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The Argument Dependency Model:
A Neurocognitive Approach to Incremental Interpretation

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Necessity is that in virtue of which it is
impossible that one can be otherwise.

James Joyce, Ulysses

Introduction

Language is not comprehended in a clause-by-clause fashion, but rather on the basis of much smaller constituents. This rather consistent psycho-linguistic finding, though befitting the intuitions of comprehenders with regard to their native tongue, may seem quite surprising when the complex internal structure of a linguistic input is taken into consideration. Hence, the question of how incremental comprehension is achieved is central to an understanding of language processing architecture.

One of the most basic prerequisites for the interpretation of a linguistic input in general, and hence also for incremental interpretation, is that the linguistic material being processed must be assigned an internal structure. The most well-known and best examined means of achieving this type of structuring relies on *syntactic* information, i.e. on information determining the hierarchical and functional dependencies between constituents on a purely formal level. For example, in the English sentence *Amanda visited Steve*, it is the relative positioning of the two arguments *Amanda* and *Steve* that determines who is the 'visiter' (i.e. *Amanda*) and who the 'visitee' (i.e. *Steve*). In this way, the hierarchical (syntactic) relations between the two arguments of the sentence may be mapped onto a semantic representation, where they then determine "who is doing what to whom" in the event denoted by the verb. Since it is well established that syntactic structure is built up incrementally during parsing (e.g. Crocker, 1994; Stabler, 1994), a basic level of interpretation may also be attained incrementally with reference to this structure.

The aim of this thesis is to present a model of argument processing in which syntactic information provides but one of two possible processing pathways by which the hierarchical internal structure required for the interpretation of a linguistic input may be established. In contrast to syntactic processing, the second processing pathway to be assumed here will be shown to be entirely non-syntactic in nature. Rather, it operates upon *morphological* information in order to establish an alternative form of hierarchical structure on the basis of *thematic* dependencies. In this way, we will argue that syntactic and thematic dependencies are generally not built up simultaneously during argument processing, but rather that, following initial processes of word

category identification and structuring into constituents, the human sentence processor selects one or the other 'processing route' on the basis of the information available to it at a given time during parsing. Specifically, access to the thematic route is possible when the arguments of a sentence bear unambiguous morphological case marking. If this is not the case, processing must proceed via the syntactic route. We will refer to this dual pathway approach to sentence comprehension as the 'argument dependency processing model'.

Why should sentence comprehension be so redundant as to require two processing pathways that function in a similar manner but operate on different types of linguistic structures? Firstly, there are clear advantages associated with the processing of morphologically case marked structures, in particular the fact that, as we will show, this type of morphological marking provides a more direct means of arriving at an interpretable form than is offered by syntactic information. In other words, morphological case will be considered much more than an overt spell-out of the features associated with particular structural positions, since it crucially provides more information than is derivable from structural properties alone. However, these advantages of morphological case marking cannot be capitalised upon at all times for the simple reason that, even in case marking languages, unambiguous morphological marking is not always available. Thus, in these cases, an alternative means of processing must be accessible, i.e. the syntactic processing route. In this way, the argument dependency model is able to derive processing behaviour for languages with and without morphological case marking in a unified manner.

This thesis is essentially divided into two parts. The first of these, comprising Chapters 1 to 3, introduces the argument dependency model and describes the broader theoretical and neurocognitive frameworks into which it is embedded. In Chapter 1, the theoretical prerequisites of the model are described (section 1.1), before the model itself is introduced (section 1.2). Alternative approaches to the processing of thematic information are discussed in relation to the present proposal in Chapter 2. Chapter 3 outlines the experimental methods that will be employed to empirically test the model's claims (section 3.1), presents existing experimental findings which provide preliminary support for the model (section 3.2), and discusses how the model may be integrated into a neurophysiological processing perspective. The second part of the thesis is empirical in nature. Firstly, four

experiments in support of the model's formulation (Chapters 4 and 5) will be reported. These findings will be summarised and incorporated into a more elaborate version of the argument dependency model in Chapter 6. Several predictions formulated on the basis of this revised model will then be tested in two further experiments (Chapters 7 and 8). Finally, Chapter 9 provides a discussion of the experimental findings reported here in the context of the argument dependency model and outlines the psycholinguistic and theoretical consequences arising from the model's formulation.

Chapter 1
The Argument Dependency Processing Model

In this chapter, a model of argument processing will be introduced which assumes that incremental interpretation of obligatory sentential constituents – with the exception of verbs – may be achieved via two alternative processing pathways, namely a syntactic processing pathway and a thematic processing pathway. Both processing routes operate with the aim of establishing hierarchical dependencies between the arguments of a sentence, which may then be mapped onto a semantic representation in order to determine "who is doing what to whom" in the sentence currently being processed. Which of the two processing routes is chosen depends on the morphological case marking borne by an argument: if the argument is unambiguously case marked, it activates the thematic processing route, whereas if it is not unambiguously case marked, it is processed via the syntactic route.

While the processing mechanisms constituting the syntactic route within this "argument dependency processing model" are straightforward and comply with standard views of syntactic processing within the psycholinguistic literature, the conception of thematic processing to be presented here is rather more novel. In view of this, we will firstly provide a detailed discussion of the theoretical concepts underlying the perspective on thematic relations to be assumed here (section 1.1), before turning to a description of the model itself (section 1.2).

1.1 Theoretical prerequisites

Typically, thematic information is thought to provide a general conceptual specification of the relations between the arguments of a sentence and between the arguments and the verb. In the sentence *John kissed Barbara*, for example, *John* is the initiator of the kissing-event (the "Agent"; cf., for example, Jackendoff, 1972) and *Barbara* is the undergoer of this event (the "Patient" or "Theme"). In contrast to the elaborate semantic representation of an individual verb, thematic information generalises over a number of verbs (e.g. *hit* and *kill* both require an Agent and a Patient role, despite the fact that the semantics of these two verbs is different).

In accordance with several proposals in the literature (Dowty, 1991; Foley & Van Valin, 1984; Kibrik, 1985,1987; Primus, 1999; Van Valin, 1999; Van Valin & La Polla, 1997), the approach pursued here assumes that thematic roles may be viewed as prototypes, i.e. cluster concepts rather than discrete categories (cf. Rosch & Mervis, 1975). From this perspective, the intuitive difference between thematic roles such as Agent and Causer (cf. Grimshaw, 1990), for example, need not be expressed by assigning arguments qualitatively different thematic roles, but rather by associating them to different degrees with generalised roles or 'proto-roles' such as Proto-Agent and Proto-Patient. In this way, many of the problems associated with traditional individual thematic role labels may be circumvented (Dowty, 1991; but cf. Dürscheid, 1999, for a discussion of proto-role disadvantages).

Thematic proto-roles are defined as sets of entailments of a class of predicates with respect to one of its argument types. These entailments make reference to particular properties that an argument bears in relation to the predicate and the gradient nature of the association between an argument and a particular proto-role is accounted for by the fact that not all of the entailments contributing to this proto-role need apply to an argument in order for that argument to be associated with it.

The present processing assumptions are based on Primus' (1999) version of the proto-role approach. In contrast to Dowty (1991), Primus assumes three proto-roles, namely Proto-Agent, Proto-Patient, and Proto-Recipient. Furthermore, her definition of these proto-roles is more general than Dowty's in that it relies less on individual defining properties for each role, but rather on the dependency relations between roles. In the following we will firstly focus on Primus' characterisations of the three proto-roles, before turning to the dependency relations between these roles and the relationship between thematic structure, morphological case marking and basic word order.

Proto-Agent

Primus captures the Proto-Agent role in terms of entailments of the control relation, as principle (1) states.

(1) *Defining entailments for Proto-Agent*
The basic thematic relations defining the set of Proto-Agent relations are unilateral entailments of the control relation or of the prototypical control relation. (Primus, 1999: 51)

This definition of the Proto-Agent role is more general than that given by Dowty, who assumes discrete defining properties such as volition, sentience, etc. The most general entailment of the control relation given by Primus is shown in (2).

(2) $\forall x[\text{CONTROL}(x, \ldots) \rightarrow \text{CAUSE}(x, \ldots)]$ (Primus, 1999: 49)

As the entailment in (2) states, the most basic property of a controlling participant is that this participant *causes* the event denoted by the verb. Thus, causation is also a basic prerequisite for a Proto-Agent. Beyond the simple control-relation, Primus also assumes what she refers to as 'prototypical control' (P-CONTROL). The entailments of this relation, which are shown in (3), are desirable properties for an ideal Proto-Agent.

(3) a. $\forall x[\text{P-CONTROL}(x, \ldots) \rightarrow \text{EXPER}(x, \ldots)]$
b. $\forall x[\text{P-CONTROL}(x, \ldots) \rightarrow \text{MOVE}(x, \ldots)]$
c. $\forall x[\text{P-CONTROL}(x, \ldots) \rightarrow \text{ANIMATE}(x)]$
(Primus, 1999: 50)

Thus, apart from causing an event, an ideal Proto-Agent is also compatible with the properties in (3). The first of these, sentience (3a), is considered a necessary aspect of volition by both Primus (1999) and Dowty (1991). The second entailment (3b) states that prototypical control also involves physical activity on the part of the Proto-Agent (i.e. Primus (1999:50) cites verbs such as *laugh, work, walk, write, talk* and *hit* as unmarked in relation to (3b), whereas verbs such as *abstain from* and *refrain from* are marked). Finally, as (3c) states, an ideal Proto-Agent is animate.

Proto-Patient

Primus notes that all of the basic relations for the Proto-Patient role imply that the Proto-Patient argument is thematically dependent on another argument. Thus, a causally affected participant implies that the predicate also selects a causing participant, a stimulus implies the presence of an

experiencer, and a possessed participant implies a possessor. From these observations, she concludes “that Proto-Agents and Proto-Patients are not distinguished by different basic thematic relations, but only by their dependency relative to one another” (Primus, 1999:52). This is captured by the principle in (4).

(4) *Thematic Dependencies and Proto-Role Assignments*
For any basic thematic predicate PRED(x,y), the participant y or any participant embedded in y is thematically dependent on the participant x or the participant embedded in x.
Any participant with the properties mentioned for x is Proto-Agent and any participant with the properties mentioned for y is Proto-Patient in PRED(x,y).
(Primus, 1999:52)

Principle (4) is of crucial importance for the processing model that will be described in the next section, since it makes clear that proto-role assignments in the sense of Primus are *not* the result of determining which argument accumulates the highest number of defining properties for a particular proto-role (e.g. Proto-Agent). Rather, which proto-role an argument is assigned simply depends on the relation of that argument to the other participants involved in the event being described.

Proto-Recipient

In contrast to Dowty (1991) and other generalised role approaches (cf. Van Valin, 1999), Primus (1999) assumes a third proto-role, the Proto-Recipient. This role shares characteristics with both the Proto-Agent role and the Proto-Patient role, as the following examples illustrate.

(5) a. Peter gave Mary an apple.
$\forall x \forall y \forall z$[GIVE(x,y,z) $\rightarrow$ P-CONTROL(x, BECOME(POSS(y,z)))]

b. Peter told Mary a secret.
$\forall x \forall y \forall z$[TELL(x,y,z) $\rightarrow$ P-CONTROL(x, BECOME(EXPER(y,z)))]

In terms of the thematic dependency relation, the Proto-Recipient in (5a/b) is dependent on the Proto-Agent, since it surfaces as an argument of a thematic predicate which is embedded in the thematic representation of the

second participant of a higher thematic predicate (as is also the case for Proto-Patients). In contrast to Proto-Patients, however, Proto-Recipients are also the *first* arguments of a predicate (as is also the case for Proto-Agents). Thus, Proto-Recipients pattern with Proto-Patients in that they are thematically dependent on another argument (i.e. the Proto-Agent), but with Proto-Agents in that there may be another argument dependent on them (i.e. the Proto-Patient). Thus, again, only the hierarchical relations between participants are of importance for determining which proto-role will be assigned to which argument.

The Thematic Hierarchy

As outlined above, Proto-Patients are thematically dependent on Proto-Agents and Proto-Recipients, and Proto-Recipients are thematically dependent on Proto-Agents. Thus, on the basis of these thematic dependencies between the three proto-roles, we arrive at the general thematic hierarchy shown in (6).

(6) *The Thematic Hierarchy*
Proto-Agent $<_\theta$ Proto-Recipient $<_\theta$ Proto-Patient
(Primus, 1999:55)

The thematic hierarchy shown in (6) is assumed to be universal, since the thematic dependencies on which it is based should also hold universally.[1] Thus, this hierarchy provides a general means of establishing hierarchical dependencies between arguments that is entirely independent of syntactic structure.

Mapping Morphosyntactic Coding Categories onto Thematic Proto-Roles

In view of the processing model to be introduced below, it is important to consider how arguments may be mapped onto thematic proto-roles, since in many cases the full set of thematic entailments derivable from the predicate will not be available when parsing decisions need to be made. In particular, we will focus on verb-final sentences in German, in which all of the

[1] Interestingly, this thematic hierarchy defined on the basis of thematic dependencies is very similar to other proposed versions of the thematic hierarchy which were formulated on other grounds (e.g. Bresnan & Kanerva, 1989; Givón, 1984; Grimshaw, 1990; Jackendoff, 1972).

arguments occur before the verb. Thus, which conclusions can be drawn on the basis of the arguments alone will be crucial to determining how processing proceeds (cf. Bornkessel, Schlesewsky, & Friederici, *to appear*; Frisch & Schlesewsky, 2001). In this regard, Primus essentially focuses on two functional aspects of linguistic information, namely morphological coding (e.g. morphological case marking) and basic word order. Whereas she considers the former to be a reflection of the number of proto-role entailments compatible with a particular argument, she derives the latter in terms of the thematic dependencies between the arguments. We will consider both aspects in turn in the following.

In accordance with her 'Principle of Morphosyntactic Expression of Thematic Information' (Primus, 1999:61), Primus assumes a close link between case marking and thematic relations. In particular, the principle states that an argument is more likely to bear the most unmarked case in a given language the more Proto-Agent dependencies it accumulates, and that it is more likely to bear the second most unmarked case the more Proto-Patient dependency relations it accumulates. Markedness of particular cases is determined, for example, by subcategorisation asymmetries of predicates and the complexity of morphological realisation for individual cases, thus resulting in the case hierarchy shown in (7).

(7) The Case Hierarchy
nominative/absolutive < accusative/ergative < dative < other oblique cases
(Primus, 1999:18)

In this way, in a nominative-accusative language such as German, a basic transitive relation (i.e. a relation in which the subject accumulates a high number of Proto-Agent dependency relations and the object accumulates a high number of Proto-Patient dependency relations) will involve a nominative-marked argument (the Proto-Agent) and an accusative-marked argument (the Proto-Patient). This case marking pattern ensures maximal distinctness between the two arguments in terms of thematic properties. A dative argument, by contrast, always indicates a marked transitive relation in terms of thematic properties, since this case marking may be borne neither by ideal Proto-Patients nor by ideal Proto-Agents.

With regard to the second relevant type of functional information, Primus assumes that basic word order patterns are a result of thematic dependencies. Thus, if an argument B is thematically dependent on a second argument A, then A will be structurally superior to B in an unmarked sentence, whereby structural superiority is defined in terms of asymmetric c-command[2] and/or linear precedence (Primus' 'Principle of Structural Expression of Thematic Dependencies'; Primus, 1999:136).

Processing Consequences of Primus' Approach

As briefly outlined in the Introduction, a prerequisite for the interpretation of a sentence is that the participants in the event expressed by the predicate (i.e. the sentential arguments, for present purposes) must be hierarchically structured, for otherwise it will not be possible to establish "who is doing what to whom" within the semantic representation of the verb. Classically, the establishment of hierarchical dependencies has been considered a syntactic domain. Thus, even those approaches assuming a considerable influence of thematic information on parsing generally consider thematic roles as mediating between syntactic information and various interpretationally relevant information sources (e.g. semantics, discourse, world knowledge; cf. Chapter 2) and thus syntactic information remains crucial with regard to the sentence-internal organisation of obligatory constituents.

However, the discussion above has shown that there is also a second way of establishing this type of argument hierarchy, namely by means of the thematic proto-role relations, or, more specifically, the thematic dependencies between the arguments of a sentence. In particular, with regard to morphologically case-marking languages such as German, Primus' (1999) universal hierarchies approach predicts that the morphological case borne by an argument should be rather informative with regard to the thematic status of an argument. Consider, for example, the

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[2] C-command (Haegeman, 1994:134)
Node A c-commands node B if and only if
(i) A does not dominate B and B does not dominate A; and
(ii) the first branching node dominating A also dominates B.

Asymmetric c-command obtains if A c-commands B and B does not c-command A.

generalisations that may be derived for the three core cases of German (nominative, accusative, and dative), which are shown in (8).

