posit a violation of interpretive Minimality, since it is itself the most minimal possible analysis for this kind of input. Recall in this regard that Minimality can be considered as a kind of ambiguity resolution mechanism that only applies if there is no "explicit information to the contrary"; cf. Definition (25).

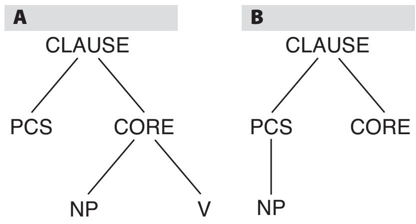

Figure 3.7: The phrase structure templates selected for arguments encountered in the core (middlefield; A) and the precore position (prefield; B) of the German clause (adapted from Diedrichsen, 2008).

encountered (e.g. [V] or [NP–V]). Phase 2 processing of an object in the prefield generates the same output as for an object in the middlefield, i.e. a transitive event and the prediction of a second (subject) argument. Crucially, this output is still compatible with the previously selected [PreCore–Core] phrase structure template. Thus, no violation of phrase structure Minimality arises from the Stage 2 output, and as a consequence, no scrambling negativity is engendered. Based on the phrase structural assumptions just described, the eADM thus correctly predicts the absence of the scrambling negativity for objects encountered in the German prefield.

Regarding the SAN effects observed in response to objects in the German prefield, the model's assumptions do not appear to be incompatible with an interpretation of these effects in terms of increased working memory load. Thus, while no Minimality violation arises from the processing of objects in the German prefield, memory processes (e.g. for maintaining the prediction of an upcoming subject; cf.Gibson, 1998, 2000) may still apply.[34] This also implies that the scrambling negativity and the SAN are not necessarily mutually exclusive. More precisely, since the scrambling negativity is assumed to be tied to the processing of core templates and core relations in the middlefield, this effect is not expected to occur along with anterior negativities in response to objects in the German prefield. On the other hand, the fact that SAN effects are rarely found along with the scrambling negativity for objects in the German middlefield can most likely be attributed to the length of the employed stimulus materials. In studies examining the scrambling negativity, the employed sentences were usually short, with noun phrases only consisting of the head noun and a determiner, and with the subject immediately following the object without any intervening sentence material (cf. Example 21). By contrast, experiments examining the SAN deliberately increased the amount of intervening sentence

[34]Recall, however, that while the assumption of an increase in working memory load can successfully explain the observed SAN effects, it does not suffice to derive the overall pattern of ERP effects on the processing of word order permutations as it cannot explain the restrictions on the occurrence of the scrambling negativity.

material to produce a sufficient increase in working memory load (cf. Example 20). Thus, it should in principle be possible to observe a SAN effect indicative of increased working memory load in addition to a scrambling negativity for scrambled sentences in the German middlefield, provided that a sufficient amount of intervening sentence material (e.g. a number of prepositional phrases) occurs between the scrambled object and the subsequent subject. Supporting evidence for this assumption stems from the observation that the SAN in the German prefield also tends to disappear in the absence of sufficiently long intervening material (e.g. Fiebach et al., 2002; see above) and from other instances of sustained ERP effects which were similarly observed in the German middlefield and prefield (i.e. sustained positivities in ambiguous sentences; Bornkessel et al., 2004a; Bornkessel, Fiebach, Friederici, & Schlesewsky, 2004b). Furthermore, similar views have also been formulated on the basis of ERP results on the processing of Japanese (Ueno & Kluender, 2003; see Section 4.2).

The absence of the scrambling negativity in initial pronouns As demonstrated by Schlesewsky et al. (2003), the scrambling negativity also does not occur in response to initial pronouns as in (27) below.

(27) *Gestern hat ihn ...*
yesterday has [him/it]$_{ACC}$ ...

While the absence of the scrambling negativity in the pronoun data reported by Schlesewsky et al. (2003) is not directly discussed in Bornkessel & Schlesewsky's (2006a) elaboration of the eADM, an account along the same lines as the one just described for objects in the prefield might offer a possible solution. Schlesewsky et al. (2003) argue that in theoretical linguistic approaches, initial pronouns are often considered to inhabit a special position in the German sentence, the so-called *Wackernagel Position* which is presumably located at the left border of the German middlefield (cf. Lenerz, 1977, 1993; Wöllstein-Leisten, Heilmann, Stepan, & Vikner, 1997). This special structural position is one possible explanation for the fact that word orders in which the pronominal object precedes a full NP subject, are considered to be canonical in languages like German, both on theoretical linguistic grounds (e.g. Lenerz, 1977, 1993; Müller, 1995; Wöllstein-Leisten et al., 1997), and as expressed in acceptability judgements (e.g. Keller, 2000a). If one assumes an underlying representation of initial pronouns along these lines, then the Wackernagel Position may be conceived as an additional non-core position in terms of the eADM (possibly located somewhere between the precore slot and the core). In this case, the phrase structural representation of an initial pronominal object would again be compatible with the output of Stage 2 processing, thus not engendering a violation of phrase structural Minimality. Consequently, no scrambling negativity for initial object pronouns would be expected under such an assumption.

The absence of the scrambling negativity for initial datives As described earlier, even the processing of initial objects that are clearly located in the German middlefield does not always engender a scrambling negativity. For example, it has been demonstrated by Bornkessel et al. (2002) that initial objects in the middlefield that bear the dative case as in (28) below (taken from Example 23) do not yield analogous ERP effects to accusative-marked objects as in (26).

(28) ... *dass dem Jäger ...*
... that [the hunter]$_{DAT}$ ...

According to the eADM, the processing difference between (26) and (28) can be attributed to the application of Minimality at the phrase structure level, as becomes apparent when the differences between accusative and dative case are considered more closely. While an initial argument bearing accusative case in German unambiguously signals that a second, nominative, argument must also occur at a later point in the sentence (see above), this need not necessarily be the case for an initial dative argument. This is illustrated by the grammatical sentence example in (29).

(29) ... *dass dem Jäger geholfen wurde.*
... that [the hunter]$_{DAT}$ helped was.
'... that the hunter was helped.'

As (29) shows, an initial dative is compatible with a minimal (one-argument) phrase structure, namely in case of a passive continuation. Thus, while the processing of an initial accusative engenders a mismatch with the originally selected one-argument phrase structure template as described above, an initial dative can be analyzed as the only argument in a passive sentence and thus does not engender a violation of phrase structural Minimality. As a consequence, no scrambling negativity arises.

This line of argumentation would also predict that when an initial dative is *not* compatible with a one-argument structure, the processing difference between datives and accusatives should no longer be observable. Interestingly, this prediction is indeed born out in the observations made by Rösler et al. (1998) and Schlesewsky et al. (2003), who investigated the processing of initial objects in the German middlefield in constructions like (30) below and observed a scrambling negativity both for initial accusatives and initial datives, as described earlier.

(30) *Gestern hat dem Jäger ...*
yesterday has [the hunter]$_{DAT}$ ...

Crucially, here a passive reading of the sentence is ruled out by the previously processed auxiliary *hat*, which is only compatible with an active reading. Therefore, datives encountered in such a sentential context, just like accusatives, signal the occurrence of a second (nominative) argument and thus engender a violation of phrase structural Minimality and, consequently, a scrambling negativity (Rösler et al., 1998; Schlesewsky et al., 2003).

The N400 in canonical word orders Let us now turn to the N400 effect observed at the position of the second argument of German subject-before-object sentences (Bornkessel et al., 2004a; cf. Example 24, or the sentence fragment below).

(31) *... welcher Jäger ... den Gärtner ...*
... [which hunter]$_{NOM}$ ... [the gardener]$_{ACC}$ ...

To account for this finding, Bornkessel et al. (2004a) pointed out that an initial accusative-marked argument in German leads to the prediction of a second (subject) argument occurring at a later point in the sentence. An initial nominative-marked argument, on the other hand, leads to no such prediction. When the second argument is encountered, it is therefore already anticipated if it follows an object, while it constitutes an unpredicted element if it follows a subject. Based on the well-known association between variations in the N400 component and the degree of an element's predictability (cf. Kutas & Federmeier, 2000), the authors concluded that the N400 at the position of the second NP reflects the relatively lower predictability of this argument in the subject-initial sentences. Clearly, this line of argumentation is highly compatible with an explanation based on the phrase structure level of Minimality in the eADM. Thus, object-initial orders might have a processing advantage at the position of the second NP from a phrase structural perspective, because a two-argument phrase structure template is already activated at this position in the object-initial sentences, while a switch from a one-argument template to a two-argument template is required in the subject-initial sentences.

Based on the specific assumptions elaborated in the previous sections, however, there is a serious caveat to such an explanation. Crucially, due the assumed phrase structural particularity of the German prefield (activating a [PreCore–Core] template), such an explanation should actually only hold for word order variations in the German middlefield. In the prefield, as described above, no phrase structural revision would ensue in response to an initial object (explaining the absence of the scrambling negativity). As a consequence, no phrase structure-based processing advantage can be expected at the position of the second NP following an object in the prefield. As the N400 effect reported by Bornkessel et al. (2002) has nonetheless been observed in exactly such a context (i.e. at the position of an object following a wh-subject in the prefield), a phrase-structural explanation seems to be ruled out. Therefore, an explanation of the effect along the lines of interpretive Minimality may be more appropriate.

Based on the application of interpretive Minimality, the effect can be derived as follows. As described above, an initial nominative argument is identified as an actor in Stage 2 of processing, and is thereby compatible with both an intransitive interpretation (i.e. as the only participant in the event) and with a (di-)transitive interpretation (i.e. as the highest-ranking participant in an event with two or more participants). On the basis of interpretive Minimality, the simpler, intransitive, reading is preferred. By contrast, an initial accusative is always interpreted as an undergoer. Due to the assumed dependency of an undergoer on an actor (cf. Footnote 27) an initial accusative therefore always indicates that the event described by the sentence is at least transitive. Thus, when the second argument is encountered, signaling that a second participant is involved in the event, a revision from an intransitive to a transitive event interpretation is required in the subject-initial condition, but not in the object-initial condition. In other words, interpretive Minimality is violated in the subject-initial condition, as the previously computed minimal event interpretation cannot be upheld when the second argument is encountered. It is a conceivable assumption that the N400 observed at this position reflects exactly this violation.

Under the assumption of an interpretive explanation of the N400 (which is applicable to both the middlefield and the prefield), the legitimate question arises why the N400 effect has not been observed more frequently. As speculated by Bornkessel et al. (2004a; see above), in some cases the N400 effect may have been misinterpreted as (or confounded with) positivity effects for the non-canonical object-before-subject condition (e.g. Fiebach et al., 2002, cf. Fig. 3.2; this might also be the case in the study conducted by Bornkessel et al., 2002, who reported a posterior positivity between 300 and 400 ms following the second argument in scrambled sentences, but unfortunately only presented second NP results for dative sentences). In other cases, the transitivity of the event was already evident before the second argument was encountered (e.g. Matzke et al., 2002), or the experimental material did not include subject-initial sentences at all (e.g. Felser et al., 2003). Finally, there are also studies that simply did not address this specific contrast at the second NP position because their hypotheses focused on other comparisons (e.g. Rösler et al., 1998; Schlesewsky et al., 2003). In conclusion, if attention was directed towards the relevant contrasts (as will be the case in the experiments reported here), the N400 effect for subject-initial word orders should be due to be observed more often.

To summarize, the data from German provide initial evidence for a Minimality-based account of word order processing involving different levels of representation. In particular, the scrambling negativity has been discussed as a correlate of the violation of phrase structural Minimality (due to a mismatch between the output of Stage 2 and the previously selected minimal phrase structure representation), while the N400 for canonical sentences has been derived from a violation of interpretive Minimality (due to the necessary revision from a minimal transitive to an intransitive event interpretation). While such an account appears highly compatible with the data pattern observed in German, it is at the same time heavily dependent on the distinction between the prefield and the middlefield region of the German clause. Since the Minimality principle is supposed to apply cross-linguistically, it is therefore of crucial importance to test the predictions derived from phrase structural and interpretive Minimality in a language in which the two levels can be dissociated more systematically. The next chapter (see Section 4.2) will show that Japanese appears to constitute an ideal test case in this regard.

Before addressing this topic, however, Section 3.2 will provide an outline of the available literature on the processing of pro-drop phenomena. The processing of pro-drop sentences is an intriguing issue in the light of the data discussed so far, because these data (especially with regard to the scrambling negativity) have provided convincing evidence that the processing of word order variations crucially depends on the elements that can be expected to occur in the remainder of the sentence. In this regard, one important factor influencing object-initiality costs in any given language should be the language's requirements regarding the overt realization of arguments in the sentence structure, since these requirements crucially determine the possible and necessary expectations regarding upcoming sentence elements. In other words, it is highly relevant whether the language under consideration allows pro-drop sentences or not. If pro-drop sentences are permitted in a language (as is the case in Japanese), this property thus on the one hand should affect the processing of word order variations, and on the other hand raises questions about how the pro-drop sentences themselves are comprehended. These questions will be addressed in the next section.

3.2 Pro-drop

In comparison to the extensive corpus of research conducted on word order related processing effects, the phenomenon of pro-drop has received relatively little attention in the psycho- and neurolinguistic processing literature. At least two important questions arise in this regard. First, as indicated above, how does the availability of pro-drop in a language influence processing mechanisms operating in complete sentences, e.g. regarding the processing of word order variations? This question will be in the focus of Experiments 1 and 2 of this thesis, which will examine the influence of the availability of pro-drop (especially subject-drop) on the processing of word order variations in Japanese (see Section 4.2). Crucially, the availability of pro-drop is precisely the property of Japanese that allows the systematic distinction of the two levels of Minimality described in the preceding sections.

Second, how does the processing system arrive at a complete sentence interpretation in the sense of "who is doing what to whom" if important information is omitted from the sentence under consideration? To the best of my knowledge, the processing of argument omission per se, i.e. in comparison to "complete" canonical sentences, has not been investigated so far, neither in Japanese, nor in any other language.[35] A few theoretical approaches to sentence processing, however, might allow the derivation of predictions regarding this comparison, and ERP results from the area of discourse processing can offer some initial clues as to which neurophysiological effects may be expected in this context. Furthermore, a number of behavioral and neurophysiological studies compared different kinds of pro-drop sentences with each other, thereby shedding some light on the issue of possible differences between the processing of subject-drop and object-drop sentences.

[35] In a recent ERP experiment on Turkish (Demiral, Schlesewsky, & Bornkessel-Schlesewsky, 2009), a language allowing subject-drop, transitive sentences with an overt first person pronoun ("I") as a subject were compared with sentences in which this pronoun was omitted. In any case, the pronoun was fully recoverable from the agreement information on the sentence-final verb. At least under certain circumstances (i.e. if the object was inanimate), the sentences with an overt pronoun led to an N400 effect as well as a P600 effect at the position of the verb in comparison to the pro-drop conditions. However, these results are not directly related to the question under consideration here, namely how the processing system accomplishes the interpretation of a sentence in which referential information is missing. Since the omitted subject referent in the Turkish sentences was fully encoded in the verb morphology, the increased processing costs observed in this study rather seemed to result from the redundancy of the overt pronouns.

3.2.1 Theoretical predictions for the processing of pro-drop sentences

To date, the question of how the processing of a pro-drop sentence might differ from the processing of a complete sentence with full lexical NPs has not been in the focus of theories of incremental sentence processing. While some accounts do not address pro-drop phenomena at all (e.g. Gibson, 1998, 2000; MacDonald et al., 1994; Vosse & Kempen, 2000), others appear to offer diverging assumptions regarding the processing of sentences with omitted arguments. Consider the comparison of transitive sentences in which either both NPs are fully lexicalized or the subject NP is omitted. For example, filler-gap based accounts like the MCP (De Vincenzi, 1991) expect the processing system to posit a pro as soon as it becomes clear that an argument has been omitted from its base position (and, in the case of an ambiguous gap, prefer this analysis over a more complex alternative involving movement and the postulation of a trace). According to the MCP a pro has the same singleton chain status as a full lexical NP, and just like a full NP it immediately receives a case feature and a thematic role (based on its position). Therefore, no additional costs seem to be predicted by the MCP for processing a sentence with an omitted argument in comparison to a sentence with full lexical NPs. It is important to keep in mind, however, that the MCP (like the AFS) is a processing strategy that is supposed to operate in the first stage of a modular parsing mechanism like the one suggested in the Garden Path Theory (Frazier, 1978; Frazier & Fodor, 1978; Frazier & Rayner, 1982). Since the first processing stage in such models is dedicated to purely syntactic analysis steps, principles such as the MCP are not designed to address possible non-syntactic processing issues that may arise in pro-drop sentences. Thus, while on a syntactic level, the MCP does not predict any processing differences between complete and pro-drop sentences, differences arising from non-syntactic processing aspects are per se not irreconcilable with the model.

Interestingly, the eADM (Bornkessel & Schlesewsky, 2006a), as a model that does not assume empty categories, makes quite different predictions regarding the syntactic (i.e. phrase structural) processing of pro-drop sentences. For example, a transitive sentence with an omitted subject is *not* assigned the same phrase structural representation as a transitive sentence with two full NPs: Based on word category information, the latter sentence type is represented as [NP–NP–V], while the former would receive the simpler (more minimal) representation [NP–V]. On an interpretive level, however, both sentence types would describe transitive events requiring an actor and an undergoer. Thus, they may not differ regarding the relational processing steps in Stage 2 of the eADM (at least in some respects, like

GR assignment). However, since in an (active) subject-drop sentence the *referent* of the actor is not explicitly specified in the sentence itself, it needs to be inferred for a complete understanding of the sentence, either from the preceding linguistic or non-linguistic context or from agreement information on the verb. As a consequence of the additional inference effort, increased processing costs for the processing of a subject-drop sentence could be expected at some point. The position in the sentence at which this inference process takes place should be determined by the language under consideration, crucially depending on when it becomes evident that the respective referent has not been and will not be overtly mentioned in the sentence (e.g. the verb in Japanese). In this case, similar costs would further be predicted for object-drop sentences in which the omitted undergoer referent needs to be inferred. Since the eADM in its current version does not address such referential inference processes, it remains open whether they should be considered as non-core processes like the processing of contextual or plausibility information, or whether they could in some way be integrated with the relational processing steps of the model. In the first case, the referential inference would possibly influence sentence interpretation in Stage 3 of the model in which all syntactic and non-syntactic information types are integrated. In the second case, the referential inference would be subsumed as a Stage 2 process, for example in connection with the interpretive linking step associated with the processing of verbs. Interestingly, the two alternatives are associated with distinct ERP signatures: While processing difficulties arising in Stage 3 of the model are typically associated with late positivities, difficulties arising during the linking process of Stage 2 typically engender earlier negativities (for example an N400, if the actor role needs to be assigned by the verb to a syntactically less prominent argument; see Bornkessel & Schlesewsky, 2006a).

3.2.2 Previous ERP correlates of referential processing

Given the current state of research, one can at best speculate about ERP components that may be associated with the increased referential processing effort that is possibly associated with the processing of pro-drop sentences. In this regard, at least two separate aspects of processing can be isolated. First, the establishment of a new referent in the event representation which is necessary once it becomes clear that not all referents of the described event are explicitly mentioned in the sentence. Second, the processing of possible referential ambiguity at this position. While the first aspect should apply to all pro-drop sentences in comparison to complete sentences, the second aspect only becomes relevant if the omitted referent cannot be unambiguously inferred, e.g. if several antecedents compete with each other for reference and there is a lack of sufficient agreement information to decide between them.

Regarding the establishment of a new referent, some data from German appear to allow an initial prognosis regarding an associated ERP component. For example, Burkhardt (2006) examined sentence pairs consisting of a context sentence (32a, b, or c) and a target sentence (32d). The target word, an NP of the second sentence (e.g. *der Dirigent*, "the conductor") was either identical with an NP in the preceding context (32a), semantically related to an NP in the preceding context (32b), or unrelated to the preceding context (32c). Crucially, following contexts (32b) and (32c), the target NP required the establishment of a new entity in the discourse representation, while following (32a) the target NP can be linked to an entity already given in the current discourse.

(32) Example sentences from Burkhardt (2006)

(a) *Tobias besuchte einen Dirigenten in Berlin.*
'Tobias visited a conductor in Berlin.'

(b) *Tobias besuchte ein Konzert in Berlin.*
'Tobias visited a concert in Berlin.'

(c) *Tobias unterhielt sich mit Nina.*
'Tobias talked to Nina.'

(d)

Er	*erzählte,*	*dass*	*der*	*Dirigent*	*sehr*	*beeindruckend*	*war.*
he	said	that	the	conductor	very	impressive	was

'He said that the conductor was very impressive.'

In a comparison of the ERPs elicited at the position of the target NP, Burkhardt (2006) observed two effects: One was an N400 effect that varied as a function of semantic relatedness between the target word and the context ($a < b < c$). The other was a P600 effect following both the related context (b) and the unrelated context (c) in comparison to the identical context. Since the strength of the effect did not differ further between the two non-identical conditions, the author attributed the P600 to the establishment of a new discourse referent that was required in both conditions in the same way. The interpretation of the observed positivity effect as a correlate of referent establishment is further supported by a follow-up experiment (Burkhardt, 2007a) in which the definiteness marking of the target NP was additionally manipulated (e.g. *der Dirigent*, "the conductor", vs. *ein Dirigent*, "a conductor"). Crucially, an indefinite marker strongly signals the introduction of a new entity into the discourse. While the N400 effect varied independently of the definiteness marking just as in the previously described experiment, all indefinite marked target NPs elicited the same P600 effect as the definite target NPs that followed contexts (b) and (c). A similar biphasic pattern of a reduced N400 followed by a reduced P600 for repeated words was already reported much earlier by Van Petten et al. (1991) who investigated word repetition effects within English texts and attributed the observed P600 effects to processes of discourse model updating. Another instance of a positivity effect in connection with discourse processing in English was reported by Kaan & Swaab (2003) at the position of a verb following the introduction of two vs. one discourse referent(s). In this case, the positivity was, as opposed to the "classic" P600 effect, rather frontally distributed.

Neurocognitive evidence regarding the processing of referential ambiguity stems from a number of experiments on pronoun (and full anaphoric NP) processing conducted by van Berkum and colleagues. For example, Van Berkum, Zwitserlood, Bastiaansen, Brown, & Hagoort (2004) demonstrated that referentially ambiguous pronouns elicited a sustained anterior negativity in comparison to referentially unambiguous pronouns (e.g. in *David noticed John when he ...* vs. *David noticed Linda when he ...*). The strength of this effect has been shown to decrease when the first clause was strongly biased towards one of the referential alternatives (e.g. *David hated John because he ...*; Nieuwland & Van Berkum, 2006). Regarding the processing of pro-drop sentences, one might expect a similar effect when comparing ERPs at the verb position of sentences that are unequivocally disambiguated towards one referent alternative (e.g. by verb agreement information) with sentences that remain ambiguous (e.g. if several antecedents match the agreement properties of the verb).

Besides the described findings for the processing of referential ambiguity, van Berkum and colleagues also provide some ERP data on the processing of referential failure that may be of interest for the processing of pro-drop sentences. More precisely, Van Berkum et al. (2004) presented sentences in which no appropriate antecedent for a given pronoun was provided (e.g. *Anna noticed Linda when he ...*). In comparison to referentially unambiguous pronouns (see above), these referentially "failing" pronouns elicited a P600 effect (see also Nieuwland & Van Berkum, 2006; Osterhout & Mobley, 1995). While this effect was generally ascribed to a syntactic mismatch between the pronoun and the given antecedents, the authors acknowledge that these sentences do not actually include a syntactic violation since the pronoun might alternatively refer to a third, unmentioned, entity. A post-experimental debriefing of the participants of an fMRI experiment that employed similar sentences (Nieuwland, Petersson, & Van Berkum, 2007) revealed that part of the participants (in that case, about one third) in fact established a sentence-external referent for the pronoun instead of interpreting it as a syntactically incorrect pronoun referring to one of the given referents. Consequently, such a referent establishment process might also be at least partially responsible for the P600 effect observed in the ERP studies described above. However, since no data regarding the participants' interpretive tendencies are available for the ERP experiments, it is impossible to conclude whether the P600 effect observed in these experiments is due to a perceived syntactic violation (as suggested by the authors), or to the establishment of a new sentence-external referent, or a combination of both.

In any case, it is important to keep in mind that none of the experiments described above actually employed pro-drop sentences. Thus, while processes of referent establishment are likely necessary in pro-drop sentences, the inference of a referent from outside of the sentence may well produce a distinct ERP effect from the establishment of a new referent at a position when the lexical information about this referent is provided. Similarly, even if pro-drop sentences may constitute cases of referential ambiguity, it remains to be seen whether the processing of a referentially ambiguous *overt* pronoun and the encounter of a word signaling the *omission* of a referentially ambiguous argument elicit a comparable ERP component. Finally, while both a pronoun lacking a matching antecedent and a word (e.g. a sentence-final verb) signaling the omission of an NP may require the establishment of a new sentence-external referent, the underlying processes might differ depending on whether the referent is required for the interpretation of a pronoun or for the interpretation of the complete event, thus possibly resulting in differential ERP signatures.

3.2.3 Processing differences between subject-drop and object-drop

While no previous findings are available regarding a direct comparison of pro-drop and complete sentences, some studies on Japanese sentence processing may allow preliminary conclusions regarding potential processing differences between subject-drop and object-drop sentences. These studies compared Japanese subject and object relative clauses (SRCs and ORCs, respectively), which have a similar structure to Japanese subject-drop and object-drop sentences up to and including the verb of the relative clause. This is due to the fact that relative clauses in Japanese are not marked as such (e.g. by an overt relativizer or a specific verb form) and precede the modified noun phrase instead of following it, as is the case in English or German. As a result, an SRC begins, just like a subject-drop sentence, with an O–V (object–verb) structure, and an ORC begins, just like an object-drop sentence, with an S–V (subject–verb) structure. Therefore, processing differences observed up to the position of the relative clause verb need not necessarily reflect the processing difference between SRCs and ORCs, but could alternatively reflect the processing difference between subject-drop and object-drop sentences.

For instance, Ishizuka, Nakatani, & Gibson (2003) examined SRCs and ORCs like the ones in (33). As noted above, up to and including the position of the relative clause verb, the SRC in (33a) and the ORC in (33b) are indistinguishable from subject-drop (34a) and object-drop (34b) main clauses in Japanese.

(33) Subject and object relative clauses in Japanese (from Ishizuka et al., 2003)

(a)

Kuruma-o	*tuisekisita*	*ootobai-ni-wa*	*[...]*	*kookoosei-ga*	*notteita.*
car-ACC	chased	motorbike-DAT-TOP	[...]	student-NOM	rode

'A student rode the motorbike that chased the car.'

(b)

Kuruma-ga	*tuisekisita*	*ootobai-ni-wa*	*[...]*	*kookoosei-ga*	*notteita.*
car-NOM	chased	motorbike-DAT-TOP	[...]	student-NOM	rode

'A student rode the motorbike that the car chased.'

(34) Subject-drop and object-drop main clauses in Japanese (adapted from Ishizuka et al., 2003)

(a)

Kuruma-o	*tuisekisita.*
car-ACC	chased

'[I/you/he/she/it/we/they/. . .] chased the car.'

(b)

Kuruma-ga	*tuisekisita.*
car-NOM	chased

'The car chased [me/you/him/her/it/us/them/. . .].'

In three self-paced reading experiments, Ishizuka et al. (2003) observed no difference between SRCs and ORCs before the position of the modified NP that disambiguated the sentences towards a relative clause reading (i.e. *ootobai-ni-wa* in the examples above). While it is not clear whether the participants originally adopted a subject/object-drop main clause reading or a relative clause reading of the initial NP–V segment, the absence of a reading time difference in this segment at least potentially reflects similar processing costs for subject-drop and object-drop sentences in Japanese. Based on a similar line of reasoning, Miyamoto & Nakamura (2003), who also examined Japanese SRCs and ORCs in two self-paced reading experiments, deliberately excluded any results preceding the modified NP position from presentation due to being "uninformative", since they expected a likely misinterpretation of the initial NP–V segments as subject/object-drop main clauses. It is however not entirely clear whether the authors did not observe any reading time differences in this region or whether they merely chose not to report them.

The only account of a reading time difference between S–V and O–V sentence segments is provided by Ueno & Garnsey (2008). These authors also examined SRC and ORC structures and observed slightly longer reading times at the position of the relative clause verb in O–V (subject-drop/SRC) sentences than in S–V (object-drop/ORC) sentences. The effect, however, only reached significance in the analysis by items, and the authors suggested that it might be a delayed effect stemming from the preceding noun phrase. Furthermore, a significant effect in the same direction was also evident at the first word of the sentences, an adjective which was completely identical between the two conditions, which points to the possibility that the effect at the verb position may also be attributable to noise in the data. Thus, especially since none of the three separate experiments conducted by Ishizuka et al. (2003) (and possibly neither of the two experiments conducted by Miyamoto & Nakamura, 2003) yielded any reading time differences at this position, the reading time difference observed by Ueno & Garnsey (2008) does not seem to be readily interpretable in terms of an actual processing difference between S–V and O–V sentence segments.

Following the self-paced reading experiment, Ueno & Garnsey (2008) also conducted an ERP experiment employing the same stimulus material. As opposed to the reading times reported above, the ERPs averaged at the position of the relative clause verb suggested increased processing costs for the sentences beginning with an S–V sentence fragment as opposed to an O–V fragment. The increase in processing cost was indicated by a negativity between 300 and 600 ms post verb onset that was only significant at the midline electrodes (this analysis included the Fz,Cz, and Pz electrode), and was modified by an interaction with ROI (a factor comprising each of the three electrodes as a single level). While no resolution of the interaction was reported, a provided isovoltage map and the authors' interpretation suggest that the effect stemmed from the Fz electrode alone. While this ERP effect might be attributed to a processing difference arising from an initial subject-drop vs. object-drop main clause reading of the (Adjective–)NP–V segment, the authors offer a number of explanations as to why the observed effect rather reflects differences associated with the processing of subject vs. object relative clauses. For one, the authors point out that a relative clause analysis was strongly supported by the experimental context, in which all sentences had the same length and none of the included filler sentences were actual pro-drop sentences. Furthermore, they rule out an interpretation of the S–V and O–V sentence segments as mono-clausal sentences since they presented a Japanese period sign at the end of each sentence. As a result, the lack of this sign after the first verb signaled that the sentence was not finished yet and thus, that the NP–V segment encountered so far most likely belonged to a relative clause. To conclude, the negativity at the Fz electrode does not seem straightforwardly attributable to a processing difference between subject-drop and object-drop sentences.

To summarize, the available findings on the processing of Japanese SRCs and ORCs do not allow straightforward conclusions regarding whether subject-drop and object-drop sentences are processed differently, and if so, which of the two structures would engender more processing costs. Taken together, however, at least the behavioral data seem to suggest that S–V and O–V structures may be processed quite similarly.

Taken together, increased processing costs may be expected when the referent of an omitted argument needs to be inferred from outside of the sentence. Previous studies on referential establishment, referential ambiguity, and referential failure in sentence processing have shown positivity effects as well as negativity effects in event-related potentials. Since these studies however only examined other sentence structures (sentences with full NPs or pronouns) in non-pro-drop languages like German and Dutch, the open question remains which ERP components are associated with the specific inferential processes required for the comprehension of a pro-drop sentence. As will be demonstrated in the next chapter (Section 4.3), Japanese offers an interesting opportunity to shed further light on this issue.

Chapter 4

Japanese as a test case

As mentioned in Chapter 3, Japanese appears to be a language providing a very interesting test case regarding the processing of word order variations and pro-drop. In the following, I will first give a short overview of the properties of the Japanese language that are relevant in this regard (Section 4.1), before discussing how Japanese may serve to shed further light on the mechanisms involved in the processing of word order variations (Section 4.2) and pro-drop sentences (Section 4.3).

4.1 Relevant properties of the Japanese language

Crucially for present purposes, Japanese shares a number of important properties with German:

(a) The arguments precede the verb (even more consistently than in German), with a basic SOV order.

(b) There is overt morphological case marking, with distinct case markers for nominatives (*-ga*), accusatives (*-o*), and datives (*-ni*). (In contrast to German, the case markers strictly follow the nouns instead of preceding them.)

(c) Argument order is flexible such that an object can precede the subject within a clause; i.e. scrambling is allowed. (In contrast to German, scrambling is also allowed across clause boundaries in Japanese. The focus of this thesis, however, lies exclusively on clause-internal cases of scrambling; cf. Footnote 4.)

These properties of Japanese are illustrated in (35) below, which is a slight alteration of Example 1 from Section 1.1.

(35) Scrambling in Japanese

(a)

Nishuukanmae	*hanji-ga*	*daijin-o*	*maneita.*
two weeks ago	judge-NOM	minister-ACC	invited

'Two weeks ago, the judge invited the minister.'

(b)

Nishuukanmae	*hanji-o*	*daijin-ga*	*maneita.*
two weeks ago	judge-ACC	minister-NOM	invited

'Two weeks ago, the minister invited the judge.'

Furthermore, as Japanese lacks a prefield position, it appears justifiable to assume that an object-before-subject order within a single clause (i.e. "local", clause-internal, scrambling; cf. Footnote 4) should be comparable to object-initial orders in the German middlefield rather than the German prefield, since here, too, the arguments are situated in the same local domain.

Crucially, however, Japanese differs from German in that it allows arguments to be omitted (i.e. pro-drop). In particular, subject omission is extremely frequent, occurring in over 70% of all sentences (Martin, 2003). Furthermore, in a corpus study of (written) Japanese sentences with initial accusative-marked arguments, Miyamoto & Nakamura (2003) found that only 2% of the 4621 sentences examined contained an overt subject in a later position. While objects can be omitted as well (see Huang, 1984), object-drop occurs about ten times less often than subject-drop (Ueno & Polinsky, submitted). The pro-drop property of Japanese is demonstrated in (36) below, with (36a) showing an instance of object-drop and (36b) illustrating the more frequent case of subject-drop.

(36) Pro-drop in Japanese

(a)

Nishuukanmae	*hanji-ga*	*maneita.*
two weeks ago	judge-NOM	invited

'Two weeks ago, the judge invited [ ].'

(b)

Nishuukanmae	*hanji-o*	*maneita.*
two weeks ago	judge-ACC	invited

'Two weeks ago, [ ] invited the judge.'

When considering Japanese as a pro-drop language, at least one further property of the language is worth emphasizing. As already mentioned earlier (Sections 1.2 and 3.2), Japanese does not feature any morphological agreement marking on the verb. In other words, the verb form does not provide any person or number information regarding the subject. As a consequence, an omitted subject such as the one in (36b) is fully referentially ambiguous and can per se refer to any kind of discourse referent, including the speaker, the hearer, a third person, or a group of people. While the omitted referent is typically inferred from the linguistic or non-linguistic context (cf. Section 1.2), there is no morphological information *within* the sentence clearly disambiguating it towards a certain referent. Similarly, cases of object-drop such as in (36a) lead to a comparable amount of referential ambiguity regarding the omitted object referent. In this regard, Japanese differs from other pro-drop languages like Italian or Turkish, in which the agreement information on the verb allows a certain degree of sentence-internal disambiguation, at least with regard to an omitted subject referent. (If the omitted referent is the speaker or the hearer, the referential ambiguity can be resolved completely via the first or second person agreement on the verb, whereas a certain amount of sentence-internal ambiguity may remain in the case of third person verb agreement).

Finally, I would like to point out again that Japanese sentences are highly ambiguous in general, most of the times up to the very final word of the sentence, and often even beyond. This is principally due to the above mentioned properties of verb-finality, scrambling, and pro-drop, as well as the fact that Japanese is not only verb-final, but strictly head-final in general (as opposed to German). As a consequence, not only do arguments precede verbs, but subordinate clauses precede main clauses, and modifiers like relative clauses precede the nouns that they modify (see Section 3.2 and Examples 33 and 34, for illustration). This ubiquitous high level of ambiguity makes it considerably difficult to examine the processing of Japanese sentences, especially if more complex structures are involved. As Inoue & Fodor (1995; p. 9) phrased it, "it is easier to argue that parsing in Japanese is impossible than to explain how it is done". At the same time, this high level of ambiguity offers a great opportunity to examine the application of ambiguity resolution mechanisms like the Minimality principle proposed by Bornkessel & Schlesewsky (2006a) even in simple main clauses, i.e. without having to rely on the investigation of more complex structures (like sentences including relative clauses) that are often necessary to create ambiguity in other, structurally less ambiguous languages, like English.

4.2 The processing of word order variations in Japanese

With regard to the processing of word order variations, the availability of pro-drop in Japanese allows a systematic validation of the two levels of the Minimality principle described in Section 3.1.4. Thus, while it is often difficult to dissociate the two levels effectively in a language like German, a clear-cut differentiation between the phrase structural and the interpretive application of the principle is possible in Japanese as a result of its pro-drop property. As will be described in detail below, this is due to the fact that the availability of pro-drop critically affects the phrase structure representation but not the interpretive representation of subject- and object-initial sentences. Below, the Minimality-based predictions for the behavior of the scrambling negativity and the N400 effect in Japanese will be outlined in turn.

With respect to an explanation of the scrambling negativity on the basis of phrase structural Minimality, the predisposition of Japanese towards omitting subjects leads to structural constellations in which an initial accusative argument can be the only overt argument in the sentence. More precisely, when the processing system encounters an initial accusative-marked object, this argument is not necessarily scrambled (cf. Example 35b) but could be the object in a sentence with a dropped subject (cf. Example 36b). As the eADM assumes that the syntactic templates selected during Stage 1 do not contain empty categories of any type (i.e. no traces in the case of word order permutations and no pros in the case of argument drop), the phrase structure of such a transitive sentence with an omitted subject would be represented as [NP–V]. Thus, when the accusative case marking of an initial object in Japanese is processed in Stage 2 of the eADM, the output of this analysis is still compatible with the minimal (one-argument) phrase structure template selected in Stage 1 of processing. Since phrase structural Minimality is – in contrast to German – not violated under these circumstances, no scrambling negativity should be observable at the position of a sentence-initial object in comparison to a sentence-initial subject.

Regarding the derivation of the N400 effect at the position of the second NP in canonical sentences, the pro-drop property of Japanese allows a clear distinction between the predictions based on the application of phrase structural vs. interpretive Minimality. If, as assumed on the basis of the data from German, the N400 is a correlate of interpretive Minimality violations, Japanese should not differ from German with regard to this effect. That is, a nominative-initial structure should initially be interpreted as describing an intransitive event, while the necessity for a transitive interpretation is clear from the very beginning for structures with an initial accusative, since an undergoer cannot be the only participant in an intransitive event and automatically leads to the assumption of an actor (even though – due to the subject-drop option – the actor need not be overtly expressed as an argument in the phrase structure). Thus, when a second argument is encountered, a nominative-initial structure calls for an interpretive switch from an intransitive to a transitive reading, while no such revision is necessary in an accusative-initial structure. As a consequence, a comparable N400 effect as in German should be observed at the position of the second argument, indicating a violation of interpretive Minimality.

On the basis of phrase structural Minimality, on the other hand, no processing difference would be predicted at the position of the second NP. While an initial accusative-marked argument predicts a transitive event based on the undergoer role assignment it receives, it does not predict that a second, nominative-marked argument must occur at some later point in the sentence. Hence, the object-initial sentences in Japanese do not have a processing advantage regarding the phrase structural representation when the second argument is encountered. Instead, both the subject- and the object-initial structure require a phrase structural extension from an [NP–V] template to an [NP–NP–V] template at the position of the second argument. Therefore, no differences between the two word orders can be expected on the basis of phrase-structural Minimality.

In summary, no scrambling negativity would be expected to occur in an object-initial Japanese sentence based on this effect's derivation from phrase structural Minimality. If the N400 effect for the canonical condition is also derivable from phrase structural Minimality, then it should covary with the scrambling negativity and thus should not be observable in Japanese. If, by contrast, the N400 effect is a correlate of Minimality violations at the interpretive level, it should also be observable in a language like Japanese, since the pro-drop property affects the phrase structural but not the interpretive level of sentence representation.

With respect to previous studies of scrambling in Japanese, the behavioral findings described in Section 3.1.1 indicate that sentences in which an accusative object precedes an overt subject are more difficult to process than their subject-initial counterparts. Interestingly, while such costs are clearly evident in offline measures recorded sentence-finally (e.g. Mazuka et al., 2002; Tamaoka et al., 2005), they do not seem to arise immediately at the position of the initial object (e.g. Mazuka et al., 2002). This pattern might be considered as a first indicator that initially, a subject-drop analysis may be preferred over a scrambling analysis of an object-initial sentence, as predicted on the basis of phrase structural Minimality.

The only ERP study on Japanese scrambling that was published before the implementation of the first experiment of this dissertation was reported by Ueno & Kluender (2003). These authors also argued for increased processing costs in scrambled structures, but did not report the comparisons critical for current purposes, namely (a) the comparison between canonical and scrambled sentences at the position of the first argument (e.g. *hanji-ga* vs. *hanji-o* in Example 35), and (b) the comparison between the canonical and scrambled sentences at the position of the second argument (e.g. *daijin-o* vs. *daijin-ga* in Example 35). Instead, Ueno & Kluender (2003) compared the ERPs elicited at the subject position in canonical sentences (i.e. at the first NP) with those elicited at the subject position in scrambled sentences (i.e. at the second NP). Therefore, the findings from this study cannot be compared with the predictions of the eADM. Interestingly, however, the authors inserted additional sentence material such as adjectives modifying the subject and a sentential adverb following the subject and found (among other effects) a SAN starting at the second word following the initial object in the scrambled sentences (as well as a P600 effect at the position of the subject of scrambled sentences in comparison to the subject of unscrambled sentences). Similarly to Fiebach et al. (2002), they argue that the sustained negativity indicates working memory load and that the effect is crucially dependent on a sufficient amount of intervening material (in their interpretation, between the filler and its gap). The observation of a SAN in scrambled sentences speaks in favor of the assumption formulated earlier (see Section 3.1.4) that such an effect could potentially – given enough intervening sentence material – also be observed along with a scrambling negativity for scrambled orders in the German middlefield. Furthermore, it is noteworthy that Ueno & Kluender (2003) also compared ERPs averaged relative to the position of the sentence-final verb and observed an anterior negativity between 300 and 900 ms post verb onset for all scrambled sentences. The authors suggested that this effect reflects "global" processing costs for all scrambled structures and that these costs do not depend on the number of predictions that have to be held in working memory (since in this regard the scrambled and canonical sentences do not differ anymore at the position of the verb). While the eADM does not provide specific hypotheses for this position based on the two levels of Minimality discussed so far, the notion of global processing costs arising at the end of scrambled sentences is not necessarily incompatible with the eADM's assumptions.

4.3 The processing of pro-drop sentences in Japanese

As Section 4.2 showed, very precise predictions can be made for the processing of word order variations in Japanese based on the application of the Minimality principle. These predictions (and the explicit assumptions of the eADM on which they are based) are the result of a long history of fruitful research on the processing of word order variations with behavioral as well as neurocognitive measures. The situation is considerably different with regard to the processing of sentences with omitted arguments. As laid out in Section 3.2, little previous evidence is available in this regard, and most processing models do not make any explicit assumptions regarding the processing mechanisms involved in the comprehension of such "incomplete" sentences. Therefore, the examination of this issue, which will be in the focus of Experiments 3 and 4 of this thesis, must remain highly explorative.

However, in an attempt to integrate the results of this exploration with an existing model of sentence comprehension, the findings will be evaluated against the background of the eADM, in line with the approach to the examination of word order variations described above. As already mentioned, the architecture of the eADM allows the derivation of some preliminary working hypotheses with regard to potentially arising processing costs for sentences with omitted arguments. Before turning to these hypotheses, however, I will shortly discuss one compelling question which automatically suggests itself based on the predictions made for word order variations in the section above.

This question is derivable from the assumed local preference for a pro-drop analysis over a scrambled analysis of a sentence when an initial object is encountered. As described above, this preference is predicted on the basis of phrase structural Minimality, since an [NP–V] template is more minimal than an [NP–NP–V] template. To further substantiate this assumption, it would doubtlessly be very interesting to compare ERPs at the position where an object-initial sentence is disambiguated towards one reading (pro-drop; OV) or the other (scrambling; OSV). After all, an initial pro-drop analysis would require a reanalysis in case of a scrambled continuation, while an initial scrambling analysis would necessitate a reanalysis in case of a pro-drop continuation. However, a direct comparison of ERPs at the point of disambiguation (the word following the initial object) would involve the comparison of a noun (in the scrambled continuation; e.g. *daijin-ga* in Example 35b) with a verb (in the pro-drop continuation; e.g. *maneita* in Example 36b). Since previous studies have demonstrated that different word categories such as nouns and verbs are associated with differences in the ERP response (e.g. Federmeier, Segal, Lombrozo, & Kutas, 2000), possible ERP correlates of the disambiguation could therefore not be disentangled conclusively from effects of word category. Due to this confound, no meaningful conclusions could be drawn from a direct comparison between scrambled and pro-drop sentences at the point of disambiguation.

Another comparison, however, may provide valuable insights about the processing of sentences with omitted arguments *per se*. The contrast of interest in this regard is computed between transitive pro-drop sentences, in which a subject or an object is omitted, and "complete" canonical sentences in which all arguments are overtly realized in their basic order. With regard to the Japanese examples given above, this corresponds to a comparison between the complete SOV sentences (35a) and the pro-drop SV/OV sentences (36a/b). Since the above-mentioned confounding of potentially interesting ERP effects with word category-based differences also applies to the comparison of SOV sentences with SV or OV sentences, the computed ERP contrasts must be restricted to the the position of the sentence-final verb. Crucially, this is the only point in the sentence at which it is possible to compare ERP responses to a word which is identical in SOV, SV, and OV sentences (i.e. a transitive verb). Furthermore, in all three sentence types, the sentence-final verb is always preceded by a noun phrase; that is, no word category differences are evident at the preceding word either. Fortunately, the sentence-final verb is also the primary position at which increased processing costs for the pro-drop sentences might be expected.

As already mentioned in Section 3.2.1, sentences with an omitted argument should not engender increased processing costs before this position based on phrase structural Minimality, since their phrase structure representation is not different from the representation of a simple intransitive clause ([NP–V]) and therefore minimal. Similarly, pro-drop sentences and complete sentences should not differ previously to the verb on the basis of interpretive Minimality. Independently of the overt realization of the arguments, accusative-marked objects signal transitive events while nominative-marked subjects are also compatible with an intransitive reading. Therefore, the GR assignments, i.e. the assignment of actor and undergoer roles at the position of the overt arguments, and the resulting transitivity assessment should be comparable between complete and pro-drop sentences.

At the position of the sentence-final verb, however, the processing demands for pro-drop sentences and complete sentences clearly seem to differ. As described earlier, the arguments need to be linked (based on their GRs) to the logical structure of the verb when the verb is encountered. Since the logical structure encodes the number of participants required by the verb, it must become evident at this position that one of the participants has not been explicitly specified in the pro-drop sentences.[36] As a consequence, additional processes are necessary at this position to arrive at a complete interpretation of the sentence: To understand "who is doing what to whom", the referent for the omitted participant needs to be inferred from outside of the sentence. Since no such inference processes are necessary for the interpretation

[36] Due to the strict verb-finality of Japanese it is also reasonable to assume that the unspecified participant will not be expected to occur at a later point in the sentence. An exception might be constituted by a relative clause continuation of an SV or OV sentence segment, in which the head noun modified by the SRC or ORC would follow the verb. Since such an interpretation would however result in a much more complex sentence representation (structurally as well as interpretationally), it appears more adequate to prefer the simpler pro-drop analysis of such structures (cf. Ishizuka et al., 2003; Miyamoto & Nakamura, 2003).

of a complete SOV sentence, increased processing costs should arise at this position for both types of pro-drop sentences in comparison to complete sentences.

It should be noted that the inference process under consideration here does not seem to be directly related to the levels of representation discussed so far, i.e. the phrase structural representation of the overt sentence constituents and the event representation including the transitivity of the event and the hierarchical ordering of the participants (actor vs. undergoer). Rather, the processes under consideration here seem to be primarily related to the referential or *discourse* level of sentence representation.

Under this assumption, the interesting question arises how exactly the processing aspects under consideration here may be integrated into the architecture of a sentence comprehension model such as the eADM. On the one hand, the need to infer referents from outside of the sentence seems to become evident as soon as the logical structure of the verb is integrated with the GRs of the overt arguments (i.e. in the *linking* step of Stage 2). On the other hand, the current version of the eADM does not incorporate the discourse level of representation in the core processing steps of Stage 2. Instead, discourse information is only integrated after the linking process is completed, namely in the *generalized mapping* step of Stage 3 (along with other information types such as plausibility or frequency). Crucially, processing difficulties associated with the linking step of Stage 2 have been shown to correlate primarily with N400 effects, while processing difficulties arising from the generalized mapping step of Stage 3 have typically engendered late positivity effects (see Bornkessel & Schlesewsky, 2006a). As described in Section 3.2.2, late positivity effects (P600s) as well as earlier negativity effects (sustained anterior negativities) have been previously observed in connection with referent establishment processes, referential ambiguity, and referential failure/inference. However, it is important to keep in mind that all of these findings were based on the examination of overt full NPs or anaphoric expressions like pronouns. Therefore, they at best allow speculations regarding possible ERP correlates of the inferential processes taking place at the position of the sentence-final verb in pro-drop sentences. Therefore, the ERP response possibly arising in a direct comparison between canonical SOV sentences such as (35a) and pro-drop sentences such as (36a/b) could provide new and valuable insights into the neurocognition of discourse referential processing, and the timing and distribution of this response may allow preliminary suggestions regarding the integration of this processing aspect with one of the processing stages of the eADM.

4.4 The current experiments

Part II of this thesis will comprise four ERP experiments which aimed at answering some of the open questions regarding the processing of word order permutations and pro-drop in Japanese. Experiments 1 and 2 were primarily concerned with the processing of word order variations in simple transitive Japanese sentences. In Experiment 1, which employed auditory presentation, canonical (SOV; nominative-before-accusative) and scrambled (OSV; accusative-before-nominative) word orders were compared and the influence of prosodic information on the incremental interpretation of the different orders was investigated. In Experiment 2, the same sentence materials were presented visually, supplemented by canonical and scrambled sentences in which the object was marked with the dative-case (nominative-before-dative and dative-before-nominative) to investigate the influence of differential case marking on the processing of scrambled word orders. Experiments 3 and 4, which also employed visual presentation, focused more strongly on the processing of pro-drop sentences. In Experiment 3, subject-drop (OV) and object-drop (SV) sentences were presented along with canonical and scrambled sentences to investigate the processes required for an incremental comprehension of sentences with omitted arguments. Finally, Experiment 4 aimed at an investigation of the influence of contextual discourse information on these processes.

Part II

Experiments

Chapter 5

Experiment 1: Word order & prosody

5.1 Introduction

Experiment 1 aimed at testing the Minimality hypothesis put forward in the eADM (Bornkessel & Schlesewsky, 2006a; see Section 3.1.4 and the previous chapter) by examining ERP responses to scrambled sentences in Japanese. It was predicted that in the default case, initial accusative arguments would not engender a scrambling negativity in comparison to initial nominatives because the availability of subject-drop, and therefore an object–verb (OV) reading of the sentence, renders an initial accusative argument compatible with a minimal (one argument) phrase structure. However, under circumstances in which the minimal reading is not accessible, a scrambling negativity should be observable. At the same time, we expected an N400 at the position of the second argument for canonical nominative-before-accusative word orders based on interpretive Minimality, independently of whether a phrase structurally minimal reading was available for initial objects or not.

To provide an intra-experimental manipulation of phrase structural Minimality, we capitalized upon a further interesting property of Japanese. Previous psycholinguistic findings have provided evidence for an association between object-before-subject word orders and particular prosodic properties. More specifically, Hirotani (2005) observed a facilitation for the processing of scrambled word orders when a prosodic boundary intervened between the initial object and the following subject.[37]

[37]This relation can also be derived on a theoretical linguistic basis. For example, based on the assumption of configurational/hierarchical phrase structure representations, it has been suggested that a prosodic boundary also signals a syntactic boundary (e.g. McCarthy & Prince, 1993; Selkirk, 1986, 1996; Selkirk & Tateishi, 1991). Since according to such accounts, an unscrambled accusative

Prosodic boundaries are signaled by a variety of acoustic (e.g. intonational and durational) characteristics in addition to the pause itself. Some of these – such as *pre-boundary lengthening* – already affect the element prior to the boundary (see, for example, Wightman, Shattuck-Hufnagel, Ostendorf, & Price, 1992). Hence, at the position of an initial object, the presence of a prosodic boundary should lead the processing system to assume a permuted (object-before-subject) order. Since this analysis is incompatible with a minimal (one argument) phrase structure, an initial object should induce a scrambling negativity under these circumstances. By contrast, if no boundary is present, the processing system should adopt the structurally "cost-free" alternative, namely a structure with an omitted subject (and the initial object as the only argument).

Thus, if the scrambling negativity indeed indexes a violation of Minimality at the phrase structure level, no such effect should be observable at an initial object in the default case, i.e. in the absence of a prosodic boundary. If a prosodic boundary following the initial object signals a scrambled (two-argument) structure, a scrambling negativity should be observable at this position, corresponding to the findings for the German middlefield.

Experiment 1 further served to examine the level of Minimality underlying the N400 effect observed for canonical word orders at the position of the second argument in German. If, as suggested by the data pattern observed in German, the N400 effect is associated with a violation of Minimality at the interpretive level, this effect should also occur in Japanese independently of the phrase structural sentence representation. Recall that an initial object always signals a transitive event, while an initial subject is compatible with an intransitive event interpretation. When a

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object (e.g. the object in a subject-drop sentence) and the verb form a minimal syntactic constituent (a VP), no boundary should intervene between these two elements. Hence, the presence of a prosodic boundary after an initial accusative argument signals that that argument is not verb-adjacent and that a second argument will follow. The processing of an initial subject, by contrast, should be unaffected by such a prosodic manipulation, since the subject does not form a minimal constituent with the verb in the same way as an object. In RRG, which assumes non-hierarchical syntactic templates without a VP, the adjacency constraint between an unscrambled object and the verb in languages like Japanese is derived on an information structural instead of a phrase structural representation level: The verb and the preceding unscrambled object are assumed to form an information structural unit together (the actual focus domain), which is also represented as a prosodic unit and thus should not be disrupted by a prosodic boundary (Van Valin, 2005; see also Pierrehumbert & Beckman, 1988). Initial subjects followed by a prosodic boundary, on the other hand, are still compatible with a one-argument structure because they do not form a minimal information structural unit together with the verb (since the actual focus domain of an intransitive sentence is the verb). As a consequence, both configurational and non-configurational grammars predict that a prosodic boundary following an initial object rules out a (one-argument) subject-drop reading of the sentence and instead signals a (two-argument) scrambled structure, while a similar boundary following an initial subject is still compatible with a (one-argument) intransitive reading of the sentence.

second argument is encountered, this interpretation needs to be revised towards a transitive event reading in the subject-initial sentences, while no such revision is necessary in the object-initial sentences. Crucially, the resulting N400 effect for subject-initial orders should occur independently of the prosodic manipulation employed in the experiment, since the presence or absence of a prosodic boundary only influences the phrase structural representation of an object-initial sentence, but not the transitive event interpretation that is associated with it.

The alternative interpretation of the N400 effect on the basis of phrase structural Minimality, on the other hand, would predict that the N400 effect covaries with the scrambling negativity for object-initial sentences. Since in the default case in Japanese, no phrase structural advantage arises from the object-initial structure (no prediction of a second argument), no N400 should occur for subject-initial orders in this case. As described above, however, the presence of a prosodic boundary after an initial object signals that a second argument will follow. Since in this case a two-argument structure is already anticipated when the second argument is encountered in an object-initial sentence, an N400 effect would be expected for the subject-initial order in sentences with a prosodic boundary.

Thus, if the N400 indeed indexes a violation of Minimality at the interpretive level, this effect should also be observable in Japanese, independently of the prosodic manipulation. If, on the other hand, the N400 effect is another correlate of a Minimality violation at the phrase structure level (in addition to the scrambling negativity), it should only be observable when a prosodic boundary following the initial object signals a two-argument structure, but not when both the subject- and the object-initial sentences are compatible with a one-argument structure (i.e. in the absence of such a boundary).

5.2 Design and hypotheses

As outlined above, Experiment 1 sought to examine the hypothesis that initial accusative objects in Japanese should engender a scrambling negativity in the presence of a prosodic boundary (which serves to indicate a scrambled, two-argument, word order). By contrast, no such effect should occur when there is no boundary and the initial object could therefore be analyzed as the only argument in an OV sentence with a dropped subject. Furthermore, Experiment 1 aimed at testing the hypothesis that subject-initial orders always engender an N400 effect at the position of the second argument, due to the extension from an intransitive to a transitive event interpretation required at this position. These questions were investigated by means of an experimental design that crossed the factors argument order (ORDER; subject-before-object vs. object-before-subject) and intonation (INTON; prosodic boundary present vs. prosodic boundary absent). The four critical conditions resulting from this design are shown in Table 5.1. In order to avoid placing the critical first argument in the sentence-initial position, all sentences were introduced by a temporal adverb. This ensured maximal comparability to the previous word order manipulations in the German middlefield, in which the "initial" object was never the first element in the clause.

Our hypotheses were as follows:

(a) For object-initial sentences, we expected to observe a scrambling negativity at the position of the first case marker when there was a prosodic boundary (PB) after the first argument. No such effect was predicted in the comparison of the object- and subject-initial sentences without a prosodic boundary. As outlined above, the presence of a prosodic boundary is signaled by a variety of acoustic characteristics, some of which affect the element prior to the boundary. Therefore, we expected the prosodic boundary to modulate the processing of the case marker even though this element occurs before the physical pause in the auditory signal. As a result, an interaction of the factors INTON and ORDER was expected at this position.

(b) At the position of the second argument, we expected to observe an N400 for the subject-initial condition as soon as the word category of the constituent (noun phrase) is recognized. Since the prosodic manipulation was not expected to affect this processing difference between subject- and object-initial orders, a main effect of ORDER was expected at this position. (By contrast, if the effect were due to a prediction for a second argument at the phrase structure level, an interaction between ORDER and INTON should arise at this position, too.)

(c) Conditions with a prosodic boundary were expected to elicit a differential ERP response to conditions without a prosodic boundary (i.e. a main effect of INTON) in the form of a positivity marking the processing of the phrase boundary ("closure positive shift", CPS; Steinhauer et al., 1999).

5.3 Materials and methods

5.3.1 Participants

Twenty-four monolingually raised Japanese native speakers (16 female) participated in the experiment as paid volunteers. At the time of examination, participants were aged 21–33 (mean age 28.2 years) and residing in Berlin, Germany. All participants were right-handed, had normal hearing, normal or corrected-to-normal vision, and no neurological or reading disorders. A further six participants were excluded from the final data analysis because of poor behavioral performance on a comprehension task and/or excessive EEG artifacts (see below). Participants were excluded if less

Table 5.1: Example sentences for each of the four critical conditions in Experiment 1

Example word set				
	二週間前 nishuukanmae two weeks ago	判事 hanji judge	大臣 daijin minister	招きました manekimashita invited
Condition	Example sentence			
SOV-noPB	{ 二週間前 } {nishuukanmae} {two weeks ago}	{ 判事が {hanji-ga {judge-NOM	大臣を daijin-o minister-ACC	招きました } manekimashita} invited}
	'Two weeks ago, the judge invited the minister.'			
OSV-noPB	{ 二週間前 } {nishuukanmae} {two weeks ago}	{ 判事を {hanji-o {judge-ACC	大臣が daijin-ga minister-NOM	招きました } manekimashita} invited}
	'Two weeks ago, the minister invited the judge.'			
SOV-PB	{ 二週間前 } {nishuukanmae} {two weeks ago}	{ 判事が } {hanji-ga} {judge-NOM}	{ 大臣を {daijin-o {minister-ACC	招きました } manekimashita} invited}
	'Two weeks ago, the judge invited the minister.'			
OSV-PB	{ 二週間前 } {nishuukanmae} {two weeks ago}	{ 判事を } {hanji-o} {judge-ACC}	{ 大臣が {daijin-ga {minister-NOM	招きました } manekimashita} invited}
	'Two weeks ago, the minister invited the judge.'			

Abbreviations used: SOV, subject-object-verb; OSV, object-subject-verb; noPB, no prosodic boundary; PB, prosodic boundary. Prosodic boundaries are indicated by curly brackets.

than 50% of the trials in any one condition remained for analysis after exclusion of incorrectly answered trials and trials containing EEG artifacts.

5.3.2 Materials

The sentence materials were constructed on the basis of 80 word sets consisting of a temporal adverb, two common nouns with a length of three to five mora describing humans and a transitive (two participant) accusative verb expressed in the polite form and past tense (for the complete word sets, see App. B.1). All the sentences constructed from these word sets had the following basic structure: adverb–noun1–casemarker1–noun2–casemarker2–verb (see Table 5.1). An additional 320 sentences implementing a different experimental manipulation of no relevance for the issues discussed here served as filler sentences. The resulting set of 640 sentences (80 sets $\times$ 4 conditions plus 320 fillers) was subdivided into two lists of 320 sentences each. Repetitions of lexical items were counterbalanced across lists so that participants always listened to two of the four variants in Table 5.1 from one lexical set. Thus, each participant was presented with 40 sentences per condition as well as with 160 filler sentences. Each of the two sentence lists was then pseudo-randomized in four different orders. The presentation of lists and randomizations was counterbalanced across participants.

Sentences were spoken by a female speaker of Japanese (Tokyo dialect) and digitally recorded with a sampling rate of 44.1 kHz and a 16-bit resolution. Sentences were checked for naturalness by a native speaker of Japanese (who was naïve to the purposes of the experiment beyond the prosodic manipulation) and re-recorded when necessary.