(8) a. *Nominative expresses an ideal Proto-Agent*

Ich zerbrach den Zaun absichtlich. (Primus, 1999:64)
I_{NOM} broke [the fence]$_{ACC}$ deliberately.
'I deliberately broke the fence'

b. *Dative may express a Proto-Agent, but it cannot express ideal control*

(i) Mir zerbrach der Zaun. (Primus, 1999:64)
I_{DAT} broke the fence
~'The fence broke on me'

(ii) *Mir zerbrach der Zaun absichtlich. (Primus, 1999:64)
I_{DAT} broke [the fence]$_{NOM}$ deliberately.
~'The fence deliberately broke on me'

c. Accusative cannot express a Proto-Agent

*Mich zerbrach der Zaun.
I_{ACC} broke the fence
(in the sense of 'the fence broke (on me)')

The examples in (8) illustrate the interpretative differences between nominative, dative and accusative case in German. Thus, both nominative and dative may realise a Proto-Agent (i.e. an argument that is highest-ranked thematically in a transitive relation), as (8a) and (8bi) show. However, only nominative marking is compatible with a Proto-Agent argument that is consciously in control of the event expressed by the predicate, as the contrast between (8a) and (8bii), in which the adverb *absichtlich* ('deliberately') forces such a reading, shows. Furthermore, the dative-nominative case marking pattern in (8bi) shows that nominative case marking is not only compatible with a Proto-Agent status, but may also express a thematically dependent argument. Finally, the ungrammaticality of (8c) – at least with regard to a reading in which it is the fence that breaks – demonstrates that, in contrast to the dative, the accusative is not compatible

with a Proto-Agent thematic status.[3] Thus, the generalisations illustrated above show that a great deal of thematically-relevant information may be derived in languages such as German exclusively by examining the morphological case borne by an argument. Furthermore, since morphological case marking is *not* a morphological spell-out of a particular structural position, but rather an independent type of information in Primus' (1999) approach, this observation indicates that interpretationally-relevant relations may be derived during language processing *without* necessarily having to make reference to the syntactic structure of a sentence.

1.2 A dependency-based model of argument processing

In this section, we will introduce a processing model which capitalises upon the properties of morphological marking and its relation to thematic information discussed above. Note, however, that the scope of this model is at present confined to the processing of obligatory constituents, with a particular focus on the processing of arguments in the absence of verb information. Firstly, the basic architecture of the model will be outlined, before more specific aspects are discussed

1.2.1 Basic architecture

As shown above, morphological case marking provides a means of establishing hierarchical dependencies between arguments without making reference to analogous syntactic dependencies. On the basis of this observation, the argument dependency model assumes that arguments bearing unambiguous morphological case-marking may be processed independently of all but the most basic syntactic information. Rather, morphological case activates a thematic-dependency based processing route, which provides an alternative means to syntactic structure of establishing hierarchical dependencies between arguments. However, since the possibility of establishing hierarchical thematic dependencies requires

[3] Further evidence for this difference between dative and accusative case is provided by the properties of object-experiencer verbs in German: only dative object-experiencers require a "true" experiencer reading in which the dative argument is thematically higher ranked than the nominative, whereas accusative object-experiencers also allow a causative reading in which the nominative Causer is thematically higher than the accusative Experiencer (e.g. Fanselow, 2000; Primus, 1999; Wunderlich, 1997; cf. also Chapter 7).

unambiguous morphological case marking, an argument that is not unambiguously case marked must be processed via a syntactic processing 'route' in order for hierarchical relations to be built up and, thereby, for incremental interpretation to be made possible. The basic processing architecture of the model is shown in Figure 1.

Figure 1. Basic assumptions of the argument dependency model's processing architecture.

As Figure 1 shows, the choice between the syntactic and the thematic processing routes is made after (a) very basic syntactic processing such as word-category analysis and assignment of basic constituent structure, and (b) morphological analysis have taken place. Whereas the former may be envisaged as determining the word category of each input item and structuring the input into basic constituents, the latter determines the morphological status of the constituent currently being processed and is thereby a necessary prerequisite for deciding which of the two routes should be pursued for further processing. In the following, we shall outline the specific processing assumptions for the thematic and syntactic processing routes in turn.

1.2.2 Thematic processing

The operations performed by the 'thematic processor' to be proposed here essentially involve manipulating hierarchical structure. Hence, the basic functioning of the thematic processing route is virtually analogous to that of a standard syntactic parser, which of course also operates on hierarchically structured constituents. Thus, the parser to be outlined below will strike the reader as very similar to the types of parsing mechanisms typically assumed

within psycholinguistics (e.g. Altmann & Steedman, 1988; Crocker, 1994; Fodor, 1995; Frazier, 1978; Frazier & Rayner, 1982; Gorrell, 1995; Mitchell, 1994; Tanenhaus, Carlson, & Trueswell, 1989), though operating upon a different type of linguistic structure. Before formulating specific processing principles for the thematic route of the model, we shall firstly outline several basic assumptions with regard to how thematic dependencies may be built up incrementally. In this way, we will undertake certain simplifications with regard to Primus' approach and introduce a new terminology as to ensure maximal clarity.

As described above, the present model assumes that the primary importance of thematic processing lies in its ability to establish hierarchical dependencies between arguments. Thus, rather than referring to proto-roles such as Proto-Agent, which by their very name suggest interpretable content beyond the hierarchical dependencies with which the argument is associated, we will employ the term 'thematic argument status' to differentiate between arguments that are not dependent on another argument or on which another argument is dependent (arguments with a 'non-dependent status') and arguments which are dependent on at least one other argument ('dependent status'). This difference will be coded by means of the feature [dep] ('dependence') such that a Proto-Agent is coded by [+dep], a Proto-Patient by [-dep], and a Proto-Recipient by [±dep]. For example, the arguments in a sentence such as (9a), will be assigned the thematic representation in (9b).

(9) a. Gestern hat der Betrüger dem Geschäftsmann einen Plan
yesterday has [the impostor]$_{NOM}$ [the businessman]$_{DAT}$ [a plan]$_{ACC}$
vorgeschlagen.
proposed
'Yesterday, the impostor proposed a plan to the businessman.'

b. ARG1-NOM$_{[-DEP]}$ ARG2-DAT$_{[\pm DEP]}$ ARG3-ACC$_{[+DEP]}$

However, beyond these simple dependency relations we must also differentiate between arguments which are ideal instantiations of their respective thematic status and those which are non-ideal instantiations. This difference is illustrated in the following example, which is adapted from Primus (1999:64).

(10) a. Der Gärtner zerbrach den Zaun (absichtlich).
[the gardener]$_{NOM}$ broke [the fence]$_{ACC}$ (deliberately)
'The gardener (deliberately) broke the fence.'

b. Der Stein zerbrach den Zaun ($^{??}$absichtlich).
[the stone]$_{NOM}$ broke [the fence]$_{ACC}$ (deliberately)
'The stone (deliberately) broke the fence.'

The oddness of sentence (10b) with the adverb *absichtlich* ('deliberately') shows that, although a nominative-marked argument may always realise an argument marked [-dep], a [-dep] argument should, ideally, also be animate, since animacy is a prerequisite for conscious control over the event described by the predicate. Recall from section 1.1 that Primus also assumes P-CONTROL to entail animacy. Hence, it appears that the [±animate] distinction is relevant to arguments with a non-dependent thematic status only (i.e. arguments marked [-dep] or [±dep]), since there can be no analogous entailment with regard to the (in)animacy of arguments marked [+dep] (i.e. Proto-Patients in Primus' terminology). It follows, therefore, that ideal instantiations of the thematic statuses [-dep] and [±dep] are also animate ([+anim]).

1.2.3 Syntactic processing

Since syntactic processing is well-examined and described in the psycholinguistic literature, we shall focus only very briefly on the syntactic processing route proposed as part of the argument dependency model. However, several important qualifications in this regard will be discussed briefly in the following.

As for the thematic processing route, the syntactic processing route in the argument dependency model, i.e. the part of syntactic processing that takes place alternatively to thematic processing, also applies to obligatory constituents only and is particularly concerned with the processing of arguments. This basic assumption is compatible with proposals in the literature that a constituent is preferably interpreted as an argument rather than an adjunct (e.g. Crocker, 1991; Frazier & Clifton, 1996) and that only arguments are immediately integrated into a syntactic position (Frazier & Clifton, 1996).

A precise characterisation of how arguments are processed by the syntactic route also relies on the notion of dependency, although the dependencies that are important here are *syntactic* rather than thematic in nature and thereby differ from the dependencies described for the thematic processing route above. In contrast to thematic dependencies, these syntactic dependencies can be envisaged as similar to syntactic predictions in the sense of Gibson (1998). Thus, since a sentence must typically, i.e. in most languages, consist of at least a subject and a finite verb in order to be well-formed, a subject is dependent on a finite verb and an object is in turn dependent on a subject. From this assumption, many of the 'minimal structure building' principles that have been proposed in the literature (e.g. Frazier, 1978; Frazier & Rayner, 1982; de Vincenzi, 1991; Gibson, 1998; Schlesewsky & Friederici, *to appear*) may be derived. In this way, the syntactic processing behaviour of the argument dependency model will essentially be a consequence of the principle "Avoid unnecessary dependencies".

As for the thematic processing route, it is assumed that the syntactic processing route establishes a hierarchically structured linguistic input, thereby enabling semantic interpretation to take place. To this purpose, we will adopt the standard assumption that "X hierarchically dominates Y" in syntactic terms corresponds to "X c-commands Y" (cf. Footnote 2).[4] Thus, we will assume that syntactic structure is built up incrementally, thereby establishing the hierarchical relations between obligatory constituents required for interpretation

1.2.4 Processing principles and their application

Having discussed the basic assumptions for the thematic and the syntactic processing routes, let us now discuss in detail how processing takes place on each of these two pathways. The specific processing principles assumed are shown in Table 1.

[4] An exception is provided by Gorrell's (1995) approach, in which both dominance and precedence are assumed to play a role during parsing. On the other hand, the distinction between dominance and precedence may be superfluous, since recent proposals in theoretical syntax assume a mapping from asymmetric c-command to linear precedence Kayne (1994).

Principle	Thematic	Syntactic
Economy	The first argument is assigned the status [-dep] if at all possible	An argument is associated with the grammatical function compatible with the least number of syntactic dependencies
Dependency	For any two arguments A and B, either A must hierarchically dominate B in terms of thematic status, or B must dominate A	For any two arguments A and B, either A must c-command B or B must c-command A
Distinctness	For relations consisting of ≥ 2 arguments, each argument must be maximally distinct from every other argument in terms of thematic status	For any two arguments A and B, either A must *asymmetrically* c-command B or B must *asymmetrically* c-command A

Table 1. Processing principles for the thematic and syntactic processing routes in the argument dependency model.

Importantly, the essence of each of the three processing principles is very similar for both processing routes, thus underlining the assumption that thematic processing in the sense envisaged here functions in a similar manner as syntactic processing, although it operates upon a different type of linguistic structure. In this way, the *Economy* principle states that, in both thematic and syntactic processing, the thematic status/grammatical function of an argument should preferably be assigned in such a way as to minimise the number of dependencies that are created. This principle is therefore compatible with the minimality principles generally assumed in the psycholinguistic literature (see above). The second principle, *Dependency*, captures the idea that sentential arguments must be structured hierarchically – be it in a thematic or a syntactic manner – in order for interpretation to be able to take place.[5] Finally, the *Distinctness* principle states that any two arguments should always be maximally different from one another in terms of thematic status, i.e. the two arguments in a transitive relation will always be marked [-dep] and [+dep], never [-dep] and [±dep].

With regard to syntactic processing, *Distinctness* requires that arguments should be in a relationship of asymmetric c-command to one another. Note that all reference to grammatical functions with regard to the syntactic route may plausibly be replaced with references to particular cases (e.g. nominative rather than subject) for case-marking languages such as German. Referring to morphological case in a syntactic sense does not contradict the assumption that morphological case directly maps onto a restricted set of possible thematic statuses, since the dual (i.e. thematic and syntactic) nature of morphological case has been argued for on the basis of a number of experimental studies (e.g. Frisch & Schlesewsky, 2001, *submitted*) and also from a variety of theoretical perspectives (e.g. Neeleman & Weerman, 1998; Primus, 1999). We refer to grammatical functions here in order to also allow for an application of the processing principles to languages such as English, thereby ensuring maximal generality.

In addition to the main principles stated in Table 1, the thematic processing route of the model also requires a small number of more specific principles

[5] Similar principles are assumed by many theoretical approaches, often under names such as 'Uniqueness' (e.g. Wunderlich, 1997).

with regard to the mapping of cases to thematic statuses. These are given in (11) for German.

(11) *Thematic Mapping Principles for German*

(i) In the absence of explicit (verb-specific) information to the contrary, NOM [+anim] must be assigned [-dep]

(ii) ACC is not compatible with [-dep]

The principles in (11) essentially capture the generalisations with regard to morphological cases and their thematic interpretations following from Primus' (1999) approach (cf. section 1.1). Thus, an animate, nominative-marked argument instantiates an ideal [-dep] argument and therefore takes precedence over all other arguments (e.g. datives) with regard to [-dep] assignment. Accusative-marked arguments, by contrast, are always thematically dependent and can therefore never be assigned [-dep]. Although these mapping principles are stated as language-specific for German in (11), it is highly likely that they generalise at least to other languages with a nominative-accusative case-marking system.

In the following, the application of the principles introduced above will be illustrated on the basis of several examples. Consider firstly a straightforward case, in which a nominative-marked argument precedes an accusative-marked argument in a transitive relation.

(12) Maria glaubt, dass der Junge den Großvater besucht.
Maria believes that [the boy]$_{NOM}$ [the grandfather]$_{ACC}$ visits
'Maria believes that the boy visits the grandfather.'

On the basis of its nominative case marking, the first argument *der Junge* ('the boy') is processed via the thematic route, in which it is assigned the feature [-dep]. Since this argument also bears the feature [+anim], it is an ideal instantiation of a [-dep] argument. When the second argument is processed, its accusative case marking determines the [+dep] assignment, thus establishing a hierarchical thematic dependency between the two arguments: Arg1 $>\theta$ Arg2 (i.e. Arg1 thematically dominates Arg2 and Arg2 is therefore thematically dependent on Arg1). The thematic representation established in this way may thus be mapped onto a semantic representation

such that the higher-ranked argument (Arg1; *der Junge*) is associated with the higher-ranked argument in the lexical entry of the verb, and the lower-ranked argument (Arg2; *der Großvater*) is associated with the lower-ranked argument in the verb's lexical representation. Thus, informally stated, the nominative-marked argument is interpreted as the visitor, and the accusative-marked argument as the person being visited.

A more complex example is shown in (13).

(13) Maria glaubt, dass dem Jungen der Clown gefällt.
Maria believes that [the boy]$_{DAT}$ [the clown]$_{NOM}$ pleases
'Maria believes that the clown is appealing to the boy.'

Here, the (initial) dative-marked argument *dem Jungen* ('the boy') is assigned the status [-dep] on the basis of the *Economy* principle. However, when the second argument *der Clown* ('the clown') is processed, mapping principle (i) for German states that this argument should be marked [-dep], since it is both nominative and animate. Thus, since by *Dependency* only one argument may bear the [-dep] status, the status of the first argument must be reassigned to [+dep]; a [±dep] assignment is not possible here, since *Distinctness* requires that the two arguments be maximally different from one another.[6] Crucially, this hierarchical ranking with Arg2 >θ Arg1 can only be maintained until the verb is processed, since *gefallen* ('to be appealing to') is an object-experiencer verb, which requires that the dative-marked argument must thematically dominate the nominative-marked argument. Thus, the thematic statuses of the two arguments must again be interchanged, with the final representation - which is mapped onto the semantic structure - then being Arg1 >θ Arg2 (i.e. dative >θ nominative).
Before considering examples involving ambiguous case marking, let us briefly discuss a ditransitive example to illustrate the assignment of [±dep]. To this purpose, the example in (9) above is repeated here as (14).

[6] Note that these assumptions imply that there will be an initial preference for a transitive structure in ditransitive clauses such as (9). Evidence in support of this view stems from a study showing that the assignment of a dative to an ambiguous object in a clause medial position is not costly in German (Scheepers, Hemforth, & Konieczny, 1998), as would be expected if [±dep] were initially assigned. With regard to ditransitive structures, we assume that the reassignment of [±dep] to the dative argument is not costly, since it does not require a change in the hierarchical relations between arguments established so far, i.e. in the hierarchy Arg1 >θ Arg2 (cf. Chapter 3.2).

(14) a. Gestern hat der Betrüger dem Geschäftsmann einen Plan
yesterday has [the impostor]$_{NOM}$ [the businessman]$_{DAT}$ [a plan]$_{ACC}$
vorgeschlagen.
proposed
'Yesterday, the impostor proposed a plan to the businessman.'

As in the examples discussed above, the initial nominative noun phrase in (14) is assigned [-dep] on the basis of *Economy*. Yet it is the next processing step that is of particular interest for this example: when the dative argument is encountered, it is assigned [+dep], rather than [±dep], in accordance with the *Distinctness* principle. Thus, when the accusative argument, which must be assigned [+dep], is encountered, a reassignment of [±dep] to the dative takes place. This reassignment should not be costly since it does not involve a change in the hierarchical thematic structure previously established (cf. Chapter 3.2 and Footnote 6).

Although the application of the syntactic processing route is straightforward and certainly does not involve any novel proposals, its application shall be illustrated by means of the following example.

(15) Klaus weiß, dass Maria Geigerinnen zuhört /zuhören.
Klaus knows that Maria$_{NOM/ACC/DAT.SG}$ violinists$_{NOM/ACC/DAT.PL}$
listens-to$_{SG/PL}$
'Klaus knows that Maria listens to violinists.'/
'Klaus knows that violinists listen to Maria.'

In (15), both arguments are three-way ambiguous between nominative, accusative and dative case. Thus, processing must take place along the syntactic route. In accordance with the syntactic form of *Economy*, the first argument, *Maria*, is assigned the subject grammatical function. On the basis of *Distinctness*, the second argument, *Geigerinnen* ('violinists') is assigned the direct object grammatical function. If the clause final verb is singular (*zuhört*, 'listens to'), these assignments are confirmed; but if the sentence is concluded by a plural verb (*zuhören,* 'listen to'), they must be reversed, thus giving rise to a syntactic reanalysis in the standard sense (cf. Fodor & Ferreira, 1998, for an overview).

Finally, let us turn to the question of how the two processing routes interact. Since it is the presence or absence of unambiguous morphological case marking that determines which processing route will be applied at which point during processing, the interaction of both processing pathways may be observed in sentences with both unambiguously case marked and ambiguously case marked arguments such as (16).

(16) a. Gestern hat der Direktor die Schauspielerin eingeladen.
yesterday has [the director]$_{NOM}$ [the actress]$_{NOM/ACC}$ invited
'Yesterday, the director invited the actress.'

b. Gestern hat die Schauspielerin der Direktor eingeladen.
yesterday has [the actress]$_{NOM/ACC}$ [the director]$_{NOM}$ invited
'Yesterday, the actress invited the director.'

Examples such as (16a) are relatively straightforward. Clearly, the first argument is processed thematically on the basis of its nominative marking and is thus assigned [-dep]. When the second argument is encountered, it may be assigned [+dep] despite its ambiguous case marking, since the properties of this argument cannot contradict the assignment of [-dep] to the first argument under any possible resolution of the ambiguity.

The reverse case, i.e. a sentence in which the first argument is case ambiguous and the second argument is unambiguously case marked, is illustrated in (16b). In accordance with our discussion of example (15) above, the initial argument in (16b) will be processed syntactically and therefore assigned the subject grammatical function. However, the processing of the second argument initiates processing on the thematic route by way of its unambiguous case marking. Clearly, this argument should be assigned [-dep] on the basis of its nominative case marking, yet since the input to the thematic processing route at this point includes a representation of the basic constituents having been processed so far, it is immediately apparent that the nominative-marked noun phrase is not the first argument to have been processed. Thus, a processing conflict between the thematic *Economy* principle (requiring that the *first* argument be assigned the status [-dep]) and the thematic mapping principle (11i) (requiring that an animate, nominative-marked argument be assigned [-dep]) arises. Since no overt thematic assignments have as yet been made, this conflict is resolved in favour of the mapping principle and the second

argument is marked [-dep]. On the basis of the 'thematic anchoring point' thus established, the first argument may now be put into a hierarchical thematic relation to the second argument: more specifically, it is assigned [+dep] in a similar manner as was the case for the second argument in example (16a). In this way, the syntactic processing route may be abandoned and processing continues on the thematic pathway.

In summary, with regard to the interaction between the thematic and the syntactic processing routes, we will assume that the thematic route will be preferred over the syntactic route whenever possible. Specifically, this will be the case when there is no possible resolution of the ambiguity associated with a case ambiguous element that may contradict the thematic processing decisions made on the basis of the unambiguously case-marked arguments in the sentence.[7]

1.3 Outlook

In this chapter, the basic assumptions and concrete principles of the argument dependency model were outlined and the processing behaviour predicted by the model was described. Chapter 2 will compare this model to other proposals regarding the processing of thematic information from the psycholinguistic literature, in order to show how its basic assumptions and predictions differ from previous approaches. In Chapter 3, the specific processing behaviour predicted by the model will be discussed in detail by describing how the model may be embedded within a more general, time-sensitive processing framework.

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[7] In contrast to (16b), it is not entirely clear how the processing of examples such as (i) should be envisaged.

(i) Gestern hat die Schauspielerin dem Direktor geholfen.
yesterday has [the actress]$_{NOM/ACC}$ [the director]$_{DAT}$ helped
'Yesterday, the actress helped the director.'

Although the second argument should be associated with the [-dep] status on the basis of Economy, it is not an ideal [-dep] constituent and therefore does not force an assignment of [+dep] to the first argument in all possible resolutions of the (thematic) ambiguity. Thus, it is possible that no processing conflict arises here.

Chapter 2
A Comparison of the Argument Dependency Model and other Approaches to the Processing of Thematic Relations

One of the central claims of the argument dependency model is that thematic relations play a crucial role in online sentence comprehension. However, the idea that thematic information is actively used during parsing is certainly not new and has been widely advocated in the psycholinguistic literature. In view of this, the present chapter aims to illustrate how thematic processing in the sense of the argument dependency model differs from previous conceptions of thematic information in sentence processing. To this end, we will firstly outline four general approaches to thematic processing proposed in the literature[8], before turning to a discussion of the argument dependency model in comparison to these proposals.

2.1 The garden path model

One of the most prominent sentence processing theories of the last two decades, the garden path model (e.g. Frazier, 1978; Frazier, 1987; Frazier & Rayner, 1982), assumes a two-stage view of parsing in which initial parsing decisions are based exclusively on word category information in combination with principles of minimal structure building such as Minimal Attachment and Late Closure.[9] In a second stage, other types of information are then taken into account.

The notion of a 'thematic processor' operating within the garden-path architecture was firstly introduced by Rayner, Carlson, & Frazier (1983).

[8] Note that processing approaches pertaining to the use of thematic information in reanalysis only will not be taken into account in this chapter.

[9] Minimal Attachment (Frazier & Rayner, 1982:180)
Attach incoming material into the phrase-marker being constructed using the fewest nodes consistent with the well-formedness rules of the language.

Late Closure (Frazier, 1978:33):
When possible, attach incoming material into the phrase or clause currently being parsed.

Essentially, these authors proposed that thematic processing mediates between syntactic information and influences of plausibility (thereby incorporating discourse factors, pragmatics, world knowledge, etc.) by using thematic grid information[10] to delimit the set of relations whose pragmatic plausibility will be taken into consideration during parsing. Specifically, processing is assumed to proceed in the following manner: "*using the initial syntactic analysis of an input string to identify (minimal) major phrases, the language processor then calls on real world knowledge and information about the current discourse to compare the pragmatic plausibility of whatever sets of relations between phrases are listed in the thematic structures associated with the head of a phrase.*" (Rayner et al., 1983:367). If this 'thematic selection' produces a relation that is more plausible than the analysis being pursued, a reanalysis is initiated.

This conception of thematic selection is based on the finding that pragmatic plausibility does not determine which syntactic analysis is initially chosen (Rayner et al., 1983), but may influence the ultimate interpretation of a sentence (Crain & Coker, 1979). The assumption of a thematic processor in the sense of Rayner et al. (1983) accounts for this influence while avoiding (a) that plausibility may be used to select from alternative syntactic structures, or (b) that the relative plausibilities of all possible relations between major syntactic constituents (e.g. noun phrases) are compared. Whereas the former appears unlikely in view of the initial syntactically-based preference observed by Rayner et al. (1983), the latter is undesirable in view of the processing complexity resulting from such unconstrained calculations.

In this way, the basic conception of thematic processing within the garden path model is that, once the (role-assigning) head of a phrase has been identified, a plausibility evaluation with regard to all possible thematic frames is initiated and proceeds in parallel with more elaborate syntactic processing steps (cf. Frazier, 1990). If the thematic frame associated with the highest plausibility is *not* compatible with the analysis being pursued, a revision of the current analysis is attempted.

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[10] A 'thematic grid' specifying the thematic roles assigned by a predicate, e.g. <Agent,Patient> for the verb *to kill*, is typically thought to form part of a verb's lexical entry (cf. Haegeman, 1994).

2.2 Constraint-based approaches

In contrast to the hierarchically structured processing architecture of the garden path model, constraint-based approaches to language comprehension assume that multiple information sources are consulted simultaneously to select among a set of competing analyses (e.g. Bates & McWhinney, 1989; MacDonald, Pearlmutter, & Seidenberg, 1994; Taraban & McClelland, 1988; Trueswell, Tanenhaus, & Kello, 1993; Tyler & Marslen-Wilson, 1977). From such a perspective, even the earliest parsing decisions may be guided by non-syntactic information.

In this regard, advocates of constraint-based processing have assumed that thematic information – again in the sense of thematic grids associated with the lexical entries of verbs and other role assigning heads – may be used to select among alternative syntactic analyses (cf. Tanenhaus et al., 1989). It has therefore been proposed that, although only a single analysis is pursued in the parse process, multiple thematic grids may be kept active simultaneously, thus allowing for relatively low-cost revisions if the analysis initially pursued turns out to be untenable (Carlson & Tanenhaus, 1988). On these assumptions, processing is essentially serial, but with a certain degree of parallelism stemming from the lexicon.

Various experimental studies have provided evidence for this view. Consider, for example, the following sentences, which Trueswell, Tanenhaus, & Garnsey (1994) examined in an eye-tracking experiment:

(17) a. The man recognized by the spy took off down the street.
b. The van recognized by the spy took off down the street.

The examples in (17) are instantiations of the well known ambiguity between a main clause and a reduced relative clause analysis (i.e. the verb *recognized* is ambiguous between a main verb and a reduced relative verb reading). Although the two sentences are identical in syntactic structure, they differ from one another in that the head noun of the relative clause is animate in (17a) and inanimate in (17b). Thus, assuming that the thematic grid of the verb *to recognise*, i.e. <Perceiver,Stimulus> or similar, is both accessible and made use of in the resolution of the ambiguity, the main verb reading should *not* be preferred in (17b), since the inanimate noun phrase *the van* does not fulfil the requirement that arguments bearing the

‘Perceiver’ thematic role must be animate. Trueswell et al.’s (1994) results confirmed this hypothesis: while reduced relative clauses with ambiguous head nouns such as (17a) gave rise to significantly longer reading times at the position of the disambiguating by-phrase in comparison to unambiguous controls, no such difference was apparent between ambiguous and unambiguous reduced relatives with inanimate head nouns. In light of these findings, Trueswell et al. argue that thematic information is used to select among competing analyses.

In addition to assuming that non-syntactic information may influence initial processing choices, constraint-based models typically allow for thematic role assignments to be guided by various information types including semantic and discourse-based information. This point of view has been advocated most directly and elaborately by McRae and his colleagues (e.g. McRae, Ferretti, & Amyote, 1997; Ferretti, McRae, & Hatherell, 2001). These authors conceive of on-line thematic assignment as a process that is determined by world knowledge and plausibility factors, a view clearly standing in contrast to the widely held conception that thematic roles should be characterised as “syntactically specified slot and filler mechanisms with minimal conceptual content” (McRae et al., 1997: 139). It is assumed that role concepts are event-specific (i.e. verb-specific) and that they are defined by way of everyday experiences with regard to the participants that typically take part in certain events.

McRae et al. (1997) and Ferretti et al. (2001) present a number of experiments in support of their view of thematic information and its role in sentence processing. For example, McRae et al. (1997) report a questionnaire study in which participants were asked to rate the typicality with which particular nouns bear the Agent/Patient role of particular verbs on a 7-point scale. Examples of agenthood and patienthood questions are given in (18a) and (18b), respectively.

(18) a. How common is it for a
snake _____
nurse _____
monster _____
baby _____
cat _____
to **frighten** someone/something?

b. How common is it for a
snake _____
nurse _____
monster _____
baby _____
cat _____
to **be frightened by** someone/something?

The results of this study showed that certain nouns were better fillers for the Agent (or Patient) role of particular verbs than other nouns. On the basis of this finding, McRae et al. (1997) conclude that thematic roles have an internal structure, since a simple slot-and-filler mechanism cannot account for the fact that some fillers are preferred over others. As further evidence, McRae and colleagues present experiments demonstrating a featural similarity between roles and fillers (McRae et al., 1997) and showing that single word priming of different roles may be observed (Ferretti et al., 2001).

As in other constraint-based approaches, McRae and colleagues assume that thematic information - in the sense of the world-knowledge based role specifications outlined above - is immediately made accessible by the verb and that it may thus influence syntactic structure building. In support of this view, McRae et al. (1997) report a reading time study comparing sentences such as (19a/b).

(19) a. The young naïve gambler (who was) manipulated
by the dealer had bid more than he could afford to lose.

b. The shrewd heartless gambler (who was) manipulated
by the dealer had bid more than he could afford to lose.

Similarly to the examples in (17), the sentences in (19) are locally ambiguous between a main clause and a reduced relative reading when the verb *manipulated* is encountered. The crucial manipulation in the McRae et al. study consisted of varying the plausibility of associating the initial noun phrase with the Agent or Patient role of this verb: while the adjectives in (19a) bias towards a Patient-reading of this noun phrase, those in (19b) favour an Agent-reading, as was established on the basis of rating studies such as those discussed above. Reading time measures for the segment *manipulated* + *by* revealed significantly higher reading times for reduced relatives in comparison to unreduced controls with no apparent influence of featural bias. An effect of bias was observable, however, at the position of the second noun phrase, *the dealer*, where only Agent-biased reduced relative clauses showed a reading time increase in comparison to their unreduced counterparts.

McRae et al. (1997) argue on the basis of these findings that a manipulation of thematic fit has a rapid influence on the resolution of main clause / reduced relative clause ambiguities such that readers use Patient-biasing features of the initial noun to minimise processing difficulty in the reduced relative case. However, the authors concede that the influence of their manipulation was somewhat weaker than that of the animacy manipulation used by Trueswell et al. (1994), with which there was never a disadvantage for reduced relatives with an inanimate head noun.

In summary, constraint-based approaches assume that (verb-specific) thematic information may influence initial parsing decisions and that thematic role assignment is influenced to a substantial degree by semantic, world-knowledge and discourse information.

2.3 Local violations of the theta-criterion as unsatisfied constraints

A further general means of approaching the role of thematic information in sentence processing draws upon the argument-indexing view of thematic roles as a point of departure. This perspective, which was advocated particularly within the Principles and Parameters framework in generative syntax (Chomsky, 1981; cf. Haegeman, 1994, for an introduction), assumes that thematic roles primarily provide a means of keeping track of arguments during the course of a derivation, which typically involves dislocations of

various sorts in order to fulfil certain requirements of the grammar. Thus, with regard to online sentence processing, it has been proposed that local violations of the so-called 'theta-criterion', which states that there must be a one-to-one mapping of thematic roles to arguments in a given sentence, give rise to experimentally measurable processing costs (Pritchett, 1988; Gibson, 1991; Gibson, Hickok, & Schütze, 1994).

The earliest approach pursuing this type of idea was proposed by Pritchett (1988,1992), who advocated the Theta-attachment principle given in (20).

(20) *Theta-attachment*
The theta criterion attempts to apply at every point during processing given the maximal theta grid.
(Pritchett, 1992:12)

On the basis of this principle, processing behaviour is determined by the endeavour of the parser to make thematic assignments as soon as possible. Note, however, that Pritchett does not assume a concurrent activation of multiple thematic grids as in the constraint-based approaches discussed above, but rather supposes that processing is determined by the maximal thematic grid of a given role-assigning element. The erroneous assignments thus resulting at various points are thought to be easily revised if the constituent affected by a reassignment remains within the same theta-domain as before the reassignment was made. Theta-domains are defined as consisting of a thematic-role assigning element and all of the constituents to which it assigns roles. These principles derive the fact that (21a) gives rise to a conscious garden path, whereas (21b) does not.

(21) a. After Todd drank the water proved to be poisoned.

b. Susan knew her mother hated her.

In (21a), *the water* is initially assigned the Theme role of *drank*, but must be reassigned the Theme role of *proved*. This reassignment involves a change in theta-domain, since *After Todd drank* is an adjunct to the matrix clause *the water proved to be poisoned*, and the sentence thereby gives rise to conscious processing difficulties. The revision in (21b), by contrast, involves a reassignment of the Experiencer role of *hated* to *her mother*, which originally bore the Theme role of *knew*, and does not involve a change in

theta-domain because the entire embedded clause *her mother hated her* is a complement to the verb *knew*. In this way, no conscious garden path obtains in (21b).

An approach similar to Pritchett's in the sense that it attempts to maximise early assignments of thematic roles was proposed by Gibson and colleagues (Gibson, 1991; Gibson et al., 1994). In contrast to Pritchett's parser, in which processing costs arise when reassignments of roles to arguments result in changes in the thematic domain of an argument, Gibson and colleagues assume that it is the maintenance of open, but required role assignments that is costly. In this way, these authors propose a parsing architecture in which all possible readings of the string currently being parsed are concurrently maintained up to the point where the relative costs of maintenance become too demanding on working memory. This limited-capacity parallel parser computes and compares the processing costs associated with every possible structure on the basis of each new input item or empty category being processed.

Processing costs are defined in terms of the satisfaction of various constraints, one of which corresponds to the theta-criterion. In this way, processing load increases either when (a) a constituent that is a potential argument cannot be unambiguously associated with a theta-role assigner (the 'Property of Thematic Reception', Gibson et al., 1994:386/394), or (b) a thematic role that is obligatorily assigned by a head that has already been processed cannot be associated with a non-functional constituent (the 'Property of Lexical Requirement', Gibson et al., 1994:386/394). Both types of violation are deemed equally costly. Furthermore, it is assumed that alternative readings differing in cost by one violation or less may be maintained in parallel, whereas differences in cost amounting to two violations or more result in only the less costly alternative being pursued further. In this way, conscious garden paths arise when an ambiguity is resolved in favour of a reading that had been abandoned on the grounds of being too costly relative to a second reading. Easy garden paths, by contrast, result when two readings differ from one another by only one violation, in which case both alternatives are pursued, but in such a way that the less costly reading of the two is ranked above the other.