In order to ensure that the participants processed the critical sentences attentively, comprehension questions were constructed. All questions were set in the canonical word order (subject-before-object). For questions to be answered with "yes" (50% of the questions), the preceding sentence was rephrased as a question by adding a question particle and incorporating any changes necessitated by the chosen question format. Questions to be answered with "no" were constructed by either interchanging the subject and object of the sentence, or by substituting the subject, object, or verb with a similar but not identical word. Comprehension questions were prepared for visual presentation by converting them into picture files each depicting one complete question sentence in Japanese characters.

Acoustic analyses

Acoustic analyses of the critical materials were undertaken in order to ensure that the prosodic manipulation had been implemented effectively and to examine possible further prosodic differences between the experimental conditions. For each sentential constituent (adverb, NP1, NP2, verb) in each critical sentence, the following parameters were extracted: duration, intensity, and fundamental frequency (F0) for constituent onset and offset and for the F0 maximum and minimum. Mean values for duration and intensity are given in Table 5.2 and F0 contours are visualized in Fig. 5.1.

Descriptively, the acoustic analyses confirmed the effectiveness of the prosodic manipulation: Sentences with a prosodic boundary showed longer durations for NP1 (prefinal lengthening), a longer pause between NP1 and NP2 (see Table 5.2)

Table 5.2: Mean intensity and duration values for the critical stimulus materials in Experiment 1

	Mean intensity (dB)			
Condition	Adverb	NP1	NP2	Verb
SOV-noPB	70.3 (2.2)	71.3 (1.8)	71.0 (1.9)	65.7 (1.3)
OSV-noPB	70.2 (1.9)	71.3 (1.9)	70.9 (1.9)	65.6 (1.3)
SOV-PB	70.0 (2.1)	69.8 (1.7)	71.5 (2.1)	66.2 (1.5)
OSV-PB	70.0 (2.2)	70.4 (1.9)	71.2 (2.1)	66.0 (1.3)
	Mean duration, constituents (ms)			
Condition	Adverb	NP1	NP2	Verb
SOV-noPB	807 (254)	705 (99)	615 (91)	991 (105)
OSV-noPB	816 (234)	697 (93)	626 (94)	998 (104)
SOV-PB	840 (231)	860 (109)	635 (85)	992 (109)
OSV-PB	839 (229)	856 (109)	648 (89)	994 (98)
	Mean duration, pauses (ms)			
Condition	Adv–NP1	NP1–NP2	NP2–Verb	
SOV-noPB	221 (123)	10 (18)	10 (17)	
OSV-noPB	200 (145)	13 (19)	10 (14)	
SOV-PB	246 (108)	277 (122)	11 (17)	
OSV-PB	248 (110)	252 (121)	10 (15)	

Standard deviations are given in parentheses.

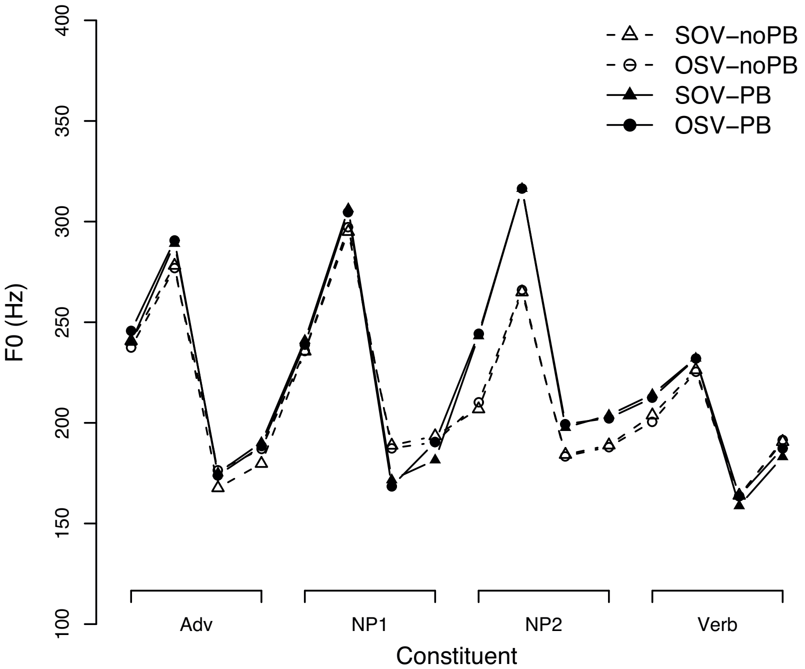

Figure 5.1: F0 contours for the critical conditions in Experiment 1.

and a pitch reset after NP1. The pitch reset can be seen in Fig. 5.1, in which a continuing downward trend of the F0 contour is apparent for the sentences without but not for the sentences with a prosodic boundary due to a "resetting" of the pitch after the boundary. All of these properties are characteristic markers of a prosodic boundary (cf. Wightman et al., 1992), thus indicating that the prosodic manipulation was indeed implemented successfully. Furthermore, it appears from Table 5.2 and Fig. 5.1 that there were no other major differences between the critical conditions.

These descriptive impressions were confirmed by the statistical analysis. All critical acoustic parameters were subjected to an item-based analysis of variance (ANOVA) involving the condition factors INTON (with prosodic boundary vs. without prosodic boundary) and ORDER (subject-before-object vs. object-before-subject). Furthermore, in order to quantify the pitch reset between NP1 and NP2, the difference between the F0 maxima at NP1 and NP2 was calculated and similarly analyzed with an ANOVA. Note that significant effects related to pitch differences will only be reported when they exceed the threshold for perception (see Rietveld & Gussenhoven, 1985; t'Hart, Collier, & Cohen, 1990).

With regard to the duration of the constituents, statistical analyses showed main effects of INTON for adverb, NP1 and NP2 (all Fs > 30, $p < .001$). For NP2, a main effect of ORDER also reached significance ($F(1, 79) = 7.69$, $p < .007$). The constituent durations thus showed the expected lengthening prior to the prosodic boundary. The analysis of the duration of the pauses revealed a significant effect of INTON for the pause between the adverb and the first NP ($F(1, 79) = 9.59$, $p < .003$) as well as for the pause between NP1 and NP2 ($F(1, 79) = 545.53$, $p < .001$). As is apparent from Table 5.2, the pause between the first and second NPs was particularly prominent (in the range of approximately 250 ms).

Statistical analyses of the F0 differences revealed the following effects: For the second NP, the F0 value at onset and the F0 maximum differed significantly between conditions with and without a prosodic boundary ($F(1, 79) = 105.14$, $p < .001$, and $F(1, 79) = 692.62$, $p < .001$, respectively). The statistical analysis of the pitch reset after NP1 (F0 difference between the NP1 and NP2 maxima) also showed a significant main effect of INTON ($F(1, 79) = 255.65$, $p < .001$), which was due to an F0 increase in conditions with a prosodic boundary and a decrease in conditions without such a boundary.

Statistical analyses of the mean intensity values showed a main effect of INTON for the second NP ($F(1,79) = 128.53$, $p < .001$). No other systematic intensity differences were observed (all differences < 1 dB).

In summary, all acoustic parameters indicate that the manipulation of the prosodic boundary was indeed implemented successfully in the stimulus materials. Thus, prosodic differences between the critical sentence types were conditioned primarily by the prosodic manipulation.

5.3.3 Procedure

Experimental sessions were conducted in a dimly lit, sound attenuated room at the Charité Campus Benjamin Franklin in Berlin, Germany. Participants were seated in a comfortable chair at a distance of 100 cm from a 17 in. computer screen. Each trial began with the presentation of a fixation asterisk in the center of the screen. After 500 ms, a sentence was presented via loudspeakers. After sentence offset, the asterisk remained on the screen for another 1000 ms. Five hundred milliseconds later, the comprehension question was presented on the screen and remained visible until the participant answered by pressing one of two buttons labeled "yes" and "no" on a response box, or until a period of 5500 ms had elapsed. After an intertrial interval (ITI) of 1000 ms the next trial began.

Participants were asked to fixate the asterisk throughout the duration of its presentation (from 500 ms before sentence onset to 1000 ms after sentence offset) and to avoid movements and eye blinks during that time. The experimental session began with a 16-trial practice run, which was repeated in case of either low performance or a high eye blink or movement rate, and then proceeded with the pseudo-randomized presentation of the 320 experimental trials, which was carried out in eight blocks of 40 sentences each. The randomization ensured that lexical materials were not repeated within the same block.

5.3.4 EEG recording and preprocessing

Twenty-five Ag/AgCl electrodes were fixed at the participant's scalp by means of an elastic cap (Electrocap International, Eaton, OH). EEG signals were recorded from the following positions on the scalp: AFz (Ground), F7, F3, Fz, F4, F8, FC5, FC1, FCz, FC2, FC6, Cz, CP5, CP1, CPz, CP2, CP6, P7, P3, Pz, P4, P8, POz, O1, and O2 (cf. Fig. 2.2). Vertical and horizontal eye movements were registered (EOG), and the left mastoid electrode served as reference. Electrode impedances were kept below 4 kΩ. The EEG was amplified using a Twente Medical Systems DC amplifier (TMS International BV, Enschede, the Netherlands) and digitized with a sampling rate of 250 Hz. In order to exclude slow signal drifts, the EEG data were filtered offline with 0.3–20.0 Hz band pass. The data were subsequently rereferenced from the left mastoid to linked mastoids. Automatic and manual rejections were carried out to exclude periods containing EOG, movement or technical artifacts from the data analysis. Trials for which the comprehension question was answered incorrectly were also excluded from further analysis. ERPs were calculated per participant, electrode, and condition in intervals from -200 to 1200 ms relative to each critical time-locking point, before grand averages were computed over all participants.

No baseline corrections were performed, in order to avoid a distortion of the critical ERP epochs via possible transient signal differences in the baseline interval. Instead, we applied filter settings that were suited to excluding slow drifts and thus avoiding stimulus-independent differences between conditions, while at the same time including the relevant language related ERP activity (for a more detailed discussion of this issue, see Section 2.2.1; for a similar advance in a comparable experimental environment, see Friederici, Wang, Herrmann, Maess, & Oertel, 2000).

5.3.5 Statistical analyses

For the comprehension task, error rates and reaction times were analyzed by means of repeated measures analyses of variance (ANOVA) containing the condition factors ORDER (subject-before-object vs. object-before-subject) and INTON (with vs. without prosodic boundary after the first NP) and the random factor participants (F_1) or items (F_2). Incorrect responses were excluded from the reaction time analysis.

For the statistical analysis of the ERP data, repeated measures ANOVAs were conducted to compare the mean amplitude values per condition in each time window of interest. The ANOVAs comprised the condition factors ORDER (subject-before-object vs. object-before-subject) and INTON (with vs. without prosodic boundary after the first NP). Apart from the two condition factors, the analyses included an additional topographical factor ROI (region of interest). Analyses were conducted separately for lateral and midline electrodes. For the lateral electrodes, regions of interest (ROIs) were defined as follows: left-anterior: F3, F7, FC1, and FC5; left-posterior: CP1, CP5, P3, and P7; right-anterior: F4, F8, FC2, and FC6; right-posterior: CP2, CP6, P4, and P8. For the midline electrodes, each electrode (FZ, FCZ, CZ, CPZ, PZ, and POZ) represented one ROI of its own. The time windows for the analysis of the ERP effects were chosen via visual inspection. As there are no previous published auditory ERP studies on the processing of Japanese, any predefined choice of time windows would have been exceedingly speculative.

Here and throughout the remainder of the experiments, only significant effects (i.e. effects with a p value smaller than .05) will be reported. The statistical analyses were carried out hierarchically, i.e. only interactions which reached significance were resolved. Huynh-Feldt (H-F) corrected significance values were chosen whenever a statistical analysis included a factor with more than one degree of freedom (df) in the numerator (Huynh & Feldt, 1970).

5.4 Results

5.4.1 Behavioral data

Error rates and reaction times for the behavioral task are displayed in Table 5.3. With respect to the error rates, a repeated measures ANOVA revealed main effects of INTON (only significant in the analysis by participants; $F_1(1, 23) = 5.96$, $p < .03$) and ORDER ($F_1(1, 23) = 30.78$, $p < .001$; $F_2(1, 79) = 40.85$, $p < .001$) as well as an interaction ORDER×INTON ($F_1(1, 23) = 8.32$, $p < .009$; $F_2(1, 79) = 7.96$,

$p < .007$). Resolving this interaction by INTON revealed an effect of word order both in the conditions without a prosodic boundary ($F_1(1, 23) = 36.94$, $p < .001$; $F_2(1, 79) = 38.25$, $p < .001$) and in those with a prosodic boundary ($F_1(1, 23) = 9.41$, $p < .006$; $F_2(1, 79) = 12.47$, $p < .001$). Thus, object-initial sentences always yielded higher error rates than their subject-initial counterparts, but this processing disadvantage was reduced in the presence of a prosodic boundary.

The ANOVA for the reaction time data showed a main effect of ORDER ($F_1(1, 23) = 21.80$, $p < .001$; $F_2(1, 79) = 11.38$, $p < .002$) stemming from longer reaction times for the object-initial conditions. We refrained from interpreting the reaction times in detail as they were not directly time-locked to the critical manipulations. Nevertheless, and in accordance with the error rates, they do appear to suggest that object-initial sentences were more difficult to process than their subject-initial counterparts.

5.4.2 ERP data

In accordance with our hypotheses, we calculated ERPs relative to the onset of the case marker of NP1[38] and to the onset of NP2. We also examined ERPs relative to the case marker of NP2: If present, possible increased integration costs at the position of the subject following the object (cf. Fiebach et al., 2002) should be

[38] We chose to compute ERPs relative to the the case marker instead of the noun of NP1 because of the relatively high degree of variance with respect to the duration of the first noun. Thus time-locking to the onset of NP1 would result in a much larger temporal jitter (i.e. temporal variation in the onset of the critical case marking information) across trials. By contrast, this acoustic jitter is reduced considerably for the case marker. The mean duration of the first noun was as follows across conditions (standard deviations and minimum-maximum ranges are given in parentheses): SOV-noPB: 576 (100/361–784); OSV-noPB: 564 (96/367–764); SOV-PB: 637 (103/429–855); OSV-PB: 638 (101/426–914). The mean durations, standard deviations, and minimum-maximum ranges of the first case marker were as follows: SOV-noPB: 129 (24/70–191); OSV-noPB: 133 (30/61–208); SOV-PB: 223 (21/186–295); OSV-PB: 218 (33/169–357).

Table 5.3: Mean error rates and reaction times in the comprehension task of Experiment 1

Condition	Mean error rate (%)		Mean reaction time (ms)	
SOV-noPB	3.8	(4.0)	2149	(638)
OSV-noPB	13.4	(8.4)	2258	(667)
SOV-PB	4.3	(4.5)	2157	(668)
OSV-PB	8.9	(7.0)	2327	(663)

Standard deviations (of the participant analysis) are given in parentheses.

observable here. Though we did not have any explicit predictions for the clause-final verb, we also examined the ERPs at this position for the sake of comparability with previous studies (cf. Ueno & Kluender, 2003). Finally, to ensure that the critical conditions did not elicit differential ERP responses prior to the first NP, we examined ERPs time-locked to the sentence-initial adverb. These control comparisons for the adverb position, which did not show any significant differences between conditions, are presented in App. A.1.

NP1: Case marker

In order to examine whether initial objects yielded a scrambling negativity, grand average ERPs were calculated relative to the onset of the case marker of NP1 (see Fig. 5.2). As is apparent in the figure, the object-initial condition with a prosodic boundary (Fig. 5.2A) engendered a broadly distributed negativity between approximately 125 and 250 ms, while no comparable effect is observable for the sentences without a prosodic boundary (Fig. 5.2B). Visual inspection of all four conditions together (see magnified center panel of Fig. 5.2) further shows a large positivity (CPS) between approximately 500 and 1000 ms for the conditions with a prosodic boundary. ANOVAs were calculated for both time windows.

In the early time window (125–250 ms), the analysis of the midline electrodes showed a main effect of ORDER ($F(1, 23) = 12.27$, $p < .002$) and a main effect of INTON ($F(1, 23) = 22.03$, $p < .001$), as well as an interaction ORDER×ROI ($F(5, 115) = 3.80$, $p < .03$), an interaction INTON×ROI ($F(5, 115) = 5.89$, $p < .008$), and an interaction ORDER×INTON ($F(1, 23) = 6.63$, $p < .02$). Resolving the interactions with ROI revealed significant effects of ORDER and INTON for all electrodes (ORDER: all Fs > 5, ps < .03; INTON: all Fs > 7, ps < .01). Resolving the ORDER×INTON interaction by INTON revealed a significant effect of ORDER only in sentences with a prosodic boundary ($F(1, 23) = 21.65$, $p < .001$), but not in sentences without a boundary ($F < 1$). A similar pattern was apparent in the global analysis of the lateral ROIs. Besides a main effect of ORDER ($F(1, 23) = 14.52$, $p < .001$) and a main effect of INTON ($F(1, 23) = 31.85$, $p < .001$) the interaction ORDER×INTON reached significance ($F(1, 23) = 4.29$, $p < .05$). Resolving the interaction by INTON again showed a significant effect of ORDER in sentences with a prosodic boundary ($F(1, 23) = 17.73$, $p < .001$), but not in sentences without a prosodic boundary ($F < 1$). Thus, as predicted, we observed increased processing cost at the position of the first case marker in object-initial sentences only in the presence of a prosodic boundary.

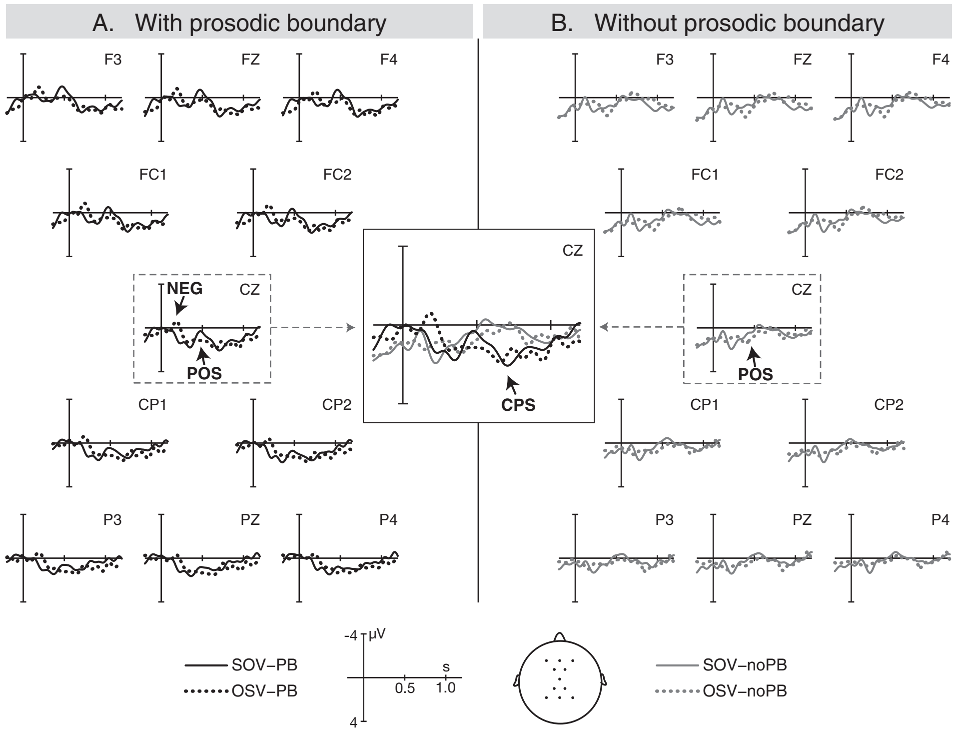

Figure 5.2: Grand-average ERPs (N = 24) time-locked to the case marker of NP1 (onset at the vertical bar) in Experiment 1. Pairwise comparisons of subject- and object-initial sentences with and without a prosodic boundary after NP1 are shown in (A) and (B), respectively. The enlarged center panel shows a direct comparison of all four conditions at one electrode. In this and all following ERP figures, negativity is plotted upwards.

In the second time window for the first case marker (500–1000 ms), the analysis of the midline electrodes showed a main effect of INTON ($F(1, 23) = 26.68$, $p < .001$) and the interactions INTON×ROI ($F(5, 115) = 7.66$, $p < .004$) and ORDER×ROI ($F(5, 115) = 3.82$, $p < .05$). Examining the effects for each ROI separately revealed significant effects of INTON for all electrodes (all Fs > 10, ps $< .005$; conditions with a prosodic boundary more positive), while an effect of ORDER was only observable at CPZ ($F(1, 23) = 5.93$, $p < .03$), PZ ($F(1, 23) = 5.76$, $p < .03$) and POZ ($F(1, 23) = 7.78$, $p < .02$; object-initial conditions more positive). The effects at lateral electrode sites resembled those on the midline electrodes: The analysis revealed a main effect of INTON ($F(1, 23) = 29.28$, $p < .001$), an interaction INTON×ROI ($F(3, 69) = 7.08$, $p < .002$), and an interaction ORDER×ROI ($F(3, 69) = 6.62$, p

$< .003$). Here, too, each ROI showed a main effect of INTON (all Fs > 8, ps $< .01$; conditions with a prosodic boundary more positive), while the effect of ORDER was significant only in the left-posterior ROI ($F(1, 23) = 11.05$, $p < .004$; object-initial conditions more positive).[39]

Visual inspection suggests that the posterior effect of word order described above may stem from a slightly overlapping time window: The object-initial conditions engendered more positive-going ERPs than their subject-initial counterparts between approximately 400 and 650 ms post onset of the case marker. This impression was confirmed by the statistical analysis of this time window. We observed a main effect of ORDER for both the midline electrodes ($F(1, 23) = 8.86$, $p < .007$) and the lateral electrodes ($F(1, 23) = 8.34$, $p < .009$). Thus, in addition to reflecting the beginning of the CPS (see Footnote 39), the analysis of the 400–650 ms time window revealed a positivity for both object-initial conditions.

NP2: Onset / word category recognition point / case marker

Onset Grand average ERPs relative to the onset of NP2 are shown in Fig. 5.3. The most pronounced difference between conditions in Fig. 5.3 is prosodically-conditioned. Thus, we again see the positivity (CPS) for the conditions with a prosodic boundary due to the overlapping time windows between case marker 1 and the onset of NP2 (see Footnote 39). By contrast, the effects of word order appear to be relatively diffuse. We reasoned that this might be due to a temporal jitter within the critical stimuli: The expected effect cannot occur until the word category of the second constituent is identified, i.e. until the point in time at which the processing system recognizes that the word is a noun and not – as would be anticipated in the alternatively assumed structure with a single argument – a verb. The word category recognition point (WCRP), however, occurs at a variable distance from NP2 onset so that possible effects at this position might be overshadowed by a temporal jitter when ERPs are calculated relative to NP onset.

Word category recognition point Therefore, we determined the WCRP for all second NPs by means of a dictionary search in which a native speaker of Japanese identified the point at which each of the critical nouns was no longer compatible with a verb reading (see Van den Brink & Hagoort, 2004, for a similar procedure).

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[39] Note that the CPS was also observable in the 400–650 ms time window relative to the case marker of NP1 and in all time windows examined relative to NP2. However, as these all partially overlap with the 500–1000 ms time window for NP1, no further statistical analyses related to the CPS effect will be reported.

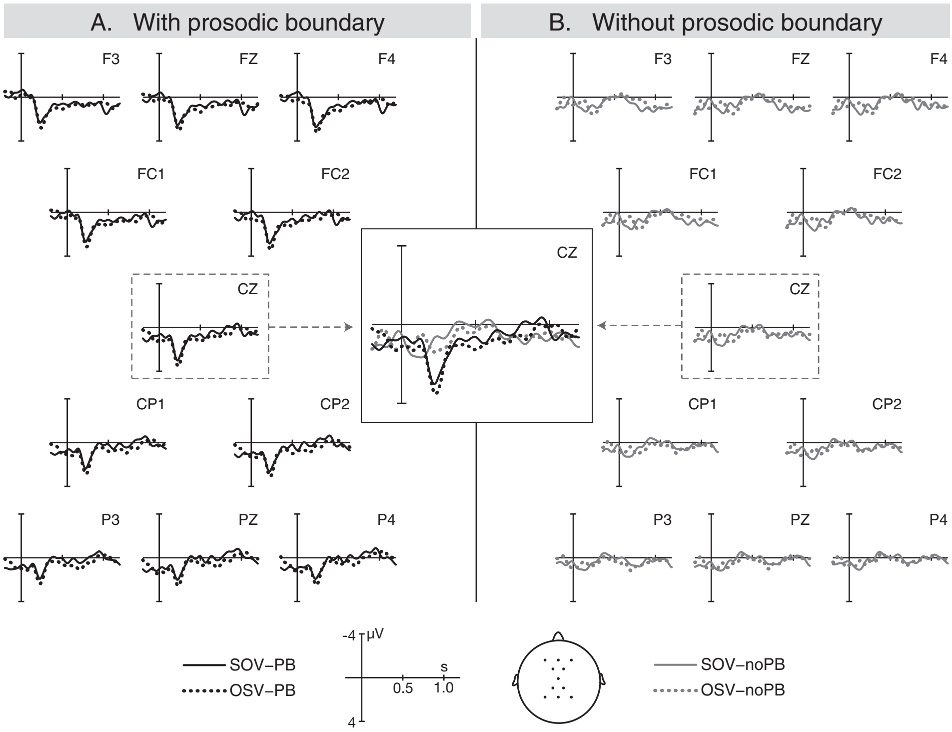

Figure 5.3: Grand-average ERPs (N = 24) time-locked to the onset of NP2 (onset at the vertical bar) in Experiment 1. Pairwise comparisons of subject- and object-initial sentences with and without a prosodic boundary after NP1 are shown in (A) and (B), respectively. The enlarged center panel shows a direct comparison of all four conditions at one electrode.

Note that no compensation was made for a possibly earlier onset of this point in auditory presentation (e.g. via coarticulation) because such a compensation would have been highly subjective in nature. Grand average ERPs relative to the WCRP are shown in Fig. 5.4 for subject- and object-initial conditions.

Visual inspection of the figure suggests that subject-initial sentences engendered an early negativity relative to the WCRP in comparison to object-initial sentences. This impression was supported by the statistical analysis in a time window from 0 to 250 ms, in which the main effect of ORDER was significant both at midline ($F(1, 23) = 22.45$, $p < .001$) and lateral electrodes ($F(1, 23) = 29.85$, $p < .001$). The interaction ORDER×INTON did not approach significance in either the midline or

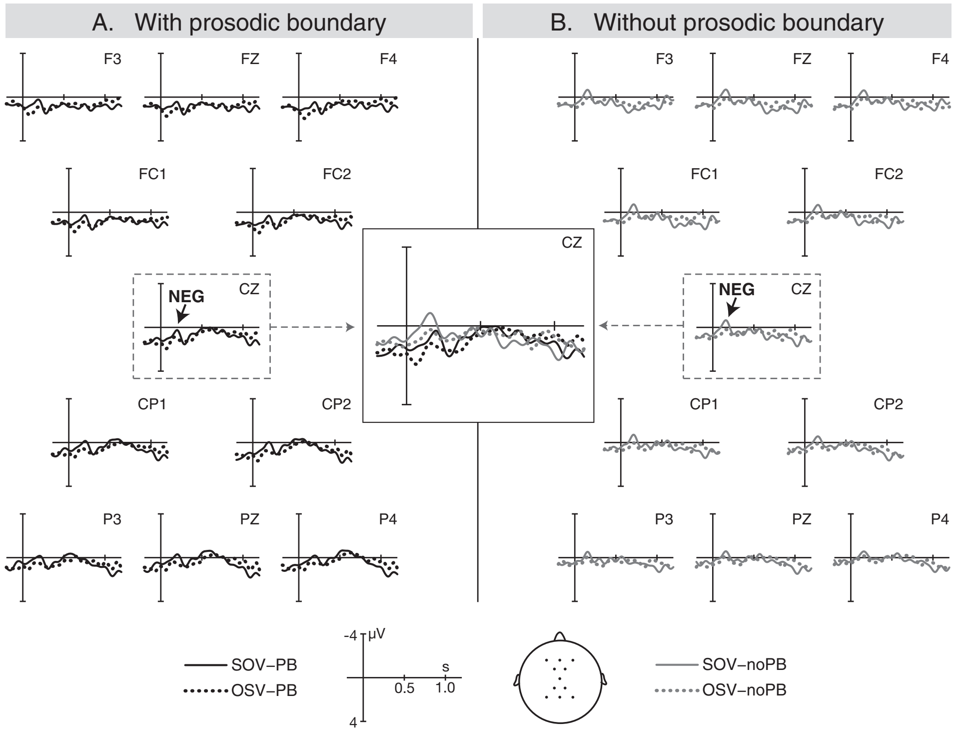

Figure 5.4: Grand-average ERPs (N = 24) time-locked to the word category recognition point (WCRP) of NP2 (WCRP at the vertical bar) in Experiment 1. Pairwise comparisons of subject- and object-initial sentences with and without a prosodic boundary after NP1 are shown in (A) and (B), respectively. The enlarged center panel shows a direct comparison of all four conditions at one electrode.

the lateral analysis (both Fs < 1). As in the analysis relative to the onset of NP2, there were again significant effects of INTON due to the CPS effect (see Footnote 39).

Case marker Finally, we also examined ERPs relative to the onset of the case marker of NP2, as this is the position at which the word order (accusative-nominative vs. nominative-accusative) is fully disambiguated. Grand average ERPs at this position are shown in Fig. 5.5. Visual inspection of the figure suggests that the object-initial conditions engendered an early positivity (200–350 ms) relative to their subject-initial counterparts. This effect appears to be somewhat more pronounced in the condition with a prosodic boundary.

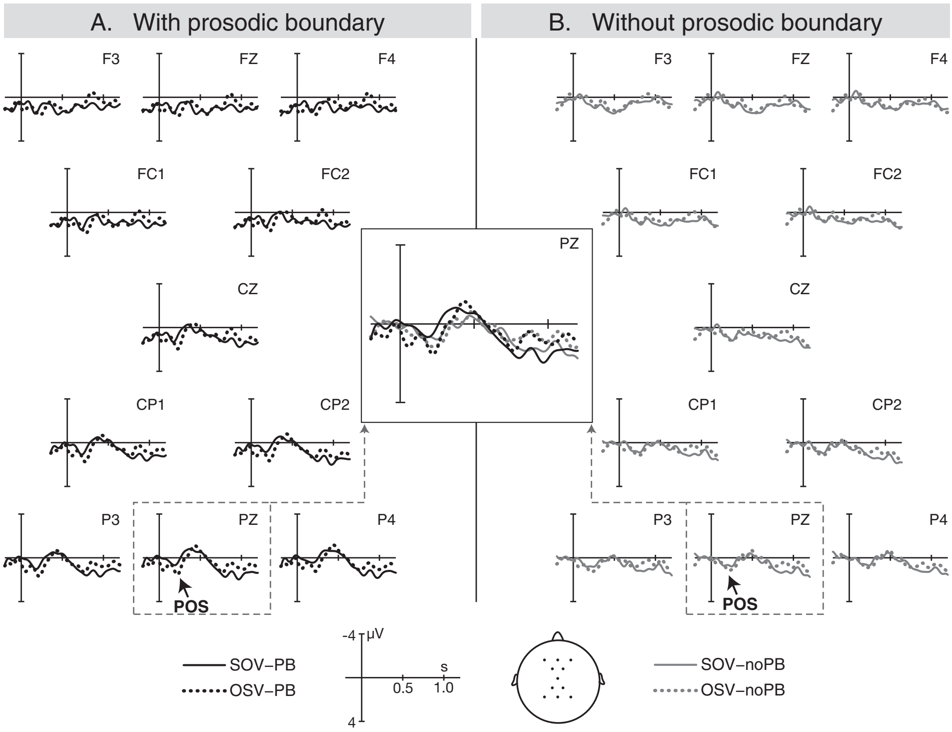

Figure 5.5: Grand-average ERPs (N = 24) time-locked to the case marker of NP2 (onset at the vertical bar) in Experiment 1. Pairwise comparisons of subject- and object-initial sentences with and without a prosodic boundary after NP1 are shown in (A) and (B), respectively. The enlarged center panel shows a direct comparison of all four conditions at one electrode.

The statistical analysis in the 200–350 ms time window revealed a main effect of ORDER at midline sites ($F(1,\ 23) = 5.04$, $p < .04$). At lateral electrodes, the statistical analysis revealed an interaction ORDER×ROI ($F(3,\ 69) = 4.98$, $p < 0.02$). Resolving the interaction by ROI showed significant effects of ORDER only at posterior sites (left: $F(1,\ 23) = 6.25$, $p < .03$; right: $F(1,\ 23) = 7.15$, $p < .02$). The prosodic influence on this effect was not confirmed statistically. As in the earlier time windows at the position of NP2, further effects of INTON again reached significance in this time window (see Footnote 39).

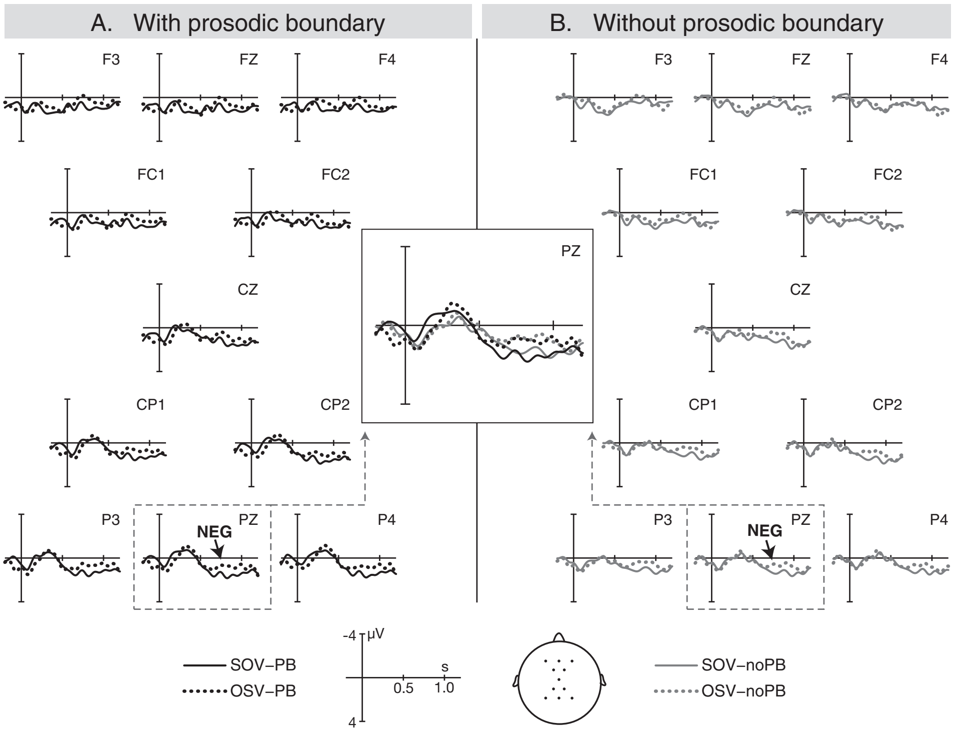

Figure 5.6: Grand-average ERPs (N = 24) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 1. Pairwise comparisons of subject- and object-initial sentences with and without a prosodic boundary after NP1 are shown in (A) and (B), respectively. The enlarged center panel shows a direct comparison of all four conditions at one electrode.

Verb: Onset

Fig. 5.6 shows grand average ERPs relative to the onset of the clause-final verb. Visual inspection of the figure shows a late negativity between approximately 650 and 1050 ms for the object-initial conditions in both the sentences with and the sentences without a prosodic boundary. This effect seems to be most pronounced at parietal sites.

At midline electrodes, the statistical analysis for this time window revealed a main effect of ORDER ($F(1, 23) = 17.62$, $p < .001$) and an interaction ORDER×ROI ($F(5, 115) = 5.95$, $p < .006$). Resolving the interaction revealed significant effects of ORDER at all electrodes, though these were more pronounced at posterior than at anterior sites (minimum at Fz, $F(1, 23) = 5.97$, $p < .03$; maximum at POz, $F(1,$

23) = 29.25, $p < .001$). The analysis of the lateral ROIs also showed a significant main effect of ORDER ($F(1, 23) = 14.66$, $p < .001$) accompanied by an interaction ORDER×ROI ($F(3, 69) = 4.88$, $p < .01$). Here, too, the effect of ORDER reached significance in each topographical region, with stronger effects in the posterior ROIs than at the anterior ROIs (minimum at right-anterior electrodes, $F(1, 23) = 5.26$, $p < .04$; maximum at left-posterior electrodes, $F(1, 23) = 30.48$, $p < .001$).

5.5 Discussion

The following effects were observed in Experiment 1: (a) a broadly distributed negativity (125–250 ms) relative to the first case marker for initial objects followed by a prosodic boundary, but not for objects not followed by such a boundary; (b) a broadly distributed negativity (0–250 ms) relative to the WCRP of the second NP for all subject-initial orders; (c) a posterior negativity (500–1000 ms; CPS) relative to the first case marker for all conditions with a prosodic boundary; (d) a broadly distributed positivity (400–650 ms) for all object-initial orders relative to the first case marker; (e) a broadly distributed positivity (200–350 ms) for all object-initial orders relative to the second case marker; (f) a posterior negativity (650–1050 ms) for all object-initial orders relative to the onset of the verb. In the following, I will first discuss the findings regarding the scrambling negativity and the N400 effect (and the CPS), which were in the focus of the experiment (a–c), before turning to a discussion of the additional effects observed at various positions (d–f).

5.5.1 Scrambling negativity and N400

In accordance with the hypotheses, Experiment 1 revealed the following two main findings: a scrambling negativity for initial objects followed by a prosodic boundary, and an N400 effect for the second argument of subject-initial sentences, independently of the prosodic manipulation.

The scrambling negativity for object-initial orders

A scrambling negativity was observed for object-initial sentences in Japanese when the initial object was followed by a prosodic boundary, but not in the absence of such a boundary. This finding provides strong converging support for the assumption that the scrambling negativity reflects a violation of Minimality at the phrase structure level. In Japanese, an initial object could, in principle, be the only argument in a canonical sentence due to the availability of subject-drop. By contrast, the presence of a prosodic boundary provides the processing system with strong evidence for a scrambled structure (i.e. a structure in which the object will be followed by a subject). Hence, the initial object is compatible with a one-argument phrase structure in the first, but not in the second case. This state of affairs is precisely mirrored by the ERP findings at the position of the first case marker: A scrambling negativity is only elicited in the presence of a prosodic boundary. The presence of a CPS in the conditions with a prosodic boundary provides additional evidence that participants indeed processed the boundary information.

The N400 effect for subject-initial orders

Experiment 1 showed a negativity (N400) for subject-initial conditions at the position of NP2, independently of the presence of a prosodic boundary. As is common in studies employing auditory presentation (Domalski et al., 1991), this effect showed a broad topographical distribution instead of the posterior distribution more typically observed in experiments using visual stimuli. As discussed in detail above, an initial accusative only gives rise to the prediction of a second argument in the phrase structure in the presence of a prosodic boundary, but it generally (i.e. under all prosodic conditions) signals the presence of a transitive event at the interpretive level. Thus, the N400 effect appears to index the extension from an intransitive reading (as permitted by an initial nominative but not by an initial accusative) to a transitive reading (as required by a second NP). Together with the data from German, the present findings therefore strongly indicate that the level of Minimality at issue here is indeed interpretive rather than phrase structural in nature. For ease of exposition, the type of N400 effect observed in this context will be referred to as *extension N400* in the remainder of the thesis.

The latency of the effects

While the ERP patterns in Experiment 1 thus essentially supported the hypotheses, the relatively short latency of the effects that were interpreted as a scrambling negativity (125–250 ms) and as an N400 (0–250 ms) warrants some discussion. These effects were observed within a time window that is generally associated with early left-anterior negativity (ELAN) effects, which are typically engendered by word category violations (see Friederici, 2002; Neville, Nicol, Barss, Forster, & Garrett, 1991) and have hitherto only been reported in violation contexts. However, the current study included no such violations – or, more precisely, included no violations at all. Therefore, and due to the fact that the effects did not show a left-anterior distribution, it does not seem reasonable to interpret the effects observed at the case marker of NP1 and the WCRP of NP2 as ELAN components.

Several factors may have led to the relatively short latency of the scrambling negativity in Experiment 1. First, the point of averaging was very close to the critical point in the stimulus (i.e. the onset of the critical case marker). This stands in contrast to the majority of studies in the literature, which often compute averages relative to the onset of the word containing the critical information, but rarely time-lock averages directly to a critical morpheme. (In many cases, this is also not as straightforwardly possible as in Japanese, which exhibits an almost perfect correspondence between functions and overt morphemes, e.g. in case morphemes, a passive morpheme, a causative morpheme etc.) Second, the specific properties of auditory presentation may also lead to latency shifts: Early prosodic differences or effects of coarticulation can render the critical information available at an earlier point in time than one would expect by examining only the segmental properties of the critical stimuli. On account of these differences between the present study and previous electrophysiological investigations of word order processing, it seems justified to interpret the effect observed at the position of the first case marker as an instance of a scrambling negativity.

A similar line of argumentation holds for the effect observed at the word category recognition point of NP2, which was interpreted as functionally identical to the N400 reported by Bornkessel et al. (2004a) for the second argument in subject- vs. object-initial sentences in German. Here, too, the ERPs were not averaged to the onset of the noun phrase but to the critical point in the stimulus (the WCRP); and the auditory presentation mode may have led to an additional latency shift via prosodic cues and coarticulation. Furthermore, the extension N400 was also discernible in a more typical time window (350–500 ms) when ERPs were averaged relative to the onset of NP2 (see Fig. 5.3): Even though the effect appears quite diffuse due to the temporal jitter, it still reaches significance between 350 and 500 ms, as is evident in a main effect of ORDER at both the midline electrodes ($F(1, 23) = 6.60$, $p < .02$) and the lateral electrodes ($F(1, 23) = 5.56$, $p < .03$).

5.5.2 Additional ERP effects for object-initial orders

In addition to the predicted effects, Experiment 1 revealed several further ERP correlates for object-initial vs. subject-initial sentences: a broadly-distributed positivity (400–650 ms) relative to the case marker of NP1, a broadly distributed positivity (200–350 ms) relative to the case marker of NP2, and a posterior negativity (650–

1050 ms) relative to the onset of the verb. These effects shall be discussed in the following.

Positivities relative to the case markers of NP1 and NP2

Experiment 1 revealed positivity effects for object-initial sentences relative to the onset of the case markers of both NP1 (400–650 ms) and NP2 (200–350 ms). The effect at NP2 will be discussed first, since it is more easily explained in terms of the existing literature. Following this, the effect at NP1 will be considered. In accordance with previous findings and suggestions in the literature (e.g. Fiebach et al., 2002; Phillips et al., 2005; Ueno & Kluender, 2003), the positivity for object-initial sentences at NP2 may be interpreted as reflecting the resolution of a dependency introduced by an initial accusative-marked argument. Interestingly, the use of auditory presentation in Experiment 1 allowed a dissociation of this positivity for object-initial orders from the extension N400 for subject-initial orders that was described in the previous section (cf. Bornkessel et al., 2004a). The present findings seem to support the hypothesis put forward earlier (see Section 3.1.4) that effects at the position of NP2 in visual studies on word order permutations may, in fact, comprise both of these aspects of processing: the extension from an intransitive to a transitive reading in subject-initial structures (reflected in an N400) and the resolution of a dependency in object-initial structures (reflected in a positivity). As these processes must be initiated on the basis of different information types (word category vs. case marking of NP2), they can be dissociated in auditory presentation, where these information sources become available at separable points in time. By contrast, when the critical NP is presented as a whole, as is the case in visual presentation, the two effects are relatively difficult to tease apart, as they both imply more negative-going ERPs for subject- as opposed to object-initial conditions. Hence, with visual presentation, the positivity induced by dependency resolution in object-initial sentences may be masked by the extension N400 for subject-initial conditions, or vice versa (cf. Fiebach et al., 2002, vs. Bornkessel et al., 2004a).

The preceding discussion also provides a possible explanation for the positivity observed for object-initial sentences between 400 and 650 ms post-onset of the case marker of NP1. Assuming, as argued above, that the positivity observed for object-initial sentences at the case marker of NP2 can be viewed as a correlate of dependency resolution, it appears plausible to assume that the positivity relative to the case marker of NP1 might reflect dependency *formation*. However, as this effect occurred both in sentences with a prosodic boundary (in which the processing system commits to a scrambling analysis at the position of the first argument) and in sentences without a prosodic boundary (in which no such commitment seems to be made), the dependency in question does not appear to be strictly dislocation-based. In other words, it is not the type of dependency between the surface position of a scrambled accusative argument and its gap position, which has featured prominently in previous accounts of word order processing (e.g. De Vincenzi, 1991; Fiebach et al., 2002; Gibson, 1998, 2000). Similarly, it does not appear to be the dependency between an argument and the subcategorizing verb (e.g. Felser et al., 2003; Kaan et al., 2000; Phillips et al., 2005). Rather, it may reflect some aspect of the dependencies that every accusative object introduces independently of whether it has been dislocated or not: As described above, the presence of an accusative argument indicates that the event being described is transitive, i.e. involves a second participant (whether it is expressed overtly or not). While this assumption of a transitive event per se does not seem to engender an increase in processing cost (no N400 at the position of the first case marker; see Section 3.1.4), undergoer arguments (which are typically marked with the accusative case) have been analyzed as thematically dependent on actor arguments (Primus, 1999; see also Footnote 27). Hence, accusative arguments, while not necessarily introducing an open dependency on a structural level (e.g. with a gap), do always introduce an open dependency on a semantic level (i.e. with an actor). Importantly, this type of dependency is not restricted to a particular sentence construction (e.g. scrambling), but rather always needs to be established when an accusative is encountered. Thus, the positivity observed relative to the case marker of all initial accusative arguments may reflect the formation of this type of dependency. Due to the lack of additional evidence in support of this assumption, however, further research is clearly required for a better understanding of this component (see Section 9.3.2).

Negativity relative to the sentence-final verb

At the position of the verb, a late posterior negativity was observed for object- vs. subject-initial sentences. This result is partly compatible with a previous ERP finding on Japanese: As mentioned in Section 4.2, Ueno & Kluender (2003) reported an anterior negativity (300–900 ms) for scrambled vs. non-scrambled sentences at the position of the verb and posited that this negativity reflects "global working memory demands of having had to process a non-canonical scrambled structure" (Ueno & Kluender, 2003, p. 266). In spite of the superficial similarity between this previous finding and the present results, however, it is not entirely clear whether the observed negativities are indeed comparable. First, in contrast to the anterior distribution of the negativity observed by Ueno and Kluender, the negativity observed in the present experiment had a clear posterior maximum. Second, its latency (which had an onset at approximately 650 ms) was substantially longer than that of the negativity observed by Ueno and Kluender. Whereas Fiebach et al. (2002) also reported a marginally significant *posterior* negativity at the position of the verb for object- vs. subject-initial sentences in German, this effect again occurred considerably earlier (400–700 ms) than the negativity observed here. Given these many differences across experiments, it is virtually impossible to derive a precise interpretation of the negativity observed in the present study based on previous experiments. It does, however, appear noteworthy that this effect occurred in both of the object-initial conditions. It was thus independent of the prosodic realization of the sentence and, thereby, of the occurrence of a scrambling negativity. Therefore it seems reasonable to also favor an interpretation of the effect in terms of global processing costs for object-initial sentences. Such an explanation also appears plausible in view of the error rates and reaction times for the behavioral task in Experiment 1, which consistently revealed higher processing costs for all object-initial structures, independently of whether they engendered a scrambling negativity or not.

5.5.3 Conflicting evidence from a visual experiment on Japanese?

In a study that was not yet published at the time of implementation of Experiment 1, Hagiwara et al. (2007) employed somewhat different sentence structures to the ones used here, as illustrated in (37) below, in a visual experiment. As the initial object in (37b) is dislocated from a base position in the subordinate clause, Hagiwara and colleagues in fact investigated a case of more complex across-boundary scrambling instead of the local scrambling within main clauses that is in the focus of this thesis. Nonetheless, their results may still be compared with the findings revealed in Experiment 1, at least partially, since due to the high level of ambiguity in Japanese, the initial accusative object in (37b) could alternatively be interpreted as the scrambled object of a simple main clause. Rather than comparing the initial accusative with an initial nominative, though, Hagiwara and colleagues used arguments bearing the topic marker *-wa* in their control condition for scrambling (37a). However, as topic-marked NPs typically appear in the sentence-initial position in Japanese and mostly concur with the sentence subject, the structures used by Hagiwara and colleagues may be considered comparable to the sentences employed in Experiment 1, at least at the position of NP1.

(37) Example sentences from Hagiwara et al. (2007)

(a)

Kaiken-de	*shacho-wa*	*hisho-ga*	*bengoshi-o*
at the meeting	president-TOP	secretary-NOM	lawyer-ACC
sagasiteiru	*to*	*itta*	
was looking for	COMP	said	

(b)

Kaiken-de	*bengoshi-o*	*shacho-wa*	*hisho-ga*
at the meeting	lawyer-ACC	president-TOP	secretary-NOM
sagasiteiru	*to*	*itta*	
was looking for	COMP	said	

'At the meeting, the president said that the secretary was looking for the lawyer.'

Similar to Ueno & Kluender (2003), Hagiwara et al. (2007) reported a sustained anterior negativity (SAN) for the processing of scrambled sentences, in addition to a widely distributed positivity between 300 and 600 ms at the position of the subject NP of the subordinate clause (NP3), and an anterior negativity between 200 and 600 ms at the position of the sentence-final main clause verb. Even though the sentence structures employed by Hagiwara and colleagues involved across-boundary scrambling, the latter two effects may be considered comparable to the effects described in Section 5.5.2 above.

Thus, in accordance with previous findings (Fiebach et al., 2002; Phillips et al., 2005; Ueno & Kluender, 2003) and with the ERPs averaged at the position of the second case marker in the current experiment, the positivity effect at the position of the subject NP may reflect the resolution of a dependency introduced by the initial accusative-marked object NP (i.e. the dependency between the identified undergoer and the actor upon which it is semantically dependent). In addition, since Hagiwara and colleagues employed visual stimulus materials, the effect may also comprise an extension N400 for the canonical word order, as discussed above (cf. Bornkessel et al., 2004a, and the ERPs averaged at the position of the WCRP of NP2 in the current experiment). This latter conclusion must however remain hypothetical at this point because the complex sentences employed in this experiment involved the representation of more than one event, thus complicating the derivation of assumptions regarding the event related interpretive processes that may be involved here.

The anterior negativity observed at the position of the sentence-final main clause verb (*itta*) seems to correspond to the ERP effect observed by Ueno & Kluender (2003), as well as (at least partially) to the one observed in the current experiment at the position of the clause-final verb. Hagiwara and colleagues assumed that this negativity is engendered by some general aspect of the processing cost required by scrambled structures. More precisely, because these costs were only observable at the matrix verb in their study, they interpreted them as an index of "recomputing the grammatical relations and thematic roles of the two clauses" (Hagiwara et al., 2007, p. 192). As mentioned above, the varying distributions and latencies of the negativity effect in this and other experiments (e.g. Fiebach et al., 2002; Ueno & Kluender, 2003; the present study) do not allow ultimate conclusions regarding in how far these negativities are related to comparable underlying processes. In principle, however, the negativity effect reported by Hagiwara and colleagues and the interpretation offered by the authors are also compatible with an analysis of the effect in terms of global processing costs for object-initial sentences, as suggested by Ueno & Kluender (2003) and adopted for the effect revealed in the current experiment.

As discussed in Section 3.1.4, the observation of a SAN is also not at odds with the present findings: This effect appears to reflect the maintenance of an open dependency rather than the costs of processing a marked word order per se. In the current experiment, the subject followed the scrambled object immediately without any intervening sentence material. As a consequence, the open dependency between the identified undergoer and the predicted actor did not need to be maintained over a long distance, thus not giving rise to a SAN effect between the point of dependency formation (case marker of NP1) and the point of dependency resolution (case marker of NP2; see Section 5.5.2 above). Crucially, in Hagiwara and colleagues' stimuli, the dependency between the undergoer and the actor of the subordinate clause had to be maintained over a much longer time than in the present study, hence allowing the SAN to develop in their experiment.[40]

To summarize, the results reported by Hagiwara et al. (2007) that were discussed so far appear to be essentially compatible with the results observed in the current experiment. Importantly, however, the SAN reported by Hagiwara and colleagues began quite early (i.e. around 300 ms post-onset of the initial object) and showed no anterior distribution for the first part of the effect (300–500 ms). One might therefore argue that this experiment in fact yielded a scrambling negativity *before* the onset of the actual SAN. The fact that the first part of the negativity effect could plausibly be characterized as a scrambling negativity is not so easily reconciled with the present findings. Recall that when the processing system encounters an initial object, it was argued that it adopts the phrase structurally minimal analysis as a default, namely an analysis in which the object is taken to be the only argument in a sentence with a dropped subject. Hence, additional prosodic information was

[40] As noted in Section 4.2, Ueno & Kluender (2003) also observed a SAN at positions following scrambled objects. However, in contrast to Hagiwara et al. (2007) and to the present study, Ueno & Kluender (2003) compared ERP responses to elements in different positions within the clause. Therefore a comparison with the results presented here is only possible to a limited extent.

required in order to trigger the more costly scrambling analysis in Experiment 1. In experiments without such an additional prosodic manipulation, one should therefore expect the processing system to adopt the default subject-drop interpretation, thus not engendering a scrambling negativity. Why, then, did Hagiwara and colleagues' study show a scrambling negativity whereas the noPB-condition in Experiment 1 did not? In essence, there were two main differences between the two experiments: (a) auditory vs. visual presentation and (b) the choice of control condition (involving an initial topic-marked argument vs. an initial nominative-marked argument). Either of these properties could, in principle, be responsible for the finding of a scrambling negativity by Hagiwara and colleagues and the absence of such an effect in the structures without a prosodic boundary in the current experiment. However, given the fact that both nominative-marked and topic-marked arguments are preferentially positioned clause-initially in Japanese and are both most likely to indicate the subject of the clause, it appears somewhat unlikely that the different results were engendered by this distinction. Rather, it might be the case that visual presentation leads the system to make the same processing assumptions as in structures with a prosodic boundary. This hypothesis was tested in Experiment 2.

Chapter 6

Experiment 2: Word order & object case

6.1 Introduction

Experiment 2 aimed to examine whether visual presentation of the sentence conditions used in Experiment 1 would engender a scrambling negativity for initial accusative objects. If this were indeed the case, the apparent discrepancy between the findings of Experiment 1 and the results reported by Hagiwara et al. (2007) could be attributed to processing differences induced by visual vs. auditory presentation. More precisely, the observation of a scrambling negativity in visual presentation would speak in favor of a correspondence between the word-by-word visual presentation and the auditory presentation *with* a prosodic boundary following the initial argument. Recall in this regard that it was originally assumed that a visually presented initial accusative should be processed in a comparable fashion to an auditorily presented accusative *without* a prosodic boundary, since both of these presentation modalities should allow a phrase structurally minimal reading of the accusative object as the only argument of a sentence with an omitted subject (i.e. an OV reading). Due to adjacency constraints between the accusative object and the verb in an OV sentence, a prosodic boundary following the initial object rules out this minimal one-argument reading and leads to the prediction of a second argument. Following an initial subject, on the other hand, the prosodic boundary does not engender the prediction of a second argument, since a subject does not form a minimal syntactic or information structural unit together with the verb. Therefore, a revision from a one-argument phrase structure to a two-argument phrase structure is only necessary following an initial object with a prosodic boundary, but not following an initial object without such a boundary or following an initial subject (with or without a boundary). Crucially, the original assumption that visually presented initial objects should be processed similarly to auditorily presented initial objects without a prosodic boundary (and thus engender no scrambling negativity) is critically challenged by the finding of a scrambling negativity for visually presented initial objects (Hagiwara et al., 2007). These results rather suggest that visual presentation is somehow comparable to auditory presentation *with* a prosodic boundary after the initial argument. Possible reasons for such a correspondence may lie in the segmentation of the sentences for visual presentation, as will be discussed in more detail in Section 6.5. To examine the hypothesis that the occurrence of a scrambling negativity in Hagiwara and colleagues' experiment was due to the employed presentation modality and a correspondence between visual presentation and the prosodically marked auditory presentation modality, the accusative- and nominative-initial sentences from Experiment 1 were presented visually in a word-by-word paradigm in Experiment 2.

In addition, and in order to provide a further test for the assumption that the scrambling negativity reflects a violation of the Minimality principle at the phrase structural level, Experiment 2 introduced a second manipulation. Thus, in addition to sentences with accusative objects (as in Experiment 1), we also examined sentences with dative objects, that is sentences in which the object bears a different morphological marker. This variation is conditioned by the particular type of verb (for example, *maneku*, "to invite", takes an accusative object, while *kougisuru*, "to object to", takes a dative object; similar to the distinction between *besuchen* and *helfen* in German; cf. Examples 21 and 23). The distinction between accusative and dative case is potentially relevant from the phrase structural perspective on the scrambling negativity because the two types of case markers can be associated with different structural options in many languages. Recall from Section 3.1.3 that sentences with an initial dative argument in the German middlefield (such as Example 23b) have been shown to engender no scrambling negativity under certain circumstances (Bornkessel et al., 2002). As discussed in detail in Section 3.1.4, the absence of a scrambling negativity in such dative-initial sentences can be explained via the application of phrase structural Minimality: Dative-marked arguments could be the only argument in the sentence, namely in the case of a passive continuation (as in Example 29). If such an analysis is adopted for an initial dative-marked argument, no second argument is predicted in the phrase structure, and thus phrase structural Minimality is not violated at the position of an initial dative-marked NP.

While this type of phrase structural distinction between dative and accusative case is not possible for Japanese (dative sentences do not behave differently from accusative sentences in passivization), another kind of distinction between dative and accusative case in Japanese may have similar phrase structural consequences. In this regard it is important to know that Japanese constitutes a language with *dative subject constructions*.[41] This type of construction is illustrated in (38).

(38) Dative subject sentence (from Sugioka, 1985; cited from Ura, 2000)

Taroo-ni	*eigo-ga*	*dekiru.*
Taroo-DAT	English-NOM	understands

'Taroo understands English.'

In sentences such as (38), the initial dative argument is the subject of the sentence, and also, in interpretive terms, the actor (typically, the type of actor described by a dative subject is an *experiencer*, while the type of undergoer described by the nominative object in such a construction is usually a *stimulus*). Due to the possible subject interpretation, initial dative arguments should behave like initial nominative arguments on a phrase structural level. More precisely, the dative-marked argument in a dative subject construction does not form a minimal unit together with the sentence-final verb (i.e. there is no adjacency constraint between these elements), neither in the complete version of such a sentence as in (38), nor in a reduced version with the dative NP as the only overt argument (i.e. an object-drop sentence; for example, *Taroo-ni dekiru*, "Taroo understands [ ]"). Therefore, a one-argument reading should be possible for an initial dative independently of the insertion of a prosodic boundary (and possibly, by extension, visual presentation). Thus, as opposed to an initial accusative, an initial dative should never engender a scrambling negativity, since no mismatch with the previously selected minimal phrase structure template ([NP–V]) arises from the dative case information, and phrase structural Minimality is therefore not violated.[42]

[41] From the perspective of traditional grammar, "dative subject" may appear as a contradiction in terms because nominative marking is one of the classic defining properties of subjecthood. However, cross-linguistic research has revealed the existence of non-nominative subjects in a number of languages from all parts of the world, e.g. Hindi, Russian, Icelandic (cf. Bhaskararao & Subbarao, 2004). While these arguments do not bear nominative case and sometimes show no (or only reduced) agreement with the verb, they display a number of other subject properties e.g. with respect to control, reflexivization, deletion under conditions of coreference, etc.

[42] Note that this prediction crucially hinges upon the confirmation of the primary hypothesis stated above, namely that visually presented initial arguments in Japanese are processed in a comparable manner to auditorily presented initial arguments followed by a prosodic boundary. If this assumption turned out to be incorrect, any predictions regarding the difference between initial accusatives and datives would be rendered obsolete. However, as the findings reported by Hagiwara et al. (2007)

Interestingly, the distinction between dative and accusative arguments on a phrase structural level does not extend to the interpretive level of representation, i.e. regarding the transitivity of the described event. As mentioned above, an initial dative-marked argument can be interpreted as an actor, for example as the experiencer in an event described by a so-called *psych-verb* such as *dekiru* ("to understand") in (38). However, as opposed to an actor that is represented by a nominative-marked argument, an actor in a dative subject construction can never be the sole participant in an intransitive event. This is due to the fact that verbs describing intransitive events in Japanese always assign nominative case to their actors, while dative case is only assigned to undergoers or actors of transitive events (i.e. by active verbs or psych-verbs, respectively). Based on interpretive Minimality, an initial dative should thus behave just like an initial accusative: Both types of arguments signal a transitive event, while an initial nominative is compatible with a more minimal intransitive event reading. Therefore, increased processing costs for the revision from an intransitive to a transitive event (in the form of an extension N400) should arise at the position of a second argument following an initial nominative, but not following an initial accusative or dative argument.

6.2 Design and hypotheses

In summary, visually presented initial accusatives were expected to elicit a scrambling negativity based on the application of phrase structural Minimality, and due to a correspondence between visual word-by-word presentation and the prosodically marked auditory presentation modality. Since initial dative-marked arguments could alternatively be interpreted as subjects, no such effect was expected for initial datives. Since, however, initial accusatives and initial datives both signal transitive events, both were expected to entail a processing advantage in comparison to their nominative-initial counterparts at the position of a second argument, based on the application of interpretive Minimality. Thus, initial datives in Japanese were predicted to behave differently from initial accusatives with regard to the phrase structural representation level but similarly to initial accusatives with regard to the interpretive representation level. To examine these differential predictions, Experiment 2 employed the critical sentence conditions illustrated in Table 6.1. As the table shows, the design crossed the factors word ORDER (subject-before-object vs. object-before-subject) and object CASE (accusative object vs. dative object).

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strongly speak in favor of a scrambling negativity for visually presented initial accusatives, the prediction of a similar effect for the accusative sentences in the present experiment seems reasonable.

Our hypotheses were as follows:

(a) If the presence of a scrambling negativity in the study by Hagiwara et al. (2007) was due to the use of visual presentation (and thus, to the correspondence of this presentation modality with the prosodically marked auditory presentation in Experiment 1), we should observe a scrambling negativity for initial accusative objects in comparison to initial subjects in Experiment 2. Therefore, at the position of NP1, a significant effect was predicted for the comparison between initial nominative- and accusative-marked arguments.

Table 6.1: Example sentences for each of the four critical conditions in Experiment 2

Example word set				
	二週間前 nishuukanmae two weeks ago	判事 hanji judge	大臣 daijin minister	招きました manekimashita invited 抗議しました kougishimashita objected to
Condition	**Example sentence**			
SOV-Acc	二週間前 nishuukanmae two weeks ago	判事が hanji-ga judge-NOM	大臣を daijin-o minister-ACC	招きました manekimashita invited
	'Two weeks ago, the judge invited the minister.'			
OSV-Acc	二週間前 nishuukanmae two weeks ago	判事を hanji-o judge-ACC	大臣が daijin-ga minister-NOM	招きました manekimashita invited
	'Two weeks ago, the minister invited the judge.'			
SOV-Dat	二週間前 nishuukanmae two weeks ago	判事が hanji-ga judge-NOM	大臣に daijin-ni minister-DAT	抗議しました kougishimashita objected to
	'Two weeks ago, the judge objected to the minister.'			
OSV-Dat	二週間前 nishuukanmae two weeks ago	判事に hanji-ni judge-DAT	大臣が daijin-ga minister-NOM	抗議しました kougishimashita objected to
	'Two weeks ago, the minister objected to the judge.'			

Abbreviations used: SOV, subject-object-verb; OSV, object-subject-verb; Acc, accusative; Dat, dative. Segmentation for visual presentation is indicated by spaces.

(b) If, as we have hypothesized thus far, the scrambling negativity reflects the violation of phrase structural Minimality, we would expect to observe no such effect for initial dative arguments. As a consequence, no significant effect was predicted at the position of NP1 for the comparison between initial nominative- and dative-marked arguments.[43]

(c) As in Experiment 1, we expected to observe an extension N400 for subject- as opposed to object-initial sentences at the position of NP2. Since the extension from an intransitive to a transitive event at this position was required in both subject-before-object orders (nominative-before-accusative and nominative-before-dative) in comparison to both object-before-subject orders (accusative-before-nominative and dative-before-nominative), a main effect of ORDER was expected at this position.

(d) If the additional positivity effects observed for object-before-subject structures in Experiment 1 (relative to the case markers of NP1 and NP2) are robust correlates of word order processing, we may observe comparable effects in Experiment 2. A further interesting question in this regard may be whether these effects only occur in accusative sentences or also in dative sentences. On the one hand, only the initial accusatives unambiguously identify an undergoer which is semantically dependent on an unmentioned actor. Therefore, the dependency formation and resolution processes described in Section 5.5.2 may only apply to accusative-initial sentences. On the other hand, some kind of dependency may also be formed in the dative sentences, even if a dative subject reading is initially chosen (in that case, a dependency from an identified actor to a predicted dependent undergoer). Thus, the related positivity effects may be expected for dative-initial sentences as well. In any case, it should be kept in mind that it was most likely due to the auditory presentation modality in Experiment 1 that the effects arising at the position of the case markers could be separated from otherwise confounding effects arising at the the nouns' onset or WCRP positions. Since in visual word-by-word presentation, the nouns and their case markers are presented simultaneously (see Section 6.3.2), the positivity effects might again turn out to be inseparable from other effects arising at these positions.

[43]Note that the predictions of Hypotheses (a) and (b) are not formulated in the form of an ORDER×CASE interaction, because in both subject-before-object orders the NP1 stimulus was identical (a nominative-marked argument). Therefore, all nominative-initial sentences were collapsed under one condition at the position of NP1 (see 6.3.5), resulting in a three-level factor comprising word order and case at this position.

(e) If the late negativity observed for object-before-subject sentences in Experiment 1 (relative to the onset of the verb) is a robust correlate of word order processing, we should observe a comparable effect in Experiment 2. If, as hypothesized before, this effect reflects global processing costs for object-initial structures, it should not be affected by the case manipulation, since at the position of the verb it is clear that the dative-before-nominative sentences are scrambled OSV sentences with a dative object and not canonical SOV sentences with a dative subject. Therefore, global sentence-final processing costs should arise for both types of scrambled sentences, resulting in the prediction of a main effect of ORDER at the position of the verb.

6.3 Materials and methods

6.3.1 Participants

Twenty-four participants (21 female; aged 22-43; mean age 29.5 years) entered the statistical analysis. All participants were monolingually raised native speakers from the Japanese community of Berlin, right handed, and not impaired in vision or reading abilities. None of the participants had taken part in Experiment 1. A further five participants were excluded from the analysis on the basis of the same criteria for rejection as described in Experiment 1.

6.3.2 Materials

To ensure maximal comparability, the accusative sentences used in Experiment 2 corresponded exactly to the sentences from Experiment 1 (see App. B.1). The dative sentences were constructed by reapplying the adverb-noun1-noun2 triplets employed in the accusative sentences and completing them with dative verbs and case markers (see App. B.2). See Table 6.1 for an example of the resulting four critical conditions.[44] The experimental sentences were segmented for visual presentation. Presentation took place in four bitmap files per sentence, each depicting one *bunsetsu*.[45] One *bunsetsu* had an average length of 3.17 (*SD* 0.76) Japanese

[44] Note that the polite verb form in Japanese is typically restricted to spoken language such as the one used in in Experiment 1 (Kaiser, Ichikawa, Kobayashi, & Yamamoto, 2001). In Experiment 2, however, we nevertheless employed this verb form in visual presentation for the sake of maximal comparability with Experiment 1. In Experiments 3 and 4, which also employed visual presentation but did not include identical stimulus materials, the verbs were presented in the shorter plain form.

[45] A *bunsetsu* is a basic phonological phrase consisting of a content word (such as adverb, noun, verb) and its associated functional particles (such as case markers). For ease of exposition, the more

characters for the adverbs, 3.97 (*SD* 0.89) characters for the noun phrases, 5.98 (*SD* 0.65) characters for the accusative verbs, and 6.38 (*SD* 1.16) characters for the dative verbs.

The inclusion of filler sentences, division of the sentence material into two lists, randomization of the lists and the construction of comprehension questions was carried out according to the procedures described for Experiment 1.

6.3.3 Procedure

Experimental sessions were conducted in the same setting as in Experiment 1. Again, the procedure consisted of 16 practice trials, followed by eight blocks of 40 sentences each. In each trial, after the presentation of a fixation asterisk for 650 ms, the critical sentence was presented one bunsetsu at a time. Each bunsetsu was visible in the center of the computer screen for 650 ms,[46] followed by an interstimulus interval (ISI) of 100 ms. One thousand milliseconds after the end of each sentence, the comprehension question was presented on the screen in the same way as for Experiment 1. After an intertrial interval (ITI) of 1000 ms the next trial began. Participants were asked to avoid movements and only blink between the onset of the comprehension task and the onset of the asterisk preceding the next sentence.

6.3.4 EEG recording and preprocessing

The EEG was recorded and data preprocessing steps were undertaken in an analogous manner to Experiment 1.

6.3.5 Statistical analyses

Error rates and reaction times in the comprehension task were analyzed by means of a repeated measures analysis of variance (ANOVA) containing the condition factors ORDER (subject-before-object vs. object-before-subject) and CASE (sentence with an accusative object vs. sentence with a dative object) and the random factors participants (F_1) and items (F_2). Again, incorrect responses did not enter the reaction time analysis.

For the statistical analysis of the ERP data averaged at the positions of NP2 and the verb, repeated measures ANOVAs also comprised the condition factors

conventional term word-by-word presentation will be used in the remainder of the thesis to refer to bunsetsu-by-bunsetsu presentation.

[46] The presentation duration of 650 ms was considered reasonable due to the complexity of Japanese characters, and was perceived as a comfortable reading rate by most participants of the current experiment (for a similar presentation rate, see Ueno & Kluender, 2003).

ORDER (subject-before-object vs. object-before-subject) and CASE (sentence with an accusative object vs. sentence with a dative object).

For the analysis of the first NP, the two nominative-initial conditions (which were identical at this point) were combined into a single condition, resulting in a single 3-level experimental factor CONDITION (nominative-initial vs. accusative-initial vs. dative-initial). As described above, the following two pairwise comparisons were of interest: nominative-initial vs. accusative-initial (i.e. SOV vs. OSV-Acc), and nominative-initial vs. dative-initial (i.e. SOV vs. OSV-Acc). While it is a very common strategy to first perform an omnibus F test (e.g. in our case a one-factorial 3-level ANOVA) and investigate so-called "post-hoc" multiple comparisons between the factor levels only if this analysis reaches significance, statisticians actually point out that this practice is neither pragmatically advisable nor logically or mathematically correct. In fact, none of the multiple comparison procedures employed in research today – with the one exception of the very conservative Scheffé test – was designed to follow up on an omnibus ANOVA. Consequently, the results produced by such procedures are not statistically coherent with the results of a preceding omnibus F test, which should therefore not be employed as a screening instrument for them (for an in-depth discussion of the pragmatical, logical and statistical reasons why most multiple comparison methods such as the Bonferroni procedure need not and in fact *should* not be preceded by an omnibus F test, see, for example, Castaneda, Levin, & Dunham, 1993, Wilkinson & the Task Force on Statistical Inference, 1999, Jaccard & Guilamo-Ramos, 2002, Ruxton & Beauchamp, 2008). Due to these restrictions, the results presented here and in the course of the following experiments (which also included factors comprising more than two levels) will focus directly on the planned comparisons of interest. Since in the current experiment, based on Hypotheses (a) and (b), two pairwise comparisons were planned for the ERPs averaged at the position of NP1, the comparisonwise p values were adjusted to counteract an inflation of the familywise error rate employing a Bonferroni procedure ($p_b = 2 \times p$). Below, the corrected p values will be reported for each of the pairwise comparisons (PC).

For the analysis of interactions with topographical factors, regions of interest (ROIs) were defined as in Experiment 1, thus resulting in four lateral and six midline ROIs. Again, statistical analyses were carried out hierarchically and Huynh-Feldt (H-F) corrections were applied when necessary.

6.4 Results

6.4.1 Behavioral data

Error rates and reaction times for the behavioral task are shown in Table 6.2. As in Experiment 1, object-initial structures engendered higher error rates and longer reaction times, thereby suggesting increased overall processing difficulty.

For the error rates, a repeated measures ANOVA revealed a significant main effect of ORDER ($F_1(1, 23) = 44.46$, $p < .001$; $F_2(1, 79) = 98.32$, $p < .001$). This effect resulted from a generally higher error rate for object-initial as opposed to subject-initial conditions.

With regard to the reaction times, the analysis also showed a main effect of ORDER ($F_1(1, 23) = 23.20$, $p < .001$; $F_2(1, 79) = 23.55$, $p < .001$). As in Experiment 1, reaction times will not be interpreted further.

6.4.2 ERP data

For the analysis of the ERP data, we proceeded according to the predictions formulated in Section 6.2. Thus, we examined ERPs at the position of NP1 to test the hypotheses with respect to the scrambling negativity, and ERPs at the position of NP2 to investigate whether subject-initial sentences engendered an extension N400. Potential positivity effects for the formation and resolution of dependencies were expected to become evident at the same positions. (Due to the mode of segmentation chosen for visual presentation, ERPs could not be time-locked to the onset of the case marker as in Experiment 1.) Finally, we also examined ERPs at the position of the verb in order to see whether we would replicate the late negativity for object-initial sentences observed in Experiment 1.

Table 6.2: Mean error rates and reaction times in the comprehension task of Experiment 2

Condition	Mean error rate (%)		Mean reaction time (ms)	
SOV-Acc	4.8	(4.8)	1705	(303)
OSV-Acc	16.7	(11.1)	1795	(329)
SOV-Dat	5.1	(3.0)	1684	(290)
OSV-Dat	17.0	(10.4)	1839	(304)

Standard deviations (of the participant analysis) are given in parentheses.

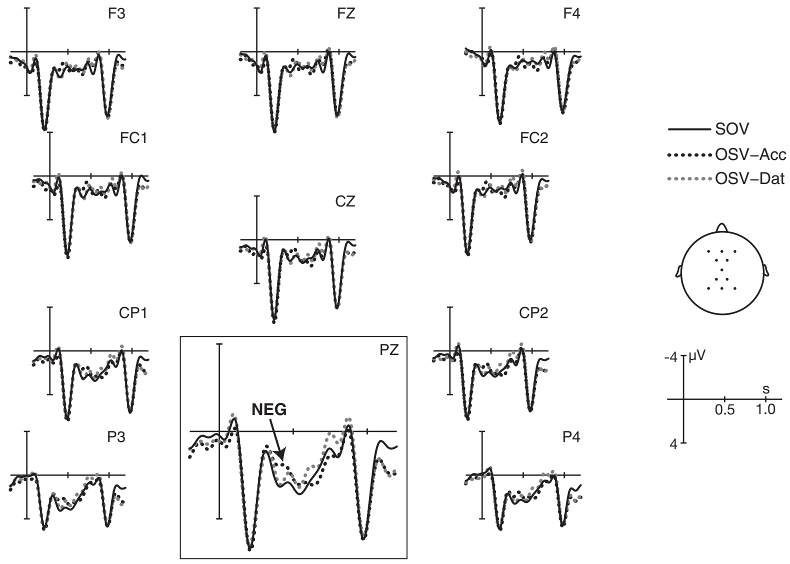

Figure 6.1: Grand-average ERPs (N = 24) time-locked to the onset of NP1 (onset at the vertical bar) in Experiment 2.

NP1

Fig. 6.1 shows grand average ERPs at the position of NP1. As the two subject-initial sentences (SOV-Acc and SOV-Dat) were still identical at this point (nominative-marked first NP), they were collapsed to form a single condition SOV. The figure shows a negativity for accusative-marked first NPs between approximately 350 and 500 ms. In comparison, the effect seems strongly reduced for dative-marked NPs.

For this time window, the pairwise comparison (PC) between the accusative-initial condition and the nominative-initial condition showed a significant main effect of PC both at midline electrodes ($F(1, 23) = 8.58$, $p_b < .02$) and at lateral electrodes ($F(1, 23) = 9.29$, $p_b < .02$). At lateral electrodes, the main effect was further accompanied by a significant interaction PC×ROI ($F(3, 69) = 5.03$, $p_b < .009$). Resolving the interaction by ROI revealed significant effects at all topographical regions with the exception of the right-anterior ROI ($F(1,23) = 1.30$, $p_b = .53$; all other positions: Fs > 7, p_bs $< .03$).

While the main effect of PC did not reach significance in the pairwise comparison between the dative-initial condition and the nominative-initial condition (both Fs < 1), this analysis revealed a significant interaction PC×ROI at midline electrode sites ($F(5, 115) = 7.27$, $p_b < .003$) as well as in lateral regions ($F(3, 69) = 6.09$, p_b

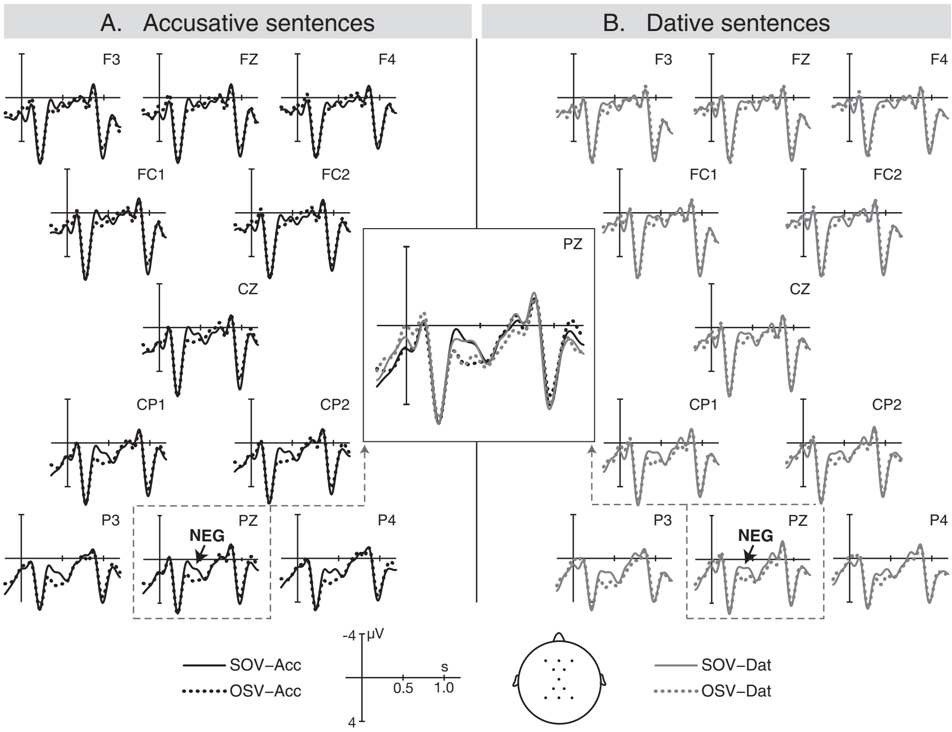

Figure 6.2: Grand-average ERPs (N = 24) time-locked to the onset of NP2 (onset at the vertical bar) in Experiment 2.

< .005). Resolving these interactions by ROI, however, did not reveal a significant effect of PC at any topographical region (all Fs < 4, all p_bs $> .18$).

While the analysis of the 350–500 ms time window thus revealed a negativity only for accusative-initial sentences, visual inspection of Fig. 6.1 suggests that the dative-initial structures may have led to a later negativity, i.e. between approximately 500 and 800 ms. Additional analyses computed within this later time window, however, did not reveal any significant effects at midline or at lateral electrode sites.

NP2

Grand average ERPs time-locked to the onset of NP2 are shown in Fig. 6.2. Visual inspection shows a negativity for subject-initial sentences between approximately 300 and 500 ms, which seems to be stronger at central and parietal electrodes than at frontal sites and which is equally clear for accusative and dative sentences.

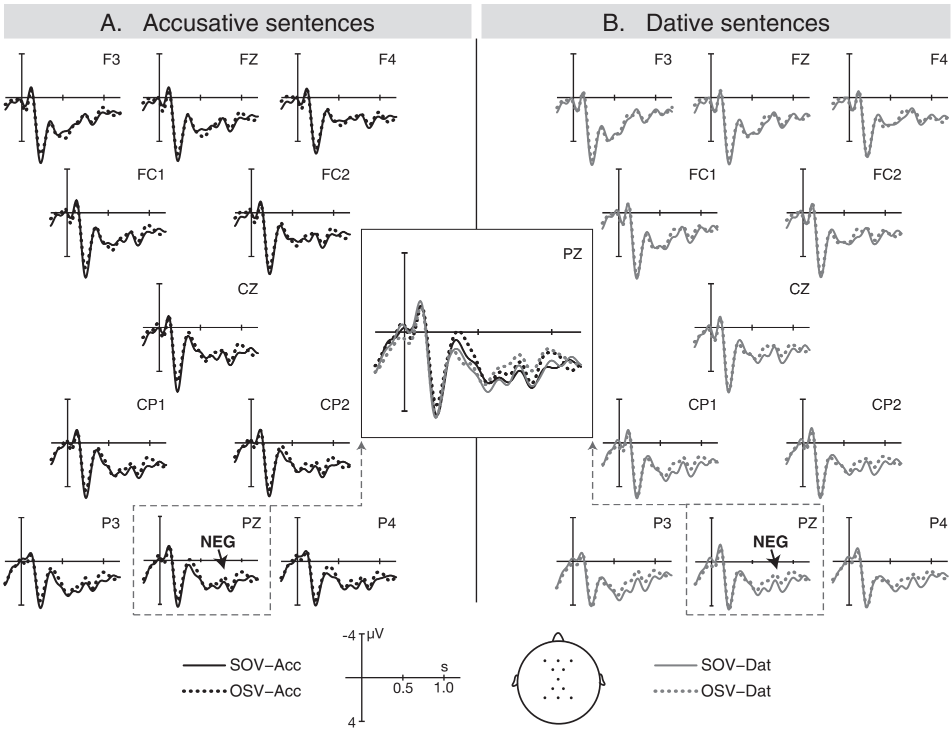

Figure 6.3: Grand-average ERPs (N = 24) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 2.

At midline sites, the statistical analysis for this time window showed a main effect of ORDER ($F(1,\ 23) = 10.60$, $p < .004$) as well as an interaction ORDER×ROI ($F(5,\ 115) = 7.50$, $p < .001$). The effect of ORDER reached significance at all electrodes (all Fs > 5, ps $< .04$). The analysis of the lateral electrodes showed a similar pattern with a main effect of ORDER ($F(1,\ 23) = 9.55$, $p < .006$) and an interaction ORDER×ROI ($F(3,\ 69) = 14.78$, $p < .001$). Resolving the interaction revealed significant effects of ORDER in all topographical regions except for the right-anterior ROI ($F(1,23) = 1.14$, $p = .30$; all other positions: Fs > 7, ps $< .01$).

Verb

Grand average ERPs relative to the onset of the verb are shown in Fig. 6.3. Visual inspection suggests that, as in Experiment 1, all object-initial conditions engendered a negativity with a parietal maximum in comparison to their subject-initial counterparts. This effect was analyzed in the same time window as in Experiment 1 (650–1050 ms). As the conditions also appear to differ from one another between approximately 350 and 550 ms post-verb onset, we additionally performed a statistical analysis for this earlier time window.

The midline analysis for the earlier time window (350–550 ms) revealed a significant main effect of CASE ($F(1, 23) = 8.40$, $p < .009$; accusative sentences more negative) as well as an interaction ORDER×ROI ($F(5, 115) = 8.33$, $p < .002$). Resolving the interaction by ROI did not yield significant effects of ORDER at any electrode position (all Fs < 3, ps $> .09$). The analysis of the lateral electrodes also showed a significant main effect of CASE ($F(1, 23) = 10.02$, $p < .005$) accompanied by an interaction ORDER×ROI ($F(3, 69) = 5.16$, $p < .005$). Resolving the interaction by ROI again led to no significant effects (all Fs < 1). Since the dative and accusative verbs differed with regard to a number of properties (e.g. lexical characteristics; see also Schlesewsky & Bornkessel, 2006, or Haupt, 2008, for a similar negativity effect for accusative verbs in comparison to dative verbs in German), and because the case manipulation was considered interesting primarily with regard to possible interactions with the word order manipulation, the main effect of CASE at this position will not be discussed in any more detail.

The statistical analysis of the midline electrodes for the later time window (650–1050 ms) revealed a main effect of ORDER ($F(1, 23) = 13.13$, $p < .002$), as well as an interaction ORDER×ROI ($F(5, 115) = 4.93$, $p < .03$). Resolving the interaction revealed significant effects of ORDER at all electrodes but FZ ($F(1, 23) = 1.27$, $p = .27$; all other Fs > 5, ps $< .03$). A similar pattern was observable in the analysis of the lateral electrodes, which also showed a main effect of ORDER ($F(1, 23) = 7.13$, $p < .02$) and an interaction ORDER×ROI ($F(3, 69) = 4.93$, $p < .01$). Here, the effect of ORDER only reached significance in posterior regions (left: $F(1, 23) = 28.36$, $p < .001$; right: $F(1, 23) = 15.88$, $p < .001$).

6.5 Discussion

The following effects were observed in Experiment 2: (a) a posterior negativity (350–500 ms) at the position of NP1 for initial accusative-marked arguments, but not for initial dative-marked arguments; (b) a posterior negativity (300–500 ms) at the position of NP2 for all subject-initial orders; (c) a posterior negativity (650–1050 ms) for all object-initial orders at the position of the verb. In the following, I will first discuss the findings regarding the scrambling negativity and the N400 effect, which were in the focus of the experiment (a–b), before turning to a discussion of the additional effect observed for object-initial orders at the verb position (c) and the additional effects that were observed for object-initial orders in Experiment 1 but not in Experiment 2 (cf. Hypothesis d).

6.5.1 Scrambling negativity and extension N400

The results of Experiment 2 confirmed the main predictions formulated on the basis of Experiment 1: A scrambling negativity was observed for initial accusatives but not for initial datives, and an extension N400 was observed for the second argument of all subject-before-object sentences, independently of the object case.

The scrambling negativity for object-initial orders

Using visual presentation, we observed a scrambling negativity for the identical accusative-initial sentences that had only engendered such an effect in the presence of a prosodic boundary in Experiment 1. Note that the posterior topography of the effect does not preclude its interpretation as a scrambling negativity, as several studies on German have also reported scrambling negativities with centro-parietal distributions (Bornkessel & Schlesewsky, 2006b; Bornkessel et al., 2003). In addition, the finding that effects which are widely distributed under auditory presentation conditions show a more centro-parietal focus in studies using visual presentation is well documented (e.g. in the N400 literature; Domalski et al., 1991). The observation of a scrambling negativity in Experiment 2 thus provides strong converging support for the assumption that the results by Hagiwara et al. (2007) were crucially influenced by the modality of presentation. These findings suggest that the visual word-by-word presentation had a similar effect as the prosodic segmentation in Experiment 1: In both cases, an initial accusative argument led to the prediction of a second (nominative) argument in the phrase structure, thereby engendering a mismatch with the minimal (one-argument) phrase structure previously selected on the basis of word category information and phrase structural Minimality. The implications of a convergence between the visual presentation modality and a marked prosodic realization will be discussed in more detail below (see Section 6.5.3).

In contrast to initial accusative arguments, initial dative arguments did not engender a scrambling negativity. This result is in accordance with the hypothesis that the scrambling negativity reflects a violation of phrase structural Minimality. Due to the possibility of dative subjects, an initial dative does not require the prediction of a second argument in the phrase structure, not even if it is followed by a syntactic or information structural boundary as indicated by a prosodic pause and apparently also by visual presentation (see below). Therefore no mismatch with a previously selected one-argument phrase structure arises and thus Minimality is not violated. From this perspective, it was predicted that the specific properties of dative case in Japanese should lead to an attenuation of the scrambling negativity, and this was, in fact, precisely what we observed.

The extension N400 for subject-initial orders

Experiment 2 revealed an N400 for subject- vs. object-initial sentences at the position of NP2 which did not differ between the accusative and dative conditions. This finding precisely mirrors the predictions that were made on the basis of interpretive Minimality. As described before, an initial nominative-marked subject is in principle compatible with an intransitive event reading, and based on interpretive Minimality, this intransitive reading will be preferred. When the second NP is subsequently encountered, an extension is necessary from the intransitive to the transitive reading. By contrast, initial accusatives always signal a transitive event. Crucially, initial datives also signal a transitive event, even if they are not interpreted as undergoers, since sentences with dative subjects never describe intransitive events either. Thus, on an event related interpretive level, it does not matter whether an initial dative is analyzed as the undergoer of a transitive event (object interpretation) or as the actor of a transitive event (subject interpretation). In both cases, a transitive event is signaled already at the position of the initial dative argument. Since an extension from an intransitive to a transitive reading is therefore necessary at the position of the second NP for all nominative-initial sentences, but neither for the accusative- nor for the dative-initial sentences, an extension N400 arises in all subject-initial sentences (nominative-before-accusative and nominative-before-dative) in comparison to all object-initial sentences (accusative-before-nominative and dative-before-nominative).

Interestingly, the present results indicate that in contrast to the assumptions formulated earlier, the transitivity assessment regarding the described event does not seem to depend on the GR (actor/undergoer) assigned to the argument under consideration. Recall that previously (e.g. in Section 3.1.4 or 4.2), the transitive event interpretation at the position of an initial accusative was derived from the interpretation of an accusative as an undergoer and the resulting prediction of an actor (since an undergoer is hierarchically dependent on an actor). The fact that datives, which do not need to be interpreted as undergoers, appear to behave similarly to accusatives regarding the event interpretation seems to indicate that the transitivity assessment does not rely upon GR assignment but is independently motivated by the case information. In terms of the eADM (Bornkessel & Schlesewsky, 2006a) this would speak in favor of an additional process in Stage 2b of the model (e.g. "event transitivity assessment"), which is also informed by case information (and possibly other information types in other languages) and operates in parallel to the GR assignment processes. In the case of Japanese, accusative and dative case marking would thus directly allow an interpretation of the event as being transitive, independently of the GRs they assign to the NPs that they mark. Nominative case marking, on the other hand, would be compatible with a transitive and an intransitive event interpretation, and the intransitive reading should be preferred based on interpretive Minimality (which in the revised version of the eADM should apply precisely in this "event transitivity assessment" step).

The latency of the effects

Importantly, the results of Experiment 2 support the assumption made earlier (see the Discussion of Experiment 1; Section 5.5.1) that the unusually short component latencies observed in Experiment 1 can be attributed to the particular properties of auditory presentation in combination with a direct time-locking of ERPs to the critical information. Thus, when presented visually, the identical stimuli to those employed in Experiment 1 engendered effects with latencies that corresponded closely to those reported previously for similar manipulations in other languages (namely 350–500 ms for the scrambling negativity at NP1 and 300–500 ms for the extension N400 at NP2).

6.5.2 Additional ERP effects for object-initial orders

In contrast to Experiment 1, we did not observe any positivity effects for object-initial sentences, neither at the position of NP1 nor at the position of NP2. We did, however, replicate the late posterior negativity for object-initial sentences at the position of the verb (650–1050 ms). These findings shall be discussed in the following.

The lack of positivity effects at the positions of NP1 and NP2

While broadly distributed positivities were observed relative to the case markers of NP1 and NP2 in Experiment 1, no such effects were discernable at the positions of NP1 and NP2 in Experiment 2. As already mentioned in the Discussion of Experiment 1 (Section 5.5.2), the absence of these effects in visually presented sentences may be explained with the specific properties of the presentation modality. Thus, a positivity effect indicative of dependency resolution at the position of the second NP may have been masked by the N400 arising at the same position in Experiment 2, similar to the confounding of these two effects in previous visual experiments on word order variations in German and Japanese (e.g. Bornkessel et al., 2004a; Fiebach et al., 2002; Hagiwara et al., 2007).

Appealing to a similar line of argumentation as that advanced for NP2 above, one might speculate that the differences between Experiment 1 and Experiment 2 regarding the positivity at the position of NP1 could also have been due to the particular properties of auditory vs. visual presentation. As case markers are realized as postpositions in Japanese, during auditory presentation, the comprehension system first processes the noun before encountering its accompanying case information (note that the initial nouns had a mean length of approximately 600 ms in Experiment 1). To meet the demands of incremental interpretation, certain preferences as to the role of the noun in the event being described will likely already be applied during this time. As argued in detail above, the preferred reading is most likely the one that minimizes the number of required dependencies, i.e. an actor (nominative) reading of NP1. When the accusative case marker is subsequently encountered, this assumption must be revised and a dependency postulated. In this regard, it seems more reasonable to assume that it is the *revision* of the dependency assumption that is costly rather than the formation of a dependency per se (as assumed, for example, in the SPLT/DLT; Gibson, 1998, 2000; or in the Discussion of Experiment 1; cf. Section 5.5.2). If the formation of a dependency were generally costly, a positivity should also be observable when the case information of NP1 is immediately available, as is the case during visual presentation. An account along these lines also provides a tentative explanation for why previous ERP studies of object-before-subject structures did not observe positivities at the position of the initial object. As all of these previous studies used visual presentation, the case information of the initial argument was available immediately and, as in Experiment 2, no revision of the "no dependency" assumption was necessary.[47] While this explanation appears to offer a plausible account of the present findings and their relation to previous results, it must of course be validated in further systematic investigations (see Section 9.3.2).

[47] In fact, Ueno & Kluender (2003) refer to an ERP study of scrambling in Japanese by Mazuka, Itoh, & Kondo (2001), in which a late positivity was observed at the position of an initial accusative. Thus, this finding does not appear to be entirely unprecedented. However, as Mazuka and colleagues' findings are not accessible in the published literature, it is virtually impossible to ascertain how their study and Experiment 1 may have differed from other ERP investigations of word order permutations.

Note that such an explanation is also in accordance with the suggested independence of transitivity assessment and GR assignment: As just described, the fact that a positivity effect at the position of NP1 only occurs in auditory presentation but not in visual presentation speaks in favor of the assumption that an initial argument is already analyzed as an actor *before* any case information becomes available. The transitivity assessment process, on the other hand, does not seem to be initiated before the relevant case information is available, since otherwise the auditory presentation in Experiment 1 should also have produced an extension N400 for all object-initial sentences at the position of the case marker of NP1 (in addition to the positivity effect for dependency revision; see also Footnote 33).

Since it was not possible to effectively disentangle potential positivity effects from other effects arising at the same positions, any questions regarding the difference between accusative and dative sentences cannot be satisfactorily answered at this point. For a further investigation of these questions, e.g. whether comparable positivity effects also arise in response to the formation and resolution of dependencies between an identified actor and a predicted undergoer, more research employing auditory presentation appears imperative (see Section 9.3.2). Initial evidence in favor of such an assumption is provided by recent ERP results on the processing of Hindi, which revealed positivities indicative of dependency formation also for initial ergative-marked arguments (i.e. arguments marked as actors of transitive events) in comparison to absolutive-marked arguments (i.e. arguments marked as actors of intransitive events; cf. Choudhary, in preparation; Choudhary, Schlesewsky, Roehm, & Bornkessel-Schlesewsky, in press).

The negativity relative to the sentence-final verb

Like in Experiment 1, a late posterior negativity was elicited in response to the verb of all object-initial sentences. Since the effect had the same latency and distribution as the one observed in Experiment 1, an identical interpretation is adopted here: The effect seems to reflect global, sentence-final processing costs for object-initial structures. The fact that the effect was observable for dative as well as accusative object-initial sentences further supports the idea that the effect is largely independent of local processing costs such as the ones engendering the scrambling negativity. Finally, the error rates and reaction times for the behavioral task were again higher for both object-initial orders, thereby further supporting the assumption of global sentence-final processing costs for all object-before-subject sentences.

6.5.3 A correspondence between visual and prosodic segmentation?

As described above, initial accusative objects engendered a scrambling negativity in the visual modality, just like initial accusative objects followed by a prosodic boundary in the auditory modality. But why should visual presentation induce a similar effect to that observed for sentences with a prosodic boundary after the first argument? Speculatively, an important factor may be that while many languages mark word boundaries orthographically by means of spaces in the text (e.g. English, German), others (e.g. Japanese, Chinese, Thai) do not. Thus, (39) below illustrates the standard (unsegmented) orthographic realization of one of the experimental stimuli with an initial accusative argument (cf. the depiction of condition OSV-Acc in Table 6.1, which shows the segmentation adopted for the visual presentation of the identical sentence).

(39) 二週間前判事を大臣が招きました
'Two weeks ago, the minister invited the judge.'

It appears possible that the segmented presentation mode that is typically employed in visual ERP experiments might influence the processing system differently in languages for which readers do not usually encounter word boundaries within a text. In particular, when there is an ambiguity with respect to the possible presence of a prosodic boundary, the unusual segmentation may lead the system to prefer a boundary analysis over a non-boundary analysis. Hence, at the position of NP1 in the critical sentence conditions, the visual segmentation may have led the system to adopt a scrambling analysis for the accusative-initial sentences in accordance with the consequences of inserting a prosodic boundary after an initial accusative object.

While this explanation is clearly speculative at this point, it is supported by further cross-linguistic findings on word order processing in a language that is very similar to Japanese in many respects, namely Turkish (Demiral et al., 2008). Like Japanese, Turkish is a verb-final language with morphological case marking, free word order and the possibility of subject-drop. The linearization possibilities for an initial accusative object are therefore very similar to those in Japanese, i.e. the accusative could either have been scrambled or it could be the only argument due to subject-drop. However, Turkish differs from Japanese in that it employs a Roman writing system with an orthographical marking of word boundaries. As predicted on the basis of phrase structural Minimality, Demiral et al. (2008) observed no scrambling negativity for initial accusative objects in spite of the use of visual presentation. This finding thus supports the assumption that the scrambling negativity observed for accusative objects when using visual presentation in Japanese may be due to the interaction of language-specific properties (the availability of subject-drop), prosodic constraints (the consequences of a prosodic boundary following an initial object) and orthographic requirements (the absence of orthographically marked word boundaries).

Of course, other possible explanations cannot be entirely ruled out at this point. For example, segmented visual presentation with similar stimulus onset asynchronies might lead the processing system to adapt to a two-argument sentence schema more readily within an experimental context and to thereby not entertain the possibility of argument drop as strongly as it normally would. However, such an account seems to run into difficulties at explaining the differential results for initial datives and initial accusatives. After all, if the steady presentation rhythm ruled out pro-drop interpretations, this should also have been the case in the analysis of initial datives (which also must be analyzed as sentences with an omitted argument to be compatible with a one-argument structure). Based on the same line of argumentation, one might also wonder why the uniform presentation schema did not also rule out a one-argument reading for the subject-initial sentences (which should have resulted in a complete lack of differences at the position of NP1).

Clearly, however, further empirical investigation is required in order to isolate the source of the interrelations between auditory and visual presentation observed here. In a first attempt to validate the assumption of a convergence between visual segmentation and prosodic segmentation, Experiment 3 sought to investigate whether the presence of pro-drop sentences in an experiment employing visual word-by-word presentation would serve to alleviate the prosodic boundary-like effects of visual segmentation.

Chapter 7

Experiment 3: Word order & argument drop

7.1 Introduction

The purpose of Experiment 3 was twofold: On the one hand, the experiment served to test whether under certain circumstances the scrambling negativity for initial accusatives in Japanese can be alleviated even in visual word-by-word presentation. On the other hand, the experiment aimed at a first ERP investigation of the processing of pro-drop sentences. Since the focus of Experiment 3 was clearly on the latter research objective, I will first address the questions that may be answered by the current experiment in that regard, before turning to the implications that the inclusion of pro-drop sentences in a visual ERP experiment may have for the processing of scrambled sentences.

As discussed earlier, the investigation of the processing of pro-drop sentences with ERP methods necessarily has a highly explorative character and does not yet allow the prediction of specific variations in predefined ERP components. It is, however, reasonable to assume that the inference of non-mentioned referents from outside of the sentence, which ultimately becomes necessary at the position of the sentence-final verb of pro-drop sentences, may be associated with additional processing costs, and that this increase in processing costs should be reflected in the form of some kind of ERP effect arising at this position. Thus, an ERP effect indicative of a referential inference process may be expected for transitive Japanese sentences with an omitted subject or an omitted object in comparison to canonical sentences in which both referents are given within the sentence itself.

The latency, topography, and polarity of the ERP component possibly observable in this case may allow first steps towards an integration of the described inferential processes into a neurocognitive sentence comprehension model such as the eADM (Bornkessel & Schlesewsky, 2006a). As discussed in Section 4.3, in the framework of the eADM, the need to infer missing discourse referents from outside of the current sentence would probably arise during the linking step of verb processing (due to the remaining empty positions in the LS of the verb). In its current version, though, the eADM incorporates an interaction of core processes with discourse processes (such as the required inferential process) only after Stage 2 processing, and thus linking, is completed. Under such an assumption, the linking step of Stage 2 would produce the output that referents are missing, and the generalized mapping step of Stage 3 would initiate the inference of these referents from the discourse. In this case, the inference process should be reflected in a late positivity, i.e. the ERP component typically observed for increased processing costs arising in Stage 3 of the eADM. Increased processing costs arising during the linking step itself, on the other hand, have mainly been associated with earlier negativities (N400 effects). Thus, if the inferential process were entirely subsumed under this processing step, it might engender a similar negativity effect.[48]

In addition, one may speculate whether subject-drop (OV) and object-drop (SV) sentences would elicit the same kind of ERP effect, and if so, whether differences between the two types of pro-drop would influence the strength of this effect. Potential differences between SV and OV sentences may arise on various levels. On the one hand, object-drop sentences are doubtless much less frequent than subject-drop sentences in Japanese (Ueno & Polinsky, submitted). Thus, from a frequency-based perspective (cf. Jurafsky, 1996; Levy, 2005; MacDonald et al., 1994; Trueswell et al., 1994; Vosse & Kempen, 2000), object-drop sentences may be expected to engender stronger effects than subject-drop sentences. On the other hand, in active transitive sentences, the omission of a subject requires the inference of an actor referent, while the omission of an object requires the inference of an undergoer referent. This difference regarding the specific type of inference also may or may not lead to differential effects in terms of amplitude, latency or even polarity of the elicited ERP effects. While the observation of amplitude differences between subject-drop and object-drop

[48]Note that the type of ERP component observed here can only provide initial cues as to how a referential inference process may be integrated with the model under consideration here. In this regard, recall the short discussion of “semantic” P600 effects and “syntactic” N400 effects from Section 2.2.4, which demonstrated that components allegedly indicative of syntactic processing also arise in response to semantic manipulations and vice versa. Therefore, while the emergence of an ERP difference between two experimental conditions speaks in favor of an increase in processing costs for one condition in comparison to another, the specific characteristics of the component should not be mistaken for a precise diagnostic tool regarding the underlying cognitive processes.

sentences in the current experiment would be equally compatible with both predictions described above, the observation of entirely different ERP components might be difficult to reconcile with a purely frequency-based explanation. A complete lack of differences between the ERP effects elicited by OV and SV sentences would also speak strongly against a frequency-based account, and would furthermore suggest that the processing costs reflected in these ERP effects are not determined by the GR of the missing referent.

Besides the investigation of pro-drop processing per se, the inclusion of pro-drop sentences in the experimental material might allow an intra-experimental loosening of the association between an orthographic boundary and the expectation of a second argument. More precisely, it was argued in the Discussion of Experiment 2 that the visual segmentation may have had the same effect on the processing of Japanese as a prosodic segmentation, at least at positions where there is an ambiguity with respect to the possible presence of a prosodic boundary, for example following an initial argument. In this case, the orthographic segmentation of the sentences seemed to lead to a preference for a boundary analysis over a non-boundary analysis, and as a consequence, to a scrambling analysis of initial accusative objects. Crucially for present purposes, the inclusion of actual pro-drop sentences in the experimental material of a visual word-by-word ERP study might cause this preference to change. After all, for word-by-word presentation, pro-drop sentences have to be segmented similarly to canonical and scrambled sentences, thus providing (among others) a case of a one-argument object-initial sentence (subject-drop; OV) with an orthographic boundary between the unscrambled object and the adjacent verb, i.e. at a position in which no prosodic boundary would occur. The presence of such orthographic boundaries in all subject-drop sentences of the experiment could thus weaken the association between an orthographic boundary and a prosodic boundary, and, as a consequence, also the association between an accusative object followed by such a boundary and a scrambled (two-argument) phrase structure. Since phrase structural Minimality would not be violated if a one-argument structure was assumed in such a case, no scrambling negativity should arise.

7.2 Design and hypotheses

As described above, Experiment 3 aimed at investigating potential ERP effects for the inference of omitted referents at the position of the verb of Japanese transitive subject-drop and object-drop sentences. Issues of interest included the kind of ERP component observable in the comparison of these sentences with canonical complete sentences, and possible differences depending on the GR of the inferable referent. Furthermore, the prediction was tested that the presence of pro-drop sentences in the experimental environment should loosen an association between the orthographic segmentation in a visual word-by-word paradigm and a prosodic segmentation such as the one employed in the PB conditions of Experiment 1. As a result, no scrambling negativity was expected for sentence-initial accusative objects in this experiment. To investigate these issues, transitive subject-object-verb (SOV) and object-subject-verb (OSV) sentences comparable to the accusative sentences in Experiments 1 and 2 were employed in a visual study along with transitive subject-drop (OV) and object-drop (SV) sentences. An example of the four critical conditions resulting from this design is shown in Table 7.1.

Our hypotheses were as follows:

(a) If the presence of sentences with omitted arguments in the experimental environment aided a subject-drop analysis of object-initial sentences (overruling the scrambling analysis encouraged by the orthographic segmentation), no scrambling negativity for initial objects should be observable in Experiment 3. On the other hand, if the scrambling negativity is not affected by the experimental environment, then such an effect should also arise for initial objects in the present experiment, thus mirroring the results observed in previous experiments employing visual presentation (Hagiwara et al., 2007; Experiment 2). In this case, a significant effect of ORDER (subject-initial vs. object-initial) would be expected at the position of NP1.

(b) As in Experiments 1 and 2, we expected to observe an extension N400 for subject-before-object (SOV) as opposed to object-before-subject (OSV) sentences at the position of NP2, reflecting the revision from an intransitive to a transitive event representation. As a consequence, a main effect of ORDER (OSV vs. SOV) was predicted at this position.

(c) If the late negativity relative to the onset of the verb observed in Experiments 1 and 2 reflects global processing costs for all scrambled word orders, as assumed thus far, then Experiment 3 should reveal a comparable effect for the scrambled object-before-subject sentences in comparison to the canonical subject-before-object sentences at the same position (OSV vs. SOV).

(d) At the position of the verb, we predicted an ERP effect indicating the inference of a missing referent in both conditions with an omitted argument (SV and OV) in comparison to the canonical SOV condition. In this case, significant differences should be observed in the comparison of subject-drop as well as object-drop sentences with canonical sentences (OV vs. SOV and SV vs. SOV). In addition, if the extent of processing costs for inferring an actor referent differed from that for inferring a referent for the undergoer role, we should observe a difference in the amplitude of the ERP effect between the subject-drop and the object-drop condition (OV vs. SV); and if the underlying processes of actor and undergoer inference were fundamentally different, such a difference might even be reflected in distinct ERP components for the two pro-drop conditions. Due to the lack of comparable results from previous research, it would however be premature to make concrete predictions at this point with regard to the kind(s) of component(s) to be expected.

Table 7.1: Example sentences for each of the four critical conditions in Experiment 3

Example word set				
	二週間前	太郎	花子	招いた
	nishuukanmae	Taroo	Hanako	maneita
	two weeks ago	Taroo	Hanako	invited
Condition	**Example sentence**			
SOV	二週間前	太郎が	花子を	招いた
	nishuukanmae	Taroo-ga	Hanako-o	maneita
	two weeks ago	Taroo-NOM	Hanako-ACC	invited
	‘Two weeks ago, Taroo invited Hanako.’			
OSV	二週間前	花子を	太郎が	招いた
	nishuukanmae	Hanako-o	Taroo-ga	maneita
	two weeks ago	Hanako-ACC	Taroo-NOM	invited
	‘Two weeks ago, Taroo invited Hanako.’			
SV	二週間前	太郎が	招いた	
	nishuukanmae	Taroo-ga	maneita	
	two weeks ago	Taroo-NOM	invited	
	‘Two weeks ago, Taroo invited [ ].’			
OV	二週間前	花子を	招いた	
	nishuukanmae	Hanako-o	maneita	
	two weeks ago	Hanako-ACC	invited	
	‘Two weeks ago, [ ] invited Hanako.’			

Abbreviations used: SOV, subject-object-verb; OSV, object-subject-verb; SV, subject-verb; OV, object-verb

7.3 Materials and methods

7.3.1 Participants

Twenty-four native speakers of Japanese (17 female) residing in Berlin, Germany, participated in the experiment. None of the subjects had previously participated in Experiment 1 or 2. All participants were monolingually raised, right-handed, between 21 and 35 years old (mean age 29.0 years) and did not have any neurological, reading, or uncorrected vision impairments. A further nine participants were excluded from the analysis for reasons of poor performance on a behavioral task, excessive EEG artifacts, or due to technical problems that arose initially from the implementation of a new electrode cap system (see Section 7.3.4).

7.3.2 Materials

80 word sets each consisting of a temporal adverb, two noun phrases, and a verb served as basis for the construction of the experimental sentences. The noun phrases were Japanese given names all consisting of two Japanese characters, with an equal number of word sets including two female names (27 sets), two male names (27 sets), or one female and one male name (26 sets). The verbs were transitive accusative verbs with a length of three or four Japanese characters, expressed in the past tense and plain form. The choice of proper nouns for the noun phrases (as opposed to common nouns as in Experiments 1 and 2) was made for two reasons: On the one hand it allowed for better control of the length of the visually presented stimuli in keeping them short and without variation between experimental trials (mean length 3.0 characters including the case marker suffix; *SD* 0.0 characters).[49] Furthermore, the use of given names would facilitate the later integration of the experimental sentences with preceding context sentences (see Experiment 4). The selection of verbs and the change from polite to plain form in the verb endings (cf. Footnote 44) also served the purpose of increased readability by reducing the verb length in

[49] Since the core of the Japanese writing system is formed by *kanji* (logographic characters adopted from Chinese whose pronunciation can change according to context), the grapheme-phoneme correspondence and therefore the relationship between the number of written characters in a word and the duration of the same word spoken out loud can be quite weak in comparison to most alphabetical languages which undertake a visual codification of speech (e.g. German). Therefore, a collection of words with well-controlled auditory duration (as the materials employed in Experiment 1) does not necessarily translate into written words with a similarly controlled length. To actually gain increased control of the number of characters in written words, one thus needs to create new stimulus materials with this new objective in mind. Recall that in Experiment 2, this potential increase of control was given up intentionally in favor of maximal comparability with Experiment 1, which was accomplished by employing identical stimulus materials.

average as well as minimizing the variability in verb length between trials (mean length 3.78 characters; *SD* 0.42 characters).

From each of the word sets (for a complete list, see App. B.3) four experimental sentences were constructed, as demonstrated for an example word set in Table 7.1 (SOV, subject-object-verb sentences; OSV, object-subject-verb sentences; SV, subject-verb sentences; OV, object-verb sentences). In order to obtain completely balanced materials, each sentence was also constructed in a second version in which the two given names were interchanged. This allowed us to compare conditions SOV and OSV in an identical manner to Experiments 1 and 2, i.e. at NP1 and NP2 the two noun phrases that were compared were identical up to the case suffix, so that the actual comparison drawn was not *Taroo-ga* vs. *Hanako-o* but *Taroo-ga* vs. *Taroo-o* (cf. *hanji-ga* vs. *hanji-o* in Tables 5.1 and 6.1).

The resulting 640 sentences (80 sets $\times$ 4 conditions $\times$ 2 name sequences) were subdivided into four lists of 160 items by allocating two realizations of every word set to each list in a counterbalanced fashion. As a result, participants were presented with two variants of each word set, and with a total of 40 sentences per condition. In addition, 40 sentences in which both the subject and the object of a transitive verb were omitted (i.e. adverb–verb sentences) served as fillers. Even though these filler sentences were also grammatical, they were expected to be highly unacceptable due to the lack of information regarding the actor *and* the undergoer of the sentence.

Each of the four sentence lists was then pseudo-randomized in two different orders. Sentences were segmented into bitmaps for visual presentation so that participants were presented with one *bunsetsu* (content word plus functional particle, see Footnote 45) at a time. Each trial thus consisted of either three (conditions SV and OV) or four (conditions SOV and OSV) bitmaps presented sequentially.

To ensure participants' attention throughout the experiment, comprehension questions were constructed in a comparable manner to Experiments 1 and 2. All questions were set in the canonical word order subject-object-verb followed by a question mark. In conditions SV and OV, the argument that was omitted from the sentence (i.e. the object or the subject, respectively) was replaced with the Japanese indefinite pronoun *dareka* ("someone") in the comprehension question. Questions to be answered with "no" were constructed employing the same procedures as in Experiments 1 and 2.

Prior to the comprehension task, participants were asked to judge the acceptability of each experimental sentence. In this regard, they were instructed to assess the acceptability of the *structure* of each sentence (rather than its semantic content). As no outright grammaticality violations were included in the sentence material, rating a sentence as "acceptable" meant that the sentence was a good example of the Japanese language which the participant might hear or read in everyday life in Japan whereas rating a sentence as "unacceptable" meant that the sentence structure sounded rather odd or unusual to the participant. The acceptability judgement was cued after each sentence by a bitmap depicting a question mark in the center of the screen with a smiley face (☺) representing the judgement "acceptable" and a frowny face (☹) representing the judgement "unacceptable" to its right and left, according to which button was assigned each alternative.

7.3.3 Procedure

Experimental sessions were conducted in the same setting as in Experiments 1 and 2. Each session started with 10 practice trials, whereupon the 200 experimental trials were presented in five blocks of 40 trials each. In each trial, after the presentation of a fixation asterisk for 650 ms, the critical sentence was presented in a word-by-word manner. Each word (bunsetsu) was visible in the center of the computer screen for 650 ms, followed by an interstimulus interval (ISI) of 100 ms. After the end of each sentence, another fixation asterisk was presented for 1000 ms to prevent participants from blinking too early after the presentation of the verb. Following another 100 ms, the cue for the acceptability judgement appeared on the screen and remained visible until the participant judged the sentence acceptability by pressing one of two buttons on a response box or until a period of 2000 ms had elapsed. The comprehension question was presented 500 ms after the removal of the acceptability cue and remained visible on the screen until the participant responded by button-press[50] or until a maximum response time of 5500 ms had elapsed. After an intertrial interval (ITI) of 1000 ms the next trial began. Participants were asked to avoid movements and not blink their eyes between the two asterisks enclosing each experimental sentence.

7.3.4 EEG recording and preprocessing

The EEG was recorded from the same 25 electrode positions as in Experiments 1 and 2. Due to setup changes in the recording laboratory, the EEG was now recorded from Ag/AgCl ring electrodes attached to an EASYCAP (EASYCAP GmbH, Mu-

[50] The same two buttons were used for giving the acceptability judgements and for answering the comprehension questions. While the assignment of the left and right button to the response options was counterbalanced across participants, one button was always associated with "acceptable" (acceptability rating) and "yes" (comprehension question) while the other button was always allocated the labels "unacceptable" and "no" to spare the participants the two other, less intuitive associations.

nich, Germany) elastic cap. Amplification and digitization of the signal as well as all following data preprocessing steps were undertaken in an analogous manner to Experiments 1 and 2.

7.3.5 Statistical analyses

The choice of statistical procedures The analysis of the behavioral data as well as the analysis of the verb related ERPs were required to provide comparisons including all four experimental conditions SOV, OSV, SV, and OV. As there are various methodological alternatives for approaching this task, it is useful to discuss the statistical approach that was adopted here in advance.

The design of the current experiment can be described as examining a single experimental factor COND with four levels constituted by the four conditions SOV, OSV, SV, and OV. This 4-level factor is supplemented by the random factor participants (F_1) or items (F_2) in the behavioral analyses and by the topographical factor ROI (region of interest) in the ERP analyses. Crucially, not all of the possible statistical analyses that such an experimental design offers are of interest. For example, in the ERP analyses of the current experiment, besides an omnibus F test including the 4-level factor COND and the topographical factor ROI, a total of 25 follow-up single-*df* comparisons could be calculated: six pairwise comparisons between the four levels of COND and 19 complex contrasts involving all combinations of the four conditions (e.g. the combined conditions SOV and OSV vs. the combined conditions SV and OV). In case of an interaction with ROI, each of these 25 tests would further have to be calculated for each of the six midline and four lateral ROIs that shows the COND effect, adding up to an additional 250 possible statistical tests. Therefore it seems advisable to focus directly on a circumscribed set of planned comparisons that are relevant for the research questions at hand. Recall from Experiment 2 (see Section 6.3.5) that there is general agreement among statisticians that it is not only pragmatically ill-advised but also mathematically and logically inappropriate to use an omnibus F test as a screening instrument before conducting multiple comparisons (unless one is interested in all possible contrasts and therefore chooses to employ the extremely conservative Scheffé procedure for error rate correction; e.g. Castaneda et al., 1993; Jaccard & Guilamo-Ramos, 2002; Keppel, 1991; Ruxton & Beauchamp, 2008; Wilkinson & the Task Force on Statistical Inference, 1999).

In the current study, we aimed to answer the following central questions: First, in how far do the two pro-drop conditions (SV and OV) differ from the canonical control condition SOV (in the form of an ERP deflection, acceptability variations, or differences regarding the comprehension task performance)? Second, if such additional costs arise, does their extent or form differ between sentences with a dropped subject (OV) and sentences with a dropped object (SV)? Third, in parallel to Experiments 1 and 2, in how far does the scrambled word order (OSV) show additional costs or reduced costs in comparison to the canonical word order (SOV)? Consequently, we were first and foremost interested in the pairwise comparisons between the canonical control and each of the three experimental conditions, that is, the comparisons OSV−SOV, SV−SOV, and OV−SOV.[51] In addition, whenever both of the pro-drop comparisons reached significance (that is, SV−SOV *and* OV−SOV), an additional pairwise comparison was conducted between the two pro-drop conditions to test whether the respective effects differed significantly (SV−OV).[52] This selection added up to a minimum of three (if none or only one of the pro-drop-vs.-control contrasts reached significance so that no further comparisons were required) and a maximum of four pairwise comparisons (if both of the pro-drop-vs.-control contrasts reached significance and needed to be compared with each other). As a result, for every analysis including all four conditions, three or four repeated measures analyses of variance (ANOVAs) were planned, each comprising a single-*df* experimental factor PC (pairwise comparison: e.g. SV−SOV) and either – for the behavioral analyses – the random factor participants (F_1) or items (F_2) or – for the ERP analysis of the verb – the topographical factor ROI (region of interest).[53] To control the familywise error rate across the pairwise contrasts, the comparisonwise p values were Bonferroni adjusted, adopting the maximum number of comparisons possibly calculated (i.e. four, thus $p_b = 4 \times p$).[54] As only two experimental conditions were compared at

[51]To avoid confusion, from here on only the three conditions OSV, SV, and OV will continue to be subsumed under the label "experimental" conditions, while condition SOV will be called the "canonical" or "control" condition in the remainder of the chapter.

[52]Note that the direct comparison of the experimental conditions SV and OV in the example above is logically and mathematically identical to comparing the differences SV−SOV and OV−SOV, as the subtraction of the SOV average is merely a linear transformation not affecting the F test results.

[53]One ostensibly suitable alternative approach would be to define two experimental factors, namely one factor ORDER (subject-initial vs. object-initial) and another factor DROP (second noun phrase dropped vs. not dropped). However, this would imply that in case of a significant interaction and a resolution by ORDER, condition SV would be compared with condition SOV and condition OV would be compared with condition OSV to detect potential effects of argument drop. Alternatively one could resolve the interaction by DROP to detect effects of scrambling (SOV vs. OSV) or of the case of the dropped argument (SV vs. OV). Considered more closely, however, neither of these alternatives do full justice to all of the research questions at hand. Especially the comparison of the subject-drop condition OV with either the scrambled condition OSV or the object-drop condition SV (instead of with the canonical condition SOV) falls short of the issues of interest here. Therefore, it is preferable to consider the canonical condition SOV as a control condition not only for the scrambled condition OSV but also for both of the conditions with a dropped argument (SV and OV) and, as a consequence, to define the four conditions as different levels of one single factor.

[54]If a Bonferroni-adjusted p value exceeded a value of 1, it was set to $p_b = 1$.

the positions of NP1 and NP2 (see below for details), the ERPs averaged at these constituents were analyzable without any adjustments.

Only significant effects (i.e. effects with a p or p_b value smaller than .05) will be reported. Analyses were carried out hierarchically, i.e. only significant interactions were resolved. Huynh-Feldt (H-F) corrections were applied whenever a statistical analysis included a factor with more than one degree of freedom in the numerator.

Behavioral data Error rates and reaction times in the comprehension task were analyzed by means of a set of repeated measures analyses of variance (ANOVAs; see above for a detailed explanation of the specific approach taken). Pairwise comparisons were calculated between the canonical condition SOV and each of the three experimental conditions (OSV, SV, and OV). In case of significant effects in both of the pro-drop comparisons, a further pairwise comparison was calculated between these two experimental conditions. For each comparison the experimental factor PC (pairwise comparison: e.g. SV−SOV) was crossed with the random factor participants (F_1) or items (F_2). To counteract an inflation of the familywise error rate, the p values for each pairwise comparison were Bonferroni adjusted ($p_b = 4 \times p$). The statistical analyses for the acceptability ratings and corresponding reaction times were conducted in an analogous manner. If an item was answered incorrectly in the comprehension task, it was excluded from the reaction time analysis of the comprehension task as well as from all analyses regarding the acceptability ratings.

Electrophysiological data With regard to the ERPs, statistical analyses differed somewhat depending on the sentence constituent under consideration. At the position of NP1, ERPs for the conditions SOV and SV were combined into a conjoint condition S (subject-initial), as up to this point the sentences of these two conditions were identical (an initial adverb followed by a subject). Based on the same rationale, the conditions OSV and OV were subsumed under the conjoint condition O (object-initial). The resulting repeated measures ANOVAs thus comprised a 2-level experimental factor ORDER (order: subject-initial vs. object-initial) and a topographical factor ROI (region of interest) which corresponded to the topographical factor ROI in Experiments 1 and 2.

At the position of NP2, only conditions SOV and OSV entered analyses, as these were the only conditions actually containing a second noun phrase. The grand average ERPs calculated for this position were thus analyzed by means of repeated measures ANOVAs comprising the 2-level experimental factor ORDER (order: subject-before-object vs. object-before-subject) and the topographical factor ROI (region of interest).