Hence, theta-criterion based approaches such as those proposed by Pritchett (1988) and Gibson and colleagues (Gibson, 1991; Gibson et al.,

1994) assume that many well-known processing phenomena may be accounted for by assuming that the parser attempts to maximise assignments of thematic roles to arguments (and, of course, also the association of arguments with thematic roles) at each point during processing. These approaches differ, however, with regard to the locus of processing difficulties: whereas Pritchett assumes that reassignments of thematic roles to arguments are costly when these involve an alteration of the argument's thematic domain, Gibson's approach predicts processing costs when alternative readings are not maintained in parallel (or, at least, in a ranked parallel manner), which becomes necessary when one reading is much more costly than the other in terms of unfulfilled thematic assignments.

2.4 Comparison with the argument dependency model

As the discussion in the previous sections showed, many researchers have emphasised the importance of thematic processing in sentence comprehension. Moreover, a further characteristic of thematic information appears to be that there is very little agreement on how the term 'thematic' should be defined and, particularly, how thematic information should be delimited from other information types. In view of this multiplicity of proposed approaches, both theoretical and psycholinguistic in nature, it is important to show exactly how the argument dependency model differs from previous approaches to thematic processing, before presenting evidence in its favour.

Arguably, the most important characteristic common to all previous approaches is that thematic information is assumed to be verb- (or, more generally, head-) dependent. Thus, the lexical entry of a verb is thought to contain, amongst other pieces of information, a 'thematic grid' specifying the thematic roles assigned by this verb, e.g. <Agent, Patient> for a verb such as *slap*. Whereas this assumption of head-dependency appears plausible for head-initial languages such as English, the question arises of how processing principles relying on the lexical information associated with a role-assigning head may apply to languages in which all arguments may occur before this head is processed[11]. Clearly, in such a constellation, the

[11] The importance of being able to process verb-final constructions in a principled manner is underlined by the observation that, in the sample of 402 languages described by Tomlin

parser must employ principles more general in nature than the information associated with individual verbs or other heads.

The argument dependency approach differs from the proposals outlined above in that thematic processing is not generally contingent upon the processing of the verb, i.e. principles of thematic structuring are considered both general and universal rather than verb specific, since they operate on the basis of the thematic entailments giving rise to the thematic hierarchy. In this way, *hierarchical* thematic structuring between arguments may take place via the properties of these arguments alone, e.g. on the basis of the morphological case borne by them, even before the lexical information associated with a particular verb is processed. From such a perspective, a lexical encoding of thematic relations in the sense of a thematic grid is no longer necessary, since the hierarchical dependencies between arguments established verb-independently may then be spelled out into individual 'roles' by association with the semantic representation of the verb (cf. Van Valin & La Polla, 1997 for a similar view).

Rather, only a hierarchical representation of thematic relations between arguments is required. This step appears useful in terms of avoiding lexical redundancy, since much of the information encoded in a thematic grid also forms part of the subcategorisation frame of a verb. In the words of Carlson & Tanenhaus (1988:268): "while [thematic] grids and subcategorizations appear to encode very much the same sort of information, they are independent of one another". Thus, whereas the argument dependency model assumes that there are lexical representations associated with both the syntactic and the thematic processing routes (i.e. subcategorisation frames and hierarchical thematic representations, respectively), these encode very different things.

In addition to its verb-independent approach to processing, the argument dependency model differs from previous approaches to thematic processing in several respects. Firstly, from the perspective advocated here, thematic processing simply provides a means of establishing hierarchical dependencies between the arguments of a sentence. Thematic information is therefore *intra-sentential* in nature and does *not* provide an interface to

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(1986), 180 languages (44.78%) had a basic order of subject-object-verb (SOV) in comparison to 168 languages (41.79%) with a basic order of SVO.

discourse information and pragmatic plausibility etc. associated with it. Secondly, thematic relations are determined on the basis of morphological case and a small set of thematically-relevant features (e.g. animacy) *only*. Therefore, in contrast to the assumptions of constraint-based models, these relations are established independently of semantic, pragmatic and world-knowledge influences. Again, many of these assumptions are derived from the need to build thematic structure even before the verb is encountered, i.e. at a point where no event-specific information is available as yet. Thus, while one might assume that thematic information combines general and verb-specific aspects, it is not at all clear how these should be incorporated into a single concept of “thematic” role. In view of this, the argument dependency model will characterise this dualism of the information previously subsumed under the label ‘thematic’ in terms of the interaction between thematic (general and verb-independent) and semantic (specific and verb-dependent) information. An integration of previous experimental results cited in favour of the approaches to thematic processing discussed above and the theoretical proposals advanced in the context of the argument dependency model will be briefly attempted in Chapter 9.

Chapter 3
Incorporating the Argument Dependency Model into a Neurocognitive Framework

As indicated at the end of the first chapter, the argument dependency model must be embedded within a more general neurophysiological framework if the model's predictions with regard to processing phenomena are to be accommodated into a real-time view of processing. To this end, we will assume Friederici's (1999, 2002) neurocognitive model of language comprehension, which will be described in detail in this chapter (section 3.1.1). Furthermore, this chapter will briefly introduce the experimental methods that will be employed in the experimental part of this thesis, namely event-related brain potentials (ERPs; section 3.1.1) and the multiple-response speed-accuracy trade-off method (SAT; section 3.1.2). These methods were chosen on account of their high degree of temporal resolution, which is crucial if the various different processes that interact during language comprehension are to be teased apart. In section 3.2, previous experimental findings supporting the argument dependency model will be discussed in detail. The chapter concludes with a concrete description of how the model is to be integrated into Friederici's neurocognitive framework and the consequences and predictions arising from this (section 3.3).

3.1 A neurocognitive processing perspective

3.1.1 Event-related brain potentials (ERPs)

Event-related brain potentials (ERPs) are small changes in the spontaneous electrical activity of the brain, which occur in response to sensory or cognitive stimuli and which may be measured non-invasively by means of electrodes applied to the scalp. Of particular importance for the examination of language comprehension is the high temporal resolution of ERP measures. Furthermore, ERP patterns ('components') are characterisable in terms of the following parameters: *polarity* (negative vs. positive), *topography* (at which electrode sites an effect is visible), *latency* (the time at

which the effect is visible relative to the onset of a critical stimulus), and *amplitude* (the "strength" of an effect). For a more detailed description of the ERP methodology and how it has been applied to psycholinguistic domains of investigation, the reader is referred to the overviews presented in Coles & Rugg (1995), Frisch (2000), Hahne (1998) and Kutas & Van Petten (1994).

In the following, the most important language-related ERP effects (or "components") will be briefly described. Note that this overview by no means aims to provide a complete review of the literature on ERPs and sentence processing, nor will alternative interpretations of the data be discussed in any detail (though brief references will be provided).

Specifically, we will assume the interpretation of the various ERP components given in Friederici's (1999, 2002) neurocognitive model of sentence processing. This model assumes that, after primary acoustical/phonological analysis, sentence processing may be subdivided into three phases. During phase 1, word category identification takes place, thus allowing the word currently being processed to be integrated into the syntactic structure that has been built up so far. Phase 2 sets in when the lexical information associated with this word is accessed and is constituted by two processing pathways, one functional and the other interpretative in nature, which are though to proceed simultaneously but autonomously. Finally, in phase 3, processes of reanalysis and/or repair set in when necessary, i.e. specifically when the two independent representations built up during phase 2 cannot be successfully mapped onto one another. A schematic representation of the model is shown in Figure 2 (on the following page). In the following, the three phases of the neurocognitive model and the electrophysiological responses characteristic of each will be described in turn.

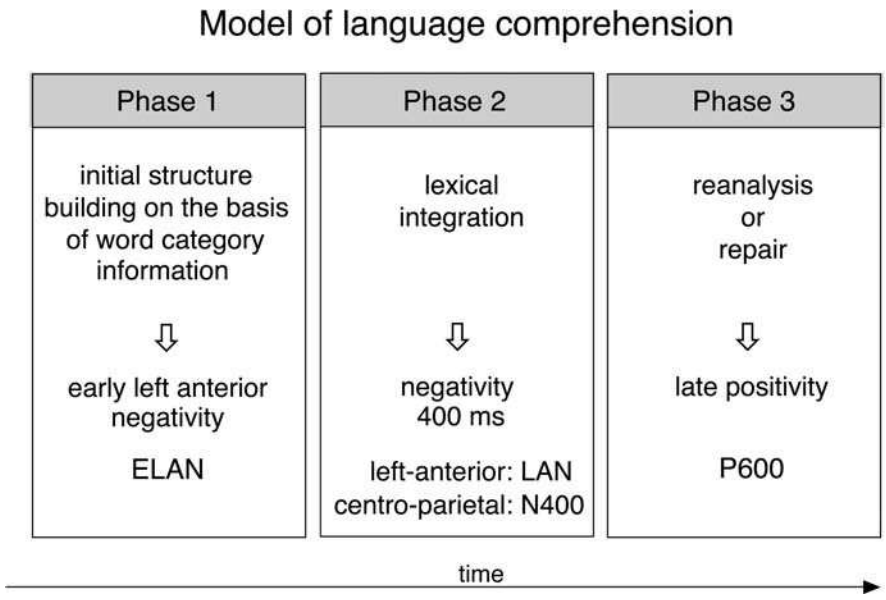

Figure 2. A simplified schematic illustration of the functional and temporal properties of Friederici's (1999, 2002) neurocognitive model of language comprehension.

Phase I: The ELAN

In terms of ERP effects, the first phase of processing is associated with the early left anterior negativity (ELAN), which, as its name suggests, is a negative component observable between approx. 150 and 200 ms post onset of a critical word at left anterior electrode sites. ELAN effects occur in response to phrase structure violations, such as in (22), from Hahne & Friederici (2002).

(22) *Das Eis wurde im gegessen.[12]
the ice cream was in-the eaten

Sentence (22) is ungrammatical because the phrase-structural requirement that a preposition be followed by a noun is not fulfilled. Thus, in comparison to a control sentence, the participle *gegessen* ('eaten') in (22) elicits an ELAN component and a late parietal positivity (i.e. a 'P600', see Phase 3,

[12] Throughout this thesis, critical positions in example sentences (i.e. positions at which an effect under discussion is measurable or expected) will be underlined.

below)[13]. In general, the ELAN has been reported for phrase structure violations in sentences containing regular words (Friederici, Pfeifer, & Hahne, 1993; Hahne, 2001; Hahne & Friederici, 2002; Neville, Nicol, Barss, Forster, & Garret, 1991) and in sentences containing pseudowords with morphological markings (Hahne & Jescheniak, 2001).

Phase 2: The LAN and the N400

The second processing phase sets in between approximately 300 and 500 ms post onset of a critical word and encompasses the processes that are initiated when the lexical information associated with this word becomes available. Two processing routes are assumed, the first concerned with the processing of functional information and the second associated with the processing of interpretative information. Processing difficulties of a functional type are reflected in a left-anterior negativity (LAN), a component similar to the ELAN in polarity and topography, but with a longer latency (generally observable between 300 and 500 ms post critical word onset), e.g. for gender mismatches as in (23), from Gunter, Friederici, & Schriefers, 2000:

(23) *Sie bereist den Land auf einem kräftigen Kamel.
she travels the$_{masc}$ land$_{neuter}$ on a strong camel

LAN effects have also been reported for other functional mismatches such as agreement incongruencies (Coulson, King, & Kutas, 1998; Gunter, Stowe, & Mulder, 1997; Kutas & Hillyard, 1983; Osterhout & Mobley, 1995) and morphological errors (Penke, Weyerts, Gross, Zander, Münte, & Clahsen, 1997; Weyerts, Penke, Dohrn, Clahsen, & Münte, 1997).[14] As for the ELAN, LAN effects typically occur in combination with P600s.

Problems related to the intepretability of a sentence are typically reflected in the N400 component, a bilateral centro-parietal negativity (often with a slight

[13] Note that all of the ERP components reported for the sentences shown in this section are observable in comparison to a minimally contrasting control condition even when this is not stated explicitly.

[14] For an alternative interpretation of the LAN in terms of working memory load, see for example Kluender & Kutas, 1993; King & Kutas, 1995; Rösler, Pechmann, Streb, Röder, & Henninghausen, 1998). In part, these conflicting views may perhaps be reconciled by differentiating between focal LAN effects and sustained negativities with a left-anterior distribution (cf. Fiebach, 2001; Schlesewsky, Bornkessel, & Frisch, *in press*).

focus to the right), which is also observable between 300 and 500 ms post onset of a critical word. This component is typically elicited by words that do not fit into the preceding sentence context (as in 24, from Kutas & Hillyard, 1980).

(24) He spread the warm bread with socks.

Specifically, though the integration of a (content) word generally gives rise to an N400 component, this component becomes more pronounced with a higher degree of unexpectedness (i.e. a lower cloze probability) for the critical word (Kutas & Hillyard, 1984). Furthermore, the N400 is modulated by word frequency and sentence context (Van Petten & Kutas, 1990), repetition (Van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991), lexical status (i.e. open vs. closed class; Nobre & McCarthy, 1994) and various other lexical-semantic manipulations (for a review see Kutas & Federmeier, 2000).

Phase 3: The P600

In the third processing phase, which takes place from approx. 500-600 ms post critical word onset onwards, reanalysis and repair mechanisms set in when necessary. Specifically, the neurocognitive model assumes that such processes are required when the two representations (functional and interpretative) built up in Phase 2 cannot be mapped onto one another. When this is the case, a P600, i.e. a parietal positivity typically observable between 600 and 900 ms post critical word onset, results. As is consistent with this interpretation, the P600 has been observed in the disambiguating region of garden path sentences (e.g. Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992, 1993). An example of this kind is shown in (25) (from Osterhout & Holcomb, 1992, 1993).

(25) The broker persuaded to sell the stock was sent to jail.

The verb *persuaded* in (25) is ambiguous between a main verb and a reduced relative clause interpretation, for which numerous studies have demonstrated a strong preference for the former reading (e.g. Ferreira & Clifton, 1986; Frazier & Rayner, 1982; Rayner et al., 1983) such that processing difficulties are observable when material disambiguating the sentence towards the dispreferred reduced-relative reading is processed,

i.e. at positions analogous to that of *to* in (25). Since processing difficulties thus elicited in a disambiguating region are typically thought to reflect a reanalysis of the previously built structure, the finding of a P600 at such positions supports the analysis of this component in terms of reanalysis/repair costs.

However, the P600 also occurs in response to outright syntactic violations (Osterhout & Holcomb, 1992, 1993; Osterhout, Holcomb, & Swinney, 1994), often in combination with one of the aforementioned negativities (e.g. Coulson et al., 1998; Friederici & Frisch, 2000; Gunter et al., 1997, 2000). Thus, it would appear that the type of reanalysis processes reflected by this component are always initiated, irrespectively of whether a reanalysis is possible in the particular sentence context or not. Furthermore, recent experimental studies have shown that P600 effects are also elicited by increased syntactic integration costs (Kaan, Harris, Gibson, & Holcomb, 2000; Fiebach, Schlesewsky, & Friederici, 2001) and a higher degree of syntactic complexity (Friederici, Hahne, & Saddy, 2002).

In addition to the P600, an early positive component (P345) has been observed in response to a dispreferred resolution of a subject-object ambiguity in German relative clauses. Consider the following example from Mecklinger, Schriefers, Steinhauer, & Friederici (1995):

(26) Das ist die Direktorin, die die Sekretärinnen
this is the director who$_{NOM/ACC.SG}$ [the secretaries]$_{NOM/ACC.PL}$
besucht hat / haben.
visited has$_{SG/PL}$
'This is the director who visited the secretaries.'/
'This is the director whom the secretaries visited.'

In (26), the relative pronoun *die* is case ambiguous between nominative and accusative, thereby rendering the relative clause ambiguous between a subject- and an object-relative. There is overwhelming behavioural evidence that 'subject-object ambiguities' such as this are quickly resolved in favour of a subject-initial reading both in German (e.g. Bader & Meng, 1999; Schlesewsky, Fanselow, Kliegl, & Krems, 2000; Schriefers, Friederici, & Kühn, 1995) and in other languages (e.g. Dutch, cf. Frazier & Flores d'Arcais, 1989; and Italian, cf. de Vincenzi, 1991) and that, therefore, a reanalysis becomes necessary when the disambiguating region indicates

that the clause was in fact object-initial. In accordance with this preference for subject-initiality, Mecklinger et al. (1995) observed a posterior positivity between 300 and 400 ms post-onset of the clause-final auxiliary in sentences such as (26) when the number marking of this auxiliary disambiguated towards an object relative clause (*haben*, 'have').

This finding stands in contrast to the P600 effects observed in connection with reanalyses in general and also for reanalyses of subject-object ambiguities in sentences other than relative clauses. The authors assumed that the reduced latency of the P345 resulted from the relative ease of reanalysis in relative clauses such as (26) in comparison to other structures requiring a reanalysis towards an object-initial structure, since here only a reassociation of the filler (i.e. the relative pronoun) to a base position (trace) is necessary and no additional nodes must be created. However, it has also been proposed that the P345 reflects the diagnosis preceding reanalysis (Friederici, 1998), an interpretation supported by the finding that the P600 observed for the reanalysis of subject-object ambiguities in German complement clauses consists of two subcomponents, which may be associated with the P345 and a P600-like effect, respectively (Friederici, Mecklinger, Spencer, Steinhauer, & Donchin, 2001). Under the latter interpretation, the P345 is a reflex of the borderline between phases 2 and 3.

Characterising Inter-Phase Relations

Several results speaking to the characterisation of the relations between the three phases have been reported. Particularly interesting in this regard is the question of whether and how processing difficulties in one phase affect processing in the next phase (or even in another processing pathway of the same phase), since this allows us to draw conclusions with regard to the dependencies between the processing stages and, in particular, with regard to their modular or interactive character.