At the position of the sentence-final verb, all four conditions entered the analysis. As described above, we first calculated repeated measures ANOVAs for the three pairwise comparisons between the canonical control SOV and each of the experimental conditions (OSV, SV, and OV). Whenever both of the pro-drop−control comparisons reached significance, an additional pairwise comparison was calculated between the two pro-drop conditions. To control the familywise error rate across the pairwise contrasts, the comparisonwise p values were Bonferroni adjusted ($p_b = 4 \times p$). To determine the topography of all emerging effects, in each pairwise comparison the experimental factor PC (pairwise comparison: e.g. SV−SOV) was crossed with the topographical factor ROI (region of interest).

7.4 Results

7.4.1 Behavioral data

Error rates and reaction times for the comprehension task are shown in Table 7.2. Acceptability ratings and reaction times are shown in Table 7.3. To analyze the behavioral data we first conducted pairwise comparisons (PC) between each experimental condition and the control condition, and second, if necessary, compared the two pro-drop conditions with each other (see Section 7.3.5 for a detailed account of the methodological procedure).

With regard to the error rates, the statistical analyses revealed significant effects of PC for the pairwise comparisons OSV−SOV ($F_1(1, 23) = 66.98$, $p_b < .001$; $F_2(1, 79) = 45.62$, $p_b < .001$) and OV−SOV (only in the participant analysis; $F_1(1, 23) = 9.65$, $p_b < .02$). The analysis of the reaction times yielded similar results: Significant

Table 7.2: Mean error rates and reaction times in the comprehension task of Experiment 3

Condition	Mean error rate (%)		Mean reaction time (ms)	
SOV	13.7	(6.7)	2120	(388)
OSV	32.7	(11.2)	2394	(441)
SV	16.0	(8.4)	2136	(409)
OV	9.6	(6.9)	1984	(427)

Standard deviations (of the participant analysis) are given in parentheses.

differences were observed in the comparisons OSV−SOV (F_1(1, 23) = 23.64, $p_b <$ .001; F_2(1, 79) = 46.98, $p_b < .001$) and OV−SOV (F_1(1, 23) = 10.66, $p_b < .02$; F_2(1, 79) = 12.50, $p_b < .003$).

The described pattern resulted from error rates which were higher for scrambled sentences than for canonical sentences (as in Experiments 1 and 2), while error rates for object-drop sentences (SV) were similar to those for the canonical sentences, and error rates for subject-drop sentences (OV) were lower than those for canonical sentences. The reaction time data showed a similar pattern: Participants were fastest to respond to the comprehension questions in the OV condition, followed by the SOV and SV conditions, and took the longest time to respond in the scrambled OSV condition. As in Experiments 1 and 2 before, the reaction time data will not be interpreted further.

It is striking that the comprehension task performance in the scrambled condition was far below the performance in all the other conditions. Naturally, one might argue that these sentences might not have been properly processed altogether or mistaken for and thus processed like the canonical sentences. Consequently it is conceivable that some of the ERP effects (or the lack thereof) might be due to this "mis-processing" of the scrambled sentences. To attend to this possibility, additional median-split analyses dividing participants by their comprehension task performance in the OSV sentences were calculated for all comparisons involving the OSV condition. The rationale behind this approach is that if any of the ERP effects were due to a deficient processing of the OSV sentences, the strength of these effects should vary with the participants' individual performance in the comprehension task. As no influence of the task performance on the reported ERP effects was discernable (see App. A.2 for the statistical results and a detailed discussion), it seems safe to assume that in spite of a low performance on the subsequent compre-

Table 7.3: Mean ratings and reaction times in the judgement task of Experiment 3

Condition	Mean acceptability (%)		Mean reaction time (ms)	
SOV	97.2	(3.9)	834	(231)
OSV	95.5	(7.2)	867	(246)
SV	59.1	(32.4)	888	(234)
OV	79.5	(30.4)	817	(239)

Standard deviations (of the participant analysis) are given in parentheses.

hension task, the OSV sentences have still been perceived and processed as such in real-time comprehension.

With regard to the acceptability ratings, statistical analyses revealed significant effects in the pairwise comparisons SV−SOV ($F_1(1, 23) = 32.85$, $p_b < .001$; $F_2(1, 79) = 399.98$, $p_b < .001$) and OV−SOV ($F_1(1, 23) = 9.24$, $p_b < .03$; $F_2(1, 79) = 140.71$, $p_b < .001$), as well as in the follow-up comparison SV−OV ($F_1(1, 23) = 19.52$, $p_b < .001$; $F_2(1, 79) = 92.90$, $p_b < .001$). The analysis of the reaction times revealed no significant differences, with the exception of the SV−SOV comparison which reached significance only in the item analysis ($F_2(1, 79) = 9.11$, $p_b < .02$; the object-drop sentences being rated slower than the canonical control).

Thus, all sentences with an omitted argument were rated less acceptable than the complete canonical sentences, while no acceptability loss was apparent for the scrambled sentences. Among the sentences with an omitted argument, acceptability was higher for the subject-drop sentences (OV) than for the object-drop sentences (SV).[55]

7.4.2 ERP data

In accordance with the hypotheses formulated in Section 7.2, grand average ERPs were calculated relative to the onset of NP1 (to test predictions regarding the scrambling negativity), NP2 (to test predictions regarding the extension N400), and the verb (to test predictions regarding the late negativity for scrambled word orders and the potential inference effect for pro-drop sentences).

NP1

Fig. 7.1 shows the grand-average ERPs for the conjoint conditions S (subject-initial; comprising conditions SOV and SV) and O (object-initial; comprising conditions OSV and OV) at the position of NP1. As can be seen clearly in Fig. 7.1, no significant differences between subject- and object-initial sentences are evident at the position of the first noun phrase. This impression was also confirmed by a timeline analysis showing no significant effects for any two subsequent 50 millisecond time windows between 0 and 850 ms post stimulus onset[56] (main effect ORDER: midline all Fs < 3, ps > .11; lateral all Fs < 2, ps > .18; interaction ORDER×ROI only significant at

[55] As expected, the filler sentences that only consisted of an adverb and a transitive verb were rated "unacceptable" more frequently than "acceptable" (mean acceptability rating: 36.1%).

[56] For a similar procedure, see, for example, Gunter et al., 2000. The time range of 0–850 ms was chosen because at 750 ms post NP1 onset the next constituent (i.e. the second noun phrase in conditions SOV and OSV or the verb in conditions SV and OV) was presented and the first endogenous

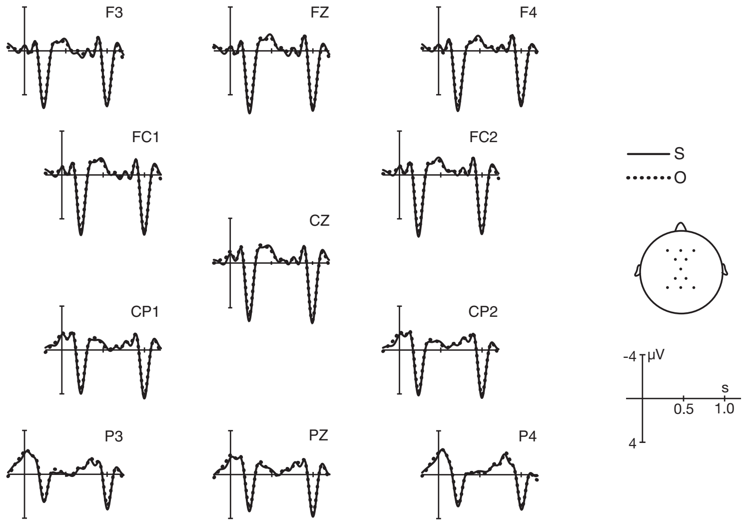

Figure 7.1: Grand-average ERPs ($N = 24$) time-locked to the onset of NP1 (onset at the vertical bar) in Experiment 3.

midline electrodes between 50 and 100 ms, $F(5{,}115) = 3.79$, $p < .04$, and at lateral electrodes between 400 and 450 ms, $F(3{,}69) = 3.63$, $p < .04$).

NP2

In Fig. 7.2 the ERPs averaged relative to the onset of the second noun phrase are displayed. Visual inspection of the figure suggests a widely distributed negativity for subject-before-object sentences (SOV) in comparison to object-before-subject sentences (OSV) between approximately 450 and 650 ms. This impression was supported by the statistical analysis which revealed a significant main effect of ORDER both at midline ($F(1,\ 23) = 12.49$, $p < .002$) and lateral ($F(1,\ 23) = 12.46$, $p < .002$) electrode sites for this time window.

Verb

The grand average ERPs calculated at the position of the verb are shown in Fig. 7.3. Note that the verb effects are only plotted for the time window of 0–650 ms, due to a programming mistake with regard to the presentation timing of the experimental

ERP components in response to this subsequent constituent could be expected from approximately 100 ms after its onset.

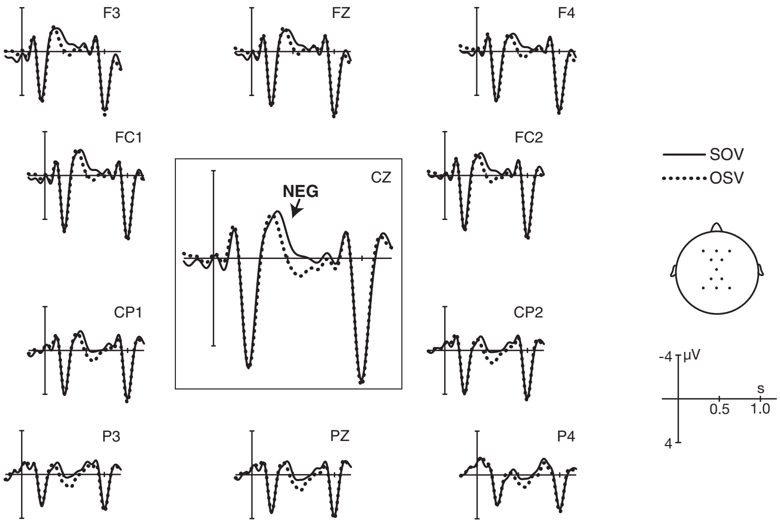

Figure 7.2: Grand-average ERPs (N = 24) time-locked to the onset of NP2 (onset at the vertical bar) in Experiment 3.

trials: In the conditions without a dropped argument (SOV and OSV), the verb was presented for the customary 650 ms and then followed by a clear screen for 100 ms before the presentation of the sentence-final asterisk commenced, while in the conditions with an omitted argument (SV and OV), the 100 ms interval between verb offset and asterisk onset was left out. Accordingly, the ERPs recorded relative to the onset of the verb originated from identical stimulation (i.e. the presentation of the verb) until 650 ms post verb onset, but from differential stimulation (i.e. a clear screen followed by an asterisk vs. an asterisk without the preceding clear screen) from 650 ms onward (see App. A.3 for a figure showing the ongoing ERP after 650 ms). Even though the impact of the differential trial timing in the current experiment seemed to be weak, any ERP differences that were evident after 650 ms must be considered as confounded and thus cannot be interpreted. Therefore, the analysis of ERP effects relative to the verb will be restricted to the time window of 0–650 ms.

As is immediately noticeable from inspecting Fig. 7.3, the scrambled sentences (OSV) did not induce an ERP response differing from the canonical control SOV at any point in the considered time interval, while the other two experimental conditions (SV and OV) do appear to differ from the canonical control: Between approximately 400 and 600 ms, there seems to be a widely distributed positivity for both

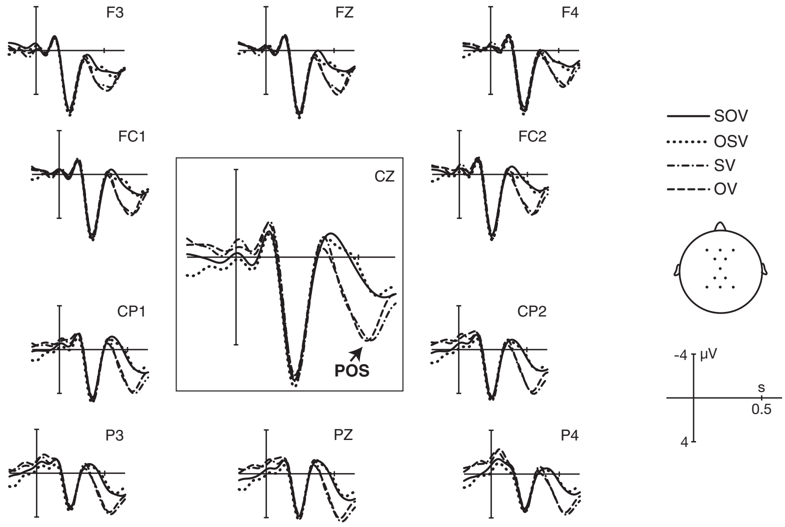

Figure 7.3: Grand-average ERPs (N = 24) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 3.

pro-drop conditions. Based on this visual impression, the time window of 400–600 ms was statistically analyzed by first conducting pairwise comparisons between each experimental condition and the control condition, and second, if necessary, comparing the two pro-drop conditions with each other (see Section 7.3.5 for a detailed account of the methodological procedure).

The analysis of the midline electrodes showed a main effect of PC (pairwise comparison) for the comparisons SV−SOV ($F(1, 23) = 39.91$, $p_b < .001$) and OV−SOV ($F(1, 23) = 40.39$, $p_b < .001$), but not for the OSV−SOV comparison ($F < 1$). At lateral electrode sites the same pattern was evident: Analyses revealed significant effects of PC for the comparisons SV−SOV ($F(1, 23) = 35.96$, $p_b < .001$) and OV−SOV ($F(1, 23) = 36.42$, $p_b < .001$), but not for OSV−SOV ($F < 1$). None of the PC×ROI effects reached significance (all Fs < 3, p_bs $> .31$).

As the comparisons between the two conditions with an omitted argument (SV and OV) and the canonical control condition (SOV) both yielded significant results, the two pro-drop conditions were subsequently compared with each other (SV−OV) to detect any potential differences in the extent of the effects. No significant differences between conditions SV and OV were evident, neither at midline nor at lateral electrode sites (both Fs < 1). Again, the PC×ROI effects did not reach significance either (both Fs < 4, p_bs $> .24$).

Additional analyses comparing the first and second half of the experiment were conducted to eliminate the possibility that the described effects between 400 and 600 ms post verb onset were in fact simply due to the expectation of the sentence-final asterisk at different times (and thus to a potentially arising shift in preparatory processes with regard to the visual stimulation and the upcoming task). The rationale behind these additional analyses lies in the fact that effects based on the expectation of a certain upcoming stimulus event would need to build up gradually in the course of an experimental session, which would lead to interactions of the effects with a temporal variable. The additional analyses therefore equaled the analyses described above, extended by the additional temporal factor HALF (first half vs. second half of the experiment). As this factor did not show any influence on the ERP effects (see App. A.4 for the statistical results), it can be reasonably assumed that the ERP effects described above did not emerge due to the differential presentation timing but were indeed caused by the intended experimental manipulation (i.e. effects of argument omission).

To summarize the verb effects, the pairwise comparison OSV−SOV did not yield any significant results between 0 and 650 ms post verb onset. The conditions with a dropped subject (OV) and a dropped object (SV) both showed significantly more positive-going ERP waveforms than the canonical control (SOV) between 400 and 600 ms post verb onset, indicating a general "pro-drop effect" in this time window. The positivity effect was widely distributed (no interaction with ROI) and did not differ in its extent between the two pro-drop conditions (no differences between the OV and SV conditions in the follow-up contrast).

7.5 Discussion

The following effects were observed in Experiment 3: (a) a broadly distributed negativity (450–650 ms) at the position of NP2 for subject-before-object sentences; (b) a broadly distributed positivity (400–600 ms) for subject-drop and object-drop sentences relative to the onset of the verb. In the following, I will first discuss the differences between canonical sentences and scrambled sentences (Hypotheses a, b, and c), before turning to the main concern of the current experiment: the effect observed in response to pro-drop sentences (Hypothesis d).

7.5.1 Differences between scrambled and canonical word orders

Regarding the comparison between scrambled and canonical word orders, the current experiment did not reveal a scrambling negativity for object-initial orders at the position of NP1, but did show an extension N400 for canonical word orders at the position of the second NP. Both of these findings will be discussed in turn below. The prediction of a late negativity for scrambled word orders at the position of the verb could not be tested in the current experiment since the ERP results were only interpretable up to 650 ms post verb onset (cf. Section 7.4.2) and the effect in question had arisen in a time window between 650 and 1050 ms in the previous experiments.

No scrambling negativity for object-initial orders

As predicted, no scrambling negativity was observable for object-initial sentences at the position of NP1. This finding is in accordance with the assumption that the presence of pro-drop (especially OV) sentences in a visual ERP paradigm loosens the association between an orthographic boundary (i.e. the word-by-word segmentation employed in such visual paradigms) and a prosodic boundary (such as the ones employed in Experiment 1). Since an orthographic boundary following an initial object thus did not signal a scrambled (two-argument) structure, a previously selected minimal one-argument template could be upheld, and phrase structural Minimality was no violated. As a consequence, no scrambling negativity was observed.

Of course it can be argued that the difference between Experiments 2 and 3 with regard to the scrambling negativity may be derived from other inter-experimental differences than the inclusion of pro-drop sentences. For example, different types of nouns were employed in the two experiments: common nouns in Experiment 2, and proper nouns (given names) in Experiment 3. However, while such an influence cannot be ruled out entirely on the basis of the current experiment, no such interaction of the scrambling negativity with noun type has been noted before. For example, Bornkessel & Schlesewsky (2006b) also compared sentence-initial nominative- and accusative-marked given names (e.g. *der Dietmar* vs. *den Dietmar*) and observed a similar scrambling negativity as in experiments employing common nouns (e.g. *der Jäger* vs. *den Jäger*; Bornkessel et al., 2002; see also Bornkessel et al., 2003; Rösler et al., 1998; Schlesewsky et al., 2003). While these findings from German cannot entirely rule out an influence of noun type in Japanese, they do seem to render an explanation based solely on noun type unlikely. Furthermore, it is not clear how exactly a change in noun type should interact with word order related processes in such a way as to engender the pattern of results observed here. Thus, it seems more likely that it was actually the inclusion of pro-drop sentences that led to an alteration in the processing of the scrambled sentences.

It should be kept in mind, however, that while the observed influence of pro-drop sentences in the experimental environment is highly compatible with the assumed correspondence between orthographic and prosodic boundaries, the occurrence of pro-drop sentences could also have affected the processing of object-initial sentences for other reasons. Therefore, the hypothesis that the orthographic segmentation and its association with prosodic segmentation was the crucial cause for the scrambling negativity observed in Experiment 2 clearly requires further testing. As will be discussed in more detail in the General Discussion (see Section 9.1.2), a combined eye-tracking and ERP paradigm employing unsegmented sentences may provide a more direct test of the segmentation hypothesis without having to rely on the inclusion of pro-drop sentences in the stimulus materials.

The extension N400 for subject-before-object orders

As in Experiments 1 and 2, a negativity for subject-before-object sentences in comparison to object-before-subject sentences was observable at the position of the second NP. As described before, this effect is highly compatible with an explanation based on interpretive Minimality, since the subject-before-object sentences, but not the object-before-subject sentences required an extension from a minimal intransitive event interpretation to a non-minimal transitive event reading when the second argument was encountered.

An issue that warrants some discussion is the distribution and latency of the negativity observed here: While the extension N400 in Experiment 2 revealed the typical latency (300–500 ms) and distribution (posterior maximum) of N400 effects reported for visual presentation, the effect in the current experiment was observed in a somewhat later time window (400–650 ms) and showed a widely distributed topography more reminiscent of the effect observed at the position of the second NP in Experiment 1. Regarding the topography, it seems most likely that the noun type of the employed NPs is responsible for the observed difference, as given names may be considered more concrete than common nouns and concrete nouns have been shown to exhibit a more anterior N400 distribution than abstract nouns (West & Holcomb, 2000). Regarding the latency of the effect, it would also seem rather incongruous to attribute the observed difference to the inclusion of pro-drop sentences in the stimulus materials since the transitivity assessment is not influenced by the assumed number of overt arguments in the sentence (and if it was, the inclusion of pro-drop sentences should have affected interpretive processing from NP1 on, thus cancelling out the N400 effect observed at the position of NP2). Therefore, the most likely candidate for explaining the latency shift again is the difference in noun types between the two experiments. Interestingly, such a longer latency of the extension N400 has also been observed in another experiment employing not only common nouns as NPs: Fiebach and colleagues 2002 employed a wh-pronoun at the position of NP1 and observed an extension N400 at the position of NP2 (interpreted as a positivity; see above) between 400 and 700 ms. Thus, so far it seems that experiments employing full common nouns elicit an extension N400 with a typical latency (e.g. Bornkessel et al., 2004a; Experiments 1 and 2 of this thesis), while experiments including other noun types like pronouns or proper names produce an extension N400 with a longer latency (e.g. Fiebach et al., 2002; the current experiment). While these speculations may provide initial cues as to why the observed latency differences have emerged, further research is clearly necessary to distentangle the cause of the latency variation from other possible intra-experimental differences and to investigate the underlying mechanisms. Two possible experimental designs to initiate such an investigation will be suggested in the General Discussion (Section 9.2.2).

Another interesting issue arising with regard to the extension N400 is the following: Under closer consideration, an ERP correlate of event extension could have been expected at one further position in the current experiment, namely at the position of the sentence-final verb. More precisely, one might argue that at this position, an extension from an intransitive to a transitive event reading was necessary in sentences of the SV condition but not in all other sentence types, since the accusative object in SOV, OSV, and OV sentences already signaled a transitive event before the verb was encountered (the OSV and OV sentences at the position of NP1, and the SOV sentences at the position of NP2), while the nominative-marked argument was compatible with an intransitive event until the transitive verb was encountered. Therefore the question arises why no extension N400 was observed in the SV condition in comparison to the other three conditions at the position of the verb. In the following, some speculations regarding the difference between the processes taking place at the positions of pre-verbal arguments in comparison to sentence-final verbs will be put forward. Recall in this regard that the representations that can be construed on the basis of pre-verbal information are highly abstract in nature; that is, the argument-based event representation merely encodes the number of participants in the event and the interpretational hierarchy between them. At the position of the verb, on the other hand, the LS information allows a non-abstract integration of the participants in a *concrete* event (e.g. inviting). One possible explanation for the absence of an extension N400 at this position may therefore be that the kind of abstract event representation construed pre-verbally is replaced at the position of the verb by a more concrete representation of the described event and its participants.

7.5.2 The pro-drop positivity: An early discourse related P600?

At the position of the verb we observed a widely distributed positivity between 400 and 600 ms for all conditions with an omitted argument. This observation raises the following questions: Which kind of component are we looking at, and what can it tell us about the underlying cognitive processes? Descriptively, the effect falls between the typical time window for a P300 effect (e.g. Sutton et al., 1965) and the typical time window for a P600 effect. Functionally, it is difficult to associate the effect observed here with other instances of P300 effects, since P300s have been typically observed in response to relevant, rare, and unpredictable target stimuli in oddball designs. In the current experiment, however, pro-drop sentences and complete sentences occurred equally frequently, and participants were required to respond to every sentence and not only to the pro-drop sentences.[57] Therefore, a classification of the effect as an (earlier and rather widely distributed) case of a P600 effect seems more promising in the light of previous literature as well as with regard to a possible functional integration of the effect with a neurocognitive processing model like the eADM.

Let us first consider how the positivity effect and the inferential process that it presumably reflects could best be integrated into the framework of the eADM. As described in Section 7.1, such a process could potentially either be connected with the linking step of Stage 2, which is typically associated with N400 effects, or with the generalized mapping step of Stage 3, which is typically associated with P600 effects. Since the observed component does not correspond directly to either of these components, both integration alternatives and the related consequences for possible modifications of the model will be discussed.

Due to the polarity of the effect, it seems most reasonable to position the assumed inference process in the generalized mapping step of Stage 3 and classify the observed positivity as an early form of a P600 effect indicative of increased processing costs arising during the mapping of core related information (the output of the linking step) with non-core information (discourse referential information). While such a view would be highly compatible with the assumptions of the eADM regard-

[57] While some P300 effects reported in language-related contexts also do not meet the described criteria (e.g. Roehm, Bornkessel-Schlesewsky, Rösler, & Schlesewsky, 2007a), these cases are similarly unsuitable for deriving the positivity effect observed here.

ing the relatively late interaction between core and non-core information, the early latency of the effect (400–600 ms) warrants some discussion. Even though the absolute timing of ERP effects is not necessarily informative with regard to the actual timing of the underlying processes (Osterhout & Holcomb, 1995), the issue remains that the effect observed here arises comparably earlier than the P600 effects or "late positivities" otherwise discussed by Bornkessel & Schlesewsky (2006a) in the context of Stage 3 processes. One relatively simple way of adapting the eADM to account for the short latency of the effect would be to change the strict seriality of the three processing stages. If partial overlaps were allowed between Stage 2 and Stage 3 processing, the information about missing referents could be relayed for generalized mapping before the linking process is fully completed. Interestingly, precisely such a modification of the eADM has been undertaken in recent revisions of the model (Bornkessel-Schlesewsky & Schlesewsky, 2008, 2009, in press-a), which picture the progression of the processing stages in a cascaded rather than a strictly serial way. This adaptation was mainly based on data from Dutch and German suggesting a partial overlap between Stages 1 and 2 (Friederici, Gunter, Hahne, & Mauth, 2004; Hahne & Friederici, 2002; Van den Brink & Hagoort, 2004) and on the assumption of a relatively early influence of discourse contextual information in the processing of Chinese, which would be implemented in a partial overlap between the Stages 2 and 3 of the eADM, at least in languages in which incremental sentence interpretation is highly discourse dependent, such as Chinese and, as the current data suggest, possibly also Japanese (cf. Bornkessel-Schlesewsky & Schlesewsky, in press-a). Under such an assumption of overlapping processing stages, an earlier positivity which is indicative of earlier generalized mapping processes would be a feasible explanation for the results observed here.

Due to the comparatively early latency of the observed effect, one could alternatively consider a subsumption of the presumed referential inference process under the linking step of Stage 2. In this case, the interaction of core processes and discourse information would not be delayed until Stage 3 of the model, and the discourse referential representation of a sentence would be included as a third representation level relevant for Stage 2 processing (besides the phrase structural and the event level of representation). Furthermore, one would have to assume that linking processes related to this referential representation level are not associated with an N400 effect but rather with a "P400" effect. While this alternative cannot be ruled out on the basis of the current results, an explanation along the lines of overlapping stages seems to provide a more economic solution: On the one hand, the inclusion of a third level of representation and a new type of component in Stage 2 seems to constitute a more profound modification of the model than the implementation of a partial overlap between the processing stages, and on the other hand the latter type of revision is already independently motivated by data from other languages (see above). While the current experiment thus cannot provide the sufficient means to decide between the two alternatives, an interpretation of the effect as a correlate of an inference process that takes place in an early onset Stage 3 currently appears to be the more straightforward and parsimonious interpretation.

While it thus seems most reasonable to associate the positivity observed here with early Stage 3 processes in the eADM, the open question remains which underlying mechanisms are exactly responsible for the effect. So far, the effect – which henceforth will be referred to as *pro-drop positivity* – has been circumscribed as reflecting some kind of discourse inferential process which becomes necessary when an argument is omitted from a sentence. The inference of omitted referents from outside of the sentence however can only serve as a cover term for a number of more specific processes possibly involved in the generation of the pro-drop positivity. For example, the inferential process may encompass the recovery of given referents from the linguistic or non-linguistic context, or, if no such referents are available, the establishment of new discourse referents. Furthermore, the effect could alternatively be caused (or at least influenced) by non-discourse related factors like the simple detection of a missing argument, or the frequency of occurrence. In the following, a more specific characterization of the potential mechanism(s) underlying the pro-drop positivity will be attempted based on the pattern of findings observed here and taking into consideration previous P600 findings reported in the literature.

First, the emergence of an identical component for OV and SV sentences provides evidence against a frequency-based interpretation of this ERP component since object-drop sentences are much less frequent than subject-drop sentences in Japanese (in a relation of about 1:10). Were the observed effect subject to frequency differences, the amplitude of the component should have differed between the two kinds of pro-drop sentences. Another point speaking against a frequency-based account of this component lies in the fact that the even less frequent scrambled sentences did not differ from canonical sentences in the respective time window. Note that based on frequency information alone, one might even expect the subject-drop sentences (but not the object-drop sentences) to engender less instead of more processing costs than canonical sentences, since they are actually even more frequent than complete sentences in everyday Japanese language. At least based on strongly interactive models (e.g. MacDonald et al., 1994; Trueswell & Tanenhaus, 1994), however, it is arguable that subject-drop sentences out of context, such as the ones presented in the current study, might actually be less common than complete sentences. Interestingly, however, a frequency related pattern seems to be apparent, at least partly, in the behavioral data: In the comprehension task, the highly frequent subject-drop sentences showed the lowest error rates, followed by complete canonical sentences and object-drop sentences, and finally the scrambled sentences, which have the lowest frequency in Japanese. In addition, the results of the judgement task revealed that the less frequent object-drop sentences were also rated less acceptable than the subject-drop sentences.[58] While frequency distributions may thus influence the ease of sentence processing at a later point in time, like in the offline comprehension task or the acceptability judgements (and maybe also in late negativity effects in response to sentence-final words, see the General Discussion, Section 9.3.2), they do not appear to affect the earlier positivity effect observed here.

The absence of differential results for OV and SV sentences further suggests that the underlying cognitive process does not directly depend on the grammatical function of the omitted noun phrase and thereby the GR of the missing referent. Therefore, the findings observed here are compatible with the interpretation that the pro-drop positivity reflects a discourse referential process which, in the eADM framework, does not depend on the specific position in the LS for which a referent needs to inferred.

When taking into account previous ERP findings, the pro-drop positivity observed in the current experiment is clearly reminiscent of discourse related P600 effects observed in several earlier studies. As described in Section 3.2.2, Kaan & Swaab (2003) reported a frontally distributed P600 at a position following the introduction of two vs. one referent(s) and attributed the effect to "increases in discourse complexity" (p. 107). More interestingly for current purposes, Burkhardt (2006; 2007a) observed P600 effects in response to German full noun phrases for which a new discourse referent needed to be established. Similar effects were also reported by Van Petten et al. (1991) for full noun phrases in English. Finally, Van Berkum et al. (2004) observed P600 effects at the position of referentially failing pronouns in Dutch which likely led at least part of the participants to establish a new sentence-external discourse referent for the respective pronoun (cf. Nieuwland et al., 2007). Thus, previous findings from German, Dutch, and English have shown P600 effects

[58] The fact that all complete sentences (i.e. the canonical *and* the scrambled sentences) were rated as more acceptable than the pro-drop sentences in general is clearly not compatible with a frequency-based explanation. It is however possible that this response tendency resulted from an increased sensitivity of the participants for "incomplete" structures in the given experimental environment. In other words, participants might consider pro-drop sentences more acceptable when they encounter them in everyday life than when they are specifically instructed to judge their acceptability in an experimental context.

in response to arguments (full NPs or pronouns) for which a new discourse referent needed to be established within the sentence or extra-sententially. Since it is reasonable to assume that new (sentence-external) discourse referents also need to be established at the position of the verb of pro-drop sentences like the ones employed here, similar processes of referent establishment may be responsible for the positivity effect observed here.[59]

Depending on the theoretical background, the establishment of new discourse referents can be viewed either as a separate process functioning on a discourse level of representation, as suggested by Burkhardt (2006, 2007a), or as part of a broader process like the integration of arguments with their subcategorizing verb, following the assumptions of the SPLT/DLT (Gibson, 1998, 2000). Recall in this regard that the integration cost component suggested by Gibson is determined by the distance between the integrated elements and the complexity of the integration, which in turn is assumed to be increased, for example, if a new discourse referent needs to be constructed. Furthermore, some instances of P600 effects in the previous ERP literature have also been attributed to increased integration costs (though not establishment related) arising at the position of the verb (e.g. Kaan et al., 2000; Phillips et al., 2005). Irrespective of the theoretical grounding, the establishment of new referents seems to be a promising candidate for the possible processing mechanisms engendering the increased processing costs for pro-drop sentences observed here.

However, when comparing the pro-drop positivity with previous findings of P600 effects in connection with referent establishment processes (i.e. Burkhardt, 2006, 2007a; Van Berkum et al., 2004; Van Petten et al., 1991), it is necessary to keep in mind that the effect observed here occurred at the position of the verb and not at the

[59]Notably, one might argue that at least the speaker referent is always a salient part of the discourse, and thus might not need to be established as a *new* referent at the position of the verb. This might, however, not be the case in isolated and visually presented sentences since these might not support the representation of a speaker as strongly as actually spoken sentences or sentences embedded in a text. Furthermore, a follow-up questionnaire revealed that even offline, the speaker indeed was not always inferred as the omitted referent. This questionnaire inquired the referents that were inferred by the participants for the omitted arguments in subject-drop and object-drop sentences. One example was given for each structure and participants were asked directly to indicate their interpretation of the omitted referents (e.g. “If you heard or read a sentence such as *Nishuukanmae Hanako-o maneita* [see Table 7.1; condition OV] in everyday life, who would you think invited Hanako?”), and answers were given in a free response format. The results showed that at least part of the participants did not infer the speaker as the missing referent but instead suggested “someone” or “someone else” (which is comparable to the kind of referent likely established in an isolated English sentence containing a third person pronoun, e.g. in *He invited Mary*; with the exception that the English pronoun provides more information regarding the unknown referent’s gender and number). At least in the case of this latter interpretation (which was indicated by the participants in response to 30% of the subject-drop sentences and 77% of the object-drop sentences), participants are likely required to establish a new extra-sentential referent in the discourse.

position of an overt argument. Therefore, one might argue that the manipulation employed in the current experiment is not fully comparable to the ones employed in the described previous studies and thus does not allow a straightforward attribution of the observed effect to similar underlying processes of referent establishment.

Alternatively, the pro-drop positivity might simply be attributable to the detection of a missing argument in the sentence. Such an interpretation would diverge from the assumptions made above in several regards. On the one hand, the simple detection of an argument omission need not be classified as a discourse related process at all. As a consequence on a theoretical level, this kind of process would probably rather be subsumed under the linking step of Stage 2 in the eADM, since this is the processing step in which the omission of an argument becomes evident. The fact that we observed a positivity and not the negativity that is typically associated with processing problems arising during the linking step may be considered as initial evidence against the possibility of a simple detection mechanism behind the pro-drop positivity; it is however not sufficient to entirely rule out such an interpretation, since one might argue that this specific detection process, though arising during Stage 2, could be reflected in an individual ERP component. Considering previous findings, the P600 effects for referent establishment reported above cannot be derived from such a process, since these results stemmed from complete sentences without missing arguments. Other instances of P600 effects that might be related to more similar processes have been reported by Kolk and colleagues in the context of their Monitoring Theory of Language Perception (Kolk et al., 2003; see also Kolk & Chwilla, 2007; Van Herten, Chwilla, & Kolk, 2006; Van Herten, Kolk, & Chwilla, 2005), according to which the P600 reflects a general process of reanalysis which applies at all levels of representation and is triggered by a conflict between an expected and an actual linguistic event or between the sentence interpretations delivered by syntactic vs. semantic/heuristic information. If such a conflict is sufficiently strong (Van de Meerendonk, Kolk, Vissers, & Chwilla, in press), the parser is assumed to check for possible perception errors, focusing on the possibility that the sentence has simply been misread or misheard. Such an account can, for example, successfully derive the "semantic" P600 effects elicited by semantic reversal anomalies, which can be reanalyzed as perfectly grammatical and semantically normal sentences under the assumption that the grammatical functions were initially mis-assigned due to an erroneous perception of the sentence. Furthermore, it has been demonstrated that the reanalysis to check for possible perceptual errors is not restricted to the sentence level but also applies at the word level (Vissers, Chwilla, & Kolk, 2006) and at the conceptual level (for example in picture-sentence mismatches; Vissers, Kolk, Van de Meerendonk, & Chwilla, 2008). Even though pro-drop sentences should have a high expectancy in a language like Japanese, it is still imaginable that the initial response to a missing argument could be to check whether the input sentence has been perceived appropriately or whether the respective argument was simply overlooked.

Thus, while the current experiment does provide initial evidence for increased processing costs for pro-drop sentences, it does not allow ultimate conclusions regarding the underlying mechanism(s) responsible for the pro-drop positivity. A promising candidate in this regard is the establishment of new discourse referents, but based on the current findings, the detection of a missing argument cannot be ruled out as a simple alternative explanation. Crucially, however, the two alternative hypotheses can be contrasted if pro-drop sentences are presented in an experimental environment manipulating the degree to which a new discourse referent needs to be established for the omitted argument. Clearly, such a manipulation should affect the strength of the pro-drop positivity if this ERP effect reflects the establishment of new discourse referents. By contrast, the ERP effect should be unaffected by such a manipulation if it merely reflects the detection of the argument omission. In Experiment 4, such a manipulation was realized by presenting the pro-drop sentences of Experiment 3 embedded in linguistic contexts providing a varying number of discourse referents.

Chapter 8

Experiment 4: Word order, argument drop, & context

8.1 Introduction

Experiment 4 served to shed further light on the underlying mechanism(s) of the pro-drop positivity that was observed for subject-drop and object-drop sentences in Experiment 3. More precisely, the variation of contextually provided discourse information served to test whether this ERP effect always arises when a sentence with an omitted argument is processed (in response to the detection of the argument omission) or whether there are circumstances under which the effect can be alleviated. As discussed in Section 7.5.2, a promising candidate for an underlying mechanism of the positivity effect is the need to establish a new discourse referent. Therefore, the critical sentences investigated in Experiment 3 were reemployed in Experiment 4, each preceded by a context sentence introducing a varying number of discourse referents.

The rationale behind this account was that if the need to establish a new discourse referent is responsible for the pro-drop positivity, the effect should be alleviated when the context provides a pre-established discourse referent for the omitted argument. This should clearly be the case whenever a compatible referent for the omitted argument is directly mentioned (i.e. given) in the preceding context.[60] In

[60]Note that the term givenness will be used here strictly in the narrow sense, i.e. only for lexically pre-mentioned entities. A comparison of several wider conceptualizations of the term (for example in the sense of predictability, saliency, or shared knowledge) is provided by Prince (1981).

this regard, recall from Section 1.2 that when the linguistic context of a pro-drop sentence (e.g. *Hanako-o maneita*; "[ ] invited Hanako") provides a compatible referent (e.g. *Taroo*) for the omitted argument, this referent will be recovered as the omitted referent (the "inviter"). Therefore, no processing costs for establishing a new discourse referent should arise in this case.

In addition to lexically given referents, a further type of pre-established referent should be considered in this context. As described in Section 1.2, the speaker and the addressee of an utterance are always salient entities in a natural discourse, be it spoken or written. While it is arguable whether this is also the case in completely isolated visually presented sentences such as the ones employed in Experiment 3, embedding the critical sentences in a longer utterance should increase the degree to which these referents are already pre-established in the discourse representation. Since in declarative subject-drop sentences without a compatible given referent, the speaker is typically inferred as the missing actor referent (Martin, 2003; see also the follow-up questionnaire results of Experiment 3), the pre-establishment of this referent should also reduce the processing costs reflected in the pro-drop positivity in response to these sentences. In declarative object-drop sentences, on the other hand, the speaker is rarely inferred as the missing undergoer referent, even if no overt alternative is given in the context. In this case, the undergoer role is rather filled with a newly established referent (cf. "someone"/"someone else" in the questionnaire results of Experiment 3). If the pro-drop positivity really reflects increased processing costs for the establishment of new discourse referents, the effect should therefore be reduced in embedded subject-drop sentences but not in embedded object-drop sentences.

Alternatively, if the pro-drop positivity is simply a correlate of argument omission per se, then contextually provided discourse information should not modulate the ERP effect at all. After all, an argument is always missing in the pro-drop sentences, independently of the pre-establishment of certain referents. As a consequence, the detection of this argument omission should always be reflected in a pro-drop positivity, independently of the context information.

In addition to gaining further insight into the underlying mechanisms of the pro-drop positivity, the design of Experiment 4 also offered the opportunity to test the cross-linguistic validity of the discourse related P600 effects observed in other languages more directly. More precisely, we investigated whether the P600 effects observed at the position of overt arguments requiring the establishment of new discourse referents in German, Dutch, and English (Burkhardt, 2006, 2007a; Van Berkum et al., 2004; Van Petten et al., 1991) could also be replicated in a more comparable experimental situation in Japanese. In this case, a similar P600 effect should be observable whenever a new discourse referent needs to be established at the position of an overt NP, i.e. whenever such an NP has not been given in the preceding context. If the effect is universal, it should be observable at the positions of NP1 and NP2 in the complete sentences as well as at the position of NP1 in the pro-drop sentences.

8.2 Design and hypotheses

As described above, Experiment 4 sought to investigate the influence of pre-established referential information on the processing of pro-drop sentences. If the pro-drop positivity is a general marker of sentences with omitted arguments, it should occur independently of the discourse-referential information that is provided. If, however, the pro-drop positivity reflects processes of referent establishment, the effect should be reduced whenever a potential subject (actor) referent is given in the context of subject-drop sentences and whenever a potential object (undergoer) referent is given in the context of object-drop sentences. In addition, the positivity effect should also be reduced when the context allows the inference of the pre-established speaker as the missing referent, i.e. when no compatible discourse referents are given in the context of subject-drop sentences. Furthermore, it was predicted that a P600 effect should arise at the position of all overt NPs (of complete and pro-drop sentences) which require the establishment of a new discourse referent, thereby mirroring the results observed in response to similar manipulations in German, Dutch, and English.

To test these predictions, the four critical sentence conditions from Experiment 3 (henceforward called *target* conditions; SOV vs. OSV vs. SV vs. OV) were reemployed, and each target sentence was preceded by one of four types of context sentences which served the purpose of introducing referents into the discourse. As exemplified in Table 8.1, a context sentence preceding a target sentence introduced either the target sentence's subject referent S☑O☒), its object referent (S☒O☑), both the subject and the object referent (S☑O☑), or neither of the target referents (S☒O☒). Crucially, while the referents introduced in the contexts referred to the overt subjects and objects of the complete (canonical and scrambled) sentences, a "given subject" in combination with a subject-drop target sentence and a "given object" in combination with an object-drop target sentence actually refer to the givenness of compatible and thus *recoverable* referents for the omitted arguments.

Table 8.1: Example sentences for each of the critical context and target conditions in Experiment 4

Context sentences

Condition	Example sentence
S☑O☑	二週間前、太郎と花子が大学で勉強した。 nishuukanmae Taroo-to-Hanako-ga daigaku-de benkyoushita two weeks ago Taroo-and-Hanako-NOM university-at studied ‘Two weeks ago, Taroo and Hanako studied at the university.’
S☑O☒	二週間前、太郎が大学で勉強した。 nishuukanmae Taroo-ga daigaku-de benkyoushita two weeks ago Taroo-NOM university-at studied ‘Two weeks ago, Taroo studied at the university.’
S☒O☑	二週間前、花子が大学で勉強した。 nishuukanmae Hanako-ga daigaku-de benkyoushita two weeks ago Hanako-NOM university-at studied ‘Two weeks ago, Hanako studied at the university.’
S☒O☒	二週間前、大学で招待講演があった。 nishuukanmae daigaku-de shoutaikouen-ga atta two weeks ago university-at guest lecture-NOM took place ‘Two weeks ago, a guest lecture was given at the university.’

Target sentences

Condition	Example sentence			
SOV	そこで	太郎が	花子を	招いた
	sokode	Taroo-ga	Hanako-o	maneita
	there	Taroo-NOM	Hanako-ACC	invited
	‘There, Taroo invited Hanako.’			
OSV	そこで	花子を	太郎が	招いた
	sokode	Hanako-o	Taroo-ga	maneita
	there	Hanako-ACC	Taroo-NOM	invited
	‘There, Taroo invited Hanako.’			
SV	そこで	太郎が	招いた	
	sokode	Taroo-ga	maneita	
	there	Taroo-NOM	invited	
	‘There, Taroo invited [ ].’			
OV	そこで	花子を	招いた	
	sokode	Hanako-o	maneita	
	there	Hanako-ACC	invited	
	‘There, [ ] invited Hanako.’			

Abbreviations used: S☑, subject of the target sentence given; S☒, subject of the target sentence not given; O☑, object of the target sentence given; O☒, object of the target sentence not given; SOV, subject-object-verb target sentence; OSV, object-subject-verb target sentence; SV, subject-verb target sentence; OV, object-verb target sentence.

Our hypotheses were as follows:

(a) Since the contextual manipulation was not expected to affect the processing of word order variations in complete target sentences (in which no discourse referents needed to be established), we expected a replication of the findings from Experiment 3 with regard to the differences between the canonical and the scrambled word orders. That is, we expected to observe no scrambling negativity for object-initial orders at the position of NP1 (due to the presence of pro-drop sentences in the experimental environment), but an extension N400 for subject-before-object (SOV) as opposed to object-before-subject (OSV) sentences at the position of NP2, reflecting the revision from an intransitive to a transitive event representation. As a consequence, no effect of ORDER (subject-initial vs. object-initial) was predicted at the position of NP1, and a main effect of ORDER (SOV vs. OSV) was predicted at the position of NP2.

(b) At the position of the noun phrases, we investigated additional effects of the contextual manipulation independently of the NPs' grammatical function. If the P600 previously observed for English, Dutch, and German is a cross-linguistically universal marker of referent establishment, a P600 effect should be observed if an NP of the target sentence required the establishment of a new discourse referent. In addition, a reduced N400 was expected if an NP of the target sentence was pre-mentioned in the context sentence (a lexical repetition effect; cf. Bentin & Peled, 1990; Burkhardt, 2006, 2007a; Nagy & Rugg, 1989; Rugg, 1987, 1990; Van Petten et al., 1991). Thus, a biphasic N400-P600 effect was predicted for all new NPs in comparison to all given NPs, independently of their grammatical function (i.e. independently of the ORDER manipulation).

(c) At the position of the verb, we predicted the emergence of a pro-drop positivity comparable to the one observed in Experiment 3 in both conditions with an omitted argument (SV and OV) in comparison to the canonical SOV condition, i.e. significant effects in the OV–SOV and SV–SOV comparisons. If the pro-drop positivity simply reflects the detection of an omitted argument, then no interactions of these two pairwise target comparisons with the context manipulation should arise. If, however, the pro-drop positivity reflects processes of referent establishment as assumed, then the effect should be reduced whenever a compatible referent for the omitted argument is given in the preceding context. Thus, in the OV–SOV comparison the pro-drop positivity should be reduced whenever a potential subject referent is given in the preceding context (context conditions S☑O☑and S☑O☒), and in the SV–SOV comparison it should be reduced whenever a potential object referent is given in the preceding context (context conditions S☑O☑and S☒O☑). In addition, the positivity effect should also be reduced whenever the context allows the inference of the pre-established speaker as the missing referent, which is assumed to be the case in the OV–SOV comparison when no overt referents are given (context condition S☒O☒) and possibly also when only the overt object is given (context condition S☒O☑). Since all of the referents were overtly realized and therefore did not need to be inferred from outside of the sentence in the scrambled condition, no comparable positivity effect and no contextual influence were expected in the OSV-SOV comparison.

8.3 Materials and methods

8.3.1 Participants

Experiment 4 was conducted with 26 students (8 female) of the Tohoku University in Sendai, Japan. All participants were right-handed, monolingually raised native speakers of Japanese, and all had normal or corrected-to-normal vision and no neurological or reading disorders. At the time of experiment conduction, participants were aged 18–24 (mean age 20.5 years). A further four participants were excluded from the statistical analysis due to excessive EEG artifacts and/or low performance in the comprehension task.

8.3.2 Materials

Table 8.1 shows example sentences for the experimental conditions of Experiment 4. As is apparent from the bottom half of the table, the sentences from Experiment 3 which comprised the four critical conditions SOV (subject-object-verb sentences), OSV (object-subject-verb sentences), SV (subject-verb sentences), and OV (object-verb sentences), were reemployed as a basis for the materials of Experiment 4. While in Experiment 3 the critical sentences were presented on their own, in Experiment 4 they were each preceded by one of four types of context sentences which are presented in the top half of the table. A context sentence preceding a target sentence introduced either both the subject and the object of the target sentence (S☑O☑), only the subject of the target sentence (S☑O☒), only the object of the target sentence (S☒O☑), or neither the subject nor the object of the target sentence (S☒O☒). The combination of the four context conditions with the four target conditions resulted in a total of $4 \times 4 = 16$ critical conditions. Note again that when combined with a subject-drop target sentence (OV), an S☑ context merely denotes the givenness of a *potential* subject referent, as the actual subject was omitted from the target sentence. The same applies to the givenness of a *potential* object referent (O☑) in combination with an object-drop target sentence (SV).

The temporal adverbs initiating the critical sentences in Experiment 3 (e.g. *nishuukanmae*, "two weeks ago"; see Table 7.1) were moved to the beginning of the context sentences, and the following target sentences uniformly began with the conjunctive adverb *sokode* ("there/then"; see Table 8.1). The context sentences that introduced potential target referents (context conditions S☑O☑, S☑O☒, and S☒O☑) were all constructed following the same pattern: The sentence-initial temporal adverb was followed either by [referent1]-*and*-[referent2]-NOM (in context condition S☑O☑) or by [referent]-NOM (in context conditions S☑O☒ and S☒O☑), which was in turn followed by the description of an activity carried out by the introduced referent(s) (e.g. *studying*) in a certain location or situation (e.g. *at the university*). In the S☑O☑ condition, the order of referent introduction was counterbalanced, i.e. in half of the sentences the (potential) subject referent of the target sentence was introduced first, while in the other half the (potential) object referent of the target sentence was introduced first. The context sentences in condition S☒O☒ began with the same temporal adverb as the sentences of the other three conditions and described an event taking place in the same situational context (e.g. *at the university*) without introducing any entities that could potentially serve as actor or undergoer referents for the event described in the following target sentence.

As the context sentences were to be presented on the screen as a whole in an unsegmented manner, their total number of characters was controlled. The average number of characters for each of the context conditions is shown in Table 8.2. By definition, the sentences of condition S☑O☑ were always three characters longer than the sentences of conditions S☑O☒ and S☒O☑, due to the addition of the

Table 8.2: Mean length of the context sentences in Experiment 4

Condition	Mean length (number of characters)
S☑O☑	21.0 (2.8)
S☑O☒	18.0 (2.8)
S☒O☑	18.0 (2.8)
S☒O☒	19.4 (2.8)

Standard deviations are given in parentheses.

coordinator *to* (“and”; one character) and a second referent (two characters). The S☒O☒ sentences were matched in length to accord with the other three context conditions.

Forty sets of context sentences were constructed in this manner. A complete list of all context sets is provided in App. B.4. The target sentence sets were constructed from the 80 target word sets from Experiment 3 (see App. B.3) as demonstrated for the example word set in Table 8.1. From the 40 context sets and 80 target sets, 80 context-target sets were created. To this avail, each context set was matched in content to two of the target sets. For example, the contents of the “university” context set could be combined with the names *Taroo* and *Hanako* as shown in the top half of Table 8.1 and with a target set built with the same two names and the verb *maneita*, as presented in the bottom half of the table. In a second context-target set, the “university” context was combined with two other given names (*Ayumi* and *Hironobu*) and another target set was built with these two names and the verb *mushishita* (“ignored”).

The complete experimental material thus comprised 80 context-target sets × 4 context conditions (S☑O☑, S☑O☒, S☒O☑, S☒O☒) × 4 target conditions (SOV, OSV, SV, OV) × 2 name sequences in the target conditions[61] = 2560 critical sentence pairs. The sentence pairs were subdivided into four lists of 640 items each by allocating eight of the 16 realizations of every context-target set to each list in a counterbalanced fashion. As a result, participants were presented with eight variants of each context-target set, and with a total of 40 sentence pairs per condition. To provide maximal comparability with Experiment 3, the same 40 filler sentences were reemployed in Experiment 4. Like in Experiment 3, the filler sentences consisted only of an adverb (here *sokode*; “there/then”) and a verb and were expected to be rated highly unacceptable. Like the experimental sentences, each filler sentence was preceded by one of four kinds of context sentences, thus resulting in a total of 160 filler sentence pairs, which guaranteed the same filler-to-experimental sentence ratio as in Experiment 3 (160/640; cf. 40/160 in Experiment 3). Each of the four lists was then pseudo-randomized in two different orders.

The context sentences were prepared for visual presentation by converting them into bitmap files each depicting a complete context sentence in one line with no spaces or line breaks. The target sentences were again segmented into bitmaps for visual presentation so that participants were presented with one *bunsetsu* (content word plus functional particle, see Footnote 45) at a time. Each trial thus consisted

[61] Like in Experiment 3, the two name sequences were created to guarantee a complete balance in the experimental materials and a maximal comparability to Experiments 1 and 2, cf. Section 7.3.2.

of one bitmap showing the context sentence, followed by either three (conditions SV and OV) or four (conditions SOV and OSV) bitmaps sequentially depicting the target sentence.

Participants were again asked to give acceptability judgements. Like in Experiment 3, they were instructed to assess the acceptability of the structure of the target sentence rather than its semantic content. Furthermore, they were asked to also take the combination of the sentences into account for their judgement. Thus, rating a sentence pair as “acceptable” meant that the sentence pair was a good example of the Japanese language and a sentence structured like the target sentence might well follow a sentence like the preceding context sentence in natural spoken or written Japanese. Rating a sentence pair as “unacceptable”, on the other hand, meant that the structure of the target sentence and/or the combination of the two sentences sounded rather odd or incoherent to the participant. The acceptability judgement was again cued by a bitmap depicting a question mark with a smiley face (☺) and a frowny face (☹) to its left and right.

Participants were further asked to complete a control task in each experimental trial to ensure their attention throughout the experiment. As participants were required to process not only the target sentences but also the context sentences attentively, it was not sufficient to adopt the comprehension task from Experiment 3 which only tested the content of the target sentences. Therefore, a probe detection task was employed which demanded participants’ attention in both the context and the target sentence. After each experimental sentence pair, participants were presented with one word and had to decide whether the word had been part of the preceding sentence pair or not. The probe could stem from either the context sentence or the target sentence (or both, in the case of referent repetition). Only content words were used as probes; case markers or other functional particles were not included. The adverb *sokode* was never employed as a probe, as it occurred in every sentence pair. The inflections on the verbs were left identical in the corresponding probes. Taking the sentence pair S☑O☒-OV from Table 8.1 as an example, the following words were extracted as potential positive probes (probes to be answered with “yes”): *nishuukanmae*, *Taroo*, *daigaku*, *benkyoushita*, *Hanako*, *maneita*. Negative probes (probes to be answered with “no”) were constructed by replacing a positive probe from the sentence pair with a similar but not identical word. The probes were prepared for visual presentation by creating one bitmap file for each probe word.

8.3.3 Procedure

Experiments were conducted at the Tohoku University in Sendai, Japan, in a room comparable to the one used in Experiments 1–3. Again, participants were seated in a comfortable chair at a distance of 100 cm from a 17 in. computer screen and were giving their responses through a two-button response box. Experiments were split into two sessions (with an inter-session interval of two to three weeks), each comprising 400 trials. In each experimental session, participants were first presented with 20 practice trials, followed by 8 blocks of 50 experimental trials each. In each trial, first the context sentence was presented as a whole in the center of the screen. Participants were instructed to read the sentence quickly and attentively, and press any button on the response box once they had finished reading the sentence. After the button press (or after a period of 6000 ms had elapsed), the context sentence disappeared from the screen, and after another 500 ms the presentation of the target sentence proceeded in an analogous manner to Experiment 3: A fixation asterisk was presented for 650 ms, followed by the presentation of the target sentence one bunsetsu at a time. Each bunsetsu was visible in the center of the computer screen for 650 ms, followed by an interstimulus interval (ISI) of 100 ms. After the end of each target sentence, another fixation asterisk was presented for 1000 ms to prevent participants from blinking too early after the presentation of the verb. Following another 100 ms, the cue for the acceptability task appeared on the screen and remained visible until the participants judged the acceptability of the sentence pair by pressing one of the two buttons on the response box or until a maximum response time of 2000 ms had elapsed. Five hundred ms after the removal of the acceptability cue, the probe word was presented in the center of the screen and remained visible until the participants responded by button-press[62] or until a period of 3000 ms had elapsed. After an intertrial interval (ITI) of 1000 ms the next trial began. As the EEGs recorded during the presentation of the context sentence were not intended for analysis, participants were asked to avoid movements and eye blinks only between the two asterisks enclosing the target sentence.

[62] Analogous to Experiment 3, the same two buttons were used for giving the acceptability judgements and for deciding on the probes. Again, the assignment of the left and right button to the response options was counterbalanced across participants, and one button was always associated with “acceptable” (acceptability rating) and “yes” (probe detection) while the other button was always allocated the labels “unacceptable” and “no” (cf. Footnote 50).

8.3.4 EEG recording and preprocessing

The EEG was recorded using the same electrode cap system as in Experiment 3. The EEG was amplified using a portable BrainVision BrainAmp DC amplifier (Brain Products GmbH, Munich, Germany) and digitized with a sampling rate of 250 Hz. All following data preprocessing steps were undertaken in an analogous manner to Experiments 1–3.

8.3.5 Statistical analyses

As in Experiment 3, the design of Experiment 4 offers an abundance of options for statistical analyses that could possibly be conducted, even more so since here the experimental 4-level target factor (SOV, OSV, SV, OV) is – in addition to the random factors in the behavioral analyses and the topographical factor in the ERP analyses – crossed with a second experimental 4-level factor: the context variable (S☑O☑, S☑O☒, S☒O☑, S☒O☒). Consistent with the approach taken in Experiment 3, we again focused directly on the interesting research questions at hand and selected the appropriate statistical tests accordingly (For an in-depth discussion on the rationale behind the focused selection of specific comparisons, see Experiment 3, Section 7.3.5).

The main focus of Experiment 4 was on the influence of preceding context information on the processing of sentences with dropped arguments. To investigate this primary interest, we crossed the experimental target factor (ORDER or PC, depending on the analyzed position; cf. Experiment 3) with the four-level context factor (CONT), checking the results for main effects of the target factor and interactions of the target factor with the context factor. In case of such an interaction, we resolved the interaction by CONT to investigate whether differential target effects arose in different context conditions, e.g. if the pro-drop effect for target conditions SV and OV was modulated by context information. Main effects of the context manipulation were only of interest in the analysis of NP1 and NP2 (cf. Hypothesis b) and were only interpreted if no ORDER×CONT interactions were evident in the respective constituents.[63] In this case, pairwise comparisons (PC_{cont}; see below) were conducted between all four context conditions.

[63]Context effects were only examined in the absence of interactions with the target factor because the presence of an ORDER/PC×CONT interaction would make any simple differences between context conditions uninterpretable as they would attain diverging values depending on the level of the interacting target factor. Since all emerging interactions between target and context factors were already resolved by CONT to investigate the main concern of the experiment, we refrained from additional analyses resolving the same interactions in the other direction (i.e. by ORDER or PC).

Regarding the experimental context factor, it should be noted that the hypotheses stated in Section 8.2 required different definitions of the context conditions depending on the analysis under consideration. At the position of the verb, the four context conditions were defined as outlined so far, i.e. with regard to whether the (potential) subject and object of the target sentence were given in the preceding context (S☑O☑ vs. S☑O☒ vs. S☒O☑ vs. S☒O☒). The same definitions were also employed in the analysis of the behavioral data. For the noun phrase positions, however, Hypothesis (b) predicted context effects depending on whether the encountered NP had been given in the preceding context, and this effect was conceptualized as being independent of the noun phrase's grammatical function and position. Given the context definitions described above, however, NP1 givenness would be equivalent to the givenness of the *subject* in subject-initial sentences, but to the givenness of the *object* in object-initial sentences (and vice versa for NP2 givenness). To avoid the resulting artificial interactions and to be able to analyze context and target effects independently, the context conditions were therefore redefined for the analyses of the noun phrases, centering on whether NP1 and NP2 of the target sentence were given in the context (1☑2☑ vs. 1☑2☒ vs. 1☒2☑ vs. 1☒2☒). A table displaying the assignment of regular to redefined condition names is given in App. A.5.

As usual, analyses were carried out hierarchically and only significant effects will be reported. H–F corrections were applied whenever a statistical analysis included a factor with more than one degree of freedom in the numerator. Below, a more detailed description of the procedures employed for the analysis of the behavioral data and of the ERP data at each constituent will be given.

Behavioral data The error rates and reaction times in the probe detection task as well as the acceptability ratings and reaction times in the judgement task were analyzed by calculating separate pairwise comparisons (PC) between the canonical condition SOV and each of the three experimental target conditions (OSV, SV, and OV), resulting in the three pairwise target comparisons SV−SOV, OV−SOV and OSV−SOV. Since apart from the differential context influence, direct differences between the two pro-drop conditions were not in the focus of this experiment, no further pairwise comparisons between the two pro-drop conditions were added, thereby reducing the number of tests and avoiding an unnecessary loss in statistical power.

In each of the three analyses, the target factor PC (pairwise comparison between target conditions: e.g. SV vs. SOV) was further crossed with the second experimental factor CONT (context; S☑O☑ vs. S☑O☒ vs. S☒O☑ vs. S☒O☒) to investigate the influence of the preceding context information on the processing / evaluation of the target sentences, and with the random factor participants (F_1) or items (F_2). The p values for each of the resulting three pairwise comparisons were Bonferroni adjusted to counteract an inflation of the familywise error rate ($p_b = 3 \times p$). Incorrect responses to an item in the probe detection task led to the exclusion of the item from the reaction time analysis of the probe detection task and from all judgement task analyses.

Electrophysiological data The statistical procedures employed for the analysis of the ERP data differed slightly depending on the constituent under consideration.