Firstly, it is apparent that processing in phase 2 is crucially dependent on the successful completion of processing in phase 1. Thus, in a sentence combining a phrase structure violation and a semantic violation (27a, from Hahne & Friederici, 2002), an ELAN-P600 pattern obtains:

(27) a. * Das Türschloß wurde im gegessen.
the lock was in-the eaten

b. Das Türschloß wurde gegessen.
The lock was eaten

Thus, when a phrase structure and a semantic violation are simultaneously induced, the resulting ERP pattern is analogous to that found for a phrase structure violation alone (i.e. ELAN-P600, example 22), and does not show an N400 (as is observable for the semantic violation (27b) alone). This 'blocking' of the N400 by the ELAN indicates that, when word category information cannot be successfully processed, semantic integration does not occur, i.e. phase 2 not only temporally succeeds, but is also functionally dependent on phase 1. Similar results have been reported for combined phrase-structure and argument-structure violations (Frisch, 2000).

Findings such as this provide evidence for a *hierarchical* processing of different information types and are thereby not compatible with sentence processing models assuming that all types of linguistic information are simultaneously applied (i.e. models assuming 'strongly interactive parsing'; e.g. MacDonald et al., 1994; Trueswell et al., 1993). Note, however, that results such as these do not allow us to determine whether the dependency between phases 1 and 2 is *temporal* or *hierarchical* in nature, i.e. whether phase 1 necessarily precedes phase 2 because the required information becomes accessible earlier, or whether both are available at the same time with one given processing priority of the other.

The relationship between the two processing streams (functional and interpretative) in phase 2 stands in contrast to the serial dependency between phase 2 and phase 1. Thus, a LAN and an N400 may be simultaneously elicited by the same critical word, for example when this word realises both an agreement violation and a semantic violation (cf. 28, from Gunter et al., 1997):

(28) * De vuile matten werden door de hulp koken
the dirty doormats were by the housekeeper cook

This Dutch example shows that the LAN and the N400 may appear independently from one another, thus attesting to the simultaneity and

modularity of the two processing streams operating within phase 2 (for similar results, cf. Gunter et al., 2000).

Finally, let us briefly consider some pieces of evidence as to why the reanalysis processes thought to be reflected in the P600 set in when there is a *mapping* problem with regard to the two representations built up in phase 2. In an experiment crossing a gender mismatch with a cloze probability manipulation at the position of the critical word (cf. example (23) above), Gunter et al. (2000) found that the N400 observed was independent of the gender mismatch, the LAN was independent of the state of semantic expectancy, whereas the two variables were found to interact in the P600. This elegantly demonstrates that, while functional and interpretative processes operate independently during phase 2, an interaction between these processes takes place during phase 3.

3.1.2 Speed-accuracy trade-off (SAT)

A further experimental technique allowing for a precise characterisation of the time course of sentence processing is the speed-accuracy trade-off (SAT) procedure. This method capitalises upon the fact that, even if two (behavioural) observations show the same accuracy, their underlying representations need not be the same, i.e. it need not be the case that the two conditions differ in the speed of processing, since it is also possible that the two underlying representations differ from one another. SAT measures allow for these two scenarios to be teased apart by distinguishing between processing *speed* and processing *accuracy*.

In this way, the SAT method may also be used to supplement ERP measures, since it is often able to provide a more precise qualification of the exact functional processing characteristics addressed by the manipulations in psycholinguistic paradigms. The advantages of using this method to examine language processing have been demonstrated in a number of studies (e.g. McElree, 1993, 1996; McElree & Griffith, 1995, 1998), one particularly fruitful outcome being that it allows for an isolation of the particular aspect of processing giving rise to an increased processing cost in comparison to a control condition. By means of this method, several findings in support of the hierarchically structured processing architecture assumed by the neurocognitive model have been reported (McElree & Griffith, 1995, 1998).

Basic Concepts

Essentially, the SAT method provides measures of the accuracy attained at successive points during the course of processing and thereby allows for an examination of processing accuracy as a function of processing time as a dependent measure. A typical example of an SAT function thus obtained is illustrated in Figure 3.

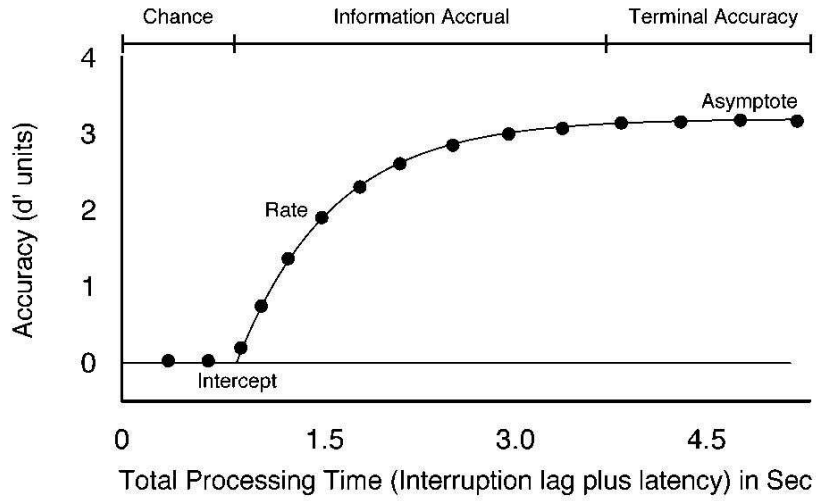

Figure 3. The typical characteristics of an SAT function.

An SAT function such as in Figure 3 may be subdivided into three different processing phases: (a) a period of chance-level performance, (b) a period in which accuracy increases, and (c) an asymptotic level of accuracy which is indicative of the accuracy attained with functionally unlimited processing time. This type of function may be quantitatively summarised by an exponential approach to a limit equation as shown in (29) (Dosher, 1976, 1979, 1981, 1982, 1984; McElree, 1993, 1996; McElree & Dosher, 1989, 1993; Reed, 1973, 1976; Wickelgren, 1977).

(29) $d'(t) = \lambda(1-e^{-\beta(t-\delta)})$, for $t > \delta$, otherwise 0.

Equation (29) makes use of three parameters to describe how accuracy increases with time: (a) δ, the *intercept* parameter, specifies at which point during processing accuracy departs from chance (i.e. from a d' value of 0);

(b) β, which determines the *rate of rise* from chance to asymptotic performance; and (c) an asymptotic parameter λ, which reflects the level of processing accuracy ultimately attained. Collectively, the δ and β parameters characterise the *dynamics* of processing (i.e. processing speed); this has been interpreted in terms of either the rate of continuous information accrual or the distribution of finishing times of discrete processes (Dosher, 1976, 1979, 1981, 1982, 1984; Meyer, Irwin, Osman, & Kounios, 1988; Ratcliff, 1988). Thus, there is a fundamental distinction between two SAT functions differing in terms of asymptote alone and two SAT functions differing in terms of one or both of the dynamical parameters, which allows, for example, for a differentiation between processing costs arising from the lower retrieval probability of a particular reading (asymptotic differences) and processing costs that are the result of a particular reading taking longer to compute in comparison to a control condition (dynamics differences). Differences in SAT functions related to language processing phenomena have been reported for asymptotic differences alone (e.g. McElree, 1993), for dynamic differences alone (e.g. McElree, 1996; McElree & Griffith, 1995) and for a combination of both (McElree & Griffith, 1995, 1998)

Two alternative SAT methodologies have been applied to the examination of psycholinguistic phenomena, namely the *response-signal* speed-accuracy trade-off procedure (e.g. McElree & Griffith, 1995, 1998) and the *multiple-response* speed-accuracy trade-off procedure (e.g. Wickelgren, Corbett, & Dosher, 1980; McElree, 1993). Although the advantages of SAT outlined above apply to both of these methods, they differ somewhat in how the speed-accuracy function is obtained. In the response-signal paradigm, processing is interrupted at a certain point in each trial by a signal to respond which is typically a tone. By systematically varying the lag of tone presentation over trials, an SAT function may be derived. The multiple-response paradigm, by contrast, allows for all data points to be collected at every trial: participants are taught to respond continuously in response to tones sounded every 300 to 350 ms. Thus, the advantage of the multiple-response method is that it allows for a great reduction of experimental trials in comparison to the response-signal method.

A Psycholinguistic Example

An illuminating example of how the SAT methodology may be employed to examine language processing is provided by a series of experiments reported by McElree & Griffith (1998), who used the signal-response SAT method to examine the time course of processing filler-gap dependencies. Specifically, these authors contrasted the violations in (30)[15] to shed light on the time course of gap filling.

(30) a. Subcategorisation violation
*It was the essay that the writer knew the editor had gloated.

b. Thematic violation
*It was the essay that the writer knew the editor had amazed.

c. Island violations
(i) *It was the essay that the writer scolded the editor who admired.
(ii) *It was the editor who the writer examined the essay which admired.

Whereas the sentences in (30c) are ungrammatical because they violate global structural ("island") constraints, the ungrammaticality of the examples in (30a-b) stems from a violation of local lexical constraints. The SAT functions for these three conditions were best fit with separate intercepts (δ) and asymptotes (λ), but with one rate (β) for the island violations and a second rate for both subcategorisation and thematic violations. The island violations showed an earlier intercept, a faster rate and a higher asymptote than both of the other violation types, whereas the intercept for subcategorisation violations was earlier than that for thematic violations, but thematic violations showed a higher asymptote than subcategorisation violations.

These data indicate that global structural constraints (i.e. island constraints, in this case) are operative 200 – 400 ms earlier (as measured by the intercept differences) than specific lexical (i.e. subcategorisation and thematic) constraints. Additionally, the dynamics differences between

[15] Note that the McElree & Griffith (1998) study included several additional conditions, which we will not discuss here for the sake of brevity.

subcategorisation and thematic violations indicate that subcategorisation information is calculated more rapidly than thematic information[16].

In summary, SAT measures may be used to supplement ERP measures, since they not only possess a high degree of temporal resolution, but also allow for a functional dissociation between dynamic and non-dynamic differences in processing behaviour.

3.2 Previous experimental findings in support of the argument dependency model

Several recent studies on the processing of case and thematic information in German provide initial support for the argument dependency model. We will discuss the relevant findings in turn in the following.

3.2.1 Evidence for the link between morphological case and thematic proto-roles

With regard to the assumed link between morphological case and thematic information, we shall discuss ERP studies examining the processing of double case ungrammaticalities in German that were reported by Frisch (2000) and Frisch & Schlesewsky (*submitted*). The sentences in question were rendered ungrammatical by virtue of including two identically case marked arguments, i.e. two nominatives (31a), two accusatives (31b) or two datives (31c). Both subordinate clauses such as (31), in which the two arguments occur before the verb, and main clauses with an argument-verb-argument order were examined.

(31) a. NOM-NOM
*… welcher Dichter der Lehrer besuchte.
... [which poet] $_{NOM}$ [the teacher] $_{NOM}$ visited

[16] This finding does not invalidate the claim of the argument dependency model that syntactic and thematic information are processed within the same time range, since McElree & Griffth (1998) examined English sentences, which of course are not morphologically case marked. In this way, the thematic processing route described here cannot be activated and all interpretative processes relating to „who is doing what to whom“ must proceed via verb information and syntactic information.

b. ACC-ACC
*… welchen Dichter den Lehrer besuchte.
... [which poet] $_{ACC}$ [the teacher] $_{ACC}$ visited

c. DAT-DAT
*… welchem Dichter dem Lehrer folgte.
... [which poet]$_{DAT}$ [the teacher] $_{DAT}$ followed

At the position of the second noun phrase, each of the ungrammatical sentences in (31) elicited a biphasic N400-P600 ERP response in comparison to its respective grammatical control sentence. Frisch & Schlesewsky (*submitted*) interpret the finding of an N400 for sentences with two identically case marked arguments as reflecting the inability to thematically hierarchise the arguments with respect to one another. The P600, by contrast, is viewed as a marker of ungrammaticality detection.

Interestingly, in main clauses, the violation conditions differed from one another in that double accusatives showed a larger N400 than double nominatives, whereas double datives and double nominatives did not differ from one another with regard to this component[17]. These differences are in line with the assumptions laid out in Chapter 1.1 that, in transitive sentences, nominative- and dative-marked arguments may realise either the thematically higher-ranked or the thematically lower-ranked of the two arguments, whereas accusative-marked arguments may realise only a thematically lower-ranked (dependent) argument. In this way, nominative and dative possess a higher degree of *thematic variability* than accusative. Consequently, since a hierarchical ordering between two nominative- or two dative-marked arguments is more easily conceived of than a hierarchical ordering between two accusative-marked arguments, double nominatives and datives are more readily interpretable than double accusatives, thus giving rise to smaller N400 effects.

Inasmuch as the above results support the assumption that the specific properties of different morphological cases are mapped onto thematic properties, preliminary evidence for fact that thematic interpretation in the sense referred to here crucially *requires* the presence of morphological case

[17] There were also differences in the P600, but this need not concern us here, since the P600 elicited by the structures in question does not appear to reflect thematic processes (cf. Frisch & Schlesewsky, *submitted*, for details).

marking stems from a comparison of the above results with a study by Coulson et al. (1998). These authors examined the processing of sentences such as (32).

(32) *The plane took we to paradise.

Similarly to the German examples above, example (32) is ungrammatical because the argument designated as the object by its position in the sentence structure (*we*) bears nominative case. In contrast to Frisch & Schlesewsky's (*submitted*) findings, however, Coulson et al. (1998) observed a LAN followed by a P600 at the position of the critical pronoun. Thus, it appears that in English, violations such as (32) occur as a result of the mismatch between a particular structural position and the morphological realisation of the element encountered in that position. In German, by contrast, two arguments bearing the same case give rise to thematic/ interpretative problems, i.e. problems encountered on the thematic processing route.

Further evidence for a thematic processing route that establishes hierarchical relations between arguments on the basis of the thematic properties compatible with each of the arguments stems from a study by Frisch & Schlesewsky (2001), which demonstrated that the N400 observed for double case ungrammaticalities may be modulated by a manipulation of thematically-relevant features. The critical contrast is illustrated in (33).

(33) a. *… welcher Mönch der Bischof begleitete.
… [which monk]$_{NOM}$ [the bishop]$_{NOM}$ accompanied

b. *… welcher Mönch der Zweig streifte.
… [which monk]$_{NOM}$ [the twig]$_{NOM}$ brushed

Whereas the sentence in (33a) is analogous to the double nominative sentences referred to above, example (33b) contains an animate and an inanimate participant. Following Primus (1999), we may assume that animacy is a thematically relevant property (cf. Chapter 1.1), which, in the case of (33b), should serve to endow the animate first noun phrase, *welcher Mönch* ('which monk') with more Proto-Agent entailments than the inanimate second noun phrase *der Zweig* ('the twig'). Thus, (33b) should give rise to fewer problems with regard to thematic hierarchising than (33a). This

prediction is indeed borne out: in the Frisch & Schlesewsky (2001) study, (33a) elicited an N400-P600 pattern at the position of the second NP in comparison to a grammatical control condition, while (33b) only gave rise to a P600. It therefore appears that the N400 elicited by two identically case-marked arguments in German indeed reflects the interpretative problems that arise when the thematic properties compatible with each of the arguments do not allow a hierarchical ordering to be established between them.

3.2.2 Evidence for the incremental processing of thematic dependencies and for thematic predictions

The experimental results discussed above indicate that, at least in sentences with unambiguous morphological case marking, the thematic properties compatible with the sentential arguments are actively used during processing and that if it is not possible to establish a hierarchical thematic ordering between two arguments, a processing problem occurs. However, these findings only show that the language processing system examines whether a hierarchical relation may *possibly* be established between the arguments of a sentence, while providing only indirect evidence that hierarchical thematic relations are established incrementally (i.e. even before the verb is processed) in grammatical sentences. Evidence for the latter stems from a study by Bornkessel et al. (*to appear*), which contrasted structures such as (34a) and (34b).

(34) Maria glaubt, …
Maria believes, …

a. ... dass der Mönch dem Bischof folgt und ...
... that [the monk]$_{NOM}$ [the bishop]$_{DAT}$ follows and ...
'... that the monk follows the bishop.'

b. ... dass der Mönch dem Bischof gefällt und ...
... that [the monk]$_{NOM}$ [the bishop]$_{DAT}$ pleases and ...
'... that the monk is appealing to the bishop.'[18]

[18] Note that the sentences involving object-experiencer verbs are *not* passive constructions. The passive paraphrase was chosen in order to allow for an intuitive feel of the dative-Experiencer reading, which lacks an English equivalent.

The two example sentences in (34) are identical up to the point of the clause-final verb. The crucial difference between the verbs *folgen* ('to follow') and *gefallen* ('to be appealing to') is that the former is an active verb (i.e. the nominative argument thematically dominates the dative argument), while the latter is an object-experiencer verb (i.e. the dative argument thematically dominates the nominative argument). Thus, with the processing of the verb, it becomes clear that the hierarchical thematic relations are reversed between sentences (34a) and (34b). Assuming a thematic processing strategy which thematically hierarchises sentential arguments with respect to one another even before the verb is reached, (34b) should give rise to a reanalysis of the thematic relations in comparison to (34a), since nominative case marking is compatible with more prototypical control properties than dative case marking (see Chapter 1.1).

As predicted, Bornkessel et al. (*to appear*) found that sentences such as (34b) give rise to an early (300-600 ms) parietal positivity at the position of the verb in comparison to sentences such as (34a). This effect was independent of the word order of the clause (i.e. nominative-dative or dative-nominative) and is interpreted by the authors as reflecting processes of *thematic reanalysis*, i.e. operations involved in reversing the hierarchical thematic ordering between the two arguments.

The aforementioned study by Bornkessel et al. (*to appear*) essentially shows two things. Firstly, it is apparent that a hierarchical thematic ordering is established between the arguments even before the verb is processed, a finding that supports the predictions of the argument dependency model. Secondly, the hierarchising operations are not influenced by the word order of the clause. Taken together, these findings provide evidence for the thematic processing route as described in Chapter 1.2.2 and its independence from the syntactic processing route.

Having shown that thematic hierarchy information is actively used during language processing, let us now turn to a study by Schlesewsky & Frisch (*submitted*), which demonstrates that thematic dependencies allow for the prediction of upcoming arguments in a sentence. Similarly to the Frisch & Schlesewsky (2001) study described above, the experiment in question employed an animacy manipulation. The critical sentences are shown in (35).

(35) a. … welchen Mönch der Bischof begleitete.
… [which monk]$_{ACC}$ [the bishop]$_{NOM}$ accompanied

b. … welchen Mönch der Zweig streifte.
… [which monk]$_{ACC}$ [the twig]$_{NOM}$ brushed

As discussed in section 1.1, accusative case marking is not compatible with the [-dep] thematic status (the Proto-Agent role) and therefore the processing of an initial accusative-marked argument establishes a thematic dependency requiring the presence of a higher-ranked argument. By way of the *Distinctness* principle, which states that the thematic distinctness between two arguments in a transitive relation should be maximal, this should lead to the prediction of an ideal [-dep] argument, i.e. an argument that is both nominative-marked and animate (cf. Chapter 1.1). In this way, the prediction should be borne out in (35a), but is violated in (35b).

At the position of the second NP in sentences such as (35), Schlesewsky & Frisch (*submitted*) observed an N400 for (35b) in comparison to (35a), thus showing that predictive processes during sentence processing are not only purely syntactic in nature (as assumed, for example, by Gibson, 1998), but may also make use of thematic dependencies under certain circumstances (i.e. particularly for the processing of sentences with unambiguous case marking).[19]

3.2.3 Evidence for the proposed interaction between the syntactic and the thematic processing route

In Chapter 1.2.4, predictions for the interaction between the thematic and the syntactic processing routes were discussed. Here, it was assumed that the syntactic processing route will initially be chosen in a sentence in which the first argument is ambiguous with respect to case marking, but that a switch to the thematic route should take place when a further argument bearing unambiguous case marking is encountered. Experimental evidence

[19] A further finding compatible with the assumption that the processing of an initial argument which cannot be associated with the [dep] status is costly is reported by Bornkessel, Schlesewsky, & Friederici (2002). These authors found that, in embedded German clauses introduced by the complementiser *dass* (‘that‘), initial dative-marked arguments did not elicit neurophysiologically distinct responses in comparison to initial nominative-marked arguments, whereas initial accusative arguments elicited a central negativity between 300 and 450 ms post onset of the phrase (cf. also Chapter 5.1.3).

in favour of this assumption stems from a study by Friederici, Mecklinger, Steinhauer, & Meyer (1998). These authors contrasted the electro-physiological responses to the sentences (36a) and (36b).

(36) a. Das sind die Direktoren, die den Sekretär
these are the directors who $_{NOM/ACC}$ [the secretary]$_{ACC}$
gesucht haben.
sought have
'These are the directors who were looking for the secretary.'

b. Das sind die Direktoren, die der Sekretär
these are the directors who $_{NOM/ACC}$ [the secretary]$_{NOM}$
gesucht hat.
sought has
'These are the directors whom the secretary was looking for.'

In both of the sentences in (36), the relative pronoun *die* is ambiguous between nominative and accusative case until disambiguation is effected via the case marking of the second argument within the relative clause (*den/der Sekretär*, '[the secretary]$_{ACC/NOM}$'). In accordance with the preference for subject-initiality discussed in section 3.1.1, the relative pronoun should be initially associated with the subject grammatical function/nominative case marking. In the case of (36b), this initial assignment must be revised when the second argument is encountered, since this argument is unambiguously marked as a nominative (subject). From the perspective of a processing model relying exclusively on syntactic relations, the reanalysis that becomes necessary at the position of the second argument in (36b) should give rise to the typical ERP component for syntactic revisions, i.e. to a P600. However, Friederici et al. (1998) observed an N400 for (36b) in comparison to (36a).

This finding may be straightforwardly derived within the argument dependency model. Although processing has taken place along the syntactic route up to the point of the second argument, the nominative case of this argument in combination with the feature [+anim] *requires* that this argument be associated with the [-dep] status. Thus, processing may be transferred to the thematic route and the argument previously processed (i.e. the relative pronoun) must be thematically interpreted in relation to the unambiguously marked second argument. However, although the second

argument is the first to be processed on the thematic route, it is not the initial argument, thus violating the expectation that the argument which is thematically highest should be realised as the initial argument. This mismatch is reflected in the N400.

A further finding from the Friederici et al. (1998) study is also compatible with the model, though its interpretation is admittedly more speculative than that of the N400 given above. In addition to the N400 at the positioon of the second argument, Friederici and colleagues observed an early positivity (P345) at the position of the sentence-final auxiliary for (36b) in comparison to (36a). At a first glance, this finding appears somewhat surprising, since the P345 in relative clause constructions such as (36) is thought to reflect reanalysis processes that become necessary when a preference-based subject assignment must be revised, yet the N400 at the position of the second NP in (36b) indicates that the erroneous assignment of the subject grammatical function to the relative pronoun has been recognised before the auxiliary is even encountered. Thus, from the perspective of a single (syntactically-based) processing route, this finding is not easily accounted for.

From the perspective that there are two processing routes, however, the pattern of results reported by Friederici et al. (1998) appears more easily comprehensible. Thus, while the (now superfluous) syntactic route is, to all intents and purposes, abandoned at the position of NP2, remnants of the representations created by it remain. In this way, when the auxiliary is processed, the attempt to establish subject-verb agreement (i.e. a syntactic process) between the auxiliary and the constituent that is thought to bear the subject function (i.e. nominative case) fails, since only the relative pronoun was associated with the functional interpretation compatible with nominative case assignment.[20]

[20] This account is compatible with independent findings that remnant pieces of erroneous analyses may influence comprehension even after a reanalysis has taken place (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira, Christianson, & Hollingworth, 2001).

3.3 The argument dependency model from a neurocognitive perspective

This section will attempt to integrate the argument dependency model as introduced in Chapter 1 with Friederici's neurocognitive model of language processing. In particular, we shall be concerned with illustrating how the predictions made by the argument dependency model may be expressed in terms of time-dependent processing variables and neurophysiological processing responses. A schematic illustration of the model's architecture within the neurocognitive framework is shown in Figure 4.

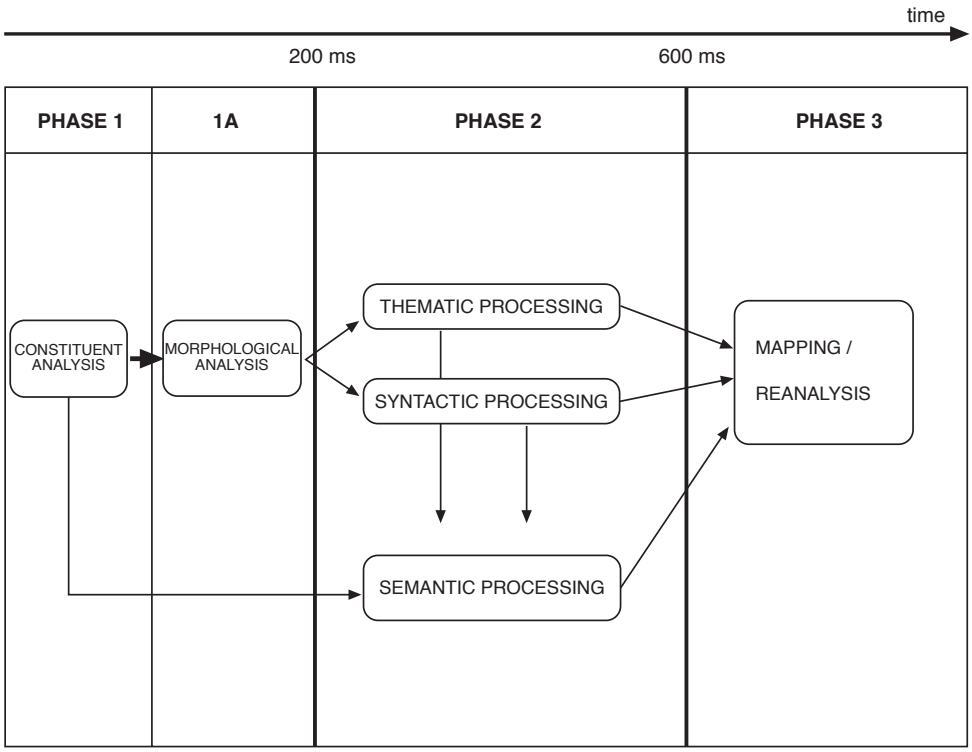

Figure 4. The argument dependency model from a neurocognitive perspective.

As Figure 4 shows, the basic subdivision into 3 processing phases assumed by the neurocognitive model is well suited to accommodating the processing architecture of the argument dependency model. In the following, we will briefly discuss each of the processing phases and their interpretation within this model in turn.

Phases 1 and 1a: Basic Constituent Structure Analysis and Morphological Analysis

The basic constituent analysis required in the argument dependency model is compatible with phase 1 in the neurocognitive model, in which a basic phrase structure is thought to be built up on the basis of word category information. Problems in this basic structuring process elicit an ELAN component and generally lead to an abortion of processing.

The assumption of a phase constituted by morphological analysis, i.e. phase 1a, is a new addition to the neurocognitive model that is required by the alternative thematic and syntactic pathways assumed in the argument dependency approach. Hence, no electrophysiological correlate can be associated with this processing step as yet. Note, however, that the morphological analyser's task does not consist of processing morphological information in the sense that it analyses and detects violations in agreement features and similar information types typically coded by morphological marking, since this type of processing is carried out in phase 2 of processing. Rather, the morphological analyser's basic function is to serve as a choice point with regard to which of the thematic and syntactic processing routes will be pursued in phase 2 when an argument is encountered, and it therefore appears exceedingly difficult to imagine a suitable violation for determining the ERP component indicative of this processing step (if, indeed, there should be one).

Phase 2: The Thematic and Syntactic Processing Routes

Let us now turn to a discussion of phase 2 of processing and, hence, particularly to the alternative and therefore temporally parallel syntactic and thematic processing routes assumed to operate within this stage.

The syntactic processing route assumed within the argument dependency model is rather straightforward in that it does not incorporate any novel insights diverging from standard views in the literature. Thus, syntactic processing consists basically of establishing and checking functional dependencies beyond those resulting merely from local, word-category based grouping into constituents, e.g. the assignment of grammatical functions and the checking of specifier-head agreement. Violations of these functional requirements may be conceived of as mismatches between

formal features and are reflected in a LAN component in terms of electrophysiological measures.

By contrast, the thematic processing route requires somewhat more elaboration. On the basis of the experimental findings discussed in the last section, we may provide a basic taxonomy of components relevant to thematic processing in the sense envisaged here. Thus, processing difficulties arising from the impossibility of hierarchising two arguments thematically give rise to an N400 component (Frisch & Schlesewsky, 2001), as do violations of a thematic prediction (Schlesewsky & Frisch, *submitted*).[21] Furthermore, N400 effects obtain when the [-dep] status must be assigned to a non-initial argument, though without reversing a hierarchical thematic ordering between arguments that was already established. Typically, this will be the case in sentences with a case ambiguous initial argument and a nominative-marked second argument, in which processing must switch from the syntactic to the thematic route (cf. the results of Friederici et al., 1998). In this way, it appears that the N400 components observed for thematic processing index rather similar processes to the LAN components generally associated with syntactic operations: both may be conceived of as reflecting a 'mismatch' in a rather general sense.

By contrast, a reanalysis of the hierarchical thematic relations between arguments gives rise to an early positivity (Bornkessel et al., *submitted*). On the one hand, the finding of such a component is not surprising, since the revision of hierarchical thematic structure is simply a special case of the revision of a hierarchy, as indeed syntactic reanalyses are too. Hence, the class of language-related positivities may be broadly defined as generally reflecting *a revision of hierarchical dependencies*. Furthermore, it does not seem surprising that a thematic reanalysis should take place entirely within the thematic processing route (i.e. within phase 2 of processing) since all of the information required for such operations to proceed is available within this processing phase. Yet why should the same reasoning not apply to syntactic reanalysis, which must be delayed until phase 3?

[21] Note that costs associated with the processing of non-ideal instantiations of a particular thematic status only occur when the argument in question was predicted, i.e. when the thematic dependency associated with a [+dep] argument gives rise to the prediction of a [-dep] argument (as in the Schlesewsky & Frisch, *submitted*, study). In other cases, there is no evidence for such costs.

A possible answer to this question presents itself in terms of the characterisation of the P600 within the neurocognitive model. As discussed above, several studies have shown that the P600 is modulated by both syntactic and semantic manipulations (Gunter et al., 1997, 2000), thereby indicating that this component should be envisaged as repairing a failed *mapping* process of syntactic and interpretative information. Why such a mapping should be required for syntactic but not for thematic information although the function of both is thought to consist of establishing hierarchical dependencies between arguments is straightforward: whereas thematic information is inherently interpretative in nature, syntactic information – at least in the sense of the syntactic information involved in structure building – is not. Therefore, only the latter must be mapped onto semantic information before interpretation may proceed. This proposal is captured in the Principle of Interpretational Proximity that is given in (37).

(37) *The Principle of Interpretational Proximity*
Only formal (functional) relational information must be mapped onto interpretative information in order for interpretation to proceed.

The Principle of Interpretational Proximity captures the intuitive idea that a thematic representation – even in a semantically impoverished sense as advocated here – is more closely related to a semantic representation than a syntactic representation. This may be made clear by reconsidering the definition of thematic dependencies (cf. Chapter 1.1), since these are, in fact, purely conceptual in nature. Thus, thematic relations may be interpreted without making reference to any other information types, while syntactic relations may not. In this way, it also becomes apparent why a thematic processing route should be pursued under certain circumstances and a syntactic processing route in all other cases, despite the fact that syntactic information is *always* available: establishing thematic relations in the sense of the thematic processing route provides a more immediate means of attaining incremental interpretation. Hence, if the question of reanalysis is reconsidered in light of these considerations, it becomes apparent that thematic relations may be revised entirely within phase 2 of processing (i.e. without requiring reference to other information types), thereby giving rise to an early positivity. For syntactic relations, however, an additional mapping process is necessary, thereby delaying syntactic reanalyses until phase 3, where they elicit a P600.

In this way, we will assume that the interaction between the syntactic and thematic processing routes and semantic processing within phase 2 is restricted to an information flow from the relational (i.e. thematic and syntactic) processing routes to semantics. By contrast, information flow from semantics to the syntactic or thematic processing route only takes place *after* phase 2 of processing is complete.

Phase 3: Reanalysis / Repair

Phase 3 in the current approach does not differ substantially from the conception of phase 3 in the neurocognitive model. Thus, an unsuccessful mapping of the different information types operated upon in phase 2 leads to an initiation of revision/repair processes. These types of processes are reflected in a P600 component, as has been extensively demonstrated for the interaction between syntactic and semantic information.

3.4 Summary and outlook

In this chapter, the argument dependency model was integrated into the neurocognitive framework proposed by Friederici (1999, 2002). A number of previous findings in favour of the model's basic architecture were discussed and, consequently, concrete predictions for real-time nuerophysiological processing behaviour were formulated.

The following chapters will present a series of experiments in support of the argument dependency model. Firstly, we will show that the basic assumption of alternative thematic and syntactic processing routes can be empirically confirmed (Chapter 4). Secondly, evidence confirming the models' predictions with regard to the interaction between the thematic and syntactic processing routes and the relationship between general and specific information (Chapter 5) will be presented. Chapter 6 then provides a summary of these initial results and their consequences for the argument dependency model. Finally, the experiments reported in Chapters 7 and 8 will provide evidence in support of the argument dependency model's crucial prediction that the establishment of thematic dependencies cannot be influenced by discourse and semantic / world knowledge information, respectively. The thesis concludes with an integrative discussion of the

experimental findings presented in the context of the argument dependency model and of the model's more general consequences (Chapter 9).

Chapter 4
Evidence for the Dissociation between Syntactic and Thematic Processing

Having provided a detailed description of the processing architecture assumed by the argument dependency model, we shall now present empirical evidence in its favour. Specifically, the experiments to be reported in this chapter will show that the proposed distinction between thematic and syntactic processing is well motivated and, moreover, that there is empirical support for the assumption that both information types are processed within the same time range.

The crucial assumption on which the dissociation between the two processing routes is based is that thematic hierarchising only takes place with regard to unambiguously case marked arguments; otherwise, only syntactic hierarchising applies. In this way, thematic dependencies *cannot* be established on the basis of syntactic structure if no morphological information is available. Recall that thematic hierarchising between arguments may be detected by means of a verb type manipulation such as in (34), which is repeated here as (38).