At the position of NP1, target conditions SOV and SV were again combined into a conjoint S (subject-initial) condition, and target conditions OSV and OV were combined into a conjoint O (object-initial) condition, due to identical stimulation up to this point in the sentences (an adverb followed by a subject or an object, respectively). This two-level target factor was further crossed with the four-level context factor. Thus, the ERPs averaged at the position of NP1 were analyzed with repeated measures ANOVAs comprising the two experimental factors ORDER (order: subject-initial vs. object-initial) and CONT (context: 1☑2☑ vs. 1☑2☒ vs. 1☒2☑ vs. 1☒2☒), as well as the topographical factor ROI (region of interest, defined as in Experiments 1–3). Under the condition that no interactions with the target factor emerged (i.e. no ORDER×CONT or ORDER×CONT×ROI interactions), main effects of the context manipulation were examined by conducting pairwise comparisons between the four context conditions. Each of the six pairwise comparisons (PC_{cont}, e.g. 1☑2☑ vs. 1☑2☒) was crossed with the topographical factor ROI (region of interest, see above), and the p values of the resulting analyses were adjusted to control the familywise error rate using the Bonferroni procedure ($p_b = 6 \times p$).

At the position of NP2 only conditions with canonical (SOV) or scrambled (OSV) target sentences entered the statistical analyses, as these were the only sentences in which a second noun phrase was present. In the resulting repeated measures ANOVAs, the two experimental factors ORDER (order: subject-before-object vs. object-before-subject) and CONT (context: 1☑2☑ vs. 1☑2☒ vs. 1☒2☑ vs. 1☒2☒) were further crossed with the topographical factor ROI (region of interest). Under the condition of no ORDER×CONT or ORDER×CONT×ROI interactions, pairwise comparisons between the four levels of the context factor were calculated in the same manner as at the position of NP1.

At the position of the verb, all four target conditions entered the statistical analysis. Since the focus of Experiment 4 was on the influence of context information on the pro-drop positivity observed for the conditions with a dropped argument (SV and OV) in Experiment 3, analyses focused on the two primary pairwise comparisons that contrasted these two conditions with the canonical control condition SOV. The resulting SV−SOV and OV−SOV comparisons were further supplemented by the comparison OSV−SOV to test the hypothesis that no pro-drop positivity and no contextual influence should be discernible for the scrambled sentences. To analyze the influence of context information in each of the three comparisons, each of the three repeated measures ANOVAs crossed the target factor PC (pairwise comparison between target conditions: e.g. SV vs. SOV) with the second experimental factor CONT (S☑O☑ vs. S☑O☒ vs. S☒O☑ vs. S☒O☒). To investigate the distribution of the effects on the scalp, the topographical factor ROI (region of interest) was included. To control the familywise error rate, p values were Bonferroni adjusted for the three pairwise comparisons ($p_b = 3 \times p$).

8.4 Results

8.4.1 Behavioral data

Table 8.3 shows the error rates and reaction times from the probe detection task. The ratings and reaction times from the judgement task are presented in Table 8.4.

With regard to the error rates, no differences between target conditions or interactions of the target and the context factor were evident in any of the three primary pairwise comparisons (main effect PC: all F_1s < 3, p_bs $> .46$; all F_2s < 1; interaction PC×CONT all F_1s < 4, p_bs $> .11$; all F_2s < 1). The analysis of the probe detection reaction times showed a significant effect of PC only in the OV−SOV comparison ($F_1(1{,}25) = 11.31$, $p_b < .007$; $F_2(1{,}79) = 6.80$, $p_b < .04$; reaction times being longer for SOV sentences than for OV sentences).

Thus, the experimental conditions did not seem to have any influence on the participants' performance in the probe detection task. With regard to the reaction times, participants took longer to assess the probes in SOV sentences than in OV sentences. As in the previous experiments, the reaction time data will not be subject to further interpretation.

With regard to the acceptability ratings, the analysis of the OSV−SOV comparison did not yield any significant effects of PC ($F_1(1{,}25) = 1.83$, $p_b > .57$; $F_2 < 1$) or PC×CONT ($F_1 < 1$; $F_2(3{,}237) = 1.17$, $p_b = .96$). The analysis of the SV−SOV comparison showed a main effect of PC ($F_1(1{,}25) = 48.76$, $p_b < .001$; $F_2(1{,}79) = 938.71$, $p_b < .001$), with SOV sentences being rated more acceptable than SV sentences. The analysis of the OV−SOV comparison also revealed a significant main effect of PC ($F_1(1,25) = 34.62$, $p_b < .001$; $F_2(1,79) = 697.71$, $p_b < .001$), as well as a significant PC×CONT interaction ($F_1(3,75) = 4.93$, $p_b < .02$; $F_2(3,237) = 9.79$, $p_b < .001$). Resolving the interaction by CONT showed a significantly lower acceptability for OV sentences than for SOV sentences in all context conditions, with the strongest effect in context condition S⊠O⧄ ($F_1(1,25) = 47.34$, $p_b < .001$; $F_2(1,79) = 373.85$, $p_b < .001$) and the weakest effect in context condition S⧄O⊠ ($F_1(1,25) = 16.04$, $p_b < .002$; $F_2(1,79) = 62.94$, $p_b < .001$). Regarding the judgment task reaction times, a main effect of PC reached significance in the OSV−SOV comparison ($F_1(1,25) = 7.46$, $p_b < .04$; $F_2(1,79) = 13.61$, $p_b < .001$; longer reaction times for OSV sentences), the SV−SOV comparison ($F_1(1,25) = 7.94$, $p_b < .03$; $F_2(1,79) = 17.53$, $p_b < .001$; longer reaction times for SV sentences), and the OV−SOV analysis ($F_1(1,25) = 11.44$, $p_b < .007$; $F_2(1,79) = 26.44$, $p_b < .001$; longer reaction times for OV sentences). In addition, the PC×CONT interaction reached significance in the SV−SOV comparison ($F_1(3,75) = 3.76$, $p_b < .05$; $F_2(3,237) = 3.89$, $p_b < .03$). Resolving the interaction by CONT revealed significant effects of PC only in context conditions S⧄O⧄ and S⊠O⧄ in the participant analysis (both F_1s > 7.50, p_bs $< .04$) and in the same two context conditions as well as in context S⧄O⊠ in the item analysis (all F_2s > 9, p_bs $< .007$).

Table 8.3: Mean error rates and reaction times in the probe detection task of Experiment 4

Error rates (%)										
Target	Mean		Mean per context condition							
			S⧄O⧄		S⧄O⊠		S⊠O⧄		S⊠O⊠	
SOV	8.6	(3.7)	9.3	(6.7)	7.7	(4.1)	9.8	(5.6)	7.6	(3.8)
OSV	9.4	(3.7)	8.2	(5.0)	10.1	(4.3)	9.5	(4.7)	10.0	(6.1)
SV	8.8	(3.3)	8.3	(5.7)	9.8	(5.1)	8.2	(5.0)	9.0	(4.1)
OV	8.3	(3.6)	8.3	(5.9)	9.1	(4.5)	8.9	(4.7)	7.1	(5.1)
Mean			8.4	(4.4)	9.4	(3.2)	9.2	(2.9)	8.1	(3.0)
Reaction times (ms)										
Target	Mean		Mean per context condition							
			S⧄O⧄		S⧄O⊠		S⊠O⧄		S⊠O⊠	
SOV	910	(118)	897	(111)	911	(129)	891	(122)	940	(144)
OSV	914	(119)	915	(123)	895	(119)	889	(132)	955	(138)
SV	888	(101)	880	(106)	867	(115)	894	(113)	909	(112)
OV	881	(96)	872	(103)	902	(106)	868	(113)	880	(100)
Mean			887	(105)	886	(108)	877	(104)	908	(113)

Standard deviations (of the participant analysis) are given in parentheses.

The scrambled OSV sentences thus did not show an acceptability loss in comparison to the canonical SOV sentences, whereas all sentences with a dropped argument (SV and OV sentences) were rated significantly less acceptable than the canonical SOV sentences. For the sentences with an omitted subject (OV) this effect was least pronounced when the preceding context sentence introduced only a potential subject referent for the missing argument (S☑O☒), and most pronounced when the preceding context introduced only the overt object of the target sentence (S☒O☑).[64] With regard to the reaction times, participants took longer to judge OSV, SV and OV sentences than to judge the canonical SOV sentences. For the SV−SOV comparison, this difference was not significant when none of the target referents had been introduced in the context (i.e. in context condition S☒O☒). Again, the reaction time data will not be interpreted further.

[64] As in Experiment 3, the expectedly unacceptable filler sentences, in which both the subject and the object of a transitive verb had been omitted, were rated "unacceptable" more often than "acceptable" by participants, resulting in mean acceptability ratings between 23.9% and 30.2%, depending on preceding context.

Table 8.4: Mean ratings and reaction times in the judgement task of Experiment 4

Acceptability ratings (%)					
Target	Mean	Mean per context condition			
		S☑O☑	S☑O☒	S☒O☑	S☒O☒
SOV	78.7 (20.9)	83.7 (18.9)	76.5 (24.1)	84.6 (18.3)	70.9 (26.5)
OSV	79.5 (20.9)	82.4 (21.7)	78.4 (21.8)	84.0 (19.2)	73.2 (24.4)
SV	42.0 (22.0)	48.6 (28.5)	33.7 (24.6)	49.8 (21.4)	35.8 (21.8)
OV	51.5 (20.6)	55.6 (23.9)	58.0 (23.3)	48.6 (23.4)	44.0 (24.3)
Mean		58.8 (16.7)	55.2 (16.4)	59.4 (15.1)	49.4 (15.6)
Reaction times (ms)					
Target	Mean	Mean per context condition			
		S☑O☑	S☑O☒	S☒O☑	S☒O☒
SOV	553 (200)	533 (210)	557 (211)	538 (194)	582 (210)
OSV	581 (204)	543 (202)	625 (234)	584 (217)	572 (192)
SV	592 (193)	587 (199)	604 (216)	604 (203)	574 (181)
OV	597 (202)	600 (203)	611 (215)	598 (216)	581 (205)
Mean		567 (195)	592 (205)	578 (193)	568 (188)

Standard deviations (of the participant analysis) are given in parentheses.

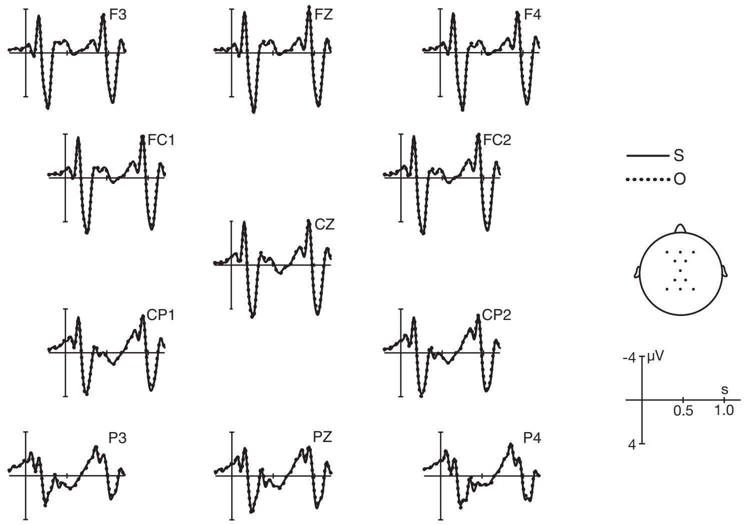

Figure 8.1: Grand-average ERPs (N = 26) time-locked to the onset of NP1 (onset at the vertical bar) in Experiment 4, averaged across context conditions.

8.4.2 ERP data

For maximal clarity, several figures will be presented for the ERPs averaged at each constituent. As no interaction of the target factor (ORDER) and the context factor (CONT) was evident in the ERPs recorded at the positions of NP1 and NP2 (as confirmed by timeline analyses, see respective subsections below), separate figures will be given for examining the main effects of the target and the context manipulation independently, one figure showing the two target conditions collapsed over context conditions and one figure showing the four context conditions collapsed over target conditions. For the ERPs recorded at the position of the verb, one plot will show the four target conditions collapsed over context conditions to allow for visual comparison with the results from Experiment 3 (see Fig. 7.3), and three separate plots will be presented for the three pairwise target comparisons that were in the focus of the study (OV−SOV, SV−SOV, and OSV−SOV), each depicting all four context levels for the respective pairwise comparison.

NP1

Fig. 8.1 shows the grand-average ERPs relative to the first noun phrase for the two conjoint target conditions S (subject-initial; comprising conditions SOV and SV)

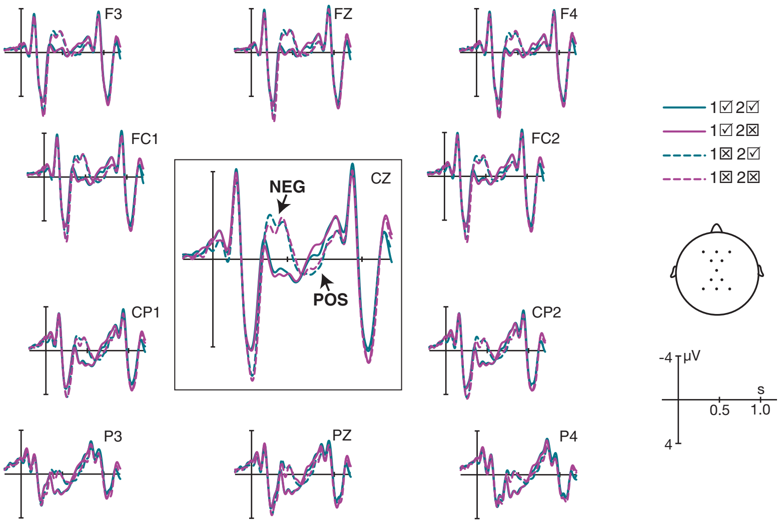

Figure 8.2: Grand-average ERPs (N = 26) time-locked to the onset of NP1 (onset at the vertical bar) in Experiment 4, averaged across target conditions.

and O (object-initial; comprising conditions OSV and OV), collapsed over context conditions. Fig. 8.2 shows the grand-average ERPs for the four context conditions (1☑2☑, 1☑2☒, 1☒2☑, 1☒2☒), collapsed over target conditions. A timeline analysis ensured that there were no significant interactions of ORDER×CONT or ORDER×CONT×ROI in any two subsequent 50 millisecond time windows between 0 and 850 ms post NP1 onset.[65]

As can be seen clearly from Fig. 8.1, no target effects were evident at the position of NP1. This impression was also confirmed by the timeline analysis which showed no significant effects of ORDER or ORDER×ROI for any two subsequent 50 millisecond time windows between 0 and 850 ms post stimulus onset (main effect ORDER only significant at 350–400 ms; midline electrodes: $F(1,25) = 5.80$, $p < .03$; lateral electrodes: $F(1,25) = 5.38$, $p < .03$).

Fig. 8.2, on the other hand, shows clear effects of the preceding context information on the ERPs at NP1: Between approximately 350 and 550 ms both conditions in which NP1 had not been introduced in the preceding context (1☒2☑ and 1☒2☒)

[65] Midline electrodes: interaction ORDER×CONT significant at 0–50 ms ($F(3,75) = 3.05$, $p < .04$), 100–150 ms ($F(3,75) = 4.01$, $p < .02$), and 250–300 ms ($F(3,75) = 3.14$, $p < .04$); interaction ORDER×CONT×ROI significant at 600–650 ms ($F(15,375) = 2.47$, $p < .04$); lateral electrodes: interaction ORDER×CONT significant at 100–150 ms ($F(3,75) = 5.45$, $p < .003$); interaction ORDER×CONT×ROI significant at 600–650 ms ($F(9,225) = 2.64$, $p < .01$).

engendered a broadly distributed negativity in comparison to conditions in which NP1 had been introduced in the context (1⧄2⧄ and 1⧄2⊠). This negativity was followed by a positivity between approximately 600 and 800 ms for the same two conditions. To confirm the effects statistically, both time windows were analyzed by calculating pairwise comparisons (PC_{cont}) between all four context conditions.[66]

For the 350–550 ms time window, the relevant test statistics are presented in Table 8.5. The midline analysis showed significant main effects of PC_{cont} for the following pairwise comparisons: 1⧄2⧄−1⊠2⧄, 1⧄2⧄−1⊠2⊠, 1⧄2⊠−1⊠2⧄, and 1⧄2⊠−1⊠2⊠, i.e. for all comparisons of conditions in which NP1 was given (1⧄) with conditions in which NP1 was new (1⊠). For all four comparisons, the interactions with ROI also reached significance. Resolving the interactions by ROI showed

[66] Fig. 8.2 also suggests a context effect in the amplitude of the P2 peak (between approximately 225 and 325 ms). Due to the lack of hypotheses for this early component, the statistical analyses for all P2 effects arising here and at the other averaging positions will be presented and discussed in App. A.6 for greater ease of exposition.

Table 8.5: Pairwise comparisons between context ERPs at the position of NP1 in Experiment 4, time window 350–550 ms

	Pairwise context comparison							
	1⧄2⧄−1⊠2⧄		1⧄2⧄−1⊠2⊠		1⧄2⊠−1⊠2⧄		1⧄2⊠−1⊠2⊠	
350–550 ms	F	p_b	F	p_b	F	p_b	F	p_b
midline								
PC_c	151.54	< .001	129.59	< .001	221.54	< .001	195.77	< .001
PC_c×ROI	6.72	< .05	10.98	< .002	22.84	< .001	20.67	< .001
Fz	86.54	< .001	110.35	< .001	135.36	< .001	125.77	< .001
FCz	106.07	< .001	132.23	< .001	182.23	< .001	174.96	< .001
Cz	137.18	< .001	134.05	< .001	216.89	< .001	197.30	< .001
CPz	157.22	< .001	125.95	< .001	228.21	< .001	195.28	< .001
Pz	183.70	< .001	103.62	< .001	244.35	< .001	182.85	< .001
POz	170.77	< .001	89.53	< .001	229.42	< .001	146.42	< .001
lateral								
PC_c	130.58	< .001	130.22	< .001	157.51	< .001	164.83	< .001

Abbreviations used here and in the following tables: PC_c, main effect of pairwise comparison between context conditions; PC_c×ROI, interaction of pairwise comparison between context conditions and ROI; ant, anterior ROIs; post, posterior ROIs. Only those of the six pairwise comparisons that showed significant effects will be listed. Degrees of freedom (*df*) for the F tests were as follows: main effects PC_c and all single ROI analyses, *1,25*; interaction effects PC_c×ROI midline, *5,125*; interaction effects PC_c×ROI lateral, *3,75*.

significant effects of PC_{cont} at all topographical regions for all four contrasts, with central to parietal maxima in all comparisons. The same four pairwise comparisons also yielded significant main effects of PC_{cont} at lateral electrode positions, albeit without any interaction with the topographical factor ROI.

For the 600–800 ms time window (for the test statistics, see Table 8.6), the midline analysis as well as the lateral analysis revealed main effects of PC_{cont} for the same four context comparisons, without any modulation of the effect by topographical factors.

To summarize the effects evident at the position of the first noun phrase, there were no interactions between the two experimental factors as well as no main effects of word order, but several effects of given context information: Initial noun phrases that had not been introduced in the preceding context (1⊠2☑ and 1⊠2⊠) elicited a broadly distributed negativity between 350 and 550 ms and a broadly distributed positivity between 600 and 800 ms in comparison to initial noun phrases that had been mentioned in the preceding context (1☑2☑ and 1☑2⊠).

NP2

Fig. 8.3 shows the ERPs averaged at the onset of the second noun phrase for the two target conditions SOV and OSV, collapsed over context conditions. The ERPs for the four context conditions 1☑2☑, 1☑2⊠, 1⊠2☑, and 1⊠2⊠, collapsed over target conditions, are displayed in Fig. 8.4. A timeline analysis confirmed that there were no significant interactions of ORDER×CONT or ORDER×CONT×ROI in any two subsequent 50 millisecond time windows between 0 and 850 ms post NP2 onset.[67]

[67] Midline electrodes: interaction ORDER×CONT×ROI significant at 150–200 ms ($F(15{,}375) = 2.70$, $p < .03$) and 250–300 ms ($F(15{,}375) = 2.66$, $p < .04$).

Table 8.6: Pairwise comparisons between context ERPs at the position of NP1 in Experiment 4, time window 600–800 ms

	Pairwise context comparison							
	1☑2☑−1⊠2☑		1☑2☑−1⊠2⊠		1☑2⊠−1⊠2☑		1☑2⊠−1⊠2⊠	
600–800 ms	F	p_b	F	p_b	F	p_b	F	p_b
PC_c midline	19.63	< .001	28.33	< .001	31.63	< .001	30.07	< .001
PC_c lateral	17.68	< .002	22.02	< .001	30.30	< .001	28.37	< .001

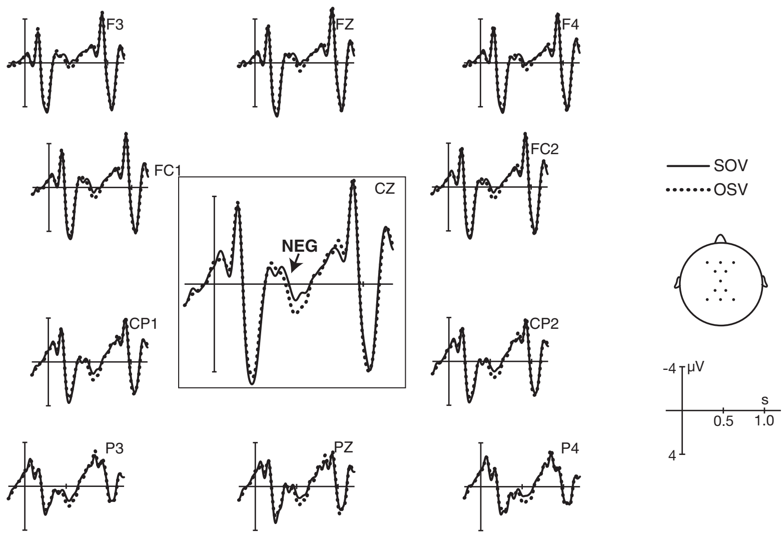

Figure 8.3: Grand-average ERPs (N = 26) time-locked to the onset of NP2 (onset at the vertical bar) in Experiment 4, averaged across context conditions.

Fig. 8.3 shows a broadly distributed negativity for subject-before-object sentences (SOV) in comparison to object-before-subject sentences (OSV) between approximately 450 and 650 ms post NP2 onset. The visual impression was confirmed by the statistical analysis of this time window which showed significant main effects of ORDER both at midline ($F(1,25) = 21.93$, $p < .001$) and at lateral electrode sites ($F(1,25) = 26.23$, $p < .001$).

Visual inspection of Fig. 8.4 reveals several effects of the given context information on the ERPs averaged relative to NP2: First, all sentences in which the second noun phrase had not been introduced in the preceding context (i.e. conditions 1☑2☒ and 1☒2☒) elicited a broadly distributed negativity between approximately 350 and 500 ms in comparison to sentences in which the second noun phrase was given in the preceding context (conditions 1☑2☑ and 1☒2☑). This negativity effect was followed by a broadly distributed positivity between approximately 550 and 750 ms for the same two conditions in comparison to condition 1☑2☑. In addition, sentences in which the second noun phrase itself was familiar from the context but the preceding *first* noun phrase had not been mentioned in the context (1☒2☑) also seemed to engender a widely distributed positivity in comparison to condition 1☑2☑, albeit starting and ending approximately 50 milliseconds earlier than for conditions 1☑2☒ and 1☒2☒, thus rather being evident between 500 and 700 ms. To examine the ef-

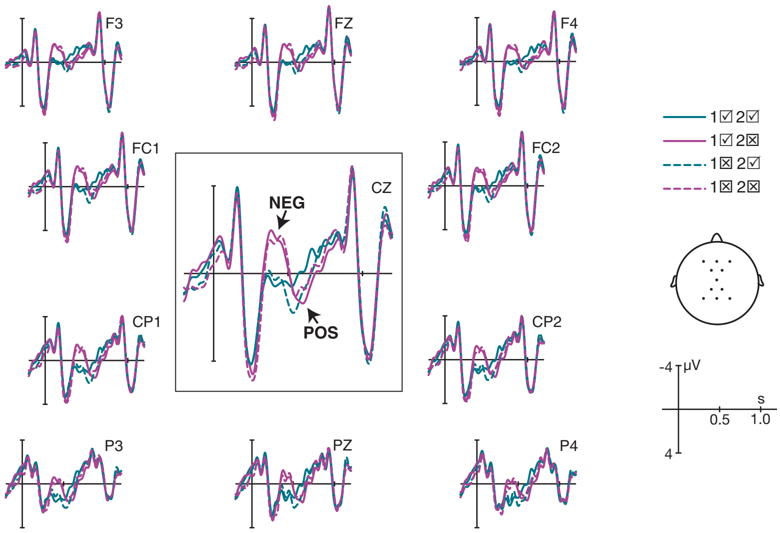

Figure 8.4: Grand-average ERPs (N = 26) time-locked to the onset of NP2 (onset at the vertical bar) in Experiment 4, averaged across target conditions.

fects statistically, pairwise comparisons (PC_{cont}) between all four context conditions were conducted for all relevant time windows.

The negativity effect was analyzed in the time window between 350 and 500 ms (for the test statistics, see Table 8.7). The statistical analysis of the midline electrodes showed main effects of PC_{cont} in the following four pairwise context comparisons: 1☑2☑−1☑2☒, 1☑2☑−1☒2☒, 1☒2☑−1☑2☒, and 1☒2☑−1☒2☒, i.e. in all comparisons between conditions in which NP2 was given (2☑) and conditions in which NP2 was new (2☒). As Table 8.7 shows, PC_{cont}×ROI interactions reached significance in three of these four comparisons. The resolution of the interactions by ROI showed significant effects of PC_{cont} at all midline electrodes, with varying maxima. The analysis of the lateral electrodes also revealed significant main effects of PC_{cont} for the same four pairwise comparisons. Only in the 1☑2☑−1☑2☒ comparison, the main effect of PC_{cont} was further accompanied by a PC_{cont}×ROI interaction. The resolution of the interaction by ROI showed a posterior maximum of the PC_{cont} effect. In addition, the PC_{cont}×ROI interaction also reached significance in a further comparison (1☑2☑−1☒2☑; $F(3,75) = 6.11$, $p_b < .02$), but the resolution of this interaction by ROI did not yield significant effects at any topographical region (all Fs < 4, p_bs $> .49$).

Due to the temporal shift between the positivity effects in conditions 1☑2☒ and 1☒2☒ on the one hand (550–750 ms) and in condition 1☒2☑ on the other hand (500–700 ms), three consecutive time windows were analyzed to scrutinize the overlapping positivity effects: First, the time window containing only the positivity effect for condition 1☒2☑ (500–550 ms), second, the time window containing the positivity effects for all three conditions (550–700 ms), and finally, the time window containing only the positivity effect for conditions 1☑2☒ and 1☒2☒ (700–750). The test statistics for the three subsequent time windows are presented in Table 8.8.

The midline and lateral analyses of the 500–550 ms time window revealed significant main effects of PC$_{cont}$ for the comparisons 1☑2☑−1☒2☑, 1☑2☒−1☒2☑, and 1☒2☒−1☒2☑. Thus, sentences of condition 1☒2☑, i.e. sentences in which the second NP of the target sentence had been given in the context but the first NP had been new when it was encountered, engendered more positive-going ERPs in this time window than sentences of all other three context conditions.

Table 8.7: Pairwise comparisons between context ERPs at the position of NP2 in Experiment 4, time window 350–500 ms

	Pairwise context comparison							
	1☑2☑−1☑2☒		1☑2☑−1☒2☒		1☒2☑−1☑2☒		1☒2☑−1☒2☒	
350–500 ms	F	p_b	F	p_b	F	p_b	F	p_b
midline								
PC$_c$	60.71	< .001	77.27	< .001	39.19	< .001	43.42	< .001
PC$_c$×ROI	8.86	< .02	6.69	< .03	n.s.		8.28	< .006
Fz	34.24	< .001	63.70	< .001	—	—	65.79	< .001
FCz	47.48	< .001	74.57	< .001	—	—	56.76	< .001
Cz	61.02	< .001	77.44	< .001	—	—	42.84	< .001
CPz	69.99	< .001	73.81	< .001	—	—	34.69	< .001
Pz	64.58	< .001	69.27	< .001	—	—	31.32	< .001
POz	52.50	< .001	59.24	< .001	—	—	25.88	< .001
lateral								
PC$_c$	65.89	< .001	76.91	< .001	33.63	< .001	34.76	< .001
PC$_c$×ROI	5.27	< .04	n.s.		n.s.		n.s.	
left-ant	34.0	< .001	—	—	—	—	—	—
right-ant	40.75	< .001	—	—	—	—	—	—
left-post	82.93	< .001	—	—	—	—	—	—
right-post	94.59	< .001	—	—	—	—	—	—

In the midline and the lateral analysis of the 550–700 ms time window, main effects of PC$_{\text{cont}}$ were evident in the following pairwise comparisons between context conditions: 1⧄2⧄−1⧄2⊠, 1⧄2⧄−1⊠2⊠, 1⧄2⧄−1⊠2⧄, and 1⧄2⊠−1⊠2⊠. Thus, the statistical results confirmed the visual impression of a positivity effect for sentences in which NP2 was new (1⧄2⊠ and 1⊠2⊠) and sentences in which NP2 was given but NP1 had been new (1⊠2⧄). In addition, sentences of condition 1⧄2⊠ engendered slightly more positive-going ERPs than sentences of condition 1⊠2⊠.

For the 700–750 ms time window, the analysis of the midline electrodes revealed significant main effects of PC$_{\text{cont}}$ for the comparisons 1⧄2⧄−1⧄2⊠ and 1⊠2⧄−1⧄2⊠. The analysis of the lateral electrode sites also showed significant effects of PC$_{\text{cont}}$ for these two comparisons, as well as a significant effect of PC$_{\text{cont}}$ in the 1⧄2⧄−1⊠2⊠ comparison. Thus, for context conditions in which NP2 was new (1⧄2⊠ and 1⊠2⊠) the positivity effect in comparison to condition 1⧄2⧄ persists in this time window, while it is not evident anymore for condition 1⊠2⧄.

To summarize the effects evident at the position of the second noun phrase, there were no interactions between the experimental factors ORDER and CONT,

Table 8.8: Pairwise comparisons between context ERPs at the position of NP2 in Experiment 4, time windows 500–550 ms, 550–700 ms, and 700–750 ms

	Pairwise context comparison							
	1⧄2⧄−1⊠2⧄		1⧄2⊠−1⊠2⧄		1⊠2⊠−1⊠2⧄			
500–550 ms	F	p_b	F	p_b	F	p_b		
PC$_{\text{c}}$ midline	13.94	$<.007$	10.04	$<.03$	11.53	$<.02$		
PC$_{\text{c}}$ lateral	16.74	$<.003$	9.46	$<.04$	12.86	$<.009$		
	Pairwise context comparison							
	1⧄2⧄−1⧄2⊠		1⧄2⧄−1⊠2⊠		1⧄2⧄−1⊠2⧄		1⧄2⊠−1⊠2⊠	
550–700 ms	F	p_b	F	p_b	F	p_b	F	p_b
PC$_{\text{c}}$ midline	40.93	$<.001$	23.71	$<.001$	32.38	$<.001$	11.10	$<.02$
PC$_{\text{c}}$ lateral	39.37	$<.001$	28.09	$<.001$	37.98	$<.001$	9.39	$<.04$
	Pairwise context comparison							
	1⧄2⧄−1⧄2⊠		1⧄2⧄−1⊠2⊠		1⊠2⧄−1⧄2⊠			
700–750 ms	F	p_b	F	p_b	F	p_b		
PC$_{\text{c}}$ midline	23.18	$<.001$	n.s.		20.34	$<.001$		
PC$_{\text{c}}$ lateral	32.75	$<.001$	13.27	$<.001$	25.74	$<.001$		

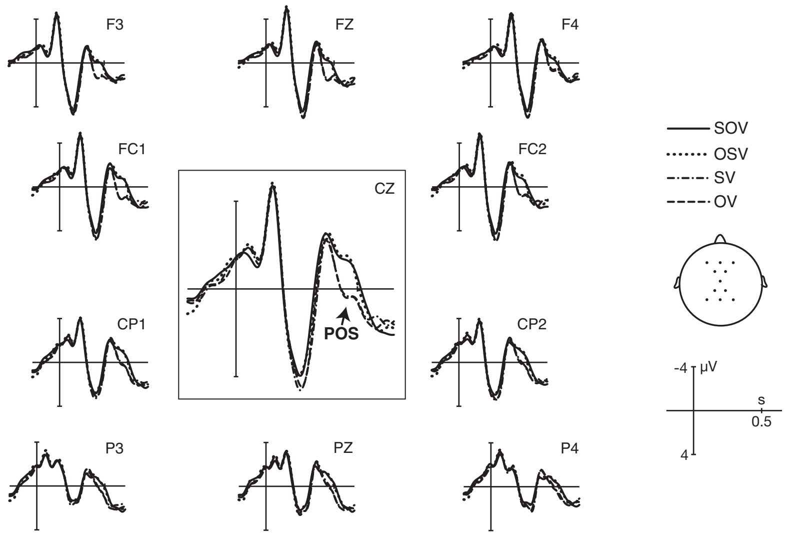

Figure 8.5: Grand-average ERPs (N = 26) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 4, averaged across context conditions.

but independent main effects of both ORDER and CONT in various time windows. With respect to the order manipulation, canonical subject-before-object orders engendered a broadly distributed negativity between 450 and 650 ms post NP2 onset in comparison to object-initial sentences, independently of the preceding context. With respect to the context manipulation, all sentences in which the second noun phrase had not been given in the preceding context (conditions 1☑2☒ and 1☒2☒) elicited a broadly distributed negativity between approximately 350 and 500 ms followed by a broadly distributed positivity between approximately 550 and 750 ms. This positivity effect was slightly more pronounced for the 1☑2☒ sentences than for the 1☒2☒ sentences. Furthermore, sentences in which NP2 but not NP1 had been given in the preceding context (1☒2☑) also elicited a broadly distributed positivity, albeit starting and ending 50 milliseconds earlier (i.e. 500–700 ms post NP2 onset).

Verb

Fig. 8.5 shows the verb related grand-average ERPs for the four target conditions SOV, OSV, SV, and OV, averaged across context conditions, to allow for visual comparison with the results from Experiment 3 (cf. Fig. 7.3). Note that the ERPs are only displayed and analyzed up to 650 ms post verb onset, as the program for

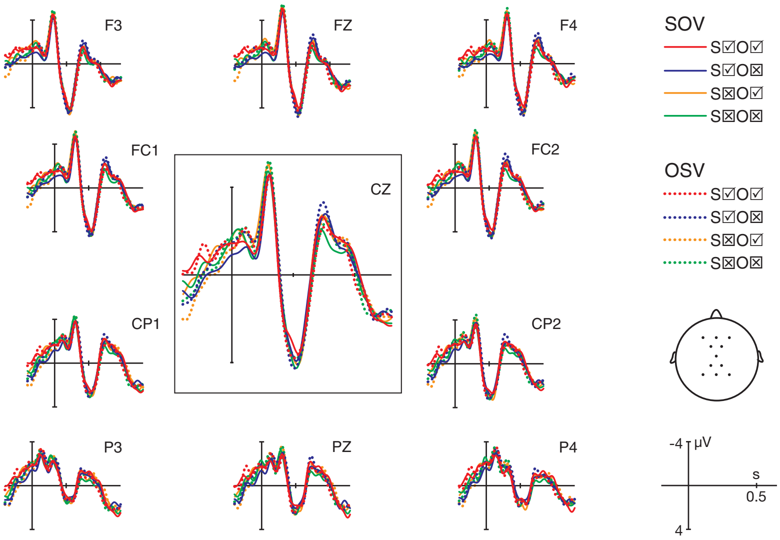

Figure 8.6: Grand-average ERPs ($N = 26$) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 4, target comparison OSV–SOV.

running the experiment was adopted from Experiment 3 and the trial-timing error in the program was not discovered until after the completion of Experiment 4 (for a detailed description of the error, see Section 7.4.2; for a figure of the ongoing ERP after 650 ms, see App. A.7). Visual inspection suggests that, as in Experiment 3, both the conditions with an omitted subject (OV) and with an omitted object (SV) engendered a widely distributed positivity in comparison to the canonical control condition SOV, albeit seemingly with an anterior maximum. The ERPs for the scrambled sentences (OSV), on the other hand, did not seem to differ from the canonical control, likewise mirroring the results from Experiment 3.

To illustrate the influence of the preceding context information in each of the pairwise comparisons OSV−SOV, SV−SOV, and OV−SOV, Fig.s 8.6, 8.7, and 8.8 show the ERPs separately for the respective pairwise comparisons, each including the four levels of CONT. While no influence of contextual information is discernible in the canonical or the scrambled condition, the size of the positivity effect for the pro-drop conditions (OV and SV) seemed to be affected by the information given in the preceding context. For the object-drop sentences (SV), the effect appeared strongest when a potential object referent was given in the preceding context along with the subject of the target sentence (S☑O☑), followed by a context in which no potential

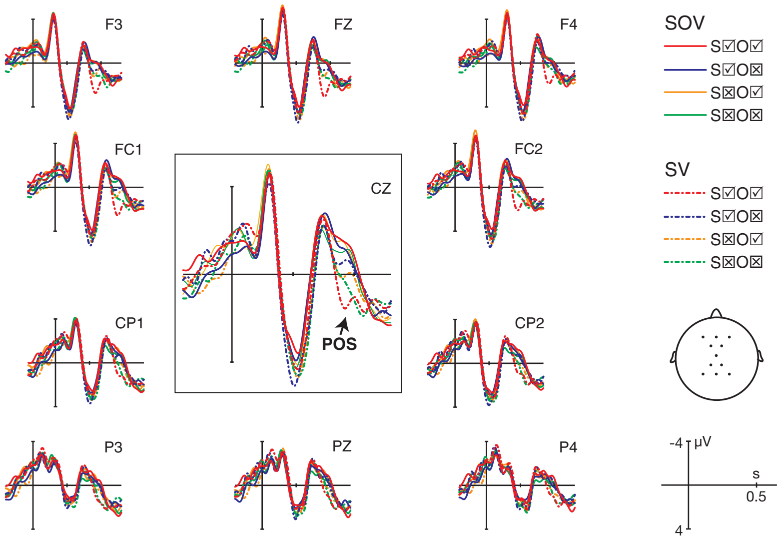

Figure 8.7: Grand-average ERPs (N = 26) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 4, target comparison SV–SOV.

referents were given at all (S⊠O⊠). The effect appeared comparatively weaker when a potential object referent was given alone (S⊠O⧄) and when the subject of the target sentence was given alone (S⧄O⊠). For the subject-drop sentences (OV) the effect seemed to be strongest when a potential subject referent was given in the preceding context along with the object of the target sentence (S⧄O⧄), followed by a context in which only the object of the target sentence was given (S⊠O⧄). The weakest effects were observable when a potential subject referent was given alone (S⧄O⊠) or when no potential referents were given at all (S⊠O⊠).

To test this visual impression, statistical analyses were conducted for the same time window in which the pro-drop positivity had been evident in Experiment 3, i.e. between 400 and 600 ms. As visual inspection suggests that the effect in the present experiment ended somewhat earlier than in Experiment 3, additional analyses were calculated for the more restricted time window of 400 to 550 ms, which yielded comparable results (see App. A.8 for the test statistics).

For the OSV−SOV comparison, the analysis did not yield any significant effects in the 400–600 ms time window, neither at midline nor at lateral electrode sites (main effect PC: both Fs < 1; interaction PC×ROI: both Fs < 1; interaction PC×CONT: both Fs < 2, p_bs $= 1$; interaction PC×CONT×ROI: both Fs < 2, p_bs $> .63$).

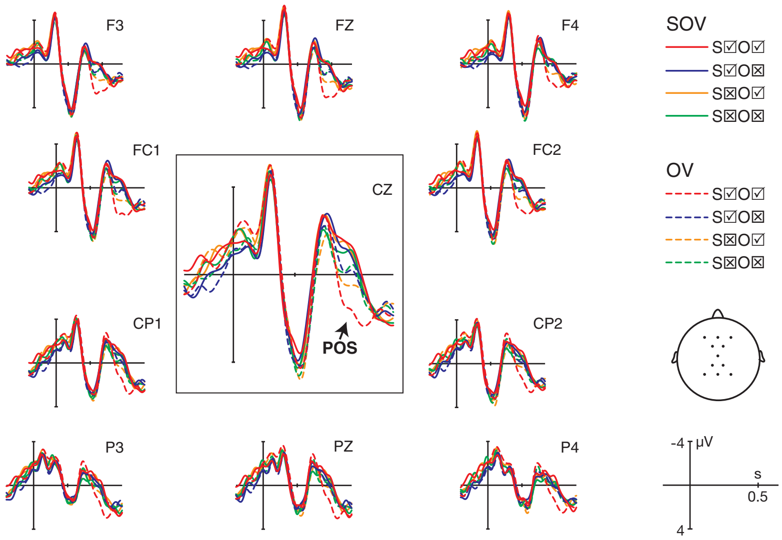

Figure 8.8: Grand-average ERPs ($N = 26$) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 4, target comparison OV–SOV.

For the SV−SOV comparison, the analysis of the midline electrodes showed a main effect of PC ($F(1, 25) = 11.28$, $p_b < .008$) and an interaction PC×CONT ($F(3, 75) = 4.20$, $p_b < .03$). Examining the effects separately for each level of CONT showed a significant effect of PC only in the S⧄O⧄ context ($F(1, 25) = 16.30$, $p_b < .002$). The effects at lateral electrode sites resembled those at midline sites: A significant main effect of PC ($F(1, 25) = 9.64$, $p_b < .02$) was accompanied by an interaction PC×CONT ($F(3, 75) = 4.29$, $p_b < .03$). Resolving the interaction showed a significant effect of PC in context S⧄O⧄ ($F(1, 25) = 16.31$, $p_b < .002$) as well as in context S⊠O⊠ ($F(1, 25) = 6.64$, $p_b < .05$).

The midline analysis for the OV−SOV comparison also yielded a significant main effect of PC ($F(1, 25) = 44.36$, $p_b < .001$) and an interaction PC×CONT ($F(3, 75) = 8.05$, $p_b < .001$). Resolving the interaction by CONT revealed significant effects of PC only in the context conditions S⧄O⧄ ($F(1, 25) = 37.74$, $p_b < .001$) and S⊠O⧄ ($F(1, 25) = 17.82$, $p_b < .001$). The same pattern was apparent at lateral electrodes: Here, too, the analysis revealed a main effect of PC ($F(1, 25) = 31.50$, $p_b < .001$) and an interaction PC×CONT ($F(3, 75) = 8.20$, $p_b < .001$). Resolving the interaction again showed significant effects of PC only in context S⧄O⧄ ($F(1, 25) = 36.66$, $p_b < .001$) and context S⊠O⧄ ($F(1, 25) = 12.28$, $p_b < .006$).

To summarize the verb effects, we observed a widely distributed positivity between 400 and 600 ms post verb onset for both drop conditions, which, when considered separately for each context condition, was visually discernible in each context condition but reached significance only in context conditions S☑O☑ and S☒O☑ for the OV condition (subject-drop) and only in context conditions S☑O☑ and S☒O☒ for the SV condition (object-drop). The scrambled OSV sentences did not yield any ERP effects in this time window.

8.5 Discussion

The following effects were observed in Experiment 4: (a) a widely distributed negativity (350–550 ms) followed by a widely distributed positivity (600–800 ms) at the position of NP1 for all sentences in which NP1 was new; (b) a widely distributed negativity (450–650 ms) at the position of NP2 for all subject-before-object sentences; (c) a widely distributed negativity (350–500 ms) followed by a widely distributed positivity (550–750 ms) at the position of NP2 for all sentences in which NP2 was new; (d) a widely distributed positivity (500–700 ms) at the position of NP2 for all sentences in which NP2 was given but NP1 was new; (e) a widely distributed positivity (400–600 ms) for subject-drop and object-drop sentences relative to the onset of the verb, which was reduced in the subject-drop sentences when only a compatible subject referent was given in the preceding context or when no referents were given at all, and in the object-drop sentences when only a compatible object referent or only the subject of the target sentence were given in the preceding context. In the following, I will first discuss the differences between canonical sentences and scrambled sentences (Hypothesis a), followed by the context main effects observed at the positions of the noun phrases (Hypothesis b), and finally the pro-drop positivity effects at the position of the verb which were the main concern of the current experiment (Hypothesis c). Before turning to the ERP effects, however, I will briefly discuss the behavioral findings of Experiment 4.

8.5.1 Behavioral findings

While the behavioral tasks employed in Experiment 4 efficiently fulfilled the purpose of ensuring the participants' attention throughout the experiment, the results obtained with these tasks appear somewhat less informative than those obtained in the previous experiments.

With regard to the probe detection task, the performance did not show any significant differences between the experimental conditions. A possible explanation for this may lie in the fact that the probe detection task, which was necessary to ensure participants' attention not only in the target sentences but also in the context sentences, appeared to be considerably easier than the comprehension task, which was employed in previous experiments but would have been inadequate in Experiment 4 considering the two-sentence format of the stimuli. The apparently low difficulty of the task resulted in very low error rates (below 10%), and therefore in a possible ceiling effect in the participants' performance, which in turn was likely responsible for the lack of performance differences between the experimental conditions.

With regard to the acceptability ratings, several problematic issues arise. First, it is striking that at least in some context conditions, the acceptability ratings of the pro-drop sentences lie below 50%, meaning that they are rated unacceptable more often than acceptable. The observation of such low ratings in spite of the grammaticality of pro-drop sentences in Japanese may be attributed to the criteria used by the participants to arrive at an acceptability judgement. On the one hand, it is possible that participants included the semantic congruency between the two sentences in their acceptability judgements, instructions to the contrary notwithstanding. This assumption is supported by the fact that *all* acceptability ratings in Experiment 4 (i.e. also those of the complete sentences) were lower than those in Experiment 3, where semantic congruency was not an issue. In addition, and as in Experiment 3, it is conceivable that participants generally employed highly conservative decision criteria for the evaluation of the sentences due to the experimental environment and the specific judgement task.

Second, the influence of the context manipulation on the acceptability of the pro-drop sentences is difficult to interpret. Descriptively (see Table 8.4), it seems that the lexical givenness of a compatible referent for the omitted argument may be the main factor determining the acceptability differences within the pro-drop sentences: Subject-drop (OV) sentences were rated more acceptable in context conditions S⧄O⧄ and S⧄O⊠ than in context conditions S⊠O⧄ and S⊠O⊠, and object-drop (SV) sentences were rated more acceptable in context conditions S⧄O⧄ and S⊠O⧄ than in context conditions S⧄O⊠ and S⊠O⊠. These differences were, however, not directly mirrored in the test statistics, since the complete canonical sentences with which the pro-drop sentences were compared were also subject to contextual influences, resulting, for example, in an interaction of the pro-drop effects with contextual effects only in the subject-drop comparison (OV−SOV), but not in the object-drop comparison (OV−SOV).

Despite these interpretational difficulties, the acceptability ratings of Experiment 4 showed a clear replication of the acceptability differences between pro-drop sentences and complete sentences. Furthermore, while some contextual influence on the judgements was discernible, this influence was not sufficient to override these target main effects (i.e., all pro-drop conditions received lower acceptability ratings than all complete conditions).

8.5.2 Differences between scrambled and canonical word orders

The current experiment did not reveal a scrambling negativity for object-initial orders at the position of NP1, but did show an extension N400 for canonical word orders at the position of NP2. A late negativity for scrambled word orders at the position of the verb could again not be tested in the current experiment since the ERP results were only interpretable up to 650 ms post verb onset. Regarding the differences between scrambled and canonical word orders, Experiment 4 thus replicated the results from Experiment 3 and further demonstrated that the extension N400 is not affected by contextual information (no interaction with the context factor).

As in Experiment 3 (see Section 7.5.1 for a detailed discussion), the absence of a scrambling negativity is highly compatible with the assumption that the presence of pro-drop sentences in a visual word-by-word paradigm loosens an association between orthographic and prosodic boundaries, and thereby between a visually presented initial object and a non-minimal two-argument phrase structure. As a consequence, the assumed association between the scrambling negativity and a violation of the Minimality principle at the phrase structural level also remains sustainable in view of the results of the current experiment. As already discussed in the context of Experiment 3, however, further research is clearly necessary to test this assumption more directly. A possible paradigm to this avail will be suggested in the General Discussion (Section 9.1.2).

Experiment 4 replicated the previous experiments' finding of a negativity for subject-before-object sentences in comparison to object-before-subject sentences at the position of the second NP. The effect showed the same distribution and latency as in Experiment 3, thereby supporting the assumption that experiment-specific factors like the usage of proper nouns instead of common nouns may be responsible for these differences between both Experiments 3 and 4 and Experiment 2. However, as already noted in the discussion of Experiment 3, future research will be necessary to disentangle the exact reasons for the latency shift (see also Section 9.2.2 in the General Discussion). In any case, an interpretation of the negativity as an extension N400 is highly compatible with an explanation based on interpretive Minimality. As already discussed in detail in the context of the previous experiments of this thesis, this effect appears to specifically reflect the extension from a minimal intransitive to a non-minimal transitive event representation. The current results support this assumption and further demonstrate that the number of given referents in the described situation seems to be irrelevant for these processes of transitivity evaluation, since the extension N400 was not modulated by contextual information (i.e. by the number of referents introduced into the situation prior to the target sentence).

8.5.3 A referent establishment P600 for new noun phrases

At the position of both noun phrases, Experiment 4 showed strong effects of NP givenness. These effects were evident in the form of a biphasic N400-P600 pattern for all target NPs that were new (i.e. not given in the preceding context). This pattern occurred independently of the respective NP's grammatical function and position. In addition, a P600 (but not an N400) was also evident at the position of the second NP when the second NP itself was given but the preceding first NP had been new.

The finding of an N400-P600 effect for all new NPs speaks in favor of a universality of both the lexical repetition effect (i.e. a reduced N400 if a word is repeated in comparison to when it is new; e.g. Bentin & Peled, 1990; Burkhardt, 2006, 2007a; Nagy & Rugg, 1989; Rugg, 1987, 1990; Van Petten et al., 1991) and, more interestingly, the discourse related P600 effect previously observed for comparable manipulations in German, Dutch, and English (Burkhardt, 2006, 2007a; Van Berkum et al., 2004; Van Petten et al., 1991). While it was arguable whether the pro-drop positivity observed at the position of the verb in pro-drop sentences is actually comparable to the P600 effects observed at the position of overt arguments in those European languages (see Section 7.5.2), the similarity of the employed manipulations makes it highly likely that the P600 effects observed here for Japanese and those observed previously for other languages reflect identical underlying processes. More precisely, this type of P600 effect always seems to arise whenever an overt argument is encountered for which a new discourse referent needs to be established.

Interestingly, such an interpretation can also derive the – at first glance somewhat surprising – finding of a P600 at the position of a given NP2 following a new NP1. For this condition, Hypothesis (b) originally predicted a reduction of the N400 component, since NP2 constituted a repeated word (which is precisely what we observed), and a reduction of the P600 component since the referent for NP2 was already established in the preceding context (which stands in direct contrast to what we observed). This seemingly contradictory finding is somewhat reminiscent of the findings reported by Burkhardt (2007a), who observed a similar combination of an N400 reduction and an enhanced P600 for arguments like *ein Dirigent* in sentence pairs like *Tobias besuchte einen Dirigenten in Berlin. Er erzählte, dass ein Dirigent sehr beeindruckend war* ("Tobias visited a conductor in Berlin. He said that a conductor was very impressive.") In this example, *ein Dirigent* in the second sentence constitutes a lexical repetition of a word in the preceding context sentence but is at the same time preceded by an indefinite article. In German, such an article strongly signals that the argument describes a new discourse referent, and consequently, the establishment of this new discourse referent was reflected in a P600 effect. Due to the complete lack of articles in Japanese, speakers of this language must rely on other clues to determine whether an argument describes a new or a pre-established referent, for example on the given-before-new principle (e.g. Halliday, 1967; see Section 1.1). Recall that according to this pragmatic rule, pre-established information should always precede new information in a discourse. In a language like Japanese, pre-established information can even be omitted altogether; in any case it is usually not uttered *following* new information. Since in the critical condition discussed here, the previously encountered NP1 described a new referent, it is conceivable that the following NP2 was simply not interpreted as a pre-established referent. As a consequence, participants may have established a new discourse referent for this argument (engendering a P600) even though it constituted a lexical repetition of a previously mentioned name (engendering a reduction of the N400), thus creating a situation representation including two separate referents with the same name (cf. a situation representation including two different conductors in the German example described above; Burkhardt, 2007a). The fact that the resulting P600 observed here occurred approximately 50 milliseconds earlier than the P600 elicited by new NP2s may be attributable to the fact that the ERPs in response to given NP2s were already more positive-going before the onset of the P600 effect (due to the reduced N400), whereas the ERPs in response to new NP2s changed from more negative-going waveforms (due to the non-reduced N400) to more positive-going waveforms.

While the latencies of the positivity effects observed here are within the typical P600 time range (beginning at 500 to 600 ms), their topography does not exhibit the posterior maximum often associated with this component. As already mentioned earlier, however, the distribution of the P600 has been shown to vary, especially in the case of discourse related P600 effects. For example, the P600 effects observed by Burkhardt (2006) and Van Petten et al. (1991) for NPs requiring referent establishment showed a left-lateralized predominance, and those reported by Van Berkum et al. (2004) for referentially failing pronouns seem rather broadly distributed. Furthermore, the P600 effect interpreted as an indicator of discourse complexity by Kaan & Swaab (2003) was described as frontally distributed (even though the authors analyzed only the frontal electrodes statistically and therefore did not rule out a wider distribution). While the question whether P600 effects with differential distributions also have distinct neural and functional generators is beyond the scope of this thesis, these previous findings at least seem to allow a discussion of the effect observed here as a (discourse related) P600 effect.

Similarly, the broad topography of the N400 observed for all new NPs does not consistently show the typical posterior distribution often associated with N400 effects. It is, however, in line with the distribution of the extension N400 effects observed in Experiments 3 and 4, and may therefore similarly be derived from concreteness differences between common nouns and proper nouns (cf. West & Holcomb, 2000; see also Section 7.5.1).

Taken together, the context effects observed at the position of the noun phrases in Experiment 4 strongly support the cross-linguistic validity of the N400 repetition effect and the P600 as a correlate of referent establishment. By extension, the fact that this "direct" effect of referent establishment is also observable in Japanese provides additional grounds for the argument that the pro-drop positivity observed at the position of the verb might reflect similar discourse related processes (see below).

8.5.4 The pro-drop positivity: Contextual influences

The pro-drop positivity observed between 400 and 600 ms post verb onset in Experiment 3 was replicated in Experiment 4. The effect was, however, substantially reduced under certain contextual circumstances. More precisely, the effect was reduced in the subject-drop (OV) target sentences when the context introduced only a potential subject referent (S☑O☒) and when the context introduced no adequate referents at all (S☒O☒). In the object-drop (SV) target sentences, the effect was reduced when the context introduced only a potential object referent (S☒O☑) and when the context only introduced the subject of the target sentence (S☑O☒).

How do these results compare with the predictions made in Hypothesis (c)? First and foremost, the fact that the contextual information affected the behavior of the pro-drop positivity clearly speaks against an interpretation of this ERP effect in terms of the mere detection of a missing argument, since an argument was omitted in all pro-drop sentences of Experiment 4. Therefore, the detection of this omission needed to take place in a comparable manner in all pro-drop sentences independently of the kind of referential information given in the preceding context, and thus cannot explain the contextual effects observed here.

The responsiveness of the pro-drop positivity to the discourse referential manipulation thus clearly speaks in favor of a discourse related process as an underlying mechanism of this ERP effect. However, the observed findings suggest that this process cannot be reduced solely to the establishment of new discourse referents. Recall that based on an establishment-centered interpretation of the component, a reduction of the pro-drop positivity was predicted whenever a compatible referent for the omitted argument was pre-established in the preceding discourse. This was supposed to be the case when a compatible referent was lexically given in the preceding context sentence of both OV and SV sentences, and, in addition, when OV sentences were embedded in a context not offering an adequate referent, since such a context should make the speaker referent available for the inferable actor role in these sentences. Clearly, the results observed in Experiment 4 are only partially compatible with these predictions.

On the one hand, as predicted, the pro-drop positivity was reduced in the subject-drop sentences when only a potential subject referent was given (S☑O☒) and in the object-drop sentences when only a potential object referent was given (S☒O☑). Furthermore, the reduction of the effect in the S☒O☒ context in the subject-drop but not in the object-drop sentences also speaks in favor of a referent establishment interpretation of the pro-drop positivity, since the speaker referent pre-established in such a context is likely to be inferred as the missing referent in the subject-drop but not in the object-drop sentences (Martin, 2003; questionnaire results from Experiment 3).

On the other hand, a reduction of the effect for all pro-drop sentences preceded by a S☑O☑ context sentence was also predicted, since this type of context also lexically provided a compatible referent for both the subject-drop sentences (S☑) and the object-drop sentences (O☑). This was however not what we observed. By contrast, OV and SV sentences embedded in this type of context appeared to engender a very strong positivity effect, even though no new discourse referent needed to be established under these circumstances.

Therefore, referent establishment processes alone do not seem to suffice to derive the emergence of the pro-drop positivity. Rather, the pro-drop positivity appears to reflect referential inference processes in a broader sense and seems to be affected by the need to establish new discourse referents as well as other factors. One of these factors may be the amount of ambiguity or competition effective during the assumed inferential process: The more discourse referents are given in the preceding context of a pro-drop sentence, the more competition should arise with regard to the referent that eventually is inferred as the missing actor or undergoer of a pro-drop sentence. Such a competition influence could straightforwardly explain the increased pro-drop positivity for SV and OV sentences in combination with a S☑O☑ context. In these cases, a compatible referent for the omitted argument role was given in the preceding context along with the referent of the overtly realized argument of the pro-drop sentences. For example, the potential subject referent of a subject-drop target sentence was given along with the actual object of the target sentence. While the object eventually had to be ruled out as the missing actor referent since it already filled the undergoer role in the described event, this argument may, at least initially, have constituted an interfering competitor for the actor role.

The assumption of an interplay between referent establishment processes and competition factors in the emergence of the pro-drop positivity can thus derive the major portion of the verb related ERP pattern in Experiment 4. The pro-drop positivity was reduced whenever a compatible referent for the omitted argument was given in the preceding context alone, i.e. without competition (conditions S☑O☒-OV and S☒O☑-SV), but it was increased whenever the same compatible referent was given along with an (eventually incompatible) competing referent (conditions S☑O☑-OV and S☑O☑-SV). Furthermore, the pre-establishment of a speaker referent in contextually embedded sentences without any given referents reduced the effect when the speaker could be inferred as the missing referent (i.e. in condition S☒O☒-OV but not in condition S☒O☒-SV).

This leaves us with the two conditions in which only the overt argument of the target pro-drop sentence was given in the preceding context. The result of a significant pro-drop effect in the S☒O☑-OV condition is actually well derivable from the joint influence of referent establishment and competition factors. As described before, in the absence of compatible given referents, the speaker is usually inferred in subject-drop sentences. Even though it is reasonable to assume that the pre-established speaker will also eventually be inferred as the missing actor in the S☒O☑ context, this context also provides an (eventually incompatible) competitor in the form of the target sentence's object. Consequently, the additional competition may have engendered increased processing costs reflected in an increased amplitude of the pro-drop positivity.

The only result that cannot be straightforwardly explained on the basis of an interplay between establishment and competition factors is the reduced pro-drop positivity in the S☑O☒-SV condition. After all, this condition requires the establishment of a new discourse referent, since neither the pre-established speaker nor the given subject of the target sentence qualify for the role of the missing undergoer. Furthermore, the given subject of the target sentence could be expected to function as a competitor. The fact that the pro-drop positivity was nevertheless reduced in this condition suggests that the mechanisms discussed so far may not apply to the processing of object-drop sentences in entirely the same way as they do to the processing of subject-drop sentences. This might be due to the fact that in subject-drop sentences the referential options are rather circumscribed (either a given referent or the speaker), while in object-drop sentences the referential interpretation in the absence of a given referent remains somewhat vague. After all, the "someone"/"someone else" interpretation indicated for the undergoer of SV sentences by participants of Experiment 3 may either refer to a concrete person, a group of people (since there is no singular/plural distinction in Japanese), or even an impersonal/unspecific reading such as the one possibly assigned to the actor referent in passive sentences (like *Mary was invited*). Put differently, object-drop sentences can support a so-called de-transitized or valence-decreased reading of the sentence, which implies a downplay of the undergoer for the benefit of emphasizing the actor of the described event (e.g. Payne, 2006). Under such an actor-centric analysis, the object-drop sentence *Taroo-ga maneita* (cf. Table 8.1) may best be translated as "Taroo extended invitations". Since no undergoer referent needs to be inferred in such an event representation, no pro-drop positivity should arise under such an analysis. This line of argumentation may also offer an explanation for the fact that the pro-drop positivity for object-drop sentences without a lexically given referent is only reduced when the subject of the target sentence is pre-mentioned, but not when no referents are given at all in the preceding context (see above). In fact, a possible reason for this difference may be that the de-transitization of the event interpretation requires a strong emphasis on the actor in the entire discourse, which in turn is more likely the case when the actor is already given in the preceding context than when it is new. However, since the ideas put forward here are merely speculations, future research is clearly necessary for a better understanding of the specific processes involved in the interpretation of object-drop sentences in Japanese.

Taken together, the majority of the data observed here speak in favor of the pro-drop positivity as a correlate of a discourse related inferential process influenced by various factors such as the degree to which the inferable referent is already established in the discourse, and the competition or interference from other referents established in the discourse. As already discussed in the context of Experiment 3 (Section 7.5.2), such a discourse related process would best be integrated in the framework of the eADM (Bornkessel & Schlesewsky, 2006a) within the generalized mapping step of Stage 3, since this is the processing stage in which core information like the LS of the verb and the GRs of the noun phrases is integrated with non-core information like lexical meanings and discourse information. Since the generalized mapping step is typically associated with P600 effects, it further seems reasonable to assume that the pro-drop positivity constitutes a comparatively early instance of a P600.

The interpretation of the pro-drop positivity as an early form of a discourse related P600 effect also finds support from previous and current results regarding both the establishment factor and the competition factor that are assumed to affect the component. As discussed in Section 8.5.3 above, P600 effects have been repeatedly reported as a correlate of referent establishment costs in other languages (Burkhardt, 2006, 2007a; Van Berkum et al., 2004; Van Petten et al., 1991) as well as in the current experiment in Japanese. Similarly, P600 effects have been reported in connection with ambiguity processing, not only in response to non-preferred disambiguations (e.g. Friederici et al., 1996; Osterhout & Holcomb, 1992, 1993), but also in response to the ambiguous sentence regions themselves (Frisch et al., 2002).

An issue that warrants some discussion in this regard is the fact that in the current experiment the discourse related positivity in response to NPs (see Section 8.5.3) occurred with the typical P600 latency, i.e. commencing at 500 to 600 ms post NP onset, while the positivity in response to the pro-drop sentences commenced comparatively early, i.e. at 400 ms post verb onset. In the discussion of Experiment 3, the short latency of the pro-drop positivity was reconciled with an interpretation of the effect as a P600 and a correlate of Stage 3 processing in terms of the eADM by assuming an overlap of Stages 2 and 3 of processing, at least in heavily discourse dependent languages such as Japanese and Chinese. This line of argumentation also holds for the short latency of the pro-drop positivity in the current experiment. The fact that the discourse related P600 following new NPs did not arise similarly early but rather occurred with the typical P600 latency can be explained when the other effects occurring at the same sentence position are considered. Crucially, in the case of an overt NP certain processes arising during and in parallel to Stage 2, like the lexical processes concerned with the noun's meaning, need to be completed before a new discourse referent for the respective noun can be established in the generalized mapping step of Stage 3. By contrast, the lexical meaning of an inferred referent does not need to be computed, thus leading to shorter positivity latencies at the position of the pro-drop sentences' verbs. This assumption is further supported by the observation that the P600 also arises somewhat earlier in NP processing when the lexical processes, which are reflected in the observed N400, are minimized (see above).[68]

In summary, the fact that the pro-drop positivity observed in Experiment 4 was subject to contextual manipulations showed that this ERP effect is not simply a general marker of argument omission per se. However, its occurrence also does not seem to be restricted to cases in which a new discourse referent needs to be established. Rather, the pro-drop positivity appears to reflect a more general process of discourse referential inference which is affected by an interplay of factors such as referent establishment and referential competition. These factors seem to affect the ease of inference in such a way that the pro-drop positivity can be reduced if a pre-established referent (i.e. a lexically given referent or a pre-established speaker) can be inferred as the missing referent without any competition from other referents. Since none of the two factors isolated here is sufficient for deriving the observed ERP pattern alone, future research is clearly necessary to further investigate the interaction of these factors as well as possible additional influences on the ease of discourse referential inference (see the General Discussion, Section 9.5.2). It is furthermore feasible that the pro-drop positivity constitutes an early subcase of a cross-linguistically valid discourse related P600 component which, in terms of the eADM, is associated with the generalized mapping step of Stage 3.

[68]Speculatively, an explanation along the same lines might also hold for the observation that the latency of the P600 effect is generally somewhat shorter at the position of NP2 than at the position of NP1 (i.e. beginning at 500/550 ms instead of 600 ms). This shift appears to be due to the fact that the duration of the preceding N400 is somewhat reduced by comparison, which in turn may be due to the typical reduction of the N400 in response to later as opposed to earlier words in a sentence (cf. Van Petten & Kutas, 1990).

Part III

General Discussion

Chapter 9

ERP effects of incremental sentence processing in Japanese

The four experiments discussed in this thesis served to test several hypotheses regarding the mechanisms of incremental sentence processing in Japanese and provided a number of additional interesting results. Below, I will give an overview of the results observed across the experiments described in Part II, starting with the ERP effects related to the processing of word order variations (Sections 9.1 to 9.3), and then turning to the ERP effects observed when investigating the processing of pro-drop sentences (Sections 9.4 and 9.5). In each section, I will summarize the respective ERP component's behavior across experiments as well as the conclusions drawn with regard to its interpretation, and discuss how some of these conclusions may be further tested in future research.

9.1 The scrambling negativity

9.1.1 Summary

A scrambling negativity was observed in Experiment 1 in response to auditorily presented initial accusative objects that were followed by a prosodic boundary (signaling a scrambled, two-argument structure) but not when no such boundary followed (signaling the possibility of a subject-drop, one-argument structure). In Experiment 2, the scrambling negativity was observable in response to visually presented initial accusatives but not datives (which could alternatively be interpreted as subjects and thus behaved similarly to initial nominatives). The scrambling negativity in the initial accusatives was attributed to the orthographic segmentation of the (normally unsegmented) Japanese sentences and a possible association between the resulting orthographic boundaries and prosodic boundaries such as the ones employed in Experiment 1. As a consequence, the orthographic boundary following an initial accusative object was taken to signal a scrambled, two-argument structure, just like the prosodic boundary did in Experiment 1. Experiment 3 provided supporting evidence for this assumption by demonstrating that the scrambling negativity for visually presented initial accusatives can be alleviated when the experimental environment includes subject-drop sentences and thereby provides intra-experimental instances of accusative-initial one-argument structures with an orthographic boundary following the initial argument. This finding was replicated in Experiment 4, which reemployed the same sentences embedded in a linguistic context. Taken together with previous findings from German and Turkish, the present results therefore strongly speak in favor of an interpretation of the scrambling negativity along the lines of phrase structural Minimality as suggested by the eADM (Bornkessel & Schlesewsky, 2006a). The application of the Minimality principle at a phrase structural level implies that minimal (i.e. one-argument) phrase structure representations will be assumed whenever possible. Such a minimal [NP–V] phrase structure is assigned to all of the examined sentences in Stage 1 of incremental processing, i.e. when the word category of the first argument is processed. The data pattern observed so far suggests that a scrambling negativity arises precisely if this minimal phrase structure representation cannot be upheld in the next processing step, namely when the case information of the first argument is processed in Stage 2. In the following, let us consider each aspect of the pattern observed here in turn.

Clearly the minimal [NP-V] phrase structure template can be upheld in all nominative-initial sentences, independently of whether a prosodic or orthographic boundary follows the nominative, since a boundary following an initial nominative does not rule out an intransitive one-argument reading of the sentence (SV). The same is true for initial datives in Japanese which can be interpreted as subjects and therefore can also be analyzed as part of a one-argument sentence (SV; in that case a sentence in which the nominative-marked object is dropped) independently of whether they are followed by a boundary or not. As a consequence, phrase structural Minimality is not violated in these structures and no scrambling negativity arises. A minimal phrase structure can also be upheld if an initial accusative is compatible with a one-argument, subject-drop (OV), reading. Such a minimal reading is accessible in auditory presentation when the initial accusative is not followed by a prosodic boundary, and should also be the default reading in natural, i.e. unsegmented, written Japanese.

Since in Japanese no prosodic boundary may intervene between an unscrambled object and the verb, such a minimal subject-drop reading of an accusative-initial sentence is ruled out if a prosodic boundary after the initial accusative signals that a second argument will follow, i.e. that the sentence is scrambled (OSV). In this case, phrase structural Minimality is violated and a revision of the phrase structure representation from a minimal [NP–V] reading to a non-minimal [NP–NP–V] reading is necessary. Due to the assumed correspondence between prosodic boundaries and orthographic boundaries in visual word-by-word presentation, a similar revision is also required when an initial object is presented visually in a word-by-word paradigm. In both cases, this revision is reflected in the emergence of a scrambling negativity. However, as soon as the experimental environment provides local evidence for one-argument accusative-initial sentences (OV) followed by an orthographic boundary, the association between an initial accusative followed by an orthographic boundary and a two-argument structure is loosened and a one-argument reading of the sentence is no longer ruled out. As a consequence, no revision of the minimal phrase structure is necessary and no scrambling negativity arises.

An interpretation of the data pattern observed here along the lines of phrase structural Minimality fits in well with the ERP results from other languages allowing scrambling, like German or Turkish. Turkish constitutes another language allowing subjects to be omitted (like Japanese). Thus, an initial accusative object in Turkish is compatible with a minimal [NP-V] phrase structure if it is analyzed as a subject-drop (OV) sentence. Since phrase structural Minimality is not violated in this case, no scrambling negativity arises (Demiral et al., 2008). The fact that these results stem from visual word-by-word presentation further support the assumption that the specific orthographic properties of Japanese were responsible for the emergence of a scrambling negativity in Experiment 2.

In German, an initial accusative in the middlefield always signals a scrambled structure with two arguments since pro-drop sentences are not licensed in German. As a consequence, a scrambling negativity always arises at the position of initial accusatives in German (Bornkessel & Schlesewsky, 2006b; Bornkessel et al., 2002, 2003; Rösler et al., 1998; for a derivation of the lack of a scrambling negativity in initial accusative pronouns and in initial accusatives in the German prefield, see Section 3.1.4). An initial dative in the German middlefield, on the other hand, can be interpreted as the only argument in a passive sentence and is thus compatible with a minimal [NP-V] reading. As a consequence, no scrambling negativity arises for initial datives in German (Bornkessel et al., 2002), unless a one-argument passive reading is ruled out (Rösler et al., 1998; Schlesewsky et al., 2003).

9.1.2 Open questions and future directions

While the behavior of the scrambling negativity in the experiments of this thesis is highly compatible with an interpretation of this ERP effect as a correlate of a Minimality violation at the phrase structure level, some of the conclusions drawn above could be tested more straightforwardly in future experiments.

A case in point is the assumption that the initial datives in Experiment 2 did not engender a scrambling negativity because they were analyzable as the subjects of so-called dative-subject constructions. This assumption may be tested more directly in an experiment exclusively focusing on nominative-dative sentences. By employing a word order manipulation (nominative-before-dative vs. dative-before-nominative) like in Experiment 2 and in addition varying the verb type (verbs taking the dative argument as a subject vs. object), we could investigate the subject/object analysis preferences for dative arguments in Japanese and the interaction of these preferences with the position of the argument. The assumptions made above on the basis of phrase structural Minimality would be confirmed if dative-before-nominative sentences were initially analyzed as dative-subject constructions. In this case we would expect a replication of the reduced scrambling negativity observed in Experiment 2, and, more importantly, reanalysis effects at the position of the verb if the verb assigns the object role instead of the subject role to the dative-marked argument.[69] Furthermore, if sentence-initial datives are indeed interpreted as subjects, they should also not engender a scrambling negativity when they are presented auditorily, i.e. in an identical manner to the accusative sentences in Experiment 1. Instead, they should behave like the auditorily presented initial nominatives, thus not engendering a scrambling negativity independently of the prosodic manipulation, since the presence of a prosodic boundary does not rule out a minimal one-argument structure if it follows an initial subject.

Next, let us consider the conclusion that the emergence of a scrambling negativity for the initial accusatives in Experiment 2 was likely due to an association between the (unnatural) orthographic boundaries in visual word-by-word presentation and prosodic boundaries in cases of interpretational uncertainty. While the results of Experiments 3 and 4 support this hypothesis by demonstrating that the scrambling negativity disappears when the assumed association is loosened, there may be more straightforward ways to test this hypothesis. A promising paradigm in this regard may be a simultaneous eye-tracking and EEG study. In such an experi-

[69] At the same position, the opposite effect should be observable for nominative-before-dative sentences if these are initially analyzed as "normal" dative-object sentences.

ment it would be possible to present the sentences continuously in an unsegmented stream (cf. Example 39) and to average the EEG relative to the point of first fixation (see Table 3.1) of each constituent. The resulting fixation-related potentials (FRPs) could offer valuable insights into the electrophysiological processes taking place during natural reading in unsegmented Japanese. While such a procedure inevitably involves an increase in eye-movement related artifacts (cf. Section 2.2.1), recent experiments demonstrated that the contribution of those artifacts can be efficiently removed from the EEG signal, and provided initial evidence for the usefulness of such a procedure in the investigation of language processing (Dimigen et al., 2006; Hutzler et al., 2007; Kretzschmar, Bornkessel-Schlesewsky, & Schlesewsky, 2009). If the sentences employed in Experiment 2 were presented in such a simultaneous paradigm, we could investigate the processing of written initial objects in a natural, i.e. unsegmented, sentential context. If the assumptions made above are correct, no scrambling negativity should occur at the position of an initial accusative-marked argument in such a paradigm, since the one-argument (OV) reading that is preferred on the basis of phrase structural Minimality is not ruled out by any orthographic or prosodic boundary information.

9.2 The extension N400

9.2.1 Summary

In all four experiments of this thesis, the second argument of nominative-initial sentences elicited an extension N400. The fact that these effects arose consistently and independently of the behavior of the scrambling negativity clearly speaks in favor of an an independent interpretation of these two effects, such as the one provided by the two levels of Minimality suggested in the eADM. More precisely, the finding of an N400 at the position of the second NP in all canonical nominative-initial sentences in comparison to their accusative- or dative-initial counterparts is highly compatible with an interpretation of the effect as a correlate of a Minimality violation at the event interpretive level. Based on interpretive Minimality, the processing system is assumed to prefer minimal event interpretations, i.e. events with as few participants as possible given the current information. At the position of the first NP, a nominative-initial sentence is per se compatible with an intransitive, a transitive, or a ditransitive event reading, while both initial accusatives and initial datives are only compatible with the latter two interpretation alternatives. Based on the application of interpretive Minimality in Stage 2 of processing (i.e. when the case information is processed), the processing system should therefore select an intransitive event interpretation in the case of a nominative, and a transitive reading in the case of an accusative or dative. When the second argument is subsequently encountered and it becomes evident that a second participant is involved in the event, the previously selected transitive event interpretation is simply confirmed in the accusative/dative-initial sentences. In the nominative-initial sentences, by contrast, the previously selected intransitive event representation cannot be upheld and needs to be extended towards a transitive event representation. The N400 effect arising at this position seems to reflect precisely this violation of interpretive Minimality and the extension from an intransitive to a transitive event representation.

The finding of an extension N400 in response to the second argument of canonical sentences in Japanese is also highly compatible with previous results from German in which a similar component was observed in response to a comparable manipulation (Bornkessel et al., 2004a; see also Bornkessel et al., 2002; Fiebach et al., 2002; Hagiwara et al., 2007; for further experiments from German and Japanese in which an extension N400 may have been confounded with positivity effects for the non-canonical conditions). Furthermore, it should once again be highlighted that the availability of pro-drop in Japanese allows a clear-cut distinction of the interpretive level of Minimality from the phrase structural level, since this property of the Japanese language critically affects the phrase structure representation but not the event representation of canonical and scrambled sentences. Recall that in German it is rather difficult to disentangle the two levels of the Minimality principle since the prediction of a transitive event at the position of an initial accusative-marked argument always goes hand in hand with the prediction of a second, nominative-marked argument in the phrase structure. In Japanese, on the other hand, an initial accusative- (or dative-) marked argument also signals a transitive event, but this does not imply that a second, nominative-marked argument must occur at some later point in the sentence, due to the availability of pro-drop. Therefore, the current observation of the extension N400 occurring independently of the presence or absence of a scrambling negativity substantially corroborates the assumption that the two levels of Minimality indeed apply independently, with phrase structural Minimality connected to the number of overt arguments in the phrase structure, and interpretive Minimality connected to the transitivity of the described event.

One further aspect of the extension N400 pattern observed in this thesis is worth mentioning here. As the results of Experiment 2 revealed, it seems to be irrelevant for the transitivity assessment of the event whether the argument under consideration is analyzed as the actor (which is the likely analysis in case of an initial dative due to the possibility of a dative-subject construction; see above) or the undergoer (which is the only possible analysis in case of an initial accusative) of the described event. Rather, the case marking seems to be a direct indicator of the transitivity of the event. While these conclusions clearly need further testing (see Section 9.1.2, above) and would certainly profit from supporting evidence from other languages (see Section 9.2.2, below), they also would require a slight modification of the eADM, since in its original version presented in Section 3.1.4, the model does not include a direct link between the case information extracted in Stage 2a and an abstract event transitivity representation (see Section 10.3.1).

9.2.2 Open questions and future directions

Open questions regarding the extension N400 primarily concern the variability of the timing and distribution of this effect in the current experiments. In auditory presentation (Experiment 1), the negativity was best recognizable in a very early time window when ERPs were time-locked to the word category recognition point. It did, however, also reach significance in a more typical N400 time window when ERPs were averaged relative to the onset of the second noun phrase. In Experiment 2, which employed identical stimuli (supplemented by dative sentences) in the visual domain, the effect also showed the typical latency of an N400. In Experiments 3 and 4, which employed given names as NPs and included pro-drop sentences in the stimulus materials, however, the negativity arose with an unusually long latency. Furthermore, the effect was widely distributed in Experiments 1, 3, and 4, which is not unusual for the auditory presentation modality employed in Experiment 1 (Domalski et al., 1991), but rather untypical for the visual presentation modality. For current purposes, considering all negativity effects observed for canonical word orders at the position of NP2 as extension N400 effects, and thereby as correlates of similar underlying processes, appeared to be the most economical and parsimonious interpretation. Nonetheless, the variations in the effect's topography and latency should be further investigated.

Since the extension N400 clearly differs from the more prominent lexical-semantic N400 in functional terms, a divergent distribution of the effect may not be altogether surprising. In fact, the extension N400 might reveal even more divergent properties under closer consideration, for example in an investigation of its underlying EEG frequency band characteristics (cf. Roehm, 2004; Roehm, Bornkessel-Schlesewsky, & Schlesewsky, 2007b; Roehm, Schlesewsky, Bornkessel, Frisch, & Haider, 2004; for a discrimination of other non-lexical N400 effects by means of this method). This argument, however, does not suffice to account for the distributional variations observed *within* the extension N400 instances in the current thesis, especially the differences between the visual experiments. These differences seem to fall together with the latency differences described above; i.e. the extension N400 showed a less typical distribution and latency in Experiments 3 and 4 than in Experiment 2.

In the discussions of Experiments 3 and 4 it has been suggested that a possible explanation for these differences might be derived from the fact that these experiments employed proper nouns instead of common nouns as NPs. As a starting point, this hypothesis could be tested by reemploying the design of Experiment 2 (i.e. the design without pro-drop sentences) using proper nouns, or the design of Experiment 3 (i.e. the design with pro-drop sentences) using common nouns. If the noun type is responsible for the latency difference, these experiments should result in a "latency reversal", i.e. longer latencies in the "Experiment 2" design and shorter, more typical N400 latencies in the "Experiment 3" design. In case of a confirmation of these assumptions, further experiments could directly compare the extension N400 elicited by sentences with proper nouns, common nouns, and pronouns to further investigate the interrelation between certain noun properties and the latency (and topography) of the extension N400.

As only few cases of this effect have occurred in the neurolinguistic literature until now, the term *extension N400* should generally be considered a "working title", and it would be interesting to see in how far other languages with differing properties exhibit similar effects. Since the interpretive representation level proposed in the eADM is assumed to be largely unaffected by structural differences between languages (as opposed to the structural representation level; see Section 9.1), we would expect cross-linguistic replications of the extension N400 rather independently of the language under consideration. It should be kept in mind, however, that not every language offers a straightforward opportunity to test this prediction, at least not in the domain of simple sentences. English, as an SVO language, is a case in point: Here, an extension from an intransitive to a transitive event interpretation would become necessary at the position of a transitive verb following a sentence-initial subject in comparison to an intransitive verb in the same position. Due to the inevitable confoundation of event level effects and lexical differences in the relevant comparison between the two verbs, an N400 indicating the extension from an intransitive to a transitive event could not be isolated from other, lexical, ERP effects possibly occurring in the same time window. Other verb-final languages with a word order allowing sentence-initial objects (like Turkish or Korean), on the other hand, would doubtless provide valuable test cases to investigate the cross-linguistic validity of the extension N400.

9.3 Additional effects for scrambled sentences

9.3.1 Summary

In addition to the two word order related effects that were in the main focus of Experiments 1 and 2 (see above), some additional ERP effects arose in response to scrambled sentences which shall be briefly summarized in the following.

In Experiment 1, all auditorily presented accusative-initial sentences engendered broadly distributed positivity effects relative to the case markers of the first and the second noun phrase. In the experiments employing visual presentation, where ERPs were averaged relative to the onset of the NPs, no such effects were evident. It was concluded that these positivity effects may be best interpreted as reflecting the processing of thematic dependencies between an identified undergoer and an actor that is predicted upon the undergoer's identification.

More precisely, the positivity at the position of the first case marker seems to indicate the formation of such a dependency or, more accurately, the revision of a pre-established minimal dependency assumption. The initial noun is assumed to be preferably analyzed as an actor, thus allowing a minimal "no dependencies" interpretation, which needs to be revised when the noun is followed by an accusative case marker identifying the NP as the undergoer of a transitive event and thereby requiring the formation of a dependency. Crucially, the independence of the positivity effect mirroring this dependency formation from the structural differences induced by the prosodic manipulation speaks against an underlying dependency mechanism on a structural level, like the dependency between a dislocated argument and its hypothetical gap in a scrambled structure (e.g. Gibson, 1998, 2000). Instead, the dependency under consideration here appears to be postulated on a thematic level, since an undergoer is always thematically dependent on an actor (cf. Primus, 1999), independently of whether it is dislocated (scrambling analysis) or encountered in its base position (pro-drop analysis). The lack of comparable effects in the other three experiments (and in previous experiments employing visual presentation) can easily be derived from the circumstance that the relevant case information is immediately available if NPs are presented visually and no revision of an initially preferred "no dependency" reading is therefore necessary.

The positivity effect at the position of the second case marker seems to reflect the resolution of the described thematic dependency as soon as the processing system identifies the actor on which the undergoer is thematically dependent. The finding of a positivity at this position is highly compatible with previous experiments reporting similar effects in German as well as in Japanese (e.g. Bornkessel et al., 2002; Fiebach et al., 2002; Hagiwara et al., 2007; Ueno & Kluender, 2003). In the visual experiments of this thesis (see also Bornkessel et al., 2004a), a comparable positivity effect for object-initial conditions was most likely masked by the observed extension N400 for the canonical comparison conditions.

Furthermore, all scrambled object-before-subject orders engendered a late negativity in comparison to their unscrambled counterparts in Experiments 1 and 2, independently of the prosodic manipulation in Experiment 1 or the case manipulation in Experiment 2. Experiments 3 and 4 did not provide reliable data regarding this effect due to a programming error precluding an analysis of the respective time window. These negativity effects (as well as some previously reported negativity effects at the position of sentence-final words in object-initial structures; Fiebach et al., 2002; Hagiwara et al., 2007; Ueno & Kluender, 2003) were interpreted as a correlate of global, sentence-final processing costs for object-initial structures. This conclusion was further supported by the observation that the prosodic or case manipulations which affected local processing costs at earlier sentence positions did not exhibit any influence on the late negativity, as well as by a close correspondence between the late negativity effect and another measure of global processing costs, namely the performance in the offline comprehension task.

9.3.2 Open questions and future directions

With regard to the positivity effects isolated in Experiment 1, more research employing auditory presentation is clearly indicated, since it appears exceedingly difficult to induce comparable effects and to disentangle them from simultaneously arising ERP effects when word category information and case information become available at the same time in visually presented noun phrases. Especially suitable for a replication of the positivity effects should be other languages in which the case information also is encoded in postpositions or suffixes and therefore only becomes available *after* the word category and lexical information (e.g. Finnish, Tamil, Turkish, or Russian; cf. Haspelmath et al., 2005; Chapter 51). If the conclusions drawn above are correct, such a constellation should allow for an initial interpretation of the first argument as a dependency-free actor before the case information identifies it as an undergoer and requires the postulation of a thematic dependency. Furthermore, these languages should also permit the distinction of a positivity reflecting the resolution of such a dependency at the encounter of a subsequent actor (as identified by a nominative case marker) from an extension N400 for the encounter of a second argument in the canonical word order (as induced by the word category information of the second noun).

An unresolved issue regarding the thematic dependencies in question here is concerned with the "directionality" of the dependencies able to elicit the described positivity effects. So far it has been demonstrated that these effects arise based on the identification of an undergoer which is thematically dependent on an actor. However, some kind of dependency may also be formed if an argument is identified as an actor that requires a dependent undergoer. As data from the processing of ergative sentences in Hindi showed, positivity effects indicating dependency formation also seem to be evident in this case (Choudhary, in preparation; Choudhary et al., in press). In Japanese, this issue could be further investigated by considering dative-subject constructions. Recall that in Japanese, dative case can mark an initial argument as the actor of a transitive event (see Sections 9.1 and 9.2, above), thereby possibly requiring the formation of a dependency from an identified actor to a dependent undergoer. If the directionality of the thematic dependency is irrelevant for the genesis of the described positivity effects, as the results from Hindi suggest, then dependency related positivity effects should also be observable for dative-initial sentences that are analyzed as dative-subject constructions. Crucially, as the dependency related positivity effects are usually not discernable using visual presentation (see above), these predictions need to be tested by presenting dative-before-nominative and nominative-before-dative sentences such as the ones employed in Experiment 2 auditorily, and possibly interspersed with "actual" dative-subject sentences (cf. Section 9.1.2).

While the late negativity at the position of sentence-final verbs was taken to reflect global processing costs for all object-initial structures, this is not the only possible explanation for this ERP effect. Recall that the interpretation of this effect as an indicator of global processing costs was corroborated by a correspondence of the effect with the participants' performance in the post-sentential comprehension task. Experiment 3, however, not only showed a performance decrease in the scrambled conditions but also a performance increase in the subject-drop conditions. Interestingly, this pattern roughly mirrors the frequency distribution of these structures in Japanese, since subject-drop sentences are highly frequent (over 70% of all sentences; Martin, 2003), while scrambled sentences are extremely rare in this language (ca. 2% of all object-initial sentences; Miyamoto & Nakamura, 2003). By extension, this observation also allows the postulation of an alternative hypothesis regarding the late negativity effect: Instead of reflecting processing costs for object-initial word orders, the late negativity may also be a more general correlate of all low-frequency structures.

Since the respective time window could not be analyzed in the experiments including pro-drop sentences, a replication of Experiment 3 with a correction of the timing error in the program would be indicated to test this alternative hypothesis. If the late negativity indeed reflects global processing costs (exclusively) for object-initial structures, as assumed thus far, then a comparable effect at the position of the verb should only arise in the OSV−SOV comparison of such an experiment. If, by contrast, the late negativity turns out to be a general sentence-final marker of low-frequency structures instead of a specific correlate of object-initial structures, then we should furthermore observe a significant effect in the OV−SOV comparison, reflecting a reduced late negativity for the highly frequent subject-drop sentences.[70]

9.4 The N400 for new words and P600 for new referents

9.4.1 Summary

In Experiment 4, target sentence NPs that were repetitions of NPs given in the preceding context sentence engendered a reduced N400 effect, which is in concert with numerous cross-linguistic findings of a reduction of this ERP component in response to lexical repetitions, be it in the context of word lists, sentences, or longer texts (e.g. Bentin & Peled, 1990; Burkhardt, 2006, 2007a; Nagy & Rugg, 1989; Rugg, 1987, 1990; Van Petten et al., 1991). In accord with these previous findings, the N400 reduction observed here was interpreted along the lines of a facilitation of the lexical-semantic integration process in repeated NPs as compared to new NPs.

Furthermore, new NPs as well as contextually given NPs that followed new NPs engendered a widely distributed P600 effect. Based on the pattern observed here and previous data from other languages like German (Burkhardt, 2006, 2007a), English (Van Petten et al., 1991), and Dutch (Nieuwland et al., 2007; Van Berkum et al., 2004), this ERP effect was interpreted as a correlate of the need to establish a new referent for the currently processed argument.

9.4.2 Open questions and future directions

While the present finding of a givenness effect in the N400 component appears highly compatible with previous findings on lexical repetition priming effects, it would be

[70] With regard to object-drop sentences, concrete predictions are more difficult to make since less frequency data are available for this type of structure. Since they are however supposed to be clearly less frequent than subject-drop sentences (about ten times; cf. Ueno & Polinsky, submitted), they should not show a similarly reduced late negativity in comparison to the complete SOV sentences as the highly frequent subject-drop sentences.

interesting to investigate whether a different N400 pattern would arise under slightly different contextual circumstances. More precisely, data from other languages have shown that if highly discourse-prominent names are repeated *within* a sentence, the repetition priming effect may be counteracted by the so-called repeated name penalty (RNP), which becomes apparent in the form of an increased N400 (e.g. Ledoux, Gordon, Camblin, & Swaab, 2007; Swaab, Camblin, & Gordon, 2004). The discourse prominence is assumed to be higher for names that stand alone in a singular noun phrase than for names that are embedded in a conjunctive noun phrase. To test whether these assumptions also hold for pro-drop languages like Japanese, the sentence pairs employed in Experiment 4 could be conjoined into two-clause sentences, for example with the help of subordinating sentential conjunctions like “after” or “because”. On the one hand, if an RNP is also evident in Japanese, it should manifest itself in a significantly more negative-going N400 component in the 1☑2☒ condition than in the 1☑2☑ condition at the position of NP1, and in a significantly more negative-going N400 component in the 1☒2☑ condition than in the 1☑2☑ condition at the position of NP2. On the other hand, it is also possible that the tendency towards omitting arguments is so strong in Japanese that the repetition of a name within the same sentence always leads to increased processing costs, thus generally counteracting the repetition priming effect observed in the present study.

9.5 The pro-drop positivity

9.5.1 Summary

The pro-drop positivity (a widely distributed positivity between 400 and 600 ms post verb onset) was observed in response to verbs of sentences with an omitted subject (OV) or object (SV) in comparison to verbs of complete canonical sentences (SOV). This effect was clearly discernible when subject-drop or object-drop sentences were visually presented in isolation (Experiment 3), but was significantly reduced when the pro-drop sentences were embedded in certain linguistic contexts (Experiment 4). The specific kind of context that allowed a reduction of the pro-drop positivity depended on whether the subject or the object of the sentence was omitted, which was attributed to differences in the type of referents that can be inferred for the two sentence structures. The complete pattern of observations suggested an interpretation of the pro-drop positivity as a discourse related ERP effect indicating the inference of missing referents from outside of the sentence. This referential inference process further appears to be affected by at least two factors: (a) whether a new discourse referent needs to be established for the omitted argument, and (b) whether there are other discourse referents competing with the inferable referent. As a result, the pro-drop positivity seems to be reduced when a pre-established referent (i.e. a lexically given referent or, in subject-drop sentences, a pre-established speaker) can be inferred as the missing discourse referent without any competition from other lexically given referents. Due to their apparent functional similarity, it was further concluded that the pro-drop positivity and the referent establishment P600 effects described in Section 9.4 may both be subcases of a cross-linguistically valid discourse referential P600 effect which occurs the earlier, the less lexical-semantic processing of the respective referent is preveniently required.

9.5.2 Open questions and future directions

First of all, a replication of the data from Experiments 3 and 4 with a correction of the trial-timing error (as suggested in Section 9.3.2 above) would certainly be appropriate to entirely rule out an attribution of the observed positivity effect to presentation timing differences. It should, however, be kept in mind that such an interpretation already seems extremely unlikely taking into account the results of the time-split analysis of the verb related ERPs in Experiment 3 (see App. A.4) and the observation that the effect varied depending on the contextual manipulation in Experiment 4.

Since the current thesis provides the first observation of this pro-drop related ERP effect, much future research is unquestionably necessary to further isolate the precise functional mechanisms responsible for the additional processing costs reflected in the pro-drop positivity. One interesting aspect suggesting itself for further investigation is the degree of competition between different discourse referents. In the subject-drop sentences of Experiment 4, the amplitude of the pro-drop positivity suggested higher processing costs when a lexically given referent competed with the given object referent (condition S☑O☑) than when the pre-established speaker competed with it (condition S☒O☑). Without competition from the object referent, on the other hand, the pro-drop positivity was equally reduced, independently of whether a lexically given referent (condition S☑O☒) or the speaker (condition S☒O☒) was inferred as the missing referent. Thus, the influence of the competition factor seems to vary depending on specific properties of the competing referents.

One of these properties could be the degree of similarity between the competing referents. After all, a lexically given subject referent shares more properties with the competing lexically given object referent than a pre-established but non-mentioned speaker does. Both the inferable subject referent and the competing object referent are animate third person referents described by given names that are introduced in the context as a conjoint subject NP and are therefore both represented as actors of the context event. The pre-established speaker, on the other hand, differs from the competing object referent in that it is a first person referent which is not overtly mentioned and is therefore not assigned any grammatical function in the context sentence and not represented as a direct participant of the context event. Therefore, the competition factor isolated in Experiment 4 may be closely related to the concept of *similarity-based interference*, a general cognitive phenomenon in the domain of memory retrieval, which indicates that the retrieval of a given element from memory experiences interference from similar elements, and which has recently also been applied to the domain of language processing (e.g. Gordon, Hendrick, & Johnson, 2001; Lewis & Vasishth, 2005; Lewis, Vasishth, & Van Dyke, 2006; Van Dyke & Lewis, 2003; Van Dyke & McElree, 2006). To test the hypothesis that the amount of competition from other referents (and thereby the extent of inferential processing costs reflected in the pro-drop positivity) is affected by the degree of similarity, future experiments could vary the competitors' similarity more directly. To this avail, it would be possible to manipulate, for example, the conjointness, animacy, noun type, grammatical function and GR of the inferable and the interfering referent.[71]

Another question open for future research regards further factors besides competition and establishment that might modulate the extent of the pro-drop positivity. Since this component is interpreted to reflect referential inference processes, this question translates to the identification of additional factors modulating the ease of the inference process. In this regard, a number of potentially important referent characteristics have been suggested in the pragmatic literature. One possible classification of such characteristics, set in a cognitive framework, is offered in the *Accessibility Theory* (AT) proposed by Ariel (1990, 2001). This theory assumes a close relationship between the "mental accessibility" of a discourse referent in the addressee's working memory and its phonological encoding in the speaker's utterance. The more accessible a discourse entity is for the addressee, the more phonologically reduced the expression will be that the speaker uses to refer to said entity. According to this relationship, the referring expressions are hierarchically ordered in an *accessibility marking scale*, ranging from full lexical expressions (full NPs) signaling minimal accessibility, through reduced forms (pronouns) signaling higher accessibil-

[71] Note that in Japanese, the amount of competition cannot be straightforwardly manipulated by simply varying the number of possible referents (cf. the ambiguity manipulation employed by Van Berkum et al., 2004), since the verb form does not provide any number information with regard to the omitted referent. In principle, the introduction of several possible referents in the preceding context could therefore simply lead to a plural interpretation of the omitted referent ("[They] invited Hanako") instead of inducing an increased level of competition for an inferable single referent role.

ity, to phonologically null expressions (pros, traces) signaling maximal accessibility of the discourse referent. Crucially for present purposes, arguments are thus supposed to be omitted when a speaker intends to refer to a maximally accessible referent.

From a comprehension point of view, AT's assumptions can be translated into the prediction that an omitted argument should be easiest to process if it refers to a maximally accessible discourse referent, and that processing difficulties should arise if the accessibility of the targeted discourse referent is reduced. Accessibility is defined in AT as a function of four cognitive factors, including the distance between the last mention of the referent and the referring expression, the topicality/saliency of the referent, the unity of the referent and the referring expression (e.g. whether they occur in the same paragraph) and the competition between several potential antecedent referents for the referential expression. Interestingly, this framework already covers the factors identified in Experiment 4: Lexical givenness may be encoded in terms of distance, since an entity that is not mentioned in the preceding context holds a greater distance to the referential expression than one that is given immediately preceding the referential expression. At the same time, the speaker of an utterance is typically considered a highly salient entity in the discourse representation (Ariel, 2001; Chafe, 1976; Prince, 1981). Finally, the competition factor seems to translate directly between the current findings and AT's conceptualization.

In summary, AT thus seems to provide a useful framework for a further investigation of the factors affecting the ease of referential inference. An interesting empirical starting point in this regard might be a closer investigation of the influence of the topicality factor comprised in AT. A number of reading time experiments on subject-drop in Italian (Carminati, 2002, 2005) have already reported initial evidence for the psychological reality of this factor by demonstrating that a missing argument (in the author's terms, a "pro") is preferably interpreted as retrieving a referent introduced in the preceding sentential context as a (highly topical) subject rather than a (less topical) object. Since Japanese also allows objects to be omitted, this conclusion could be directly contrasted with a possible alternative interpretation that only omitted subjects prefer referents introduced as subjects, whereas omitted objects prefer referents introduced as objects due to their parallel grammatical functions/GRs and despite their lower degree of topicality (cf. the notions of parallel function; Sheldon, 1974; perspective taking; MacWhinney, 1977; or case matching; Schlesewsky, 1997).

Chapter 10

General consequences for models of sentence processing

The present findings provide a number of exciting new insights into the underlying mechanisms of incremental sentence processing that need to be accounted for in order to attain a complete understanding of the (neuro)cognitive architecture of language comprehension in a cross-linguistically valid context. To this avail, I will first address two prominently debated issues in the language processing literature, the involvement of working memory and the interaction of syntactic and non-syntactic information types, and discuss the implications of the current findings for models centering around these factors (Sections 10.1 and 10.2, respectively). Then, I will discuss how the data observed here can be integrated with the neurocognitive model that the work summarized in this thesis was based on, the eADM (Bornkessel & Schlesewsky, 2006a). In this regard, some model modifications recommended by the obtained results on word order processing will be suggested (Section 10.3.1), and an application of the Minimality principle at the discourse level will be conceptualized on the basis of the results on pro-drop processing (Section 10.3.2).

10.1 Working memory aspects of sentence processing

The complete data pattern observed in this thesis seems difficult to reconcile with a purely memory-based model of sentence comprehension such as the SPLT/DLT put forward by Gibson (1998, 2000). This may be the case because like most other models of sentence processing, the SPLT/DLT assumes a relatively strict correspondence between a constituent's position in the phrase structure and that constituent's interpretation. While these two levels are indeed tightly interrelated in languages such as English, the mapping between structure and meaning is much more flexible in the vast majority of languages. The current results illustrated the necessity to separate the structural and the interpretive level of sentence representation by demonstrating that factors influencing the structural level (e.g. prosody) do not necessarily affect the interpretational level of representation. This circumstance challenges models like the SPLT/DLT and other highly syntax-centered accounts of sentence comprehension like the AFS (Frazier, 1987; Frazier & Flores d'Arcais, 1989), the MCP (De Vincenzi, 1991), or the Neurocognitive Model (Friederici, 1995, 2002).[72] For example, it is difficult to derive increased processing costs for canonical word orders from such accounts, since syntactically, and therefore also with regard to structure-based storage and integration costs, object-initial orders should always elicit higher processing costs, e.g. for maintaining the predictions of a subject and an object trace in working memory (Gibson, 1998). The observed processing costs for canonical subject-before-object orders can thus only be derived if the interpretive level of sentence representation is treated independently from the phrase structural level.

While the arguments put forward above do speak against sentence comprehension accounts relying exclusively on phrase structure representations and memory related processes, they should by no means be taken to imply that working memory does not play any role in the incremental processing of word order variations. Especially the positivity effects observed for object-initial sentences in Experiment 1 seem highly compatible with a memory-based explanation. Recall that the positivity effect observed at the position of the first case marker was discussed as reflecting the (unexpected) formation of a dependency between an encountered undergoer and the actor on which it is thematically dependent. The positivity effect observed at the position of the second case marker was discussed as an indicator of dependency resolution once said actor is encountered. Notably, the kind of dependency under consideration here could not be a syntactic dependency such as the one between a displaced object and its gap (or a predicted subject) as conceptualized by Gib-

[72] In more recent publications, Friederici and colleagues (e.g. Bahlmann, Schubotz, & Friederici, 2008; Friederici, 2004; Friederici, Bahlmann, Heim, Schubotz, & Anwander, 2006a) increasingly relinquish the original assumption that sentential meaning in the sense of "who is doing what to whom" is determined exclusively by the structural properties computed in the initial phase of processing (cf. Friederici, 1995). Instead, the concept of hierarchical long-distance dependencies has been suggested as a discrete aspect of syntactic processing, which functions independently of the local phrase structure building operations that draw on word category information alone. While the inclusion of this independent processing level constitutes a valuable extension of the Neurocognitive Model (notably also in light of the current results), its integration into the model's underlying representational assumptions yet remains to be implemented theoretically (cf. Bornkessel-Schlesewsky & Schlesewsky, in press-a).

son (1998; 2000; see also De Vincenzi, 1991; Fiebach et al., 2002), since the effect also occurred when prosodic cues allowed a pro-drop analysis, which would rule out any predictions of further overt arguments or traces in such an account as the SPLT/DLT. The thematic undergoer-actor dependencies assumed here, however, may similarly require working memory resources. In this regard, it is possible to envisage the formation of a thematic dependency as involving processes of memory encoding and the resolution of the dependency as some kind of integration process requiring memory retrieval (in the sense of Lewis et al., 2006; McElree, 2006).

Furthermore, it is conceivable that the maintenance of an open thematic dependency in working memory should also lead to increased processing costs like those reflected in the SAN (cf. Fiebach et al., 2002; Hagiwara et al., 2007; Ueno & Kluender, 2003). The fact that no such effect was observable between the two positivity effects reflecting dependency formation (at the case marker of NP1) and dependency resolution (at the case marker of NP2) in Experiment 1 was probably due to the lack of a sufficiently long interval between the point of encoding and the point of retrieval. If Experiment 1 was repeated with the additional inclusion of intervening sentence material between NP1 and NP2, we would therefore expect a replication of the positivity effects as well as a SAN effect between these two sentence positions indicating the maintenance of the open dependency in working memory. Besides being of interest in and of itself, such a finding would further support the initially stated assumption (see Section 3.1.4) that the scrambling negativity and the SAN generally need not be mutually exclusive ERP responses to object-initial word orders, and that they have not been observed within the same experiment (except possibly by Hagiwara et al., 2007; see Section 5.5.3) only because experiments investigating the scrambling negativity did not provide sufficient intervening sentence material between the scrambled object and the following subject. It should, however, be emphasized once more that the findings of this thesis demonstrated that the scrambling negativity and the dependencies responsible for the memory effects discussed here arise on independent levels of representation, with the scrambling negativity reflecting phrase structure related processing costs which cannot be explained by the same general mechanisms of dependency encoding, maintenance, or resolution. Therefore, the notion of working memory related costs is not per se incompatible with the assumptions of the eADM, these processes just seem to apply at a thematic rather than at a structural level of representation.

The way in which memory related factors may influence the processing of pro-drop sentences is much less clear and has not been explicitly elaborated in any memory-based theory of sentence processing. As suggested in Section 9.5.2, the results of Experiment 4 indicate a possible influence of similarity-based interference at the discourse level (cf. Gordon et al., 2001; Lewis & Vasishth, 2005; Lewis et al., 2006; Van Dyke & Lewis, 2003; Van Dyke & McElree, 2006), thereby suggesting an involvement of general memory retrieval processes in the mechanisms underlying the pro-drop positivity. It should be noted, however, that the conceptualization of the retrieval process that underlies accounts of similarity-based interfence critically differs from the one assumed in the SPLT/DLT, since the former accounts do not strictly differentiate between the processes taking place in working memory and long term memory and therefore implement memory retrieval as a direct, cue-controlled, access to the representations stored in long term memory, whereas the latter accounts picture working memory as a separate, limited-capacity, storage unit which holds the recently activated representations and is searched during the working memory retrieval process.

The observation that the pro-drop positivity is also sensitive to the need to establish new discourse referents, on the other hand, seems more compatible with the assumptions of the SPLT/DLT, since the integration cost component in this theory is described as a function of distance and discourse complexity, which in turn is assumed to be increased if a new discourse referent needs to be established. However, since the SPLT/DLT, unlike the eADM, would typically assume an empty category (a pro) in the structure of pro-drop sentences, it would rather predict this type of processing cost at the position where the alleged pro is posited (e.g. when an initial object is encountered). Notably, while Gibson (1998) mentions that the SPLT does not depend on the assumption of empty categories for a valid derivation of certain word order related processing effects (cf. Footnote 23), it remains undetermined in how far other processing effects that the SPLT/DLT typically draws on for evidence could be derived by the model without resorting to the concept of empty categories.

10.2 The influence of "non-syntactic" information types

The experimental results of this thesis demonstrated an influence of non-syntactic information types on incremental sentence processing in several instances. These included effects of discourse information, frequency of occurrence, and prosody. As explained before (see Section 3.1.2), the influence of such information sources is generally acknowledged in all models of incremental sentence processing; they do, however, differ with regard to the timing of such an influence. Interactive, constraint-based theories (e.g. Hagoort, 2005; MacDonald et al., 1994; Trueswell et al., 1994; Vosse & Kempen, 2000) assume an immediate interaction of all information types, while modular theories (e.g. Bornkessel & Schlesewsky, 2006a; Frazier, 1978; Frazier & Fodor, 1978; Frazier & Rayner, 1982; Friederici, 1995, 2002) assume at least one initial processing step that is based on syntactic information alone before non-syntactic information is integrated. Note that the prominence scales that are in the center of the eADM subsume information types that in other accounts of sentence processing would be considered as syntactic (e.g. case) as well as such that would be regarded as non-syntactic (e.g. animacy). For want of a more fitting term, the information types that are neither phrase structure related nor prominence related will nonetheless be referred to as "non-syntactic" information.

With regard to the integration of discourse information, the current experiments seem to suggest a late rather than immediate interaction with other information types. One observation specifically speaking in favor of such an assumption is the latency of the referent establishment P600 which appears to be dependent on the duration of the preceding N400. This finding clearly seems to suggest that a certain amount of lexical processing needs to be completed before discourse related processes can take place. If, as put forward in the discussions of Experiments 3 and 4, the pro-drop positivity is interpreted as a similar discourse related effect that is most compatible with the eADM's Stage 3, the influence of discourse contextual information on this component (but, for example, not on the scrambling negativity or the extension N400 that are both associated with Stage 2 processing) also speaks in favor of a late rather than immediate interaction of contextual discourse information and other information types.

With regard to a possible influence of frequency information, the current results have clearly demonstrated that frequency of occurrence does not suffice to derive all of the observed effects of word order permutations and argument omission. For example, neither the scrambling negativity nor the pro-drop positivity were affected by frequency distributions of the considered sentence structures, and the extension N400 for canonical word orders in comparison to the much rarer scrambled word orders is especially difficult to derive from a frequency-based perspective. Thus, the current findings, like previous findings from German (e.g. Bornkessel et al., 2002; Kempen & Harbusch, 2005), strongly speak against a purely frequency-based account of sentence comprehension (cf. Jurafsky, 1996; Levy, 2005). An influence of frequency was, however, discernible in the behavioral results, and possibly also in a late negativity effect at the position of the sentence-final word. However, since similar late negativity effects so far have predominantly been observed in response to word order permutations in Japanese (Experiments 1 and 2; Hagiwara et al., 2007; Ueno & Kluender, 2003), an association between this ERP component and frequency information is still highly speculative and clearly requires further testing (cf. Section 9.3.2). In any case, both the absence of frequency effects in earlier ERP components and the observed influence of frequency differences on the post-sententially recorded behavioral measures seem to suggest a late rather than immediate interaction of frequency information with other information types, thereby favoring modular over interactive accounts of the influence of non-syntactic information.

An exception to this rule seems to be constituted by the influence of (certain types of) prosodic information. Recall in this regard that an early integration of prosodic phrase boundary information was already demonstrated by data from German (Steinhauer et al., 1999) which showed that the presence or absence of prosodic boundaries appears to influence early processes of phrase structure building (or, in terms of the eADM, template selection). An early influence of this kind of prosodic information is also confirmed by the results of this thesis, since Experiment 1 provided evidence for an interaction of prosodic boundary information and case information in the generation of the scrambling negativity.

In summary, the current thesis provides evidence for the influence of various non-syntactic information sources on incremental sentence processing. In principle, the pattern of results observed here seems to favor modular accounts, and a precedence of syntactic (and prominence related) over non-syntactic information types, over accounts assuming an immediate interaction of all available information types (with the exception of prosodic phrase boundary information which already appears to interact with phrase structural and prominence information in the earliest steps of processing).

10.3 The eADM: Modification proposals

While the empirical findings summarized in this thesis seem highly compatible with the assumptions put forward in the eADM, some modifications of the model appear to be indicated to account for the complete data pattern observed here. In the following, I will first suggest some potential model adjustments based on the findings regarding the processing of word order permutations (Section 10.3.1), and then discuss a possibility to implement the findings regarding the processing of pro-drop sentences in the eADM framework (Section 10.3.2).

10.3.1 The processing of permuted word orders: Minimal phrase structures, events, and dependencies

As discussed in detail in the context of the experiments of this thesis and summarized in the previous chapter, the scrambling negativity was confirmed as an indicator of violations of the Minimality principle at the phrase structural level, and the extension N400 reliably seemed to reflect Minimality violations at the interpretive level. In addition, the positivity effects emerging at the positions of both NPs were interpreted as reflecting the formation/revision and resolution of thematic undergoer-actor dependencies and thereby suggested additional dependency related processes taking place at the interpretive representation level. In summary, the word order related effects observed here could thus be successfully derived based on the application of the Minimality principle at the phrase structural level (preference for one-argument structures) and the interpretive level (preference for intransitive events and zero dependencies).

Even though the dependency related effects (positivities) and the event related effects (extension N400s) can both be closely associated with the interpretive level of representation, the experimental results of this thesis spoke in favor of a certain degree of independence of the effects, so that the dependency representations and the abstract event representations might best be considered as sub-representations on the interpretive level. One point of modification suggesting itself specifically with respect to the event related processing mechanisms regards the apparent independence of the event transitivity assessment from the assignment of GRs. As Experiment 2 demonstrated, the extension N400 was also evident for nominative-before-dative sentences in comparison to dative-before-nominative sentences. This result can probably be attributed to the fact that even though an initial dative can be analyzed as an actor, it still unequivocally signals a transitive event. If this line of argumentation turns out to be correct (for empirical test proposals, see Section 9.1.2), it would be indicated to extract the event transitivity assessment from the GR assignment step in Stage 2b of the eADM and to implement a direct link between the case information extracted in Stage 2a and this "new" transitivity assessment step in Stage 2b.

It is further arguable whether the dependency assessment underlying the observed positivity effects similarly requires a more direct input of case information. While the current results do not contradict the assumption that the dependency assessment crucially depends on GR assignment (and may therefore be subsumed under this processing step), recent findings from Hindi (Choudhary, in preparation; Choudhary et al., in press) suggest that similar dependencies may also be formed between an encountered actor and a predicted undergoer, speaking in favor of a certain degree of independence between dependency assessment and GR assignment processes. As discussed before, however, this assumption so far has not been confirmed in Japanese and clearly requires more cross-linguistic research (see Section 9.3.2).

The behavior of the ERP effects discussed above further points to a more general issue, namely the question of how the sequential access to different information types in auditory presentation affects the functioning of incremental sentence processing mechanisms in general. For example, the availability of word category and lexical information before case information at the position of NP1 seems to engender a "no dependency" assumption before the case marker is encountered (hence a positivity effect at the first case marker in auditory presentation but not at the first noun phrase in visual presentation), whereas the transitivity assessment does not seem to be initiated before the case information is processed (hence the absence of an extension N400 at the first case marker in auditory presentation). Since the concept of incremental interpretation implies that each new input item is immediately taken into account in order to maximize interpretation, the matter under consideration here regards the question of which information types constitute discrete input items, and the interdependence between these different information types when they are not presented simultaneously. Especially interesting in this regard are cases in which information units that are typically considered to be analyzed first do not become available first. While the current experiments provide some evidence for a partially independent processing of word category and case information, future research employing auditory presentation in various languages will be required before this issue can be resolved satisfactorily (also see the discussion on the timing of different violation types and the related ERP effects advanced by Van den Brink & Hagoort, 2004, and Friederici et al., 2004).

A final modification proposal concerns the role of prosodic phrase boundary information in incremental sentence processing. As discussed in Section 10.2, the findings of Experiment 1, in concert with the findings reported by Steinhauer et al. (1999), speak for an early interaction of prosodic boundary information and the information types processed in Stages 1 and 2 of the eADM. While this issue was already acknowledged in the original publication of the model (Bornkessel & Schlesewsky, 2006a; p. 803), a future adaptation could incorporate the early influence of prosodic boundary information more explicitly (for example by including it in the visual illustration of the assumed processing mechanisms; cf. Fig. 3.5).

10.3.2 The processing of pro-drop sentences: Minimality at the discourse level?

The first modification suggestion arising from the pro-drop related results of this thesis was already discussed in detail in the context of Experiments 3 and 4 (see Sections 7.5.2 and 8.5.4): Since the pro-drop positivity was interpreted as reflecting a discourse related process taking place in the generalized mapping step of Stage 3, the relatively short latency of this ERP effect strongly suggested a cascaded rather than a strictly serial progress of Stages 2 and 3 of the eADM. This assumption goes hand in hand with findings suggesting a similar overlap between Stages 1 and 2 of the model (cf. Friederici et al., 2004; Hahne & Friederici, 2002; Van den Brink & Hagoort, 2004) and has already been implemented in recent revisions of the eADM (Bornkessel-Schlesewsky & Schlesewsky, 2008, 2009, in press-a).

When considering the pro-drop positivity as reflecting processes of discourse referential inference, one further issue lends itself to discussion. After the word order related effects summarized in this thesis were essentially in accord with the application of the Minimality principle at the phrase structural and the interpretive level, it appears consequential to contemplate in how far the Minimality principle may also apply at the discourse level. Clearly, the most straightforward way to think of Minimality at the discourse level would be to picture a minimal discourse representation as one in which no unnecessary discourse referents are assumed. Thus, while the application of the Minimality principle at the phrase structural level prohibits the assumption of unnecessary elements in the phrase structure, and its application at the interpretive level calls for intransitive event interpretations and prohibits the assumption of unnecessary dependencies, the application of the Minimality principle at the discourse level should prohibit the assumption of unnecessary referents in the discourse. Such a conceptualization of discourse Minimality is obviously highly compatible with the observation that the need to establish additional discourse referents leads to an increase in processing costs as reflected in the pro-drop positivity (and in the establishment P600 at the position of new overt NPs).

On the other hand, a conceptualization of discourse related Minimality should also be able to account for the influence of the competition factor isolated in Experiment 4, and it is not immediately apparent how this influence on the pro-drop positivity could be derived on the basis of a preference for minimal discourse representations. To solve this problem it may be useful to consider a suggestion made by Bornkessel-Schlesewsky and Schlesewsky in recent revisions of the eADM (Bornkessel-Schlesewsky & Schlesewsky, 2009, in press-b). Here, the authors consider Minimality as a subcase of a more general processing principle which they term *Distinctness*. On a phrase structural level, the Distinctness principle requires overt constituents of maximally distinct word categories, which can explain why a (minimal) structure consisting of only one NP and a verb is preferred over a (non-minimal) two-argument structure, since the two NPs in such a structure constitute two elements of the same word category. On an interpretive level, Distinctness is defined as in (40) below:

(40) Distinctness (Bornkessel-Schlesewsky & Schlesewsky, 2009; p. 44)
The participants in an event should be as distinct as possible from one another in terms of all available dimensions of prominence.

The application of the Distinctness principle at this level can derive the preference for (minimal) intransitive events over (non-minimal) transitive events, since the only participant in an event is automatically, or "vacuously" (Bornkessel-Schlesewsky & Schlesewsky, in press-b), distinct. In addition, the Distinctness principle predicts that if an event is transitive, it should be easiest to process if the actor and the undergoer are maximally distinct regarding all prominence related information types. That is, the actor should have as many prototypical actor properties as possible (e.g. animacy, definiteness, specificity, first or second person, first position), while the undergoer should share as few of these properties as possible. Through this prediction, the Distinctness principle can also derive increased processing costs arising when these requirements are not completely fulfilled, e.g. the finding of an N400 effect when an animate undergoer is followed by a non-prototypical inanimate actor (Frisch & Schlesewsky, 2001; see also Weckerly & Kutas, 1999).

Coming back to the issue under consideration here, the influence of referential competition on the discourse related processing costs reflected in the pro-drop positivity may similarly be attributable to the Distinctness principle, in this case by applying the principle at the discourse level. In this regard, it is conceivable that the degree of competition between two discourse referents is inversely related to the degree of their distinctness: The less distinct two referents are, the more they compete with each other. Since this approach bears a clear resemblance to proposals centering on the influence of similarity-based interference (e.g. Gordon et al., 2001; Lewis & Vasishth, 2005; Lewis et al., 2006; Van Dyke & Lewis, 2003; Van Dyke & McElree, 2006; see Section 9.5.2), it is also capable of deriving the apparent differential impact of competition from more similar (i.e. less distinct) vs. less similar (i.e. more distinct) additional discourse referents. Further note that Minimality can be considered as a case of vacuously fulfilled Distinctness on this level of representation as well: A minimal discourse representation which provides exactly one potential referent for an omitted argument automatically rules out competition for the respective argument role since there simply are no other referents from which it could be more or less distinct.

In summary, the application of the Distinctness principle (and the special subcase of Minimality) at the discourse level of representation seems to qualify for a valuable extension of the eADM architecture. However, in order to determine in how far the factors controlling the degree of distinctness between (possibly unmentioned) discourse referents differ from the prominence properties which form the basis of the distinctness evaluation in the processing of overt NPs, a considerable amount of future research will be required.

10.4 Concluding remarks

The results summarized in this thesis demonstrate that a conceptual separation of several levels of representation constitutes an important prerequisite for deriving patterns of sentence comprehension across languages. While the different levels may be tightly connected in some languages such as English, their interrelation is much more flexible in the vast majority of languages. Specifically, the experimental results presented here strongly suggest a separation of the phrase structure, interpretive, and discourse level of represention in the theoretical modeling of incremental sentence processing. As shown here, such a separation need not lead to a more complex model. Rather, we need only assume that processing is guided by Minimality, or the more general principle of Distinctness, which applies differentially to the different levels of representation. The outcome of applying Minimality/Distinctness depends crucially upon the particular representation in question and the specific properties of the language being processed. For example, at the phrase structure level, Japanese differs from German in that it exhibits pro-drop and therefore allows minimal structures with an initial object, whereas both languages behave very similarly at the level of interpretive representations, since an initial accusative and an initial dative, but not an initial nominative, unambiguously signal a non-minimal event interpretation in both languages. At the discourse level, Japanese demonstrates a preference for minimal discourse representations with as few and distinct referents as possible, and data from German, English, and Dutch point towards a cross-linguistic validity of this preference. In summary, a Minimality/Distinctness-based account incorporating several levels of representation appears to present a promising approach to deriving cross-linguistic similarities and differences in the neurocognitive signatures of incremental sentence comprehension.

Part IV

Appendix

Appendix A

Additional analyses, figures, & tables

A.1 ERPs at the adverb position in Experiment 1

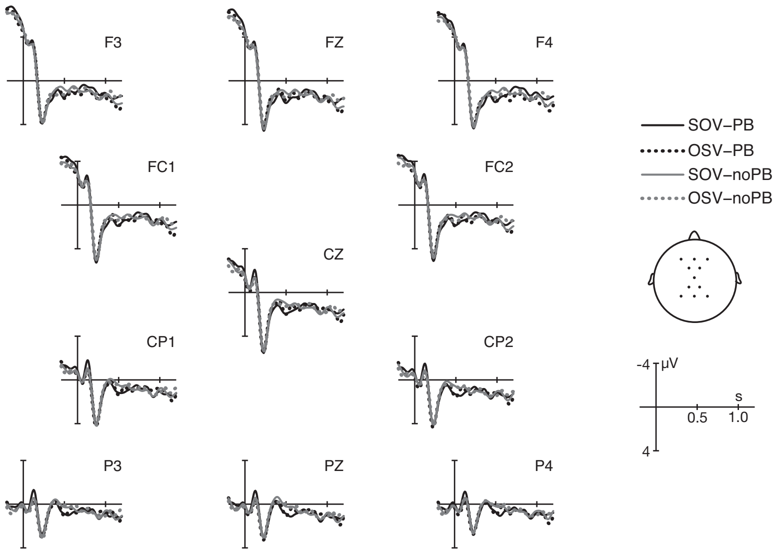

Figure A.1: Grand-average ERPs ($N = 24$) time-locked to the onset of the adverb (onset at the vertical bar) in Experiment 1.

In order to ensure that there were no differences between conditions before the onset of the critical sentence regions (i.e. the noun phrases and the verb) in Experiment 1, e.g. due to coarticulation or other early prosodic cues, we computed grand average ERPs per condition relative to the onset of the sentence-initial adverb. These are shown in Fig. A.1. A timeline analysis of 50 millisecond time windows between 0 and 1000 ms post adverb onset revealed a single significant effect over two subsequent time windows, namely a main effect of INTON between 450 and 550 ms post-onset (midline electrodes: 450–500 ms, $F(1, 23) = 11.47$, $p < .003$; 500–550 ms, n.s.; lateral electrodes: 450–500 ms, $F(1, 23) = 12.61$, $p < .002$; 500–550 ms, $F(1, 23) = 4.85$, $p < .04$; conditions with a prosodic boundary more positive).