(38) Maria glaubt, …
Maria believes, …

a. ... dass der Mönch dem Bischof folgt und ...
... that [the monk]$_{NOM}$ [the bishop]$_{DAT}$ follows and ...
'... that the monk follows the bishop.'

b. ... dass der Mönch dem Bischof gefällt und ...
... that [the monk]$_{NOM}$ [the bishop]$_{DAT}$ pleases and ...
'... that the monk is appealing to the bishop.'

As discussed in Chapter 3.2.2, Bornkessel et al. (*to appear*) observed an early positivity at the position of the verb for sentences such as (38b) in comparison to (38a), i.e. in those cases when a clause-final object-experiencer verb disconfirms the preferred hierarchical thematic structure in which the nominative-marked argument is thematically higher-ranked than the dative-marked argument. The authors interpret this component as

reflecting a thematic reanalysis, i.e. a reversal of the hierarchical thematic relations between sentential arguments. Indeed, the Bornkessel et al. (*to appear*) study provides an initial piece of evidence for the independence of thematic hierarchising from hierarchical syntactic relations, since the early positivity elicited by object-experiencer verbs was not influenced by the word order of the clause. Thus, it does not appear to be the case that a dative argument is interpreted as thematically higher-ranking than a nominative argument, even in a dative-initial sentence.[22]

However, the independence of thematic and syntactic processing may be demonstrated in a more direct way, namely by showing that thematic hierarchising does *not* take place in sentences with ambiguously case marked arguments. A suitable sentence structure for examining this question is shown in (39).

(39) ... dass Maria Sängerinnen folgt/gefällt.
... that $\text{Maria}_{\text{NOM/ACC/DAT}}$ $\text{singers}_{\text{NOM/ACC/DAT}}$ follows/pleases
'... that Maria follows/is appealing to singers.'

In (39), both arguments are three-way ambiguous with respect to case, i.e. maximally underspecified with regard to thematically relevant information in the sense outlined in Chapter 1.1. Thus, if thematic and syntactic processing are indeed independent from one another, it should not be possible to establish a hierarchical thematic ordering between the arguments before the verb is encountered and, hence, no early positivity should be observable for object-experiencer verbs in case ambiguous sentences such as (39). If thematic structure may also be established on the basis of hierarchical syntactic dependencies, by contrast, we should expect to observe an early positivity for object-experiencer verbs in such sentences in the same way as for unambiguous sentences.

Additionally, structures such as (39) provide a means of directly examining the interaction between thematic and syntactic information and the time

[22] Note that this observation is based on observations with regard to the processing of transitive sentences with two *animate* arguments. We shall leave open the question of whether a sentence with a $\text{dative}_{[+\text{anim}]}$-$\text{nominative}_{[-\text{anim}]}$ ordering may give rise to a hierarchical thematic structure in which the dative-marked argument is thematically higher-ranked.

course of their application. This may be achieved by varying the word order of sentences such as (39), as is shown in (40).

(40) a. ... dass Maria Sängerinnen folgt/gefällt.
... that $Maria_{NOM/ACC/DAT.SG}$ $singers_{NOM/ACC/DAT.PL}$ $follows_{SG}$/$pleases_{SG}$
'... that Maria follows/is appealing to singers.'

b. ... dass Maria Sängerinnen folgen/gefallen.
... that $Maria_{NOM/ACC/DAT.SG}$ $singers_{NOM/ACC/DAT.PL}$ $follow_{PL}$/$please_{PL}$
'... that singers follow/are appealing to Maria.'

Whereas (40a), which is identical to (39), is disambiguated towards a subject-initial structure by the number agreement information of the clause-final verb, (40b) is disambiguated towards an object-initial structure at the same position. In this way, an examination of the processing behaviour at the position of the verb in sentences such as (40) should serve to shed light on the interaction between thematic and syntactic processing, since, at this position, both information types either agree upon a hierarchical ordering between the two arguments (e.g. $Arg1_{SUBJ} >_{SYN} Arg2_{OBJ}$ and $Arg1_{[-DEP]} >_{THEM} Arg2_{[+DEP]}$) or conflict with one another in this regard (e.g. $Arg1_{SUBJ} >_{SYN} Arg2_{OBJ}$ but $Arg2_{[-DEP]} >_{THEM} Arg1_{[+DEP]}$). In this way, the manipulations illustrated in (40) will provide evidence with regard to (a) the time course of application of both thematic and syntactic (number agreement) information at the position of the verb as well as the interaction of both information types, and (b) whether thematic hierarchising between arguments also takes place in case ambiguous sentences.

These questions will be examined by means of three experiments. Experiment 1, an ERP study, will show whether a thematic reanalysis (as indexed by an early positivity) may be observed in case ambiguous sentences such as (40) and, moreover, provide evidence with regard to the resolution of the processing conflict that arises when the hierarchical dependencies required by the thematic information carried by the verb contradict those required by the syntactic (agreement) information associated with it. In Experiment 2, we will supplement the results of Experiment 1 by means of SAT measures. Finally, Experiment 3 will use the speeded acceptability-judgement method to shed light on the interpretation ultimately attained for sentences such as (40) and will thereby, in combination with Experiments 1 and 2, allow conclusions to be drawn with

respect to the role of syntactic and thematic processing both during the time course of processing and in determining its end point.

4.1 Experiment 1: The dissociability of thematic and syntactic processing as revealed by ERPs

As discussed above, the aim of Experiment 1 is to provide principled evidence for the assumption of separate and, indeed, mutually exclusive thematic and syntactic processing routes during argument processing. Furthermore, conflicts arising when a single constituent provides contradictory (hierarchical) thematic and syntactic information will be examined. The critical sentence materials to be used to this purpose are shown in Table 2 (on the following page).

Each of the subordinate clauses in Table 2 was preceded by a matrix clause such as *Gestern wurde erzählt, …* ('Yesterday, someone said …') and completed by an adjunct clause in order to avoid confounding effects elicited by the properties of the critical verb with sentence wrap-up effects (e.g. Frisch, 2000).

The hypotheses for Experiment 1 are as follows. Firstly, unambiguously case marked sentences with object-experiencer verbs (i.e. conditions G and H in Table 2) should show an early parietal positivity indicative of a thematic reanalysis at the position of the verb in comparison to the analogous sentences with active verbs (E/F). Case ambiguous sentences (A-D), by contrast, should not elicit such an effect, since these only allow for the establishment of syntactic – but not thematic – dependencies before the verb is encountered.

Furthermore, on the basis of the dependencies built up by the syntactic processing route, ambiguous sentences should show a preference for subject-initiality (see Chapter 3 for previous experimental findings in this regard), thereby requiring a reanalysis when the number agreement information of the verb renders a subject-initial analysis untenable. On the basis of previous studies in which the reanalysis of a subject-object ambiguity in complement clauses was shown to elicit a P600 (Friederici & Mecklinger, 1996; Friederici et al., 2001), we thus predict a P600 component for the ambiguous object-initial conditions B and D. However, in contrast to

previous studies examining reanalyses in similar structures, the object-initial conditions with object-experiencer verbs in the present study raise the interesting question of whether the hierarchical thematic structure (dative > nominative) required by these verbs may aid the syntactic reanalysis, since they provide further evidence for this alternative hierarchisation of the arguments. Thus, if syntactic reanalysis may indeed profit from thematic information, the reanalysis effect (P600) should be less pronounced when the reanalysis is effected by an object-experiencer verb (D) than when it is effected by an active verb (B).

Condition	Example
A. Ambiguous SO active	... dass Maria Sängerinnen folgt, obwohl ... ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ follows$_{SG}$, although …
B. Ambiguous OS active	... dass Maria Sängerinnen folgen, obwohl … ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ follow$_{PL}$, although …
C. Ambiguous SO obj-exp	... dass Maria Sängerinnen gefällt, obwohl … ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ pleases$_{SG}$, although …
D. Ambiguous OS obj-exp	... dass Maria Sängerinnen gefallen, obwohl … ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ please$_{PL}$, although …
E. Unambiguous SO active	... dass der Gärtner den Jägern folgt, obwohl … ... that [the gardener]$_{NOM}$ [the hunters]$_{DAT}$ follows, although …
F. Unambiguous OS active	... dass dem Gärtner die Jäger folgen, obwohl … ... that [the gardener]$_{DAT}$ [the hunters]$_{NOM}$ follow, although …
G. Unambiguous SO obj-exp	... dass der Gärtner den Jägern gefällt, obwohl … ... that [the gardener]$_{NOM}$ [the hunters]$_{DAT}$ pleases, although …
H. Unambiguous OS obj-exp	... dass dem Gärtner die Jäger gefallen, obwohl … ... that [the gardener]$_{DAT}$ [the hunters]$_{NOM}$ please, although …

Table 2. Example sentences for each of the critical conditions in Experiment 1.

Finally, recall that a further interesting question addressed by the ambiguous conditions (A-D) in the present experiment concerns how conflicting information from the thematic and syntactic domains is dealt with. The type of conflict in question arises, for example, in subject-initial sentences with object-experiencer verbs (C), in which the hierarchical thematic requirements of the verb (Arg2 $>_{THEM}$ Arg1) directly conflict with the hierarchical syntactic structure that was established before the parser encountered the verb. The observation that mismatches typically give rise to N400 or LAN components in terms of ERP measures (cf. Friederici, 2002; Kutas & Federmeier, 2000) leads us to expect a negativity within phase 2 of processing at the position of the verb in condition C, if a processing conflict indeed occurs at this point. However, whether a similar component should be observable in condition B, i.e. in sentences with active verbs and an object-initial word order, is questionable. Thus, although the mismatch between the word order of the clause and its thematic structure in this condition is essentially very similar to that in condition C, it crucially relies on the number agreement information of the verb having been processed in order for the conflict to become visible. If, however, the two information types are processed in parallel – as assumed within Friederici's (1999, 2002) neurocognitive language processing model and also within the argument dependency model – a conflict need not arise and, hence, there should be no negativity in condition B.

4.1.1 Method

Participants

Sixteen undergraduate students from the University of Leipzig participated in Experiment 1 (8 female; mean age 23.1 years; age range 20 – 27 years). In this and all of the following experiments, all participants were right-handed (as assessed by an adapted German version of the Edinburgh Handedness Inventory; Oldfield, 1971), monolingual native speakers of German and had normal or corrected-to-normal vision. Again, for all experiments to be reported here, participants received DM 13 per hour (EUR 7 per hour for Experiments 4 and 6).

Materials

The eight critical conditions for Experiment 1 are shown in Table 2 above. Eighty sets of these eight conditions were created. Additionally, there was a second version of each set in which the order of the singular and plural NPs was reversed and, consequently, the number marking on the clause-final verbs was also interchanged. This additional variation ensured that, in all conditions, disambiguation was effected by a plural verb equally as often as by a singular verb. In this way, 1280 critical experimental sentences were created. These were then assigned to 4 lists of 320 critical items (40 per condition) in a counterbalanced manner such that each participant saw four sentences from one set of lexical items, two of which were case ambiguous and two of which were unambiguously case marked (i.e. each combination of two NPs and a particular verb only appeared twice per experimental session, once with an initial singular NP and once with an initial plural NP). A complete set of materials for this and each of the following experiments is listed in Appendix A.

Procedure

Sentences were presented visually in the centre of a computer screen in a phrase-by-phrase manner (i.e. NPs were presented as a whole). Each trial began with the presentation of an asterisk (300 ms plus 300 ms inter-stimulus interval, ISI). Single words were presented for 450 ms and phrases for 500 ms with an ISI of 100 ms. After the presentation of a sentence, there was a 1000 ms pause before participants were required to complete a comprehension task, which involved judging whether a declarative main clause presented on the screen in its entirety correctly described the content of the preceding experimental sentence or not. The comprehension task required the answer ‘yes’ equally as often as the answer ‘no’ in each of the experimental conditions; in sentences requiring the answer ‘no’, the assignment of subject and object to the two NPs was a reversal of the assignments in the experimental sentence.

Participants were asked to avoid movements and to only blink their eyes between their response to the comprehension task and the presentation of the next sentence. The experimental session began with a short training session followed by 8 experimental blocks comprising 40 sentences each,

between which the participants took short breaks. The entire experiment (including electrode preparation) lasted approximately 2.5 hours.

The EEG was recorded by means of 58 AgAgCl-electrodes fixed at the scalp by means of an elastic cap (Electro Cap International). The ground electrode was positioned above the sternum. Recordings were referenced to the left mastoid, but re-referenced to linked mastoids offline. The electro-oculogram (EOG) was monitored by means of electrodes placed at the outer canthus of each eye for the horizontal EOG and above and below the participant's right eye for the vertical EOG. Electrode impedances were kept below 5 kOhm.

All EEG and EOG channels were amplified using Neuroscan synamps amplifiers (DC to 50 Hz) and recorded continuously with a digitisation rate of 250 Hz. The plots of grand average ERPs were smoothed off-line with a 10 Hz low pass filter, but all statistical analyses were computed on unfiltered data.

Average ERPs were calculated per condition per participant from the onset of the critical stimulus item (i.e. the verb) to 1000 ms post onset, before grand-averages were computed over all participants. Averaging took place relative to a baseline interval from –200 to 0 ms before the onset of the verb. Trials for which the comprehension task was not performed correctly were excluded from the averaging procedure, as were trials containing ocular, amplifier-saturation or other artefacts (the EOG rejection criterion was 40μV).

Data Analysis

For the behavioural data, error rates and reaction times were calculated for each condition. Incorrectly answered trials were excluded from the reaction time analysis. We computed a repeated measures analysis of variance (ANOVA) involving the critical factors AMBIGUITY (ambiguous vs. unambiguous), ORDER (subject-object vs. object-subject) and VERB (active vs. object-experiencer) and the random factors subjects (F_1) and items (F_2).

For the statistical analysis of the ERP data, repeated measures ANOVAs involving the critical factors AMBIGUITY (ambiguous vs. unambiguous), ORDER (subject-object vs. object-subject) and VERB (active vs. object-

experiencer) were calculated for mean amplitude values per time window per condition in six regions of interest (ROIs). Time windows were chosen on the basis of previous studies and visual inspection of the data. Regions of interest were defined as follows: *left-anterior* (F9, F7, F5, FT9, FT7, FC5); *left-posterior* (TP9, TP7, P5, P9, P7, P5); *central-anterior* (F3, FZ, F4, FC3, FCZ, FC4); *central-posterior* (CP3, CPZ, CP4, P3, PZ, P4); *right-anterior* (F10, F8, F6, FT10, FT8, FC6); *right-posterior* (TP10, TP8, CP6, P10, P8, P6). Note that the regions of interest defined here differ from those to be used in the remaining ERP experiments to be reported in this thesis (i.e. Experiments 4, 5 and 6). This is the case because the present experiment made use of a larger electrode configuration than the following experiments in order to capture (possibly) lateralised mismatch effects as outlined in the hypotheses above.

The statistical analysis was carried out in a hierarchical manner, i.e. only significant interactions ($p \leq .05$) were resolved. In order to avoid excessive type 1 errors due to violations of sphericity, we applied the correction of Huynh & Feldt (1970) when the analysis involved factors with more than one degree of freedom in the numerator. For post hoc single comparisons between conditions, the probability level was adjusted according to the modified Bonferroni procedure (cf. Keppel, 1991).

4.1.2 Results

Behavioural Data

The statistical analysis of the error rates for the comprehension task revealed significant main effects of ORDER (F_1 (1,15) = 12.48, $p < .01$; F_2 (1,79) = 118.26, $p = .0001$) and VERB (F_1 (1,15) = 6.05, $p < .03$; F_2 (1,79) = 9.20, $p < .01$). These effects were due to higher error rates for object-initial structures (14.4%) in comparison to subject-initial structures (6.1%) and for structures involving object-experiencer verbs (11.6%) in comparison to structures involving active verbs (8.9%). The interaction ORDER x VERB reached significance only in the analysis by items (F_2 (1,79) = 5.51, $p < .03$). Resolving this interaction by VERB showed significant effects of ORDER for both active (F_2 (1,79) = 94.62, $p = .0001$) and object-experiencer verbs (F_2 (1,79) = 29.44, $p = .0001$).

With regard to the reaction times, there were again main effects of ORDER (F_1 (1,15) = 8.99, p < .01; F_2 (1,79) = 12.14, p < .001) and VERB (F_1 (1,15) = 26.31, p < .001; F_2 (1,79) = 31.18, p = .0001), with object-initial structures eliciting longer reaction times (1477 ms) than subject-initial structures (1391 ms) and object-experiencer verbs eliciting longer reaction times (1499 ms) than their active counterparts (1369 ms). Additionally, the main effect of AMBIGUITY reached significance (F_1 (1,15) = 24.33, p < .001; F_2 (1,79) = 68.93, p = .0001) on account of longer reaction times for unambiguous (1531 ms) than for ambiguous sentences (1337 ms).

ERP Data

Figures 5a and 5b show grand-average ERPs for active vs. object-experiencer verbs for unambiguous and ambiguous structures, respectively. Visual inspection of Figure 5a indicates that, for unambiguous structures, object-experiencer verbs elicited an early parietal positivity in comparison to active verbs. By contrast, no such effect is apparent for the ambiguous structures in Figure 5b. For all ERP experiments reported here, a more extensive selection of electrodes is presented in Appendix B.