Please note that conditions were not fully acoustically identical at this point (i.e. there were effects of INTON for the duration of the adverb and for the duration of the pause between adverb and NP1; see Section 5.3.2). Thus, the appearance of an ERP difference conditioned by the presence or absence of a prosodic boundary later in the string is not completely surprising. Most importantly, however, we did not observe any interactions between ORDER and INTON nor any main effects of ORDER at the position of the adverb. Hence, the scrambling negativity and the other word order related ERP effects of Experiment 1 cannot be explained via differences in the EEG that occurred before the onset of NP1.

A.2 Comparison of high and low performers in Experiment 3

To eliminate the possibility that some of the ERP effects (or the lack thereof) might be due to the scrambled sentences being "mis-processed" by many participants, median-split analyses were calculated comparing the participants with an OSV performance of 65% or higher (n = 12) to the participants with an OSV performance below 65% (n = 12) on the comprehension task. These additional analyses were conducted for all the reported comparisons of the scrambled condition with the canonical control condition, i.e. for the O−S comparison calculated at NP1*, the OSV−SOV comparison calculated at NP2 and the OSV−SOV comparison calculated at the verb. Fig.s A.2, A.3, and A.4 (cf. Fig.s 7.1, 7.2, and 7.3) show the respective ERPs separately for high performers (i) and low performers (ii).

As is immediately apparent from Fig.s A.2, A.3 and A.4, no major differences were evident between high and low performers at any constituent. To substantiate this visual impression, statistical analyses were conducted for the same time windows as in the original analyses of these constituents, that is for 50 millisecond time windows between 0 and 850 ms post word onset at the position of NP1, for the 450–650 ms time window at the position of NP2, and for the 400–600 ms time window at the position of the verb. The original ORDER×ROI and PC×ROI analyses were extended by the additional between-subjects factor PERFORM (comprehension task performance in the OSV sentences: high vs. low performance).

The timeline analysis of the 17 successive 50 millisecond time windows post onset of NP1 did not yield a significant interaction of ORDER×PERFORM in any time window at midline or at lateral electrodes (midline all Fs < 3, ps $> .10$; lateral all Fs < 2, ps $> .23$). The ORDER×ROI×PERFORM interaction reached significance only in the 150–200 ms time window in the analysis of the midline electrodes ($F(5,110) = 3.41$, $p < .05$) and in the 350–400 ms time window in the analysis of the lateral electrodes ($F(3,66) = 5.18$, $p < .02$). Resolving the former interaction by PERFORM showed no significant ORDER×ROI effect in either performance group (both Fs < 2.79, ps $> .08$), while resolving the latter interaction by PERFORM revealed a significant ORDER×ROI interaction only in the high performers ($F(3,33) = 5.75$, $p < .02$). Further resolving this interaction by ROI, however, did not yield significant effects of ORDER at any topographical region (all Fs < 5, ps $>$

*As the OSV and the OV conditions were not distinguishable yet at the position of NP1, and to keep the analysis maximally comparable to the results reported for NP1 in Section 7.4.2, conditions OSV and OV were again subsumed under a conjoint condition O. The same applies to the conditions SOV and SV, which were combined into condition S.

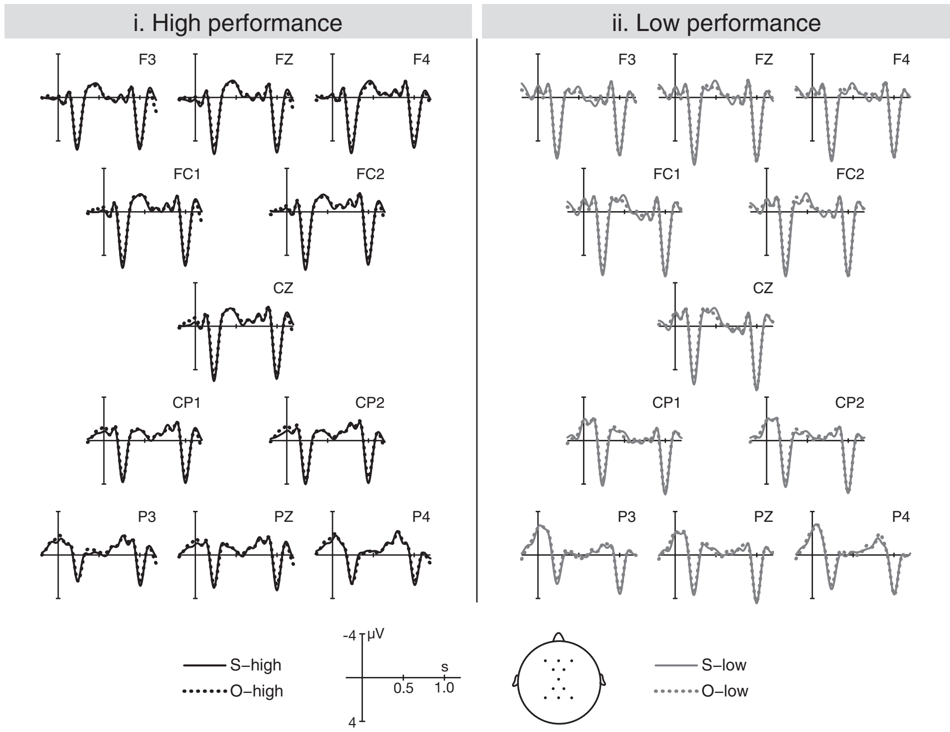

Figure A.2: Grand-average ERPs (N = 24) time-locked to the onset of NP1 (onset at the vertical bar) in Experiment 3, performance split. Comparisons for high and low performers are shown in (i) and (ii), respectively.

.05). In addition, the ORDER×ROI×PERFORM analyses resembled the respective analyses without the between-subjects factor PERFORM (see Section 7.4.2), as no significant differences between subject- and object-initial sentences were evident in any 50 millisecond time window (main effect ORDER: midline all Fs < 3, ps $> .12$; lateral all Fs < 2, ps $> .19$; interaction ORDER×ROI only significant at midline electrodes between 50 and 100 ms ($F(5{,}110) = 4.07$, $p < .03$) and at lateral electrodes between 400 and 450 ms ($F(3{,}66) = 3.60$, $p < .04$); resolving the interactions in these time windows by ROI yielded no significant effects of ORDER at any topographical region: midline (50–100 ms) all Fs < 1; lateral (400–450ms) all Fs < 2, ps $> .29$).

At the position of NP2, no interaction ORDER×PERFORM or ORDER×ROI ×PERFORM was evident, neither at midline nor at lateral electrode sites (all Fs < 1). Furthermore, the negativity for subject-before-object sentences in comparison

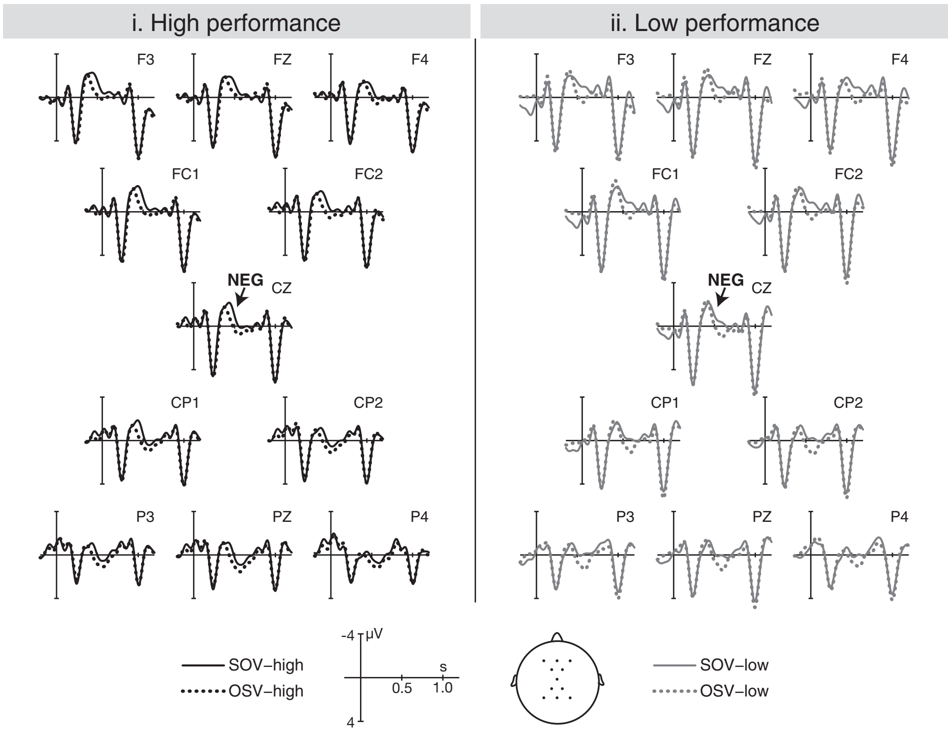

Figure A.3: Grand-average ERPs time-locked to the onset of NP2 (onset at the vertical bar) in Experiment 3, performance split. Comparisons for high (N = 12) and low (N = 12) performers are shown in (i) and (ii), respectively.

to object-before-subject sentences was also evident in this analysis (main effect of ORDER; midline $F(1,22) = 12.06$, $p < .003$; lateral $F(1,22) = 12.11$, $p < .003$).

In the OSV−SOV pairwise comparison at the position of the verb, neither the PC×PERFORM interaction nor the PC×ROI×PERFORM interaction reached significance at midline or lateral electrodes (all Fs < 1). In addition, resembling the results for the overall analysis without the performance factor, neither the main effect of PC (midline and lateral Fs < 1) nor the interaction PC×ROI (midline $F(5,110) = 1.84$, $p_b > .71$; lateral $F(3,66) = 1.54$, $p_b > .88$) was significant.

Thus, the performance with regard to the scrambled sentences in the comprehension task did not seem to coincide with any interindividual differences in the online processing of these sentences, as all effects involving the OSV condition were stable across participants, irrespectively of their performance level.

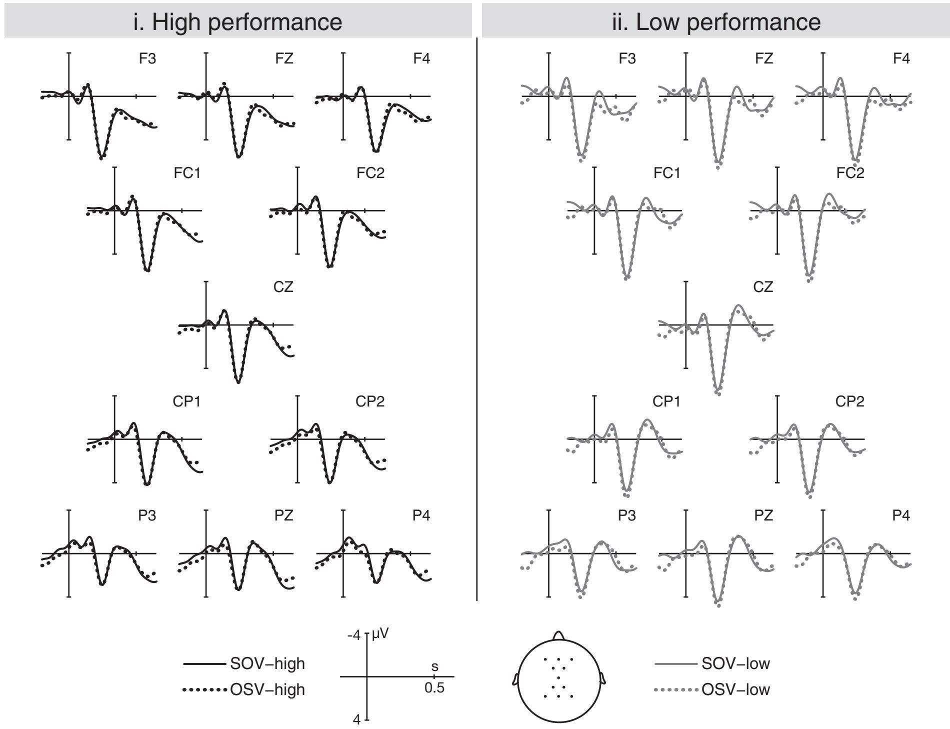

Figure A.4: Grand-average ERPs time-locked to the onset of the verb (onset at the vertical bar) in Experiment 3, performance split. Comparisons for high (N = 12) and low (N = 12) performers are shown in (i) and (ii), respectively.

Furthermore it seems reasonable to assume that if the OSV sentences had indeed been confused with and thus processes like SOV sentences, there should be no ERP differences between the two conditions at all. However, while this is true for ERPs averaged relative to the onset of NP1, canonical and scrambled sentences clearly differ relative to the onset of NP2. Therefore it is highly unlikely that the sentences were simply confused with canonical SOV sentences. Similarly, if processing of OSV sentences had collapsed altogether, we might have expected to find an entirely different electrophysiological reaction to these sentences than to all the other (assumedly processed) sentence types. Again, this does not match the results we actually found, as the ERPs in response to the object-initial sentences did not differ from the ERPs in canonical sentences at the position of NP1 or the verb.

Finally, the effects found for the OSV−SOV comparisons, i.e. the lack of a scrambling negativity for the scrambled sentences at the position of NP1 and an N400 for the canonical sentences at the position of NP2, matched exactly the effects predicted in Hypotheses (a) and (b), which in turn were based on findings from previous experiments without such a low performance in the scrambled conditions (i.e. Experiments 1 and 2).

Due to these logical and empirical arguments, we concluded that in spite of a low performance on the subsequent comprehension task, the OSV sentences were still perceived and processed correctly during online sentence comprehension.

A.3 Further course of verb related ERPs in Experiment 3

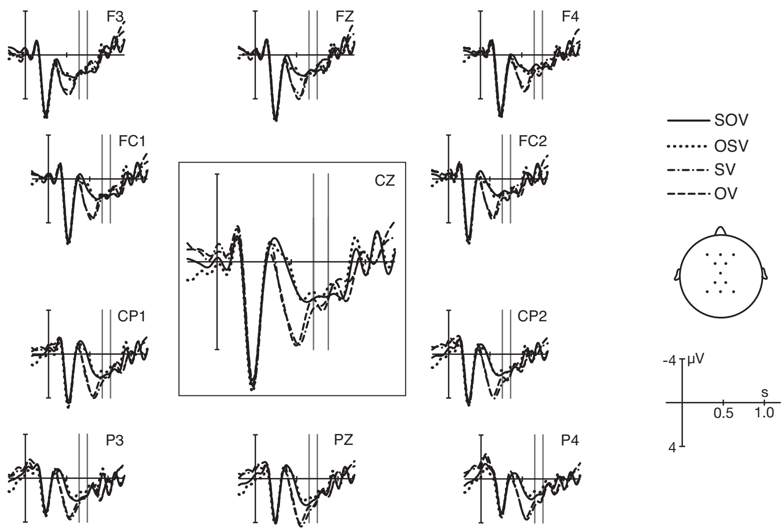

Figure A.5: Grand-average ERPs (N = 24) time-locked to the onset of the verb in Experiment 3, extended time window (onset of the verb at the first vertical bar; onset of the asterisk in conditions SV and OV at the second vertical bar; onset of the asterisk in conditions SOV and OSV at the third vertical bar).

Fig. A.5 shows the grand-average ERPs relative to the onset of the verb in an extended time window (0–1200 ms). Vertical bars signify the onset of the verb, the onset of the sentence-final asterisk in the SV and OV conditions, and the onset of the sentence-final asterisk in the SOV and OSV conditions (in this order). The impact of the differential trial programming on the ERPs can best be seen in the misalignment of the early ERP peaks (P1, N1, P2) in response to the visual stimulation by the asterisk.

A.4 Comparison of first and second half of Experiment 3

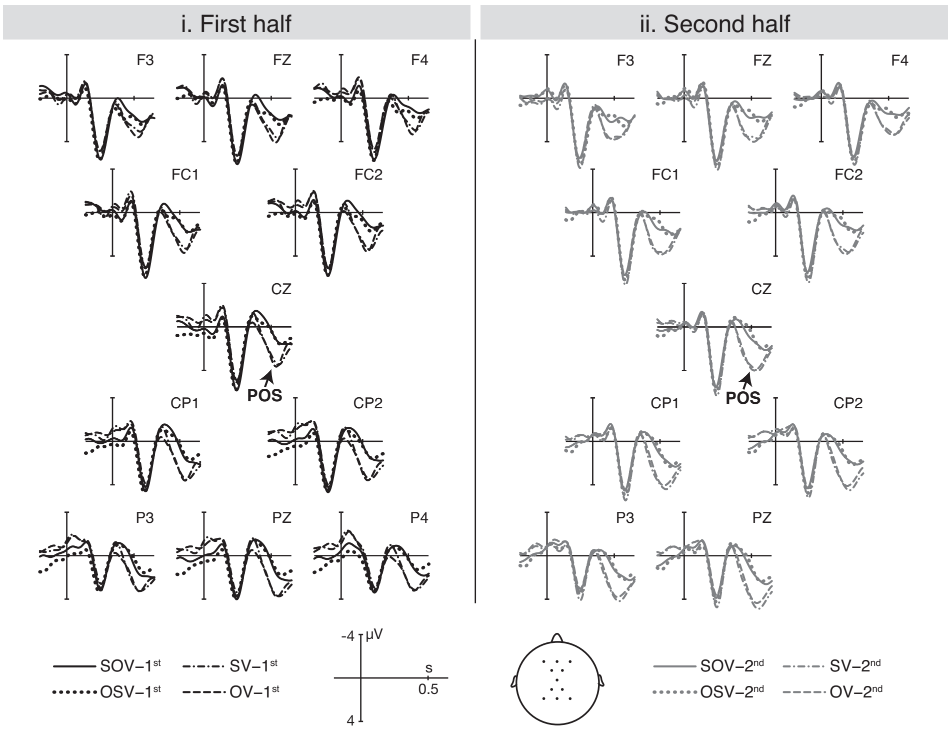

Figure A.6: Grand-average ERPs (N = 24) time-locked to the onset of the verb (onset at the vertical bar) in Experiment 3, split between first and second half of the experiment. Comparisons for the first and second half of the experiment are shown in (i) and (ii), respectively.

To test whether the verb related ERP effects reported for Experiment 3 in Section 7.4.2 (a positivity between 400 and 600 ms for the two pro-drop conditions SV and OV in comparison to the canonical condition SOV) only developed in the course of the experiment due to the time-shifted expectation of the sentence-final asterisk, the ERPs recorded at the position of the verb in the first and the second half of the experiment were compared in an additional analysis. Fig. A.6 (cf. Fig. 7.3) shows the grand average ERPs relative to the onset of the verb separately for the two halves of the experiment. Fig. A.6i shows the electrophysiological responses recorded in the first half of the experiment (Trials 1–100), and responses recorded in the second half of the experiment (Trials 101–200) are displayed in Fig. A.6ii.

Visual inspection of the figure does not reveal any differences between the first and second half of the experiment with regard to the positivity between 400 and 600 ms that was reported for the SV and OV conditions in Section 7.4.2.

To confirm statistically that the ERP effects found for the SV and OV conditions did not undergo any development in the course of the experiment, additional analyses were conducted for the 400–600 ms time window, crossing the experimental factor PC (pairwise comparison, e.g. SV−SOV) with the topographical factor ROI (region of interest) and an additional temporal factor HALF (first half vs. second half of the experiment). No significant interactions of PC×HALF or PC×ROI×HALF arose at midline (all Fs < 3, p_bs $> .67$) or at lateral electrodes (all Fs < 3, p_bs $> .29$). Furthermore, the main effects of PC reported in Chapter 7 for the comparisons SV−SOV and OV−SOV also reached significance in this analysis (SV−SOV: midline $F(1, 23) = 37.14$, $p_b < .001$, lateral $F(1, 23) = 33.62$, $p_b < .001$; OV−SOV: midline $F(1, 23) = 38.17$, $p_b < .001$, lateral: $F(1, 23) = 34.80$, $p_b < .001$). Thus, no influence of the temporal factor HALF on the relevant ERP effects was discernable and it can therefore be assumed that the ERP effects found for conditions SV and OV at the position of the verb were indeed due to the sentence structure of these conditions and did not only develop in the course of the experiment due to differential trial timing.

A.5 Redefinition of context conditions for the analysis of NP1 & NP2 in Experiment 4

Table A.1 shows the assignment of alternative context condition names for the analysis of the ERPs averaged at the positions of NP1 and NP2. The left column shows the regular condition names that were employed in the behavioral analyses and the ERP analyses conducted at the position of the verb. The context conditions were coded based on whether the (potential) subject (S) of the target sentence and whether the (potential) object (O) of the target sentence were introduced in the context sentence. The right column shows the condition definitions that were employed in the ERP analyses conducted at the positions of NP1 and NP2. Here, the context conditions were defined based on whether the first NP of the target sentence (1) and whether the second (or omitted) NP of the target sentence (2) were given in context sentence. Note that the mapping of regular to redefined context names is invariant for context conditions S☑O☑ (always redefined as 1☑2☑) and S☒O☒ (always redefined as 1☒2☒) while it is dependent on the target condition for context conditions S☑O☒ (redefined as 1☑2☒ in SOV and SV sentence pairs and redefined as 1☒2☑ in OSV and OV sentence pairs) and S☒O☑ (redefined as 1☒2☑ in SOV and SV sentence pairs and redefined as 1☑2☒ in OSV and OV sentence pairs).

Table A.1: Redefinition of context conditions for the analysis of NP1 & NP2 in Experiment 4

Regular condition name	Redefined condition name
S☑O☑-SOV	1☑2☑-SOV
S☑O☒-SOV	1☑2☒-SOV
S☒O☑-SOV	1☒2☑-SOV
S☒O☒-SOV	1☒2☒-SOV
S☑O☑-OSV	1☑2☑-OSV
S☑O☒-OSV	1☒2☑-OSV
S☒O☑-OSV	1☑2☒-OSV
S☒O☒-OSV	1☒2☒-OSV
S☑O☑-SV	1☑2☑-SV
S☑O☒-SV	1☑2☒-SV
S☒O☑-SV	1☒2☑-SV
S☒O☒-SV	1☒2☒-SV
S☑O☑-OV	1☑2☑-OV
S☑O☒-OV	1☒2☑-OV
S☒O☑-OV	1☑2☒-OV
S☒O☒-OV	1☒2☒-OV

A.6 P2 effects in Experiment 4

As is evident from Fig.s 8.2 to 8.5, various differences between conditions occurred in the time window of the P2 peak in Experiment 4. At the position of NP1, all sentences in which NP1 had not been given in the context (1⊠2☑ and 1⊠2⊠) appeared to engender an increased P2 amplitude (cf. Fig. 8.2). At the position of NP2, the P2 peak seemed to have the biggest amplitude for the 1⊠2⊠ condition, followed by the 1☑2⊠ condition, and the smallest amplitude for conditions 1☑2☑ and 1⊠2☑ (cf. Fig. 8.4). In addition, subject-before-object sentences (SOV) also engendered a slightly increased amplitude at the P2 peak in comparison to object-before-subject sentences (OSV) at this position (cf. Fig. 8.3). Finally, both conditions with an omitted argument (SV and OV) apparently also engendered an increased amplitude of the P2 peak in comparison to the canonical control condition (SOV) at the position of the verb (cf. Fig. 8.5). All of these effects were tested statistically in a time window between 225 and 325 ms.

For the analysis of the context effects apparent at NP1, the relevant test statistics are presented in Table A.2. The midline and the lateral analysis both showed significant main effects of PC_{cont} for the following pairwise comparisons: 1☑2☑−1⊠2☑, 1☑2☑−1⊠2⊠, 1☑2⊠−1⊠2☑, and 1☑2⊠−1⊠2⊠, i.e. for all comparisons of conditions in which NP1 was given (1☑) with conditions in which NP1 was new (1⊠). For all four comparisons, the interactions with ROI also reached significance. Resolving the interactions by ROI revealed that all four pairwise comparisons showed significant effects of PC_{cont} at all midline sites with the exception of the POz electrode and at all lateral regions of interest with the exception of the right-posterior ROI.

The analysis of the target effect at the position of NP2 showed significant main effects of ORDER both at midline ($F(1,25) = 9.14$, $p < .04$) and at lateral electrode sites ($F(1,25) = 11.49$, $p < .02$), confirming the visual impression of a more positive-going response for SOV sentences than for OSV sentences.

For the analysis of the context effects at this position, the test statistics for the P2 time window are presented in Table A.3. The midline analysis revealed significant context effects only for the three pairwise comparisons containing the context condition 1⊠2⊠, i.e. the comparisons 1☑2☑−1⊠2⊠, 1☑2⊠−1⊠2⊠, and 1⊠2☑−1⊠2⊠. In the 1☑2☑−1⊠2⊠ comparison the main effect was further accompanied by a significant $PC_{cont} \times$ ROI interaction. Resolving the interaction by ROI showed significant effects of PC_{cont} at all electrodes but Fz and POz. The analysis of the lateral electrodes showed significant main effects of PC_{cont} for the same three pairwise comparisons, albeit without a significant $PC_{cont} \times$ ROI interaction in any comparison.

Thus, ERPs in this time window were significantly more positive if none of the target sentence NPs had been given in the preceding context than if one or both of the NP were given.

At the position of the verb, the same three pairwise target comparisons were calculated for the P2 effect as for the other verb analyses. For the OSV−SOV comparison neither the midline nor the lateral analysis showed any significant effects of PC (both Fs < 3, p_bs $> .35$) or PC × ROI (both Fs < 1). The analysis of the SV−SOV comparison, on the other hand, showed a significant main effect of PC (midline: $F(1, 25) = 21.81$, $p_b < .001$; lateral: $F(1, 25) = 22.68$, $p_b < .001$), which was accompanied by an interaction of PC × ROI (midline: $F(5, 125) = 10.28$, $p_b < .001$; lateral: $F(3, 75) = 4.76$, $p_b < .03$). Resolving the interactions by ROI showed significant effects of PC at all midline electrodes (minimum at POz, $F(1, 25) = 7.87$, $p_b < .03$, maximum at FCz, $F(1, 25) = 29.41$, $p_b < .001$) and at all lateral regions of interest (minimum at left-posterior electrodes, $F(1, 25) = 8.02$, $p < .03$; maximum at right-anterior electrodes, $F(1, 25) = 32.31$, $p < .001$). The

Table A.2: Pairwise comparisons between context ERPs at the position of NP1 in Experiment 4, time window 225–325 ms

	Pairwise context comparison							
	1⍁2⍁−1⊠2⍁		1⍁2⍁−1⊠2⊠		1⍁2⊠−1⊠2⍁		1⍁2⊠−1⊠2⊠	
225–325 ms	F	p_b	F	p_b	F	p_b	F	p_b
midline								
PC_c	17.65	< .002	26.29	< .001	16.11	< .003	22.23	< .001
PC_c×ROI	31.54	< .001	53.92	< .001	12.92	< .001	24.49	< .001
Fz	25.39	< .001	37.87	< .001	20.64	< .001	32.63	< .001
FCz	24.16	< .001	40.18	< .001	23.57	< .001	31.80	< .001
Cz	21.97	< .001	36.25	< .001	21.71	< .001	28.01	< .001
CPz	17.93	< .002	25.37	< .001	17.04	< .003	20.88	< .001
Pz	10.24	< .03	14.89	< .005	9.24	< .04	13.65	< .007
POz	n.s.		n.s.		n.s.		n.s.	
lateral								
PC_c	19.85	< .002	25.11	< .001	16.62	< .003	20.76	< .001
PC_c×ROI	16.53	< .001	31.02	< .001	13.53	< .001	24.23	< .001
left-ant	33.39	< .001	39.65	< .001	31.75	< .001	34.49	< .001
right-ant	28.29	< .001	38.62	< .001	23.02	< .001	32.80	< .001
left-post	13.07	< .008	14.29	< .006	12.84	< .009	12.78	< .009
right-post	n.s.		n.s.		n.s.		n.s.	

analysis of the OV−SOV comparison also revealed a significant main effect of PC (midline: $F(1, 25) = 9.14$, $p_b < .02$; lateral: $F(1, 25) = 10.03$, $p_b < .02$), as well as an interaction of PC × ROI (midline: $F(5, 125) = 8.75$, $p_b < .006$; lateral: $F(3, 75) = 6.38$, $p_b < .007$). Resolving the interactions by ROI revealed significant effects of PC at the midline electrodes Fz, FCz, and Cz (all Fs > 11, p_bs < .007) and at the lateral left-anterior, right-anterior, and right-posterior ROI (all Fs > 7, p_bs < .03). In all three pairwise comparisons neither the interaction PC × CONT (all Fs < 2, p_bs > .98) nor the interaction PC × CONT × ROI (all Fs < 2, p_bs > .25) reached significance. Thus, the statistical analyses confirmed an increased P2 amplitude for both conditions with an omitted argument, while no such effect was evident for the scrambled condition.

To summarize, increased P2 amplitudes were observed for all new NP1s at the position of NP1, for new NP2s following new NP1s at the position of NP2, for all canonical word orders at the position of NP2, and for all pro-drop sentences at the position of the verb. While the previous literature offers some reports of P2 effects in connection with psycholinguistic manipulations like repetition priming and congruency variations, the results are often contradictory. For example, considering the repetition of words in English word lists, Rugg and colleagues reported increased P2 amplitudes for new vs. immediately repeated words (Nagy & Rugg, 1989; Rugg,

Table A.3: Pairwise comparisons between context ERPs at the position of NP2 in Experiment 4, time window 225–325 ms

	Pairwise context comparison					
	1☑2☑−1☒2☒		1☑2☒−1☒2☒		1☒2☑−1☒2☒	
225–325 ms	F	p_b	F	p_b	F	p_b
midline						
PC_c	10.57	< .02	20.56	< .001	18.79	< .002
PC_c×ROI	6.39	< .04	n.s.		n.s.	
Fz	n.s.		—	—	—	—
FCz	11.64	< .02	—	—	—	—
Cz	14.01	< .007	—	—	—	—
CPz	13.09	< .008	—	—	—	—
Pz	8.87	< .04	—	—	—	—
POz	n.s.		—	—	—	—
lateral						
PC_c	9.86	< .03	17.45	< .002	15.63	< .004

1987), but did not consistently replicate the effect in following studies (e.g. Rugg, 1990; Rugg, Furda, & Lorist, 1988; Rugg & Nagy, 1989). For word repetitions embedded within longer English texts, Van Petten et al. (1991) reported increased P2 amplitudes for repeated vs. new words. By contrast, Burkhardt (2006), who investigated word repetitions effects in German sentence pairs, did not report any statistical analyses for the P2 time window, but visual inspection of the ERPs in this study (Burkhardt, 2006; Fig. 1; p. 164) strongly suggests that NPs given in the context sentence engendered a reduced P2 amplitude in comparison to (semantically related and unrelated) new NPs. Thus, while the given-vs.-new ERP patterns observed by Burkhardt (2006) and Van Petten et al. (1991), as well as in Experiment 4, are highly comparable with regard to the N400 and P600 components (see Section 8.5.3), the results regarding modulations of the P2 component remain contradictory.

Furthermore, the target effects observable in the P2 time window, i.e. the increased amplitude for all canonical sentences at the position of NP2 and for all pro-drop sentences at the position of the verb, occurred independently of the contextual information (no interaction between target and context factors) but at the same time had not been observable when the same sentences were presented in isolation (cf. Experiment 3; see also Experiments 1 and 2). Similarly, no such effects had been reported in previous ERP studies on word order variations in Japanese or other languages (see Sections 3.1.3 and 4.2).

Considering the prevailing lack of consistency of P2 effects within and across studies, the functional significance of these early differences observed in Experiment 4 thus cannot be fully understood at this point. Future replications of these effects are therefore clearly necessary to determine the intra- and inter-sentential conditions that engender variations in this component in Japanese as well as other languages.

A.7 Further course of verb related ERPs in Experiment 4

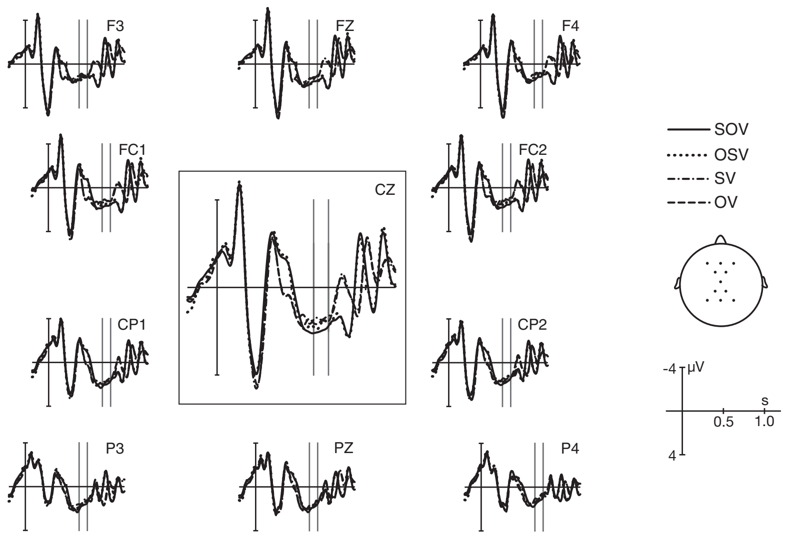

Figure A.7: Grand-average ERPs (N = 26) time-locked to the onset of the verb in Experiment 4, extended time window, averaged across context conditions (onset of the verb at the first vertical bar; onset of the asterisk in conditions SV and OV at the second vertical bar; onset of the asterisk in conditions SOV and OSV at the third vertical bar).

Fig. A.7 shows the grand-average ERPs relative to the onset of the target sentence verb in an extended time window (0–1200 ms). Vertical bars signify the onset of the verb, the onset of the sentence-final asterisk in the SV and OV conditions, and the onset of the sentence-final asterisk in the SOV and OSV conditions (in this order). Like in Experiment 3 (see App. A.3), the impact of the differential trial programming on the ERPs can best be seen in the misalignment of the early ERP peaks (P1, N1, P2) in response to the visual stimulation by the asterisk.

A.8 Verb effects in a restricted time window in Experiment 4

Visual inspection of Fig.s 8.5 to 8.8 suggests that the effect corresponding to the positivity found between 400 and 600 ms in Experiment 3 is by comparison somewhat shifted in time and already ends 50 milliseconds earlier in Experiment 4. As the effect is thus slightly out of alignment with the predetermined time window, additional analyses were conducted for the more precisely defined time window of 400–550 ms.

The analysis of the OSV−SOV comparison did not yield any significant effects in the 400–550 ms time window, neither at midline nor at lateral electrode positions (main effect PC: both Fs < 1; interaction PC×ROI: both Fs < 1; interaction PC×CONT: both Fs < 3, p_bs $> .34$; interaction PC×CONT×ROI: both Fs < 2, p_bs $> .35$).

For the SV−SOV comparison the midline analysis of the 400–550 ms time window showed a significant main effect of PC ($F(1, 25) = 15.95$, $p_b < .002$), an interaction PC×CONT ($F(3, 75) = 6.58$, $p_b < .003$), and an interaction PC×ROI ($F(5, 125) = 8.03$, $p_b < .005$). Separate analyses for each ROI showed significant effects of PC at every topographical region (min: POz, $F(1, 25) = 7.94$, $p_b < .03$; max: FCz, $F(1, 25) = 23.01$, $p_b < .001$), while separate analyses for each level of CONT showed a significant effect of PC only in the context conditions S⧄O⧄ ($F(1, 25) = 23.83$, $p_b < .001$) and S⊠O⊠ ($F(1, 25) = 9.80$, $p_b < .02$). The analysis of the lateral electrodes revealed a significant main effect of PC ($F(1, 25) = 13.69$, $p_b < .004$) and an interaction PC×CONT ($F(3, 75) = 6.67$, $p_b < .002$). Resolving the interaction by CONT again showed a significant effect of PC only in the context conditions S⧄O⧄ ($F(1, 25) = 25.71$, $p_b < .001$) and S⊠O⊠ ($F(1, 25) = 7.50$, $p_b < .04$).

For the OV−SOV comparison, the analysis of the midline electrodes similarly showed a main effect of PC ($F(1, 25) = 42.66$, $p_b < .001$) and an interaction PC×CONT ($F(3, 75) = 8.54$, $p_b < .001$), as well as an interaction PC×ROI ($F(5, 125) = 10.61$, $p_b < .002$). Resolving the latter interaction by ROI revealed significant effects of PC at every electrode position (min: POz, $F(1, 25) = 18.96$, $p_b < .001$; max: FCz, $F(1, 25) = 54.95$, $p_b < .001$), while separate analyses for each context condition showed significant effects of PC only in the context conditions S⧄O⧄ ($F(1, 25) = 40.06$, $p_b < .001$) and S⊠O⧄ ($F(1, 25) = 17.37$, $p_b < .001$). At lateral electrodes a main effect of PC ($F(1, 25) = 34.34$, $p_b < .001$) was accompanied by an interaction PC×CONT ($F(3, 75) = 9.26$, $p_b < .001$). Resolving the interaction by CONT again revealed significant effects of PC only in context conditions S⧄O⧄ ($F(1, 25) = 42.71$, $p_b < .001$) and S⊠O⧄ ($F(1, 25) = 11.17$, $p_b < .008$).

Thus, the effects found for the 400–550 ms time window resembled the effects found for the wider time window of 400–600 ms. Again, a positivity effect was found for the SV sentences with a preceding S☑O☑ or S☒O☒ context and for the OV sentences with a preceding S☑O☑ or S☒O☑ context. In the analysis of the midline electrodes, the drop effect furthermore exhibited an anterior maximum, though still being evident at all electrode sites.

Appendix B

Stimulus materials

B.1 Stimulus materials employed in Experiments 1 & 2: Accusative sentences

Table B.1: Stimulus materials employed in Experiments 1 & 2, accusative sentences

	Adverb	NP1	NP2	Verb
1	昨日 kinou yesterday	家政婦 kaseifu house keeper	運転手 untenshu driver	けなしました kenashimashita criticized
2	今朝 kesa this morning	助教授 jokyouju associate professor	会社員 kaishain office worker	睨みました niramimashita stared at
3	二日前 futsukamae two days ago	お爺さん ojiisan elderly man	演奏者 ensousha musician	援助しました enjoshimashita aided
4	数年前 suunenmae a few years ago	耳鼻科医 jibikai ENT doctor	眼科医 gankai eye specialist	治療しました chiryoushimashita treated
5	数週間前 suushuukanmae a few weeks ago	税理士 zeirishi tax consultant	清掃員 seisouin janitor	からかいました karakaimashita teased
6	一週間前 isshuukanmae a week ago	消防士 shouboushi firefighter	警備員 keibiin security guard	軽蔑しました keibetsushimashita despised
7	数時間前 suujikanmae a few hours ago	演技者 engisha theater actor	カメラマン kameraman photographer	呼び止めました yobitomemashita called after
8	五日前 itsukamae five days ago	お婆さん obaasan elderly woman	女の子 onnanoko girl	元気付けました genkizukemashita cheered up
9	今朝 kesa this morning	園児 enji kindergarten child	保母さん hobosan kindergarten teacher	追いかけました oikakemashita followed around
10	半年前 hantoshimae half a year ago	刑事 keiji detective	大使 taishi ambassador	助けました tasukemashita helped
11	三日前 mikkamae three days ago	日本人 nihonjin Japanese person	カナダ人 kanadajin Canadian person	殴りました nagurimashita hit
12	二週間前 nishuukanmae two weeks ago	科学者 kagakusha scientist	書記官 shokikan secretary	招待しました shoutaishimashita invited

Table B.1: continued

	Adverb	NP1	NP2	Verb
13	二日前 futsukamae two days ago	介護士 kaigoshi caregiver	看護婦 kangofu nurse	応援しました ouenshimashita cheered up
14	六日前 muikamae six days ago	大女優 daijoyuu actress	助監督 jokantoku assistant producer	とがめました togamemashita blamed
15	昨日 kinou yesterday	捜査官 sousakan investigator	研究者 kenkyuusha researcher	激励しました gekireishimashita encouraged
16	一ヶ月前 ikkagetsumae a month ago	僧侶 souryo Buddhist monk	神父 shinpu Christian priest	説教しました sekkyoushimashita lectured
17	十日前 tookamae ten days ago	外科医 gekai surgeon	歯医者 haisha dentist	検査しました kensashimashita examined
18	一週間前 isshuukanmae a week ago	旅行者 ryokousha tourist	ドイツ人 doitsujin German person	跳ねました hanemashita rear-ended
19	数年前 suunenmae a few years ago	パイロット pairotto pilot	乗務員 joumuin flight attendant	殺害しました satsugaishimashita murdered
20	去年 kyonen last year	弁護士 bengoshi lawyer	調理師 chourishi cook	雇いました yatoimashita hired
21	六日前 muikamae six days ago	代議士 daigishi politician	研究者 kenkyuusha researcher	突き飛ばしました tsukitobashimashita pushed over
22	数ヶ月前 suukagetsumae a few months ago	力士 rikishi sumo wrestler	ピアニスト pianisuto pianist	もてなしました motenashimashita welcomed
23	一時間前 ichijikanmae an hour ago	少女 shoujo young lady	男の子 otokonoko boy	励ましました hagemashimashita cheered up
24	二週間前 nishuukanmae two weeks ago	薬剤師 yakuzaishi pharmacist	当直医 touchokui doctor in charge	告訴しました kokusoshimashita accused
25	昨日 kinou yesterday	美容師 biyoushi hairdresser	バスガイド basugaido bus conductor	いじめました ijimemashita harassed
26	一週間前 isshuukanmae a week ago	大工 daiku carpenter	調理師 chourishi cook	侮辱しました bujokushimashita insulted

Table B.1: continued

	Adverb	NP1	NP2	Verb
27	先月 sengetsu last month	神父 shinpu Christian priest	船長 senchou captain	警戒しました keikaishimashita watched
28	一時間前 ichijikanmae an hour ago	花嫁 hanayome bride	カメラマン kameraman photographer	見送りました miokurimashita saw off
29	十年前 juunenmae ten years ago	看護婦 kangofu nurse	弁護士 bengoshi lawyer	助けました tasukemashita helped
30	一ヶ月前 ikkagetsumae a month ago	訪問者 houmonsha visitor	店長 tenchou shop manager	祝福しました shukufukushimashita blessed
31	昨夜 sakuya last night	先生 sensei master	お婆さん obaasan elderly woman	見かけました mikakemashita caught sight of
32	今朝 kesa this morning	保母さん hobosan kindergarten teacher	庭師 niwashi gardener	呼び止めました yobitomemashita called after
33	今朝 kesa this morning	お婆さん obaasan elderly woman	少女 shoujo young lady	激励しました gekireishimashita encouraged
34	一週間前 isshuukanmae a week ago	庭師 niwashi gardener	農夫 noufu farmer	侮辱しました bujokushimashita insulted
35	昨夜 sakuya last night	専務 senmu director	係長 kakarichou chief clerk	見張りました miharimashita watched
36	十日前 tookamae ten days ago	レポーター repootaa reporter	解説者 kaisetsusha commentator	中傷しました chuushoushimashita slandered
37	三日前 mikkamae three days ago	教師 kyoushi teacher	事務員 jimuin clerk	助けました tasukemashita helped
38	昨夜 sakuya last night	管理者 kanrisha superintendent	常務 joumu executive director	救いました sukuimashita rescued
39	半年前 hantoshimae half a year ago	係長 kakarichou chief clerk	監督者 kantokusha supervisor	告訴しました kokusoshimashita accused
40	一週間前 isshuukanmae a week ago	技術者 gijutsusha engineer	公務員 koumuin civil servant	救助しました kyuujoshimashita rescued

Table B.1: continued

	Adverb	NP1	NP2	Verb
41	四日前 yokkamae four days ago	先生 sensei master	消防士 shouboushi firefighter	見かけました mikakemashita caught sight of
42	昨日 kinou yesterday	レジ係 rejigakari cashier	ウェイター ueitaa waiter	手伝いました tetsudaimashita assisted
43	一ヶ月前 ikkagetsumae a month ago	書記官 shokikan secretary	議員 giin congressman	裏切りました uragirimashita betrayed
44	一年前 ichinenmae a year ago	専門医 senmoni medical specialist	税理士 zeirishi tax consultant	訴えました uttaemashita sued
45	数ヶ月前 suukagetsumae a few months ago	議員 giin congressman	理事長 rijichou CEO	買収しました baishuushimashita bribed
46	五日前 itsukamae five days ago	アーティスト aatisuto artist	力士 rikishi sumo wrestler	祝福しました shukufukushimashita blessed
47	二週間前 nishuukanmae two weeks ago	解説者 kaisetsusha commentator	編集者 henshuusha editor	見捨てました misutemashita left
48	先月 sengetsu last month	皮膚科医 hifukai dermatologist	捜査官 sousakan investigator	検査しました kensashimashita examined
49	数年前 suunenmae a few years ago	訪問者 houmonsha visitor	村長 sonchou village mayor	監禁しました kankinshimashita detained
50	二週間前 nishuukanmae two weeks ago	判事 hanji judge	大臣 daijin minister	招きました manekimashita invited
51	五日前 itsukamae five days ago	代表者 daihyousha representative	ディレクター direkutaa director	表彰しました hyoushoushimashita gave an award to
52	先月 sengetsu last month	清掃員 seisouin janitor	監視員 kanshiin lifeguard	中傷しました chuushoushimashita slandered
53	昨日 kinou yesterday	男の子 otokonoko boy	お爺さん ojiisan elderly man	呼び止めました yobitomemashita called after
54	今朝 kesa this morning	編集者 henshuusha editor	作者 sakusha writer	呼びました yobimashita sent for

Table B.1: continued

	Adverb	NP1	NP2	Verb
55	十日前 tookamae ten days ago	農夫 noufu farmer	大工 daiku carpenter	招きました manekimashita invited
56	数時間前 suujikanmae a few hours ago	作業員 sagyouin worker	駅員 ekiin station attendant	無視しました mushishimashita ignored
57	二日前 futsukamae two days ago	バスガイド basugaido bus conductor	運転手 untenshu driver	励ましました hagemashimashita cheered up
58	十年前 juunenmae ten years ago	会社員 kaishain office worker	教師 kyoushi teacher	殺害しました satsugaishimashita murdered
59	昨日 kinou yesterday	歯医者 haisha dentist	耳鼻科医 jibikai ENT doctor	からかいました karakaimashita teased
60	一年前 ichinenmae a year ago	弁理士 benrishi patent attorney	経理士 keirishi accountant	雇いました yatoimashita employed
61	去年 kyonen last year	管理者 kanrisha superintendent	職員 shokuin staff member	買収しました baishuushimashita bribed
62	数週間前 suushuukanmae a few weeks ago	司会者 shikaisha host	受賞者 jushousha prize winner	侮辱しました bujokushimashita insulted
63	昨夜 sakuya last night	村長 sonchou village mayor	僧侶 souryo Buddhist monk	迎えました mukaemashita met
64	一ヶ月前 ikkagetsumae a month ago	接骨医 sekkotsui bonesetter	外科医 gekai surgeon	脅迫しました kyouhakushimashita threatened
65	半年前 hantoshimae half a year ago	ピアニスト pianisuto pianist	指揮者 shikisha conductor	訴えました uttaemashita sued
66	数ヶ月前 suuukagetsumae a few months ago	研究者 kenkyuusha researcher	技術者 gijutsusha engineer	脅迫しました kyouhakushimashita threatened
67	十年前 juunenmae ten years ago	公務員 koumuin civil servant	助教授 jokyouju associate professor	監禁しました kankinshimashita detained
68	数週間前 suushuukanmae a few weeks ago	助産婦 josanpu midwife	介護士 kaigoshi caregiver	裏切りました uragirimashita betrayed

Table B.1: continued

	Adverb	NP1	NP2	Verb
69	昨日 kinou yesterday	生徒 seito pupil	引率者 insotsusha escorting teacher	追いかけました oikakemashita followed around
70	三週間前 sanshuukanmae three weeks ago	園長 enchou kindergarten director	来園者 raiensha kindergarten visitor	跳ねました hanemashita rear-ended
71	二週間前 nishuukanmae two weeks ago	ドイツ人 doitsujin German person	旅行者 ryokousha tourist	救助しました kyuujoshimashita rescued
72	一時間前 ichijikanmae one hour ago	レフリー refurii referee	選手 senshu player	殴りました nagurimashita hit
73	二日前 futsukamae two days ago	アーティスト aatisuto artist	担当者 tantousha person in charge	見捨てました misutemashita left
74	三日前 mikkamae three days ago	乗務員 joumuin flight attendant	操縦士 soujuushi pilot	勇気づけました yuukizukemashita encouraged
75	昨夜 sakuya last night	検事 kenji prosecutor	弁理士 benrishi patent attorney	警戒しました keikaishimashita watched
76	数週間前 suushuukanmae a few weeks ago	専門医 senmoni medical specialist	判事 hanji judge	援助しました enjoshimashita aided
77	半年前 hantoshimae half a year ago	大使 taishi ambassador	日本人 nihonjin Japanese person	もてなしました motenashimashita welcomed
78	三日前 mikkamae three days ago	事務員 jimuin clerk	経理士 keirishi accountant	応援しました ouenshimashita cheered up
79	去年 kyonen last year	演奏者 ensousha musician	ダンサー dansaa dancer	招待しました shoutaishimashita invited
80	昨夜 sakuya last night	バスガイド basugaido bus conductor	薬剤師 yakuzaishi pharmacist	元気付けました genkizukemashita cheered up

B.2 Stimulus materials employed in Experiment 2: Dative sentences

Table B.2: Stimulus materials employed in Experiment 2, dative sentences

	Adverb	NP1	NP2	Verb
1	昨日 kinou yesterday	家政婦 kaseifu house keeper	運転手 untenshu driver	同情しました doujoushimashita sympathized with
2	今朝 kesa this morning	助教授 jokyouju associate professor	会社員 kaishain office worker	質問しました shitsumonshimashita queried
3	二日前 futsukamae two days ago	お爺さん ojiisan elderly man	演奏者 ensousha musician	憤激しました fungekishimashita angered
4	数年前 suunenmae a few years ago	耳鼻科医 jibikai ENT doctor	眼科医 gankai eye specialist	助言しました jogenshimashita advised
5	数週間前 suushuukanmae a few weeks ago	税理士 zeirishi tax consultant	清掃員 seisouin janitor	あいさつしました aisatsushimashita greeted
6	一週間前 isshuukanmae a week ago	消防士 shouboushi firefighter	警備員 keibiin security guard	挑戦しました chousenshimashita challenged
7	数時間前 suujikanmae a few hours ago	演技者 engisha theater actor	カメラマン kameraman photographer	反対しました hantaishimashita opposed
8	五日前 itsukamae five days ago	お婆さん obaasan elderly woman	女の子 onnanoko girl	驚きました odorokimashita surprised
9	今朝 kesa this morning	園児 enji kindergarten child	保母さん hobosan kindergarten teacher	あいさつしました aisatsushimashita greeted
10	半年前 hantoshimae half a year ago	刑事 keiji detective	大使 taishi ambassador	警告しました keikokushimashita warned
11	三日前 mikkamae three days ago	日本人 nihonjin Japanese person	カナダ人 kanadajin Canadian person	警告しました keikokushimashita warned
12	二週間前 nishuukanmae two weeks ago	科学者 kagakusha scientist	書記官 shokikan secretary	抗議しました kougishimashita objected to

Table B.2: continued

	Adverb	NP1	NP2	Verb
13	二日前 futsukamae two days ago	介護士 kaigoshi caregiver	看護婦 kangofu nurse	賛成しました sanseishimashita agreed with
14	六日前 muikamae six days ago	大女優 daijoyuu actress	助監督 jokantoku assistant producer	質問しました shitsumonshimashita queried
15	昨日 kinou yesterday	捜査官 sousakan investigator	研究者 kenkyuusha researcher	応対しました outaishimashita received
16	一ヶ月前 ikkagetsumae a month ago	僧侶 souryo Buddhist monk	神父 shinpu Christian priest	同情しました doujoushimashita sympathized with
17	十日前 tookamae ten days ago	外科医 gekai surgeon	歯医者 haisha dentist	助言しました jogenshimashita advised
18	一週間前 isshuukanmae a week ago	旅行者 ryokousha tourist	ドイツ人 doitsujin German person	協力しました kyouryokushimashita cooperated with
19	数年前 suunenmae a few years ago	パイロット pairotto pilot	乗務員 joumuin flight attendant	驚きました odorokimashita surprised
20	去年 kyonen last year	弁護士 bengoshi lawyer	調理師 chourishi cook	電話しました denwashimashita telephoned
21	六日前 muikamae six days ago	代議士 daigishi politician	研究者 kenkyuusha researcher	挑戦しました chousenshimashita challenged
22	数ヶ月前 suukagetsumae a few months ago	力士 rikishi sumo wrestler	ピアニスト pianisuto pianist	感心しました kanshinshimashita admired
23	一時間前 ichijikanmae an hour ago	少女 shoujo young lady	男の子 otokonoko boy	感謝しました kanshashimashita thanked
24	二週間前 nishuukanmae two weeks ago	薬剤師 yakuzaishi pharmacist	当直医 touchokui doctor in charge	助言しました jogenshimashita advised
25	昨日 kinou yesterday	美容師 biyoushi hairdresser	バスガイド basugaido bus conductor	挑戦しました chousenshimashita challenged
26	一週間前 isshuukanmae a week ago	大工 daiku carpenter	調理師 chourishi cook	さわりました sawarimashita touched

Table B.2: continued

	Adverb	NP1	NP2	Verb
27	先月 sengetsu last month	神父 shinpu Christian priest	船長 senchou captain	協力しました kyouryokushimashita cooperated with
28	一時間前 ichijikanmae an hour ago	花嫁 hanayome bride	カメラマン kameraman photographer	驚きました odorokimashita surprised
29	十年前 juunenmae ten years ago	看護婦 kangofu nurse	弁護士 bengoshi lawyer	同情しました doujoushimashita sympathized with
30	一ヶ月前 ikkagetsumae a month ago	訪問者 houmonsha visitor	店長 tenchou shop manager	抗議しました kougishimashita objected to
31	昨夜 sakuya last night	先生 sensei master	お婆さん obaasan elderly woman	憤激しました fungekishimashita angered
32	今朝 kesa this morning	保母さん hobosan kindergarten teacher	庭師 niwashi gardener	応対しました outaishimashita received
33	今朝 kesa this morning	お婆さん obaasan elderly woman	少女 shoujo young lady	さわりました sawarimashita touched
34	一週間前 isshuukanmae a week ago	庭師 niwashi gardener	農夫 noufu farmer	反対しました hantaishimashita opposed
35	昨夜 sakuya last night	専務 senmu director	係長 kakarichou chief clerk	質問しました shitsumonshimashita queried
36	十日前 tookamae ten days ago	レポーター repootaa reporter	解説者 kaisetsusha commentator	挑戦しました chousenshimashita challenged
37	三日前 mikkamae three days ago	教師 kyoushi teacher	事務員 jimuin clerk	賛成しました sanseishimashita agreed with
38	昨夜 sakuya last night	管理者 kanrisha superintendent	常務 joumu executive director	抗議しました kougishimashita objected to
39	半年前 hantoshimae half a year ago	係長 kakarichou chief clerk	監督者 kantokusha supervisor	応対しました outaishimashita received
40	一週間前 isshuukanmae a week ago	技術者 gijutsusha engineer	公務員 koumuin civil servant	感心しました kanshinshimashita admired

Table B.2: continued

	Adverb	NP1	NP2	Verb
41	四日前 yokkamae four days ago	先生 sensei master	消防士 shouboushi firefighter	失望しました shitsuboushimashita disappointed
42	昨日 kinou yesterday	レジ係 rejigakari cashier	ウェイター ueitaa waiter	協力しました kyouryokushimashita cooperated with
43	一ヶ月前 ikkagetsumae a month ago	書記官 shokikan secretary	議員 giin congressman	インタビューしました intabyuushimashita interviewed
44	一年前 ichinenmae a year ago	専門医 senmoni medical specialist	税理士 zeirishi tax consultant	助言しました jogenshimashita advised
45	数ヶ月前 suukagetsumae a few months ago	議員 giin congressman	理事長 rijichou CEO	失望しました shitsuboushimashita disappointed
46	五日前 itsukamae five days ago	アーティスト aatisuto artist	力士 rikishi sumo wrestler	感謝しました kanshashimashita thanked
47	二週間前 nishuukanmae two weeks ago	解説者 kaisetsusha commentator	編集者 henshuusha editor	電話しました denwashimashita telephoned
48	先月 sengetsu last month	皮膚科医 hifukai dermatologist	捜査官 sousakan investigator	感心しました kanshinshimashita thanked
49	数年前 suunenmae a few years ago	訪問者 houmonsha visitor	村長 sonchou village mayor	驚きました odorokimashita surprised
50	二週間前 nishuukanmae two weeks ago	判事 hanji judge	大臣 daijin minister	抗議しました kougishimashita objected to
51	五日前 itsukamae five days ago	代表者 daihyousha representative	ディレクター direkutaa director	インタビューしました intabyuushimashita interviewed
52	先月 sengetsu last month	清掃員 seisouin janitor	監視員 kanshiin lifeguard	感謝しました kanshashimashita thanked
53	昨日 kinou yesterday	男の子 otokonoko boy	お爺さん ojiisan elderly man	あいさつしました aisatsushimashita greeted
54	今朝 kesa this morning	編集者 henshuusha editor	作者 sakusha writer	反対しました hantaishimashita opposed

Table B.2: continued

	Adverb	NP1	NP2	Verb
55	十日前 tookamae ten days ago	農夫 noufu farmer	大工 daiku carpenter	賛成しました sanseishimashita agreed with
56	数時間前 suujikanmae a few hours ago	作業員 sagyouin worker	駅員 ekiin station attendant	憤激しました fungekishimashita angered
57	二日前 futsukamae two days ago	バスガイド basugaido bus conductor	運転手 untenshu driver	感心しました kanshinshimashita admired
58	十年前 juunenmae ten years ago	会社員 kaishain office worker	教師 kyoushi teacher	プロポーズしました puropoozushimashita proposed to
59	昨日 kinou yesterday	歯医者 haisha dentist	耳鼻科医 jibikai ENT doctor	警告しました keikokushimashita warned
60	一年前 ichinenmae a year ago	弁理士 benrishi patent attorney	経理士 keirishi accountant	インタビューしました intabyuushimashita interviewed
61	去年 kyonen last year	管理者 kanrisha superintendant	職員 shokuin staff member	質問しました shitsumonshimashita queried
62	数週間前 suushuukanmae a few weeks ago	司会者 shikaisha host	受賞者 jushousha prize winner	さわりました sawarimashita touched
63	昨夜 sakuya last night	村長 sonchou village mayor	僧侶 souryo Buddhist monk	警告しました keikokushimashita warned
64	一ヶ月前 ikkagetsumae a month ago	接骨医 sekkotsui bonesetter	外科医 gekai surgeon	同情しました doujoushimashita sympathized with
65	半年前 hantoshimae half a year ago	ピアニスト pianisuto pianist	指揮者 shikisha conductor	プロポーズしました puropoozushimashita proposed
66	数ヶ月前 suuukagetsumae a few months ago	研究者 kenkyuusha researcher	技術者 gijutsusha engineer	憤激しました fungekishimashita angered
67	十年前 juunenmae ten years ago	公務員 koumuin civil servant	助教授 jokyouju associate professor	プロポーズしました puropoozushimashita proposed to
68	数週間前 suushuukanmae a few weeks ago	助産婦 josanpu midwife	介護士 kaigoshi caregiver	反対しました hantaishimashita opposed

Table B.2: continued

	Adverb	NP1	NP2	Verb
69	昨日 kinou yesterday	生徒 seito pupil	引率者 insotsusha escorting teacher	電話しました denwashimashita telephoned
70	三週間前 sanshuukanmae three weeks ago	園長 enchou kindergarten director	来園者 raiensha kindergarten visitor	失望しました shitsuboushimashita disappointed
71	二週間前 nishuukanmae two weeks ago	ドイツ人 doitsujin German person	旅行者 ryokousha tourist	インタビューしました intabyuushimashita interviewed
72	一時間前 ichijikanmae one hour ago	レフリー refurii referee	選手 senshu player	あいさつしました aisatsushimashita greeted
73	二日前 futsukamae two days ago	アーティスト aatisuto artist	担当者 tantousha person in charge	電話しました denwashimashita telephoned
74	三日前 mikkamae three days ago	乗務員 joumuin flight attendant	操縦士 soujuushi pilot	協力しました kyouryokushimashita cooperated with
75	昨夜 sakuya last night	検事 kenji prosecutor	弁理士 benrishi patent attorney	失望しました shitsuboushimashita disappointed
76	数週間前 suushuukanmae a few weeks ago	専門医 senmoni medical specialist	判事 hanji judge	感謝しました kanshashimashita thanked
77	半年前 hantoshimae half a year ago	大使 taishi ambassador	日本人 nihonjin Japanese person	応対しました outaishimashita received
78	三日前 mikkamae three days ago	事務員 jimuin clerk	経理士 keirishi accountant	賛成しました sanseishimashita agreed with
79	去年 kyonen last year	演奏者 ensousha musician	ダンサー dansaa dancer	プロポーズしました puropoozushimashita proposed to
80	昨夜 sakuya last night	バスガイド basugaido bus conductor	薬剤師 yakuzaishi pharmacist	さわりました sawarimashita touched

B.3 Stimulus materials employed in Experiments 3 & 4: Target sentences

Table B.3: Stimulus materials employed in Experiments 3 & 4, target sentences

	Adverb	NP1	NP2	Verb
01	先月 sengetsu last month	玲一 Reiichi Reiichi	良太 Ryouta Ryouta	けなした kenashita criticized
02	二日前 futsukamae two days ago	敏明 Toshiaki Toshiaki	万秀 Manshuu Manshuu	蹴った ketta kicked
03	昨夜 sakuya last night	尚之 Naoyuki Naoyuki	和也 Kazuya Kazuya	押した oshita hustled
04	一週間前 isshuukanmae one week ago	真之 Saneyuki Saneyuki	武司 Takeshi Takeshi	案内した annaishita guided
05	五日前 itsukamae five days ago	沙織 Saori Saori	麗子 Reiko Reiko	招待した shoutaishita invited
06	去年 kyonen last year	義勝 Yoshimasa Yoshimasa	純一 Junichi Junichi	治療した chiryoushita treated
07	六日前 muikamae six days ago	盛夫 Morio Morio	裕樹 Yuuki Yuuki	誤解した gokaishita misunderstood
08	半年前 hantoshimae half a year ago	恵一 Keiichi Keiichi	功夫 Isao Isao	救助した kyuujoshita saved
09	一年前 ichinenmae one year ago	邦浩 Kunihiro Kunihiro	右京 Ukyou Ukyou	驚かした odokashita surprised
10	昨夜 sakuya last night	歩美 Ayumi Ayumi	博信 Hironobu Hironobu	無視した mushishita ignored
11	二時間前 nijikanmae two hours ago	亮一 Ryouichi Ryouichi	敏正 Toshihmasa Toshihmasa	邪魔した jamashita thwarted
12	二年前 ninenmae two years ago	文男 Fumio Fumio	栄治 Eiji Eiji	中傷した chuushoushita slandered

Table B.3: continued

	Adverb	NP1	NP2	Verb
13	五週間前 goshuukanmae five weeks ago	一茂 Kazushige Kazushige	誠司 Seiji Seiji	した sekkyoushita lectured
14	二時間前 nijikanmae two hours ago	洋介 Yousuke Yousuke	妙子 Taeko Taeko	待った matta waited
15	先週 senshuu last week	勝弘 Katsuhiro Katsuhiro	満夫 Mitsuo Mitsuo	褒めた hometa praised
16	一週間前 isshuukanmae one week ago	弘明 Hiroaki Hiroaki	哲郎 Tetsurou Tetsurou	慰めた nagusameta comforted
17	六日前 muikamae six days ago	茂雄 Shigeo Shigeo	康弘 Yasuhiro Yasuhiro	殴打した oudashita assaulted
18	一昨年 ototoshi two years ago	康則 Yasunori Yasunori	由理 Yuri Yuri	愚弄した guroushita mocked
19	去年 kyonen last year	啓太 Keita Keita	重治 Shigeharu Shigeharu	支援した shienshita supported
20	二時間前 nijikanmae two hours ago	輝彦 Teruhiko Teruhiko	光弘 Mitsuhiro Mitsuhiro	軽蔑した keibetsushita despised
21	三週間前 sanshuukanmae three weeks ago	信之 Nobuyuki Nobuyuki	愛子 Aiko Aiko	見つめた mitsumeta stared
22	一時間前 ichijikanmae one hour ago	達也 Tatsuya Tatsuya	雄介 Yuusuke Yuusuke	裏切った uragitta betrayed
23	今朝 kesa this morning	伸一 Shinichi Shinichi	宗忠 Munetada Munetada	救った sukutta rescued
24	先月 sengetsu last month	百子 Momoko Momoko	仁美 Hitomi Hitomi	賛美した sanbishita praised
25	四週間前 yonshuukanmae four weeks ago	俊男 Toshio Toshio	直人 Naohito Naohito	罵った nonoshitta abused
26	二週間前 nishuukanmae two weeks ago	美穂 Miho Miho	浩二 Kouji Kouji	批判した hihanshita critisized

Table B.3: continued

	Adverb	NP1	NP2	Verb
27	三時間前 sanjikanmae three hours ago	和恵 Kazue Kazue	奈々 Nana Nana	傷つけた kizutsuketa wounded
28	昨夜 sakuya last night	光一 Kouichi Kouichi	作蔵 Sakuzou Sakuzou	起こした okoshita woke
29	五週間前 goshuukanmae five weeks ago	浩介 Kousuke Kousuke	孝子 Takako Takako	激励した gekireishita encouraged
30	二日前 futsukamae two days ago	義則 Yoshinori Yoshinori	俊樹 Toshiki Toshiki	怒った okotta got
31	昨日 kinou yesterday	信男 Nobuo Nobuo	宗助 Sousuke Sousuke	叱った shikatta scolded
32	四年前 yonenmae four years ago	孝幸 Kouhei Kouhei	哲也 Tetsuya Tetsuya	欺いた azamuita deceived
33	四日前 yokkamae four days ago	恵美 Megumi Megumi	隆志 Takashi Takashi	侮辱した bujokushita insulted
34	一年前 ichinenmae one year ago	総一 Souichi Souichi	保美 Yasumi Yasumi	誘導した yuudoushita directed
35	先学期 sengakki last semester	博則 Hironori Hironori	美紀 Miki Miki	追った otta followed
36	一年前 ichinenmae one year ago	智美 Tomomi Tomomi	悦子 Etsuko Etsuko	いじめた ijimeta harassed
37	二日前 futsukamae two days ago	佳乃 Yoshino Yoshino	寛子 Hiroko Hiroko	脅した odoshita menaced
38	五ヵ月前 gokagetsumae five months ago	清美 Kiyomi Kiyomi	真紀 Maki Maki	誘拐した yuukaishita abducted
39	今朝 kesa this morning	孝宏 Takahiro Takahiro	優香 Yuuka Yuuka	とがめた togameta blamed
40	三年前 sannenmae three years ago	典昭 Noriaki Noriaki	直美 Naomi Naomi	介護した kaigoshita looked

Table B.3: continued

	Adverb	NP1	NP2	Verb
41	半年前 hantoshimae half a year ago	英子 Eiko Eiko	泉美 Izumi Izumi	監禁した kankinshita detained
42	昨日 kinou yesterday	達子 Tatsuko Tatsuko	聡美 Satomi Satomi	牽制した kenseishita restrained
43	三日前 mikkamae three days ago	志保 Shiho Shiho	香奈 Kana Kana	罵倒した batoushita affronted
44	四日前 yokkamae four days ago	正樹 Masaki Masaki	由美 Yumi Yumi	警告した keikokushita warned
45	昨日 kinou yesterday	昭文 Akifumi Akifumi	清吾 Seigo Seigo	接待した settaishita served
46	二ヶ月前 nikagetsumae two months ago	杏奈 Anna Anna	聖子 Seiko Seiko	応援した ouenshita cheered
47	三時間前 sanjikanmae three hours ago	理沙 Risa Risa	純子 Sumiko Sumiko	歓迎した kangeishita warmly
48	三週間前 sanshuukanmae three weeks ago	千恵 Chie Chie	明子 Akiko Akiko	監視した kanshishita guarded
49	三ヶ月前 sankagetsumae three months ago	智子 Tomoko Tomoko	孝枝 Takae Takae	挑発した chouhatsushita provoked
50	二週間前 nishuukanmae two weeks ago	太郎 Tarou Tarou	花子 Hanako Hanako	招いた maneita invited
51	六日前 muikamae six days ago	絵美 Emi Emi	美雪 Miyuki Miyuki	支えた sasaeta backed
52	今年 kotoshi this year	博司 Hiroshi Hiroshi	春子 Haruko Haruko	介抱した kaihoushita cared
53	五日前 itsukamae five days ago	洋一 Youichi Youichi	直子 Naoko Naoko	叱責した shissekishita reprimanded
54	去年 kyonen last year	塔子 Touko Touko	直美 Naomi Naomi	見送った miokutta saw

Table B.3: continued

	Adverb	NP1	NP2	Verb
55	四時間前 yojikanmae four hours ago	宗明 Muneaki Muneaki	紀子 Noriko Noriko	威嚇した ikakushita intimidated
56	先学期 sengakki last semester	静子 Shizuko Shizuko	正和 Masakazu Masakazu	圧倒した attoushita overpowered
57	五ヶ月前 gokagetsumae five months ago	宗雄 Muneo Muneo	邦夫 Kunio Kunio	襲った osotta attacked
58	今年 kotoshi this year	知世 Tomoyo Tomoyo	栄作 Eisaku Eisaku	見捨てた misuteta left
59	四ヶ月前 yonkagetsumae four months ago	京香 Kyouka Kyouka	清一 Seiichi Seiichi	賞賛した shousanshita commended
60	三日前 mikkamae three days ago	由紀 Yuki Yuki	雪子 Yukiko Yukiko	脅迫した kyouhakushita threatened
61	二年前 ninenmae two years ago	哲治 Tetsuji Tetsuji	雄二 Yuuji Yuuji	絞殺した kousatsushita strangled
62	三年前 sannenmae three years ago	郁子 Ikuko Ikuko	次郎 Jirou Jirou	疑った utagatta suspected
63	昨夜 sakuya last night	淳子 Junko Junko	剛志 Tsuyoshi Tsuyoshi	捕まえた tsukamaeta caught
64	一ヶ月前 ikkagetsumae one month	冬子 Fuyuko Fuyuko	恭平 Kyouhei Kyouhei	誘惑した yuuwakushita seduced
65	先週 senshuu last week	弓子 Yumiko Yumiko	真琴 Makoto Makoto	警戒した keikaishita watched
66	五日前 itsukamae five days ago	初巳 Hatsumi Hatsumi	礼司 Reiji Reiji	解雇した kaikoshita dismissed
67	一週間前 isshuukanmae one week ago	雅子 Masako Masako	佳代 Kayo Kayo	尊敬した sonkeishita honored
68	四日前 yokkamae four days ago	千春 Chiharu Chiharu	民子 Tamiko Tamiko	拘束した kousokushita tied

Table B.3: continued

	Adverb	NP1	NP2	Verb
69	四週間前 yonshuukanmae four weeks ago	美咲 Misaki Misaki	香織 Kaori Kaori	励ました hagemashita cheered
70	一週間前 isshuukanmae one week ago	貞子 Sadako Sadako	勇一 Yuuichi Yuuichi	解任した kaininshita dismissed
71	三日前 mikkamae three days ago	博美 Hiromi Hiromi	慶介 Keisuke Keisuke	直視した chokushishita intently
72	三ヶ月前 sankagetsumae three months ago	邦武 Kunitake Kunitake	光政 Mitsumasa Mitsumasa	射殺した shasatsushita shot
73	一ヶ月前 ikkagetsumae one month ago	公子 Kimiko Kimiko	和美 Yasumi Yasumi	頼った tayotta relied
74	二ヵ月前 nikagetsumae two months ago	真央 Mao Mao	理菜 Rina Rina	祝福した shukufukushita congratulated
75	先月 sengetsu last month	和子 Kazuko Kazuko	絵里 Eri Eri	援助した enjoshita aided
76	五ヶ月前 gokagetsumae five months ago	麗奈 Rena Rena	梨華 Rika Rika	信頼した shinraishita relied
77	先週 senshuu last week	美和 Miwa Miwa	裕子 Yuuko Yuuko	毒殺した dokusatsushita poisoned
78	半年前 hantoshimae half a year ago	美沙 Misa Misa	信忠 Nobutada Nobutada	買収した baishuushita bribed
79	五日前 itsukamae five days ago	綾乃 Ayano Ayano	冴子 saeko saeko	避けた saketa avoided
80	四ヶ月前 yonkagetsumae four months ago	次子 Tsugiko Tsugiko	理恵 Rie Rie	看病した kanbyoushita nursed

In Experiment 4, all target sentence adverbs were replaced by the conjunctive adverb *sokode* (“there/then”), and the adverbs listed here were presented at the beginning of the context sentences (cf. Table B.4).

B.4 Stimulus materials employed in Experiment 4: Context sentences

Table B.4: Stimulus materials employed in Experiment 4, context sentences

	Context sentence
01	先月、玲一/良太がマクドナルドで働き始めた。 Last month, Reiichi/Ryouta started working at McDonald's. 先月、マクドナルドのお店は焼失した。 Last month, a McDonald's restaurant burned down.
02	二日前、敏明/万秀がデパートで買い物をした。 Two days ago, Toshiaki/Manshuu was/were shopping at the department store. 二日前、デパートで冬のセールが始まった。 Two days ago, the winter sale started at the department store.
03	昨夜、尚之/和也がディスコで踊った。 Last night, Naoyuki/Kazuya was/were dancing at the club. 昨夜、ディスコで女性割引があった。 Last night, there was a lady's discount at the club.
04	一週間前、真之/武司が動物園に行った。 One week ago, Saneyuki/Takeshi visited the zoo. 一週間前、動物園で虎の赤ちゃんが生まれた。 One week ago, tiger babies were born at the zoo.
05	五日前、沙織/麗子がレストランへ食事に行った。 Five days ago, Saori/Reiko went out to eat at a restaurant. 五日前、レストランの日替わりメニューは安かった。 Five days ago, the restaurant's daily special was cheap.
06	去年、義勝/純一が体育祭に参加した。 Last year, Yoshimasa/Junichi participated in a sports meeting. 去年、学校が体育祭を開催した。 Last year, the school hosted a sports meeting.
07	六日前、盛夫/裕樹がカラオケボックスで歌った。 Six days ago, Morio/Yuuki was/were singing at the karaoke bar. 六日前、カラオケボックスでお別れ会が開かれた。 Six days ago, there was a farewell party at the karaoke bar.
08	半年前、恵一/功夫が海で泳いだ。 Half a year ago, Keiichi/Isao was/were swimming in the sea. 半年前、海はとても荒れていた。 Half a year ago, the sea was very rough.
09	一年前、邦浩/右京がコンサートを聞いた。 One year ago, Kunihiro/Ukyou went to a concert. 一年前、有名なロックバンドの　コンサートだった。 One year ago, there was a famous rock band's concert.
10	昨夜、歩美/博信が大学で勉強した。 Last night, Ayumi/Hironobu was/were studying at the university. 昨夜、大学で招待講演があった。 Last night, a guest lecture was held at the university.

Table B.4: continued

	Context sentence
11	二時間前、亮一/敏正がサイン会に行った。 Two hours ago, Ryouichi/Toshimasa went to an autograph session. 二時間前、サイン会は騒然としていた。 Two hours ago, the autograph session became tumultuous.
12	二年前、文男/栄治が花見でたくさん飲んだ。 Two years ago, Fumio/Eiji drank a lot at the cherry blossom viewing. 二年前、花見で大量のお酒が消費された。 Two years ago, a lot of alcohol were consumed at the cherry blossom viewing.
13	五週間前、一茂/誠司がお寺をお参りした。 Five weeks ago, Kazushige/Seiji pilgrimaged to the temple. 五週間前、お寺ではお経が読まれていた。 Five weeks ago, the sutras were recited at the temple.
14	二時間前、洋介/妙子が人間ドックに申し込んだ。 Two hours ago, Yousuke/Taeko applied for the health checkup. 二時間前、人間ドックで健康診断が行われた。 Two hours ago, physical examinations were carried out at the health checkup.
15	先週、勝弘/満夫が幼稚園で遊んでいた。 Last week, Katsuhiro/Mitsuo was/were playing at the kindergarten. 先週、幼稚園で大道芸が行われた。 Last week, street art was performed at the kindergarten.
16	一週間前、弘明/哲郎が数学のテストを受けた。 One week ago, Hiroaki/Tetsurou took the math exam. 一週間前の数学のテストはとても難しかった。 One week ago, the math exam was very difficult.
17	六日前、茂雄/康弘が監房に収容された。 Six days ago, Shigeo/Yasuhiro was/were admitted to a prison cell. 六日前、監房で大混乱の騒ぎになった。 Six days ago, the racket of a frenzied chaos erupted in the prison cell.
18	一昨年、康則/由理がゴールデンウィークに旅行をした。 Two years ago, Yasunori/Yuri went on a journey during Golden Week. 一昨年のゴールデンウィークは　雨で台無しになった。 Two years ago, Golden Week was spoiled by raining.
19	去年、啓太/重治がメッセにブースを出した。 Last year, Keita/Shigeharu set up booths at the trade fair. 去年、メッセに面白いブースがあった。 Last year, there were interesting booths at the trade fair.
20	二時間前、輝彦/光弘が会場で試合を見た。 Two hours ago, Teruhiko/Mitsuhiro was/were watching the game in the assembly room. 二時間前、会場にはカメラが設置されていた。 Two hours ago, cameras were set up in the assembly room.
21	三週間前、信之/愛子が新しい新幹線に乗った。 Three weeks ago, Nobuyuki/Aiko was/were travelling with the new shinkansen. 三週間前、新幹線は初走行中だった。 Three weeks ago, the new shinkansen was on its maiden trip.

Table B.4: continued

	Context sentence
22	一時間前、達也/雄介が警察署で取調べを受けた。 One hour ago, Tatsuya/Yuusuke was/were questioned at the police station. 一時間前、警察署から車が盗まれた。 One hour ago, a car was stolen from the police station.
23	今朝、伸一/宗忠がつり橋を渡った。 This morning, Shinichi/Munetada was/were crossing the suspension bridge. 今朝、つり橋が風で大きく揺れた。 This morning, the suspension bridge was strongly swaying in the wind.
24	先月、百子/仁美が温泉でリラックスした。 Last month, Momoko/Hitomi was/were relaxing in the hot springs. 先月、温泉にはマッサージサービスがあった。 Last month, a massage service was offered at the hot springs.
25	四週間前、俊男/直人が裁判で証言しなければならなかった。 Four weeks ago, Toshio/Naohito had to testify in court. 四週間前、裁判では多くの傍聴券が配られた。 Four weeks ago, many admission tickets were handed out in court.
26	二週間前、美穂/浩二が会議で報告をした。 Two weeks ago, Miho/Kouji made reports at the conference. 二週間前の会議は六時間続いた。 Two weeks ago, the conference took six hours.
27	三時間前、和恵/奈々が有名な歌舞伎を見た。 Three hours ago, Kazue/Nana watched a famous kabuki play. 三時間前、歌舞伎で有名な芝居が上映された。 Three hours ago, a famous play was staged at the kabuki theater.
28	昨夜、光一/作蔵がホテルに宿泊した。 Last night, Kouichi/Sakuzou stayed at a hotel. 昨夜、ホテルで火事が発生した。 Last night, a fire broke out at the hotel.
29	五週間前、浩介/孝子が山でハイキングをした。 Five weeks ago, Kousuke/Takako went on a hike in the mountains. 五週間前、山には高山植物がたくさん咲いていた。 Five weeks ago, the alpine flora blossomed out in the mountains.
30	二日前、義則/俊樹が象に餌をやった。 Two days ago, Yoshinori/Toshiki fed the elephants at the circus. 二日前、サーカスで象のショーが開かれた。 Two days ago, an elephant show was performed at the circus.
31	昨日、信男/宗助が図書館で本を読んだ。 Yesterday, Nobuo/Sousuke read books at the library. 昨日、図書館には邪魔な私語が多かった。 Yesterday, disturbing murmur dominated the library.
32	四年前、孝幸/哲也が空港に爆弾を運んだ。 Four years ago, Kouhei/Tetsuya was/were taking bombs to the airport. 四年前、空港は爆破予告をされた。 Four years ago, the airport received a bomb threat.

Table B.4: continued

	Context sentence
33	四日前、恵美/隆志が絵の個展を開催した。 Four days ago, Megumi/Takashi organized an exhibition of paintings. 四日前、個展に興味深い絵があまりなかった。 Four days ago, the exhibition included few interesting paintings.
34	一年前、総一/保美がディズニーランドで誕生日を祝った。 One year ago, Souichi/Yasumi celebrated birthday in Disneyland. 一年前、ディズニーランドで　パレードが催された。 One year ago, a parade was held in Disneyland.
35	先学期、博則/美紀がオリエンテーションに連れ回された。 Last semester, Hironori/Miki was/were shown round on Orientation Day. 先学期のオリエンテーションはとても興味深かった。 Last semester, Orientation Day was very interesting.
36	一年前、智美/悦子が会社に職を求めた。 One year ago, Tomomi/Etsuko applied for a job in the company. 一年前、会社は新しい人を雇った。 One year ago, the company was hiring new people.
37	二日前、佳乃/寛子が喫茶店で挽きたてのコーヒーを飲んだ。 Two days ago, Yoshino/Hiroko was/were drinking coffee at a cafe. 二日前、喫茶店で挽きたてのコーヒーが提供された。 Two days ago, freshly ground coffee was offered at the cafe.
38	五ヵ月前、清美/真紀がドイツへ旅行した。 Five months ago, Kiyomi/Maki traveled to Germany. 五ヵ月前、ドイツでワールドカップが開催された。 Five months ago, the World Cup was held in Germany.
39	今朝、孝安/優香が市場で野菜を売った。 This morning, Takahiro/Yuuka was/were selling vegetables at the market. 今朝、市場の野菜はとても高かった。 This morning, the market vegetables were very expensive.
40	三年前、典昭/直美が大使館へ避難した。 Three years ago, Noriaki/Naomi took refuge in the embassy. 三年前、アメリカ大使館は避難所だった。 Three years ago, the American embassy provided refuge.
41	半年前、英子/泉美がマクドナルドで働き始めた。。 Half a year ago, Eiko/Izumi started working at McDonald's. 半年前、マクドナルドのお店は焼失した。 Half a year ago, a McDonald's restaurant burned down.
42	昨日、達子/聡美がデパートで買い物をした。 Yesterday, Tatsuko/Satomi was/were shopping at the department store. 昨日、デパートで冬のセールが始まった。 Yesterday, the winter sale started at the department store.
43	三日前、志保/香奈がディスコで踊った。 Three days ago, Shiho/Kana was/were dancing at the club. 三日前、ディスコで女性割引があった。 Three days ago, there was a lady's discount at the club.

Table B.4: continued

	Context sentence
44	四日前、正樹/由美が動物園に行った。 Four days ago, Masaki/Yumi visited the zoo. 四日前、動物園で虎の赤ちゃんが生まれた。 Four days ago, tiger babies were born at the zoo.
45	昨日、昭文/清吾がレストランへ食事に行った。 Yesterday, Akifumi/Seigo went out to eat at a restaurant. 昨日、レストランの日替わりメニューは安かった。 Yesterday, the restaurant's daily special was cheap.
46	二ヶ月前、杏奈/聖子が体育祭に参加した。 Two months ago, Anna/Seiko participated in a sports meeting. 二ヶ月前、学校が体育祭を開催した。 Two months ago, the school hosted a sports meeting.
47	三時間前、理沙/純子がカラオケボックスで歌った。 Three hours ago, Risa/Sumiko was/were singing at the karaoke bar. 三時間前、カラオケボックスでお別れ会が開かれた。 Three hours ago, there was a farewell party at the karaoke bar.
48	三週間前、千恵/明子が海で泳いだ。 Three weeks ago, Chie/Akiko was/were swimming in the sea. 三週間前、海はとても荒れていた。 Three weeks ago, the sea was very rough.
49	三ヶ月前、智子/孝枝がコンサートを聞いた。 Three months ago, Tomoko/Takae went to a concert. 三ヶ月前、有名なロックバンドの　コンサートだった。 Three months ago, there was a famous rock band's concert.
50	二週間前、太郎/花子が大学で勉強した。 Two weeks ago, Tarou/Hanako was/were studying at the university. 二週間前、大学で招待講演があった。 Two weeks ago, a guest lecture was held at the university.
51	六日前、絵美/美雪がサイン会に行った。 Six days ago, Emi/Miyuki went to an autograph session. 六日前、サイン会は騒然としていた。 Six days ago, the autograph session became tumultuous.
52	今年、博司/春子が花見でたくさん飲んだ。 This year, Hiroshi/Haruko drank a lot at the cherry blossom viewing. 今年、花見で大量のお酒が消費された。 This year, a lot of alcohol were consumed at the cherry blossom viewing.
53	五日前、洋一/直子がお寺をお参りした。 Five days ago, Youichi/Naoko pilgrimaged to the temple. 五日前、お寺ではお経が読まれていた。 Five days ago, the sutras were recited at the temple.
54	去年、塔子/直美が人間ドックに申し込んだ。 Last year, Touko/Naomi applied for the health checkup. 去年、人間ドックで健康診断が行われた。 Last year, physical examinations were carried out at the health checkup.

Table B.4: continued

	Context sentence
55	四時間前、宗明/紀子が幼稚園で遊んでいた。 Four hours ago, Muneaki/Noriko was/were playing at the kindergarten. 四時間前、幼稚園で大道芸が行われた。 Four hours ago, street art was performed at the kindergarten.
56	先学期、静子/正和が数学のテストを受けた。 Last semester, Shizuko/Masakazu took the math exam. 先学期の数学のテストはとても難しかった。 Last semester, the math exam was very difficult.
57	五ヶ月前、宗雄/邦夫が監房に収容された。 Five months ago, Muneo/Kunio was/were admitted to a prison cell. 五ヶ月前、監房で大混乱の騒ぎになった。 Five months ago, the racket of a frenzied chaos erupted in the prison cell.
58	今年、知世/栄作がゴールデンウィークに旅行をした。 This year, Tomoyo/Eisaku went on a journey during Golden Week. 今年のゴールデンウィークは　雨で台無しになった。 This year, Golden Week was spoiled by raining.
59	四ヶ月前、京香/清一がメッセにブースを出した。 Four months ago, Kyouka/Seiichi set up booths at the trade fair. 四ヶ月前、メッセに面白いブースがあった。 Four months ago, there were interesting booths at the trade fair.
60	三日前、由紀/雪子が会場で試合を見た。 Three days ago, Yuki/Yukiko was/were watching the game in the assembly room. 三日前、会場にはカメラが設置されていた。 Three days ago, cameras were set up in the assembly room.
61	二年前、哲治/雄二が新しい新幹線に乗った。 Two years ago, Tetsuji/Yuuji was/were travelling with the new shinkansen. 二年前、新幹線は初走行中だった。 Two years ago, the new shinkansen was on its maiden trip.
62	三年前、郁子/次郎が警察署で取調べを受けた。 Three years ago, Ikuko/Jirou was/were questioned at the police station. 三年前、警察署から車が盗まれた。 Three years ago, a car was stolen from the police station.
63	昨夜、淳子/剛志がつり橋を渡った。 Last night, Junko/Tsuyoshi was/were crossing the suspension bridge. 昨夜、つり橋が風で大きく揺れた。 Last night, the suspension bridge was strongly swaying in the wind.
64	一ヶ月前、冬子/恭平が温泉でリラックスした。 One month, Fuyuko/Kyouhei was/were relaxing in the hot springs. 一ヶ月前、温泉にはマッサージサービスがあった。 One month, a massage service was offered at the hot springs.
65	先週、弓子/真琴が裁判で証言しなければならなかった。 Last week, Yumiko/Makoto had to testify in court. 先週、裁判では多くの傍聴券が配られた。 Last week, many admission tickets were handed out in court.

Table B.4: continued

	Context sentence
66	五日前、初巳/礼司が会議で報告をした。 Five days ago, Hatsumi/Reiji made reports at the conference. 五日前の会議は六時間続いた。 Five days ago, the conference took six hours.
67	一週間前、雅子/佳代が有名な歌舞伎を見た。 One week ago, Masako/Kayo watched a famous kabuki play. 一週間前、歌舞伎で有名な芝居が上映された。 One week ago, a famous play was staged at the kabuki theater.
68	四日前、千春/民子がホテルに宿泊した。 Four days ago, Chiharu/Tamiko stayed at a hotel. 四日前、ホテルで火事が発生した。 Four days ago, a fire broke out at the hotel.
69	四週間前、美咲/香織が山でハイキングをした。 Four weeks ago, Misaki/Kaori went on a hike in the mountains. 四週間前、山には高山植物が　たくさん咲いていた。 Four weeks ago, the alpine flora blossomed out in the mountains.
70	一週間前、貞子/勇一が象に餌をやった。 One week ago, Sadako/Yuuichi fed the elephants at the circus. 一週間前、サーカスで象のショーが開かれた。 One week ago, an elephant show was performed at the circus.
71	三日前、博美/慶介が図書館で本を読んだ。 Three days ago, Hiromi/Keisuke read books at the library. 三日前、図書館には邪魔な私語が多かった。 Three days ago, disturbing murmur dominated the library.
72	三ヶ月前、邦武/光政が空港に爆弾を運んだ。 Three months ago, Kunitake/Mitsumasa was/were taking bombs to the airport. 三ヶ月前、空港は爆破予告をされた。 Three months ago, the airport received a bomb threat.
73	一ヶ月前、公子/和美が絵の個展を開催した。 One month ago, Kimiko/Kazumi organized an exhibition of paintings. 一ヶ月前、個展に興味深い絵があまりなかった。 One month ago, the exhibition included few interesting paintings.
74	二ヵ月前、真央/理菜がディズニーランドで誕生日を祝った。 Two months ago, Mao/Rina celebrated birthday in Disneyland. 二ヵ月前、ディズニーランドで　パレードが催された。 Two months ago, a parade was held in Disneyland.
75	先月、和子/絵里がオリエンテーションに連れ回された。 Last month, Kazuko/Eri was/were shown round on Orientation Day. 先月のオリエンテーションはとても興味深かった。 Last month, Orientation Day was very interesting.
76	五ヶ月前、麗奈/梨華が会社に職を求めた。 Five months ago, Rena/Rika applied for a job in the company. 五ヶ月前、会社は新しい人を雇った。 Five months ago, the company was hiring new people.

Table B.4: continued

	Context sentence
77	先週、美和/裕子が喫茶店で挽きたてのコーヒーを飲んだ。 Last week, Miwa/Yuuko was/were drinking coffee at a cafe. 先週、喫茶店で挽きたてのコーヒーが提供された。 Last week, freshly ground coffee was offered at the cafe.
78	半年前、美沙/信忠がドイツへ旅行した。 Half a year ago, Misa/Nobutada traveled to Germany. 半年前、ドイツでワールドカップが開催された。 Half a year ago, the World Cup was held in Germany.
79	五日前、綾乃/冴子が市場で野菜を売った。 Five days ago, Ayano/Saeko was/were selling vegetables at the market. 五日前、市場の野菜はとても高かった。 Five days ago, the market vegetables were very expensive.
80	四ヶ月前、次子/理恵が大使館へ避難した。 Four months ago, Tsugiko/Rie took refuge in the embassy. 四ヶ月前、アメリカ大使館は避難所だった。 Four months ago, the American embassy provided refuge.

The first row of each item shows the material used for the construction of context conditions S⧄O⧄, S⧄O⊠, and S⊠O⧄. The second row of each item shows the sentence in context condition S⊠O⊠.

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Summary

Challenges for incremental sentence processing One of the fundamental properties of language comprehension is that it proceeds incrementally. Thus, every incoming input item is integrated and interpreted as soon as it is encountered (e.g. Bader & Lasser, 1994; Crocker, 1994; Kamide & Mitchell, 1999). Consequently, a substantial portion of psycho- and neurolinguistic research has been devoted to exploring the nature and mechanisms of incremental processing and particularly to addressing the question of how interpretation can be maximized even in the face of ambiguous or incomplete input information.

A particular challenge for incremental processing and for theoretical accounts of its (neuro)cognitive architecture is posed by the multitude of languages spoken in the world that deviate from the well-researched “English-style” sentence pattern. For example, the majority of the world’s languages exhibit a basic verb-final sentence structure (cf. Example 1), requiring an interpretation and hierarchical integration of the pre-verbal arguments in the sense of “who is acting upon whom” before the predicating information encoded in the verb becomes available. The process is further complicated if a language also allows various possible linearizations (e.g. *scrambling*; Ross, 1967; cf. Example 2) and/or the omission of sentential arguments (i.e. *pro-drop*; Chomsky, 1981; cf. Example 3).

(1) Canonical SOV sentence in Japanese[1]

Hanji-ga	*daijin-o*	*maneita.*
judge-NOM	minister-ACC	invite-PAST

‘The judge invited the minister.’

(2) Scrambled OSV sentence in Japanese

Daijin-o	*hanji-ga*	*maneita.*
minister-ACC	judge-NOM	invite-PAST

‘The judge invited the minister.’

(3) Pro-drop OV sentence in Japanese

Daijin-o	*maneita.*
minister-ACC	invite-PAST

‘[I/you/he/she/we/they] invited the minister.’

[1] Abbreviations used here and in the following: SOV, subject-object-verb; OSV, object-subject-verb; OV, object-verb; SV, subject-verb; NOM, nominative case marker; ACC, accusative case marker; PAST, past tense.

Since language comprehension is based on cognitive and neural processes that are presumed to be largely independent of the individual language under consideration, a complete understanding of the (neuro)cognitive architecture of language comprehension cannot be attained without a close examination of incremental sentence interpretation in languages such as the ones described above. From this point of view, the language employed in the empirical studies presented in this dissertation qualifies as a highly applicable language for the examination of incremental sentence processing: Japanese is a verb-final language allowing word order permutations as well as the omission of arguments. Capitalizing on these properties, four experiments utilizing event-related brain potentials (ERPs) were conducted to elucidate the mechanisms of incremental sentence processing in the face of word order variations and argument omission.

Experiments 1 and 2 were primarily concerned with the processing of word order variations in simple transitive Japanese sentences. In **Experiment 1**, which employed auditory presentation, canonical (SOV; nominative-before-accusative) and scrambled (OSV; accusative-before-nominative) word orders were compared and the influence of prosodic information on the incremental interpretation of the different orders was investigated. In **Experiment 2**, the same sentence materials were presented visually, supplemented by canonical and scrambled sentences in which the object was marked with the dative case (nominative-before-dative and dative-before-nominative) to investigate the influence of differential case marking on the processing of scrambled word orders. Experiments 3 and 4, which also employed visual presentation, focused more strongly on the processing of pro-drop sentences. In **Experiment 3**, subject-drop (OV) and object-drop (SV) sentences were presented along with canonical and scrambled sentences to investigate the processes involved in the incremental comprehension of sentences with omitted arguments. **Experiment 4** embedded the same sentences in a linguistic context to examine the influence of contextual discourse information on these processes.

The processing of permuted word orders With regard to the incremental processing of word order permutations, two ERP components were in the focus of the conducted experiments: the scrambling negativity, which was previously observed in response to the first argument of scrambled object-before-subject sentences in German (e.g. Rösler, Pechmann, Streb, Röder, & Hennighausen, 1998; Schlesewsky, Bornkessel, & Frisch, 2003), and an N400 component that previously arose in response to the second argument of canonical subject-before-object sentences in German (Bornkessel, Fiebach, & Friederici, 2004). The observation of increased processing costs not only for permuted but also for *canonical* word orders was taken to indicate that the processing costs reflected in these ERP components may arise at independent levels of representation: a phrase structure level encoding the number of arguments in the phrase structure, and an interpretive level encoding the number of participants in the described event. In the Extended Argument Dependency Model (eADM; Bornkessel & Schlesewsky, 2006), it is further assumed that incremental comprehension is universally guided by a simplicity-based strategy named *Minimality* which applies at both of these levels of representation. In this regard, the application of the Minimality principle at the phrase structural level can be paraphrased as “always assume a minimal syntactic structure” (e.g. prefer phrase structure representations with one argument over those with two arguments), while its interpretive application can be expressed as “always assume a minimal event interpretation” (e.g. prefer intransitive event representations with only one participant over those with more participants). Crucially, while it is difficult to dissociate the two representation levels effectively in a language like German, a systematic validation of the phrase structural and the interpretive application of the Minimality principle is possible in Japanese, since the availability of pro-drop in this language is assumed to critically affect the phrase structure representation but not the interpretive representation of subject- and object-initial sentences.

The observed variations in the behavior of the scrambling negativity for initial objects vs. initial subjects depending on prosodic cues (Experiment 1), the case marking on the object (Experiment 2), and the presence of sentences with omitted subjects in the stimulus materials (Experiments 3 and 4) strongly spoke in favor of an interpretation of this ERP component as a correlate of the failure to maintain a minimal one-argument phrase structure representation: Whenever the case marking on the initial object argument ruled out a minimal one-argument structure, a scrambling negativity comparable to the one observed for scrambled objects in German arose. This was the case when an initial accusative-marked argument signaled a scrambled (OSV) structure because it was followed by a prosodic boundary (Experiment 1) or was presented visually in a word-by-word paradigm (Experiment 2). By contrast, no such effect arose when an initial object was still compatible with a one-argument structure. This was the case when an initial accusative-marked argument was interpretable as the object of a sentence with an omitted subject (OV) because it was not followed by a prosodic boundary (Experiment 1) or because the presence of pro-drop sentences in the experimental environment supported such an interpretation (Experiments 3 and 4). When the initial object was marked with dative case and therefore at first allowed an alternative dative-subject reading, a minimal one-argument reading could also be upheld, consequently leading to a similar attenuation of the scrambling negativity (Experiment 2).

At the position of the second argument of canonical subject-before-object sentences, an N400 arose in all four experiments, independently of the manipulations of prosodic information (Experiment 1), object case (Experiment 2), the experimental environment (Experiment 3), or contextual discourse information (Experiment 4). The invariability of the N400 effect in the face of manipulations that did affect the phrase structure related processes reflected in the scrambling negativity supports an independent functional explanation for this component: Based on the data pattern observed here, this type of N400 effect, which was tentatively termed the *extension N400*, specifically seemed to indicate the extension from a minimal intransitive event interpretation with only one participant to a non-minimal transitive event interpretation with two or more participants. In the described experiments, such an interpretive extension was always required when a second argument was encountered following an initial nominative-marked argument (which up to this point could have been the sole participant in an intransitive event), but not when it followed an initial accusative- or dative-marked argument (which from the outset signaled a transitive event).

In summary, the word order related findings of Experiments 1–4 provided strong converging support for the assumption that the scrambling negativity indicates a violation of the Minimality principle at the phrase structure level while a violation of the Minimality principle at the interpretive level is reflected in an extension N400.

The processing of pro-drop sentences With regard to the incremental processing of sentences with omitted arguments, little previous ERP evidence was available. This rendered the examination of this issue, which was in the focus of Experiments 3 and 4, highly explorative.

In these experiments, verbs of pro-drop sentences engendered a widely distributed positivity effect between approximately 400 and 600 ms post-onset in comparison to verbs of complete sentences in which all arguments were overtly expressed. This component, which was tentatively termed the *pro-drop positivity*, was observable in response to subject-drop as well as object-drop sentences when they were presented visually and in isolation (Experiment 3). However, it was significantly reduced when the pro-drop sentences were embedded in certain linguistic contexts (Experiment 4). The complete pattern of observations suggested an interpretation of the pro-drop positivity as a discourse related ERP effect indicating the inference of missing referents from outside of the sentence. This referential inference process further appeared to be affected by at least two factors: (a) whether a new discourse referent needed to be established for the omitted argument, and (b) whether there were other discourse referents competing with the inferable referent. As a result, the pro-drop positivity was reduced whenever a pre-established referent (i.e. a lexically given referent or, in subject-drop sentences, a pre-established speaker; cf. Martin, 2003) could be inferred as the missing discourse referent without any competition from other lexically given referents.

The observed reduction of the effect when a pre-established referent was provided in the discourse is reminiscent of previous studies from other languages reporting positivity effects in connection with referent establishment processes (e.g. German: Burkhardt, 2006; English: Van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991; Dutch: Van Berkum, Zwitserlood, Bastiaansen, Brown, & Hagoort, 2004) on the one hand and is highly compatible with an application of the described Minimality principle at the discourse level on the other hand, which in this case could be circumscribed as “always assume minimal discourse representations” (e.g. do not establish unnecessary discourse referents). While it is not immediately apparent how such a preference for minimal discourse representations could also account for the influence of the competition factor isolated in Experiment 4, the complete pattern of results may be derivable by taking into consideration a recent suggestion put forward in the eADM framework: Minimality may merely constitute a subcase of a more general processing principle called *Distinctness* (cf. Bornkessel-Schlesewsky & Schlesewsky, 2009, in press). This processing principle states that if the phrase structure representation contains more than one constituent or the event representation contains more than one participant, comprehension is easiest when these constituents or participants are as distinct as possible with regard to their word category or their prominence status (as determined by case, animacy, specificity, etc.), respectively. Crucially, the application of the Distinctness principle automatically derives the preference for minimal structures and events, since the only element in a representation is also necessarily, or “vacuously”, distinct. Applied to the discourse level of representation, the Distinctness principle can derive the observed increased processing costs for pro-drop sentences in discourse contexts that provide several highly similar discourse referents.

Conclusions All in all, the results summarized in this dissertation demonstrate that a conceptual separation of several levels of representation constitutes an important prerequisite for deriving patterns of sentence comprehension across languages. While the different levels may be tightly connected in some languages such as English, their interrelation is much more flexible in the vast majority of languages. Specifically, the experimental results presented here strongly suggest a separation of the phrase structural, interpretive, and discourse level of representation in the theoretical modeling of incremental sentence processing. Crucially, such a separation need not lead to a more complex model. Rather, we need only assume that processing is guided by Minimality, or the more general principle of Distinctness, which applies differentially to the different levels of representation. The outcome of applying Minimality/Distinctness depends critically upon the particular representation in question and the specific properties of the language being processed. For example, at the phrase structure level, Japanese differs from German in that it exhibits pro-drop and therefore allows minimal structures with an initial object, whereas both languages behave very similarly at the level of interpretive representations, since an initial accusative and an initial dative, but not an initial nominative, unambiguously signal a non-minimal event interpretation in both languages. At the discourse level, Japanese demonstrates a preference for minimal discourse representations with as few and distinct referents as possible, and data from German, English, and Dutch point towards a cross-linguistic validity of this preference. In summary, a Minimality/Distinctness based account incorporating several levels of representation appears to present a promising approach to deriving cross-linguistic similarities and differences in the neurocognitive signatures of incremental sentence comprehension.

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Zusammenfassung

Herausforderungen für die inkrementelle Satzverarbeitung Inkrementalität ist eine fundamentale Eigenschaft der Prozesse, die der Verarbeitung von natürlicher Sprache zugrunde liegen: Jede neue Satzeinheit wird sofort interpretiert und mit der bisher verarbeiteten Information integriert, um ohne Verzögerungen zu einem möglichst vollständigen Satzverständnis zu gelangen (Bader & Lasser, 1994; Crocker, 1994; Kamide & Mitchell, 1999). Dementsprechend beschäftigt sich ein substantieller Anteil der psycho- und neurolinguistischen Forschung mit der Untersuchung inkrementeller Verarbeitungsmechanismen und insbesondere mit der Fragestellung, wie das Satzverständnis auch angesichts mehrdeutiger oder unvollständiger Information gewährleistet werden kann.

Eine besondere Herausforderung für die inkrementelle Verarbeitung und für theoretische Erklärungsansätze zu ihren (neuro)kognitiven Grundlagen stellen Sprachen dar, die von den viel untersuchten Satzstrukturen vom "englischen Typ" abweichen. So weist die Mehrheit der auf der Welt gesprochenen Sprachen eine verbfinale Satzstruktur auf (vgl. Beispiel 1), wodurch eine hierarchische Interpretation der Argumente im Sinne von "Wer wirkt auf wen ein?" stattfinden muss, noch bevor die im Verb kodierte Information verfügbar wird. Dieser Prozess wird zusätzlich erschwert, wenn eine Sprache verschiedene Linearisierungsalternativen (z.B. *Scrambling*; Ross, 1967; vgl. Beispiel 2) oder die Auslassung von Argumenten (*Pro-Drop*; Chomsky, 1981; vgl. Beispiel 3) erlaubt.

(1) Grundwortstellung im Japanischen: SOV[1]

Hanji-ga	*daijin-o*	*maneita.*
Richter-NOM	Minister-AKK	einladen-VERG

'Der Richter hat den Minister eingeladen.'

(2) Scrambling im Japanischen: OSV

Daijin-o	*hanji-ga*	*maneita.*
Minister-AKK	Richter-NOM	einladen-VERG

'Den Minister hat der Richter eingeladen.'

(3) Pro-Drop im Japanischen: OV

Daijin-o	*maneita.*
Minister-AKK	einladen-VERG

'[Ich/Du/Er/Sie/Wir/Ihr/Sie] habe/hast/hat/habt/haben den Minister eingeladen.'

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[1] Hier und im Folgenden verwendete Abkürzungen: SOV, Subjekt-Objekt-Verb; OSV, Objekt-Subjekt-Verb; OV, Objekt-Verb; SV, Subjekt-Verb; NOM, Nominativ-Kasusmarker; AKK, Akkusativ-Kasusmarker; VERG, Vergangenheitsform.

Da Sprachverarbeitung auf kognitiven und neuronalen Prozessen basiert, die gemeinhin als sprachübergreifend angesehen werden, kann ein vollständiges Verständnis ihrer (neuro)kognitiven Architektur nicht ohne eine genaue Untersuchung der inkrementellen Satzinterpretation in Sprachen wie den eben beschriebenen erreicht werden. Hierfür erweist sich die im empirischen Teil dieser Dissertation betrachtete Sprache als besonders geeignet: das Japanische ist verbfinal und gestattet sowohl Wortstellungsvariationen als auch die Auslassung von Argumenten. Diese Eigenschaften wurden in der vorliegenden Dissertation genutzt, um in vier Experimenten mit Hilfe von ereigniskorrelierten Hirnpotentialen (EKPs) die Mechanismen der inkrementellen Satzverarbeitung zu beleuchten.

Die ersten beiden Experimente befassten sich in erster Linie mit der Verarbeitung von Wortstellungsvariationen in einfachen transitiven japanischen Sätzen. In **Experiment 1** wurden auditorisch präsentierte Sätze in der Grundwortstellung (SOV; Nominativ-vor-Akkusativ) mit Sätzen in gescrambelter Wortstellung (OSV; Akkusativ-vor-Nominativ) verglichen, wobei der Einfluss von prosodischer Information auf die inkrementelle Verarbeitung der verschiedenen Satztypen betrachtet wurde. Dieselben Sätze wurde in **Experiment 2** visuell präsentiert, ergänzt um Sätze, in denen das Objekt dativ-markiert war (Nominativ-vor-Dativ vs. Dativ-vor-Nominativ). Auf diese Weise konnte der Einfluss des Objekt-Kasus auf die Verarbeitung permutierter Wortstellungen untersucht werden. Im dritten und vierten Experiment, die ebenfalls ein visuelles Präsentationsformat verwendeten, lag das Hauptaugenmerk auf der Verarbeitung von Pro-Drop-Sätzen. In **Experiment 3** wurden hierfür Subjekt-Drop-Sätze (OV) sowie Objekt-Drop-Sätze (SV) gemeinsam mit Standard- und gescrambelten Sätzen präsentiert, um die inkrementellen Verarbeitungsprozesse zu entschlüsseln, die der Interpretation von unvollständigen Sätzen mit ausgelassenen Argumenten zugrunde liegen. In **Experiment 4** wurden dieselben Sätze in einen erweiterten sprachlichen Kontext eingebettet, um den Einfluss von Diskurs-Information auf besagte Prozesse zu beleuchten.

Die Verarbeitung permutierter Wortstellungen Bezüglich der inkrementellen Verarbeitung von Wortstellungsvariationen lag der Schwerpunkt des Interesses auf zwei EKP-Komponenten: die *Scrambling-Negativierung* wurde in vorangegangenen Studien an der Stelle des initialen Arguments von gescrambelten deutschen OSV-Sätzen nachgewiesen (z.B. Rösler, Pechmann, Streb, Röder, & Hennighausen, 1998; Schlesewsky, Bornkessel, & Frisch, 2003); im Gegensatz dazu wurde die *N400*-Komponente zuvor an der Stelle des zweiten Arguments von deutschen Sätzen in der Grundwortstellung SOV beobachtet (Bornkessel, Fiebach, & Friederici, 2004).

Das Auftreten erhöhter Verarbeitungskosten nicht nur für die permutierte, sondern auch für die Grundwortstellung wurde dahingehend interpretiert, dass die in den genannten EKP-Komponenten reflektierten Verarbeitungskosten auf unterschiedlichen Repräsentationsebenen entstehen könnten: einer phrasenstrukturellen Ebene, welche die Anzahl der Argumente in der Phrasenstruktur kodiert, und einer interpretativen Ebene, welche die Anzahl der Teilnehmer im beschriebenen Ereignis kodiert. Im Extended Argument Dependency Model (eADM; Bornkessel & Schlesewsky, 2006) wird darüberhinaus angenommen, dass die Mechanismen der inkrementellen Verarbeitung von einer universellen, einfachheitsbasierten Strategie namens *Minimality* gesteuert werden, welche wiederum auf beiden dieser Repräsentationsebenen Anwendung findet: Auf der phrasenstrukturellen Ebene lässt sich die Anwendung des Minimality-Prinzips umschreiben als "Nimm stets eine minimale syntaktische Struktur an" (z.B. in Form einer Präferenz für Phrasenstruktur-Repräsentationen mit einem Argument gegenüber solchen mit zwei oder mehr Argumenten), während seine interpretative Anwendung sich ausdrücken lässt als "Nimm stets eine minimale Ereignis-Interpretation an" (z.B. in Form einer Präferenz für intransitive Ereignis-Repräsentationen mit nur einem Teilnehmer gegenüber transitiven Repräsentationen mit zwei Teilnehmern). Während in einer Sprache wie dem Deutschen eine klare Trennung zwischen der phrasenstrukturellen und der interpretativen Anwendung des Minimality-Prinzips schwierig ist, erlaubt das Japanische eine sytematische Validierung der beiden Repräsentationsebenen, da hier die Verfügbarkeit von Pro-Drop zwar die phrasenstrukturelle, nicht jedoch die interpretative Repräsentation von subjekt- und objekt-initialen Sätzen beeinflussen dürfte.

Die beobachteten Variationen im Verhalten der Scrambling-Negativierung in Abhängigkeit von prosodischen Merkmalen (Experiment 1), Objekt-Kasus (Experiment 2) und dem Vorhandensein von Sätzen mit ausgelassenem Subjekt im Stimulusmaterial (Experimente 3 und 4) sprechen deutlich für eine Interpretation dieser EKP-Komponente als Korrelat des Verwerfens einer minimalen Phrasenstruktur-Repräsentation: Immer wenn der Kasusmarker eines initialen Objekts eine minimale 1-Argument-Strukur ausschloss, zeigte sich eine vergleichbare Scrambling-Negativierung wie für gescrambelte Objekte im Deutschen. Dies war der Fall, wenn ein initiales akkusativ-markiertes Argument eine gescrambelte (OSV) Struktur signalisierte, da ihm beispielsweise eine prosodische Pause folgte (Experiment 1) oder es visuell in einem Wort-für-Wort-Paradigma präsentiert wurde (Experiment 2). Ein vergleichbarer Effekt war hingegen nicht beobachtbar, wenn ein initiales Objekt immer noch mit einer minimalen 1-Argument-Lesart kompatibel war. Dieser Fall trat ein, wenn ein initiales akkusativ-markiertes Argument als das Objekt eines Satzes

mit einem ausgelassenen Subjekt (OV) interpretiert werden konnte, wenn ihm beispielsweise keine prosodische Pause folgte (Experiment 1), oder wenn bei visueller Präsentation die Anwesenheit von Pro-Drop-Sätzen in der direkten experimentelle Umgebung eine solche Interpretation förderte (Experimente 3 und 4). Weiterhin konnte eine minimale 1-Argument-Interpretation ebenfalls aufrechterhalten werden, wenn das initiale Objekt dativ-markiert war und deshalb zunächst eine alternative Dativ-Subjekt-Lesart erlaubte. Als Resultat war die Scrambling-Negativierung auch in diesem Falle vermindert (Experiment 2).

An der Position des zweiten Arguments von Sätzen in der Grundwortstellung (SOV) zeigte sich in allen vier Experimenten eine N400, unabhängig von den Manipulationen der prosodischen Information (Experiment 1), des Objekt-Kasus (Experiment 2), der experimentellen Umgebung (Experiment 3) oder der kontextuellen Diskurs-Information (Experiment 4). Die Unveränderlichkeit dieses N400-Effekts angesichts jener Manipulationen, die deutliche Einflüsse auf die in der Scrambling-Negativierung reflektierten phrasenstrukturbezogenen Prozesse zeigten, unterstützt eine unabhängige funktionale Erklärung dieser Komponente: Basierend auf dem beobachteten Datenmuster scheint diese Art von N400, die vorläufig als *Erweiterungs-N400* bezeichnet wurde, spezifisch die Erweiterung von einer minimalen intransitiven Ereignis-Interpretation mit nur einem Teilnehmer zu einer nicht-minimalen transitiven Ereignis-Interpretation mit zwei oder mehr Teilnehmern anzuzeigen. In den vorliegenden Experimenten war eine solche interpretative Erweiterung immer dann notwendig, wenn ein zweites Argument einem initialen nominativ-markierten Argument folgte (welches bis zu diesem Zeitpunkt noch den einzigen Teilnehmer in einem intransitiven Ereignis hätte beschreiben können), jedoch nicht wenn es auf ein initiales akkusativ- oder dativ-markiertes Argument folgte (welche von vornherein ein transitives Ereignis signalisierten).

Zusammengenommen untermauern die wortstellungsbezogenen Befunde der Experimente 1–4 damit deutlich die Annahme, dass die Scrambling-Negativierung eine Verletzung der Minimality-Anforderungen auf der Phrasenstruktur-Ebene indiziert, während eine Minimality-Verletzung auf der interpretativen Ebene sich in Form einer Erweiterungs-N400 zeigt.

Die Verarbeitung von Pro-Drop-Sätzen Zur inkrementellen Verarbeitung von Sätzen mit ausgelassenen Argumenten liegen bisher kaum EKP-Studien vor, was den vergleichsweise explorativen Charakter der Experimente 3 und 4, die sich mit dieser Thematik beschäftigten, erklärt. In diesen Experimenten erzeugten Verben von Pro-Drop-Sätzen im Vergleich zu Verben von vollständigen Sätzen, in denen alle

Argumente offen ausgedrückt waren, eine breitverteilte Positivierung zwischen etwa 400 und 600 ms. Diese Komponente, welche vorläufig die Bezeichnung *Pro-Drop-Positivierung* erhielt, war sowohl in Subjekt-Drop- als auch in Objekt-Drop-Sätzen zu beobachten, wenn diese visuell und isoliert präsentiert wurden (Experiment 3). Der Effekt war allerdings deutlich reduziert, wenn die Pro-Drop-Sätze in bestimmte sprachliche Kontexte eingebettet waren (Experiment 4). Das vollständige Ergebnismuster legte eine Interpretation der Pro-Drop-Positivierung im Sinne eines diskursbezogenen EKP-Effekts nahe, der die Inferenz eines fehlenden Referenten von außerhalb des Satzes widerspiegelt. Auf diesen referentiellen Inferenzprozess scheinen weiterhin mindestens zwei Einflussfaktoren einzuwirken, nämlich (a) ob eine neuer Diskursreferent geschaffen werden muss und (b) ob andere Diskursreferenten mit dem zu inferierenden Referenten konkurrieren. Die Wirkung dieser beiden Faktoren äußerte sich in einer Reduktion der Pro-Drop-Positivierung, wenn ein bereits etablierter Referent (also ein vorerwähnter Referent oder in Subjekt-Drop-Sätzen auch der voretablierte Sprecher; Martin, 2003) ohne Konkurrenz durch andere Referenten als der fehlende Diskursreferent des Pro-Drop-Satzes inferiert werden konnte.

Die beobachtete Reduktion des Effekts bei Verfügbarkeit eines adäquaten Referenten im vorangegangenen Diskurs erinnert zum einen an Ergebnisse aus früheren Studien zu anderen Sprachen, die von ähnlichen Positivierungseffekten im Zusammenhang mit der Schaffung von neuen Diskursreferenten berichten (z.B. Deutsch: Burkhardt, 2006; Englisch: Van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991; Niederländisch: Van Berkum, Zwitserlood, Bastiaansen, Brown, & Hagoort, 2004). Zum anderen lässt sich diese Beobachtung hervorragend mit einer Anwendung des beschriebenen Minimality-Prinzips auf der Diskursebene vereinen, welche in diesem Fall umschrieben werden könnte als “Nimm stets eine minimale Diskurs-Repräsentation an” (z.B. in Form einer Vermeidung der Schaffung unnötiger Referenten). Während nicht direkt ersichtlich ist, wie eine solche Präferenz für minimale Diskurs-Repräsentationen auch den Einfluss des in Experiment 4 identifizierten zweiten Faktors (der Konkurrenz) erklären könnte, lässt sich das gesamte Ergebnismuster ableiten, wenn man die Idee mit einbezieht, dass Minimality lediglich einen Sonderfall eines generelleren Verarbeitungsprinzips namens *Distinctness* darstellt (Bornkessel-Schlesewsky & Schlesewsky, 2009, in press). Diesem Prinzip zufolge sollte eine Phrasenstruktur mit mehreren Konstituenten müheloser zu verarbeiten sein, wenn diese Konstituenten bezüglich ihrer Wortkategorie distinkt, d.h. verschieden, sind. Dasselbe gilt für Ereignis-Repräsentationen mit mehreren Teilnehmern, wenn die Teilnehmer sich möglichst deutlich in ihrer (durch Kasus, Belebtheit, Spezifität u.a. Eigenschaften bestimmten) Prominenz unterscheiden. Die Präferenz für minimale Strukturen und Ereignisse erklärt sich hierbei automatisch dadurch, dass das einzige Element in einer Repräsentation notwendigerweise auch maximal distinkt ist. Angewendet auf die Ebene der Diskurs-Repräsentation bietet das Distinctness-Prinzip eine potentielle Erklärung für die beobachteten erhöhten Verarbeitungskosten in Pro-Drop-Sätzen mit Diskurskontexten, die verschiedene ähnliche Referenten beinhalten.

Fazit Insgesamt zeigen die in der vorliegenden Dissertation zusammengefassten Ergebnisse, dass die konzeptionelle Trennung verschiedener Repräsentationsebenen eine wichtige Voraussetzung für eine sprachübergreifend gültige Erklärung von Satzverarbeitungsprozessen darstellt. Auch wenn die verschiedenen Ebenen in Sprachen wie dem Englischen eng verbunden sein mögen, ist ihr Zusammenspiel in der überwiegenden Mehrheit der Sprachen der Welt doch wesentlich flexibler. Insbesondere sprechen die hier dargestellten experimentellen Ergebnisse für eine klare Trennung der Phrasenstruktur-, Ereignis-, und Diskursebene in der theoretischen Modellierung des inkrementellen Satzverstehens. Entscheidend ist hierbei, dass eine solche Trennung nicht notwendigerweise zu einem komplexeren Modell führen muss - im Gegenteil: Es genügt die einfache Grundannahme, dass die inkrementelle Verarbeitung auf allen Repräsentationsebenen von Minimality oder dem allgemeineren Distinctness-Prinzip gesteuert wird. Das Ergebnis der Anwendung von Minimality/Distinctness wird dabei entscheidend von der jeweiligen Repräsentationsebene sowie von den spezifischen Eigenschaften der betrachteten Sprache bestimmt. Auf der Phrasenstrukturebene unterscheidet sich Japanisch beispielsweise vom Deutschen durch seine Pro-Drop-Eigenschaft, welche minimale Strukturen mit einem initialen Objekt ermöglicht. Auf der interpretativen Ereignisebene verhalten sich beide Sprachen hingegen sehr ähnlich, da ein initialer Akkusativ oder Dativ, nicht jedoch ein initialer Nominativ ein transitives Ereignis anzeigt. Auf der Diskursebene zeigen Sprecher des Japanischen eine Vorliebe für minimale Diskurs-Repräsentationen mit möglichst wenigen und distinkten Referenten, und Daten aus dem Deutschen, Englischen und Niederländischen deuten auf eine sprachübergreifende Gültigkeit dieser Präferenz hin. Zusammenfassend bietet eine Minimality/Distinctness-basierte Betrachtungsweise unter Einbezug verschiedener Repräsentationsebenen einen vielversprechenden Ansatz zur Herleitung sprachübergreifender Ähnlichkeiten und Unterschiede in den neurokognitiven Signaturen inkrementeller Satzverarbeitung.

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Paper The present dissertation investigated the mechanisms of incremental sentence processing in Japanese, a language with word order freedom (scrambling) and argument omissibility (pro-drop). To this avail, four event-related brain potential (ERP) experiments were conducted employing simple transitive sentences, with Experiments 1 and 2 investigating the influence of prosodic information and case marking on the processing of scrambled sentences, and Experiments 3 and 4 examining the processing of pro-drop sentences in isolation and embedded in linguistic contexts. The neurophysiological data pattern observed across experiments strongly suggested the separation of a phrase structural, interpretive, and discourse level of representation, with a universal processing principle called *Minimality* applying at all three levels (requiring minimal one-argument structures, minimal intransitive events with only one participant, and minimal discourse representations without redundant referents, respectively). Crucially, depending on the level of representation, violations of the Minimality principle were reflected in different kinds of independently varying ERP signatures: A one-argument phrase structure could not be maintained whenever an initial object signaled a scrambled (OSV) sentence, engendering a *scrambling negativity* in comparison to initial subjects as a result. If, however, the prosodic information or the case marking on the initial object allowed an alternative one-argument (subject-drop, OV) reading of the sentence, no such effect was observable. Regardless of prosodic or case marking information, an *N400* always arose at the position of the second argument of canonical (SOV) sentences in comparison to scrambled (OSV) sentences, reflecting the extension from an intransitive to a transitive event interpretation that became necessary at this position. Finally, at the discourse level, Minimality effects became evident in the variations of a *positivity effect* arising at the position of the verb of subject-drop (OV) and object-drop (SV) sentences in comparison to canonical complete (SOV) sentences. This component, which was taken to reflect the inference of the missing discourse referent from outside the sentence, was particularly pronounced when a new discourse referent needed to be established, i.e. when the pro-drop sentence was presented

in isolation or when the preceding context did not provide a suitable referent. An additional sensitivity of the positivity effect to the amount of referential competition further supported a conceptualization of Minimality as a subcase of a more general processing principle calling for maximally distinct representations at all three levels. In sum, the present findings suggest that a Minimality/Distinctness based account incorporating several levels of representation qualifies as a promising approach to deriving the neurocognitive signatures of incremental sentence comprehension across languages.

Curriculum Vitae

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