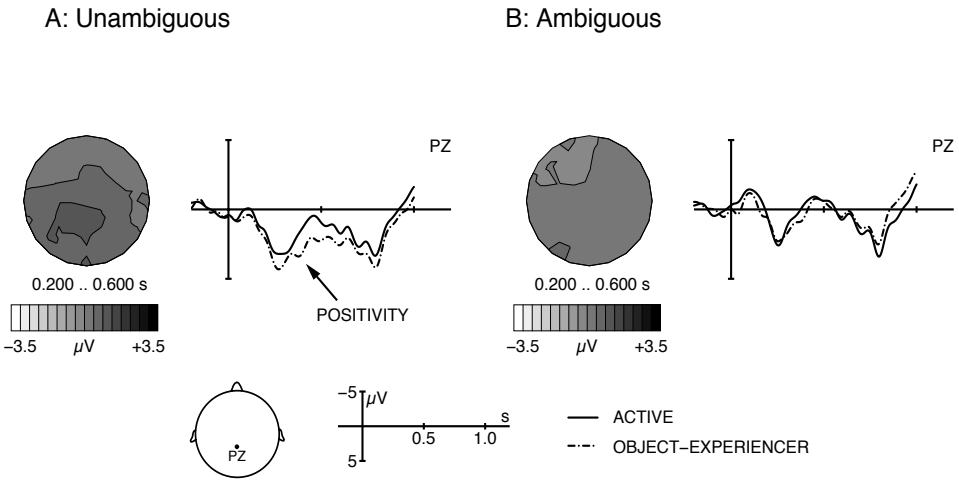

Figure 5. Grand average ERPs for active vs. object-experiencer verbs (onset at the vertical bar) for unambiguous (A) and ambiguous sentences (B) in Experiment 1. Negativity is plotted upwards. The topographical maps indicate the distribution of the voltage differences between object-experiencer and active verbs.

The statistical analysis for the time window 200-600 ms confirmed these observations. We will not compare ambiguous and unambiguous structures directly, since these differed markedly before the critical verb was reached (cf. Figure B1 in Appendix B), possibly on account of the different eye movements brought about by the single word vs. phrase-by-phrase presentation of these two sentence types.[23] For unambiguous structures, there was a main effect of VERB (F (1,15) = 8.31, p <.02), which resulted from more positive waveforms for object-experiencer in comparison to active verbs. Furthermore, there was a marginally significant interaction VERB x ROI (F(5,75) = 2.46, p <.08). For ambiguous structures, by contrast, neither the main effect of VERB nor any interactions with this factor reached significance. Rather, the statistical analysis revealed an interaction ORDER x ROI (F (5,75) = 5.36, p <.002) for ambiguous sentences.

With regard to the ambiguous structures, grand average ERPs for subject- vs. object-initial structures at the position of the verb are plotted in Figures 6a and 6b (on the following page) for active and object-experiencer verbs, respectively. Here, it is apparent that, for both active and object-experiencer verbs, object-initial structures elicited a broad, centro-parietal negativity between approximately 350 and 550 ms post onset of the verb. This effect appears to be less pronounced in the object-experiencer structures (Figure 6b) than in the active structures (Figure 6a). Additionally, in approximately the same time range as the parietal negativity, Figure 6b reveals a left-anterior negativity for subject-initial structures with object-experiencer verbs in contrast to their object-initial counterparts.

In the time window 350-550 ms, the statistical analysis revealed significant interactions ORDER x VERB in both the left-anterior (F (1,15) = 5.82, p < .03) and the left-posterior (F (1,15) = 10.14, p < .01) ROIs, as well as a significant main effect of ORDER in the central-posterior ROI (F (1,15) = 12.35, p < .01) and a marginal main effect of ORDER in the right-posterior ROI (F (1,15) = 3.63, p < .08). In both cases, the ORDER effect was due to more negative ERP waveforms in the object-initial condition.

[23] Despite these differences, the interaction AMBIGUITY x VERB reached significance in the time window 350-500 ms in the central-posterior ROI (F (1,15) = 4.55, p <.05).

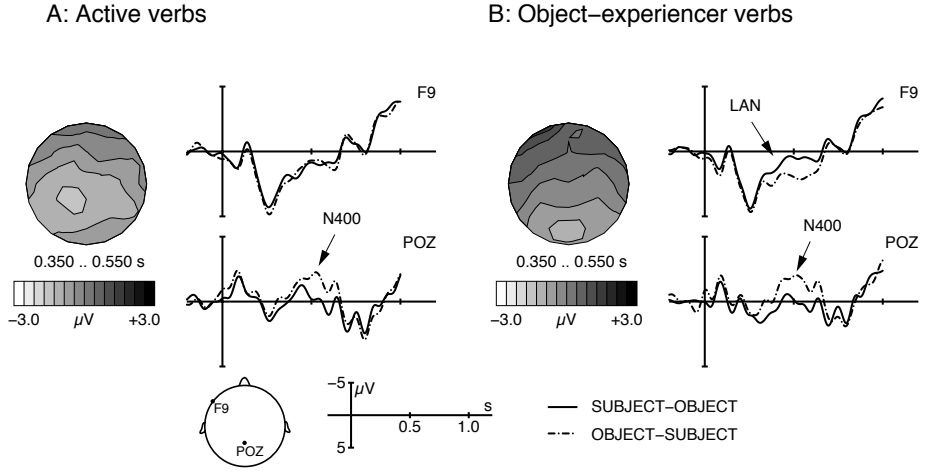

Figure 6. Grand average ERPs for object- vs. subject-initial case ambiguous structures at the position of the verb (onset at the vertical bar) for sentences with active (A) and sentences with object-experiencer verbs (B) in Experiment 1. Negativity is plotted upwards. The topographical maps indicate the distribution of the voltage differences between object- and subject-initial sentences.

The two interactions ORDER x VERB were both resolved by VERB in order to examine differences in the processing of subject-initial vs. object-initial sentences between the two verb classes. In the left-anterior ROI, planned comparisons revealed a main effect of ORDER for object-experiencer verbs (F (1,15) = 5.09, p < .04; subject-initial structures more negative), but not for active verbs (F < 1). In the left-posterior ROI, by contrast, there was a main effect of ORDER for active (F (1,15) = 17.60, p < .01; object-initial structures more negative), but not for object-experiencer verbs (F < 1).

4.1.3 Discussion

The three basic findings of Experiment 1 may be summarised as follows: (a) only unambiguously case marked structures showed an early (200 - 600 ms) parietal positivity for object-experiencer verbs that was independent of the word order of the clause; (b) all ambiguous object-initial structures showed an N400-like centro-parietal negativity between 350 and 550 ms post onset of the verb; this effect was less pronounced for sentences with object-experiencer verbs; (c) ambiguous subject-initial sentences completed by an object-experiencer verb elicited a left-anterior negativity between 350 and 550 ms post onset of the verb.

Firstly, the results of Experiment 1 show that a thematic reanalysis (as reflected by an early positivity) is initiated only in unambiguously case-marked sentences,[24] thus indicating that thematic hierarchising between sentential arguments crucially relies on morphological case marking and cannot proceed via syntactic dependencies. The data thereby show that hierarchical syntactic (word order) information is not taken into account in unambiguously case marked structures, since the thematic reanalysis component is not modulated by word order variations (as in the Bornkessel et al., *to appear*, study), and, conversely, that no attempt is made to establish hierarchical thematic relations in the absence of unambiguous morphological case marking. This observation is a striking piece of evidence in favour of the separate, and mutually exclusive, syntactic and (morphologically-based) thematic processing routes assumed for argument processing by the argument dependency model.

Furthermore, the expected mismatch component for a conflict between the thematic and syntactic hierarchies also obtained, namely in the form of a LAN for ambiguous subject-initial sentences with object-experiencer verbs. The effect demonstrates that verb-based, hierarchical thematic information applies during phase 2 of processing (i.e. approx. between 300 and 500 ms post onset of the critical word) and that a processing conflict arises between the hierarchical structure required by this information and the preferred syntactic hierarchisation between arguments. The fact that no such effect is observable when an object-initial word order is processed in the context of an active verb indicates that number agreement information is *not* accessible prior to thematic information at the position of the verb. Rather, the results are compatible with a processing architecture in which both relational information types, i.e. thematic information and subject-verb agreement, are processed in parallel, as indeed appears befitting to their functional parallelism. In this way, a crucial difference between the processing of arguments and the processing of verbs becomes apparent: while the former are processed either via the thematic or the syntactic processing route but not by both, verbs inherently activate both types of processing, since their lexical entry contains information associated with each of the two. Thus, subject-verb agreement must be checked even when the processing of the sentential arguments has taken place via the thematic

[24] This finding also shows that the early positivity reported by Bornkessel et al. (*to appear*) is not a simple, lexical verb-type effect, as one may have been led to think since verb type did not interact with any other factors (e.g. word order) in that experiment.

processing route, for otherwise agreement mismatches would not be detected in unambiguously case marked sentences, which is clearly not the case (Schlesewsky & Frisch, *in preparation*). Similarly, the hierarchical thematic information that forms part of the lexical entry of the verb affects processing even in case ambiguous sentences, in which the arguments are processed via the syntactic route, as the present finding of a LAN for subject-initial sentences with object-experiencer verbs shows.

Interestingly, the LAN effect for a mismatch between the syntactic and thematic hierarchies was only observable for ambiguous, but not for unambiguous sentences. This difference indicates that the processing conflict reflected by this component is not the result of the principled incompatibility between the two hierarchies *per se*, but rather of the consequences of this incompatibility during processing. Thus, a true conflict with regard to the hierarchical structuring of sentential arguments arises only in ambiguous structures, by virtue of the very fact that these structures *are* ambiguous.

Finally, Experiment 1 also provided evidence with regard to the role of thematic information in the reanalysis of subject-object ambiguities. Recall that an N400 effect was elicited by all object-initial structures at the position of the verb, though this component was less pronounced in the object-experiencer case. Whereas these results partly confirm our hypothesis in that the degree of processing cost elicited by a disambiguation towards an object-initial order appears to be smaller for object-experiencer than for active verbs, the general finding of an N400 for object-initial structures is surprising, since this component is not typically associated with reanalysis processes (cf. Chapter 3.1). How, then, should the N400 effect observed in Experiment 1 be characterised?

Recall from Chapter 3 that the N400 is most generally associated with semantic integration problems, i.e. this component is typically observed when a current word cannot be plausibly integrated into the sentence context built up so far (Kutas & Hillyard, 1980), or when the cloze probability for this word at the particular position in which it is encountered is low (Kutas & Hillyard, 1984). Furthermore, the N400 has been reported for verb-argument structure violations (Friederici & Frisch, 2000) and German sentences in which two noun phrases bear identical case marking (Frisch & Schlesewsky, 2001). Yet since the latter two findings involved violations,

they do not appear straightforwardly applicable to the present study. Thus, the most likely interpretation of the N400 found in Experiment 1 in terms of the established N400 literature would appear to fall under the category of low cloze probability/implausibility. Under this view, object-initial structures would be seen as more 'implausible' or as less likely completions by participants with no attempt at reanalysis being made.

However, there are several reasons for assuming that the N400 found in the present experiment may actually reflect reanalysis processes in the classical sense. Firstly, the sentence context in which this component is observable is a typical constellation for the reanalysis of a subject-object ambiguity: the first NP is associated with the subject grammatical function, as many studies have shown, and when this original assignment is disconfirmed by the verb, the clause must be reanalysed towards an object-initial structure. Furthermore, the N400 was only observable for ambiguous object-initial sentences, as the existence of a garden path plus a reanalysis would predict. If object-initial sentences were generally perceived as more implausible than their subject-initial counterparts, by contrast, this difference should also be apparent for unambiguous object-initial sentences. Thus, concluding that there is no reanalysis in this particular case would be to call into question many of the fundamental assumptions currently held about human sentence processing.

A further argument in favour of interpreting the N400 observed in Experiment 1 as an index of reanalysis is provided by the results of an ERP experiment on reanalysis reported by Osterhout (1997). Here, there were individual differences between participants with regard to whether the non-preferred resolution of a main verb/reduced relative ambiguity gave rise to a P600 or an N400. Although the author was unable to determine an independent criterion by which the two groups of participants could be dissociated, this observation shows that the finding of an N400 in a typical reanalysis constellation is not unprecedented.[25]

In sum, there appear to be two competing explanations of the N400 in the present experiment. The first, in keeping with the N400 literature, assumes

[25] In fact, an N400-like effect has also been reported for an unpreferred disambiguation of German object-object ambiguities, i.e. ambiguities between accusative and dative case (Hopf, Bayer, Bader, & Meng, 1998). This finding and Hopf et al.'s (1998) interpretation of it will be discussed in detail in section 4.2.3.

that the particular subject-object ambiguities examined here give rise to processing difficulties because participants find the object-initial structures *implausible* or less probable completions in comparison to their subject-initial counterparts. The second assumes that the object-initial sentences in Experiment 1 give rise to a reanalysis in the classical sense, albeit reflected by a component that has hitherto not been associated with this type of process. The predictions of these two alternative explanations for the N400 in Experiment 1 will be tested in Experiment 2.

4.2 Experiment 2: On the dynamics of structure-independent reanalyses and the time course of syntactic and thematic processing

Experiment 2 will make use of the multiple-response speed-accuracy trade-off (SAT) method (cf. Chapter 3.1.2) in order to supplement the findings of Experiment 1 in two respects. Firstly, since this technique's ability to dissociate between processing speed and processing accuracy provides a suitable means of distinguishing dynamical from non-dynamical processing differences during language comprehension (e.g. McElree, 1993, 1996; McElree & Griffith, 1995, 1998; cf. also Chapter 3.1.2), the SAT method will allow us to distinguish between the two possible explanations for the N400 in Experiment 1. Furthermore, on account of the high temporal resolution of SAT, this method is well suited to providing independent evidence for the parallel time course of thematic and syntactic (number agreement) processing.

In this way, the critical stimulus materials for Experiment 2 are identical to the ambiguous conditions of Experiment 1. These are repeated in Table 3. As in Experiment 1, all sentences began with a matrix clause of the form *Gestern wurde erzählt …* ('Yesterday, someone said …'). The sentences used in Experiment 2 differed from those in Experiment 1, however, in that the critical word was presented sentence-finally.

Condition	Example
A. Ambiguous SO active	... dass Maria Sängerinnen folgt. ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ follows$_{SG}$
B. Ambiguous OS active	... dass Maria Sängerinnen folgen. ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ follow$_{PL}$
C. Ambiguous SO obj-exp	... dass Maria Sängerinnen gefällt. ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ pleases$_{SG}$
D. Ambiguous OS obj-exp	... dass Maria Sängerinnen gefallen. ... that Maria$_{NOM/ACC/DAT.SG}$ singers$_{NOM/ACC/DAT.PL}$ please$_{PL}$

Table 3. Example sentences for each of the critical conditions in Experiment 2.

In accordance with the description of the properties of the SAT method given in Chapter 3.1.2, our hypotheses for Experiment 2 are as follows. If it is the case that the N400 in Experiment 1 may be viewed as reflecting reanalysis processes in the classical sense, object-initial sentences should show slower processing dynamics (i.e. a delayed intercept or a slower rate) in comparison to their subject-initial counterparts in this experiment, since a reading requiring a reanalysis should – by definition – take longer to compute. On the other hand, if the N400 in Experiment 1 should be attributed to the object-initial sentences being perceived as more implausible or unlikely continuations than subject-initial sentences, this contrast should be reflected in asymptotic differences between the two word orders. Crucially, in the latter case there should be no dynamics differences between subject- and object-initial orders because a plausibility difference is by definition a representational difference between two sentences. In this way, there is no reason that an implausible structure should take longer to compute than a plausible structure. Rather, the two should differ with regard to the acceptability ultimately attained (i.e. with unlimited processing time), thereby giving rise to an asymptotic difference in terms of SAT measures.

4.2.1 Method

Participants

Thirteen students of the University of Leipzig participated in Experiment 2 (10 female; mean age 22.6 years; age range from 20-27 years). Three further participants were excluded for not having performed well enough on the control tasks (see below). None of the participants had taken part in Experiment 1.

Materials

The critical materials for Experiment 2 were identical to those used in the ambiguous conditions of Experiment 1, though only 16 sentences were presented per condition in this experiment. Additionally, 4 comparable ungrammatical conditions were included in order to enable d'-scaling (see below). These are illustrated in (41).

(41) Gestern wurde erzählt, …
'Yesterday, someone said …'

a. *… dass der Kommissar Pastoren abraten.
… that [the superintendent]$_{NOM.SG}$ pastors$_{NOM/ACC/DAT.PL}$ dissuade$_{PL}$

b. *… dass Pastoren der Kommissar abraten.
… that pastors$_{NOM/ACC/DAT.PL}$ [the superintendent]$_{NOM.SG}$ dissuade$_{PL}$

c. *… dass der Kommissar Pastoren auffallen.
… that [the superintendent]$_{NOM.SG}$ pastors$_{NOM/ACC/DAT.PL}$ notice$_{PL}$

d. *… dass Pastoren der Kommissar auffallen.
… that pastors$_{NOM/ACC/DAT.PL}$ [the superintendent]$_{NOM.SG}$ notice$_{PL}$

Participants read two versions of a single sentence, one with an initial singular and one with an initial plural NP. The 128 experimental sentences were randomly interspersed with 152 filler sentences. These fillers

controlled that participants read the entire sentences presented to them, including the matrix clause, both arguments and the verb.

Procedure

At the beginning of each trial, a letter ("L" or "R") indicating the button (left or right) which participants should choose for their initial button press was presented for 2000 ms. After an interval of 500 ms, an asterisk signalling the onset of the sentence appeared for 300 ms, followed by blank screen for 300 ms. Then, the experimental sentence was presented as a whole at the centre of the screen. Simultaneously with the onset of the sentence, a series of tones cueing participants' responses sounded with an inter-tone-interval of 350 ms. Participants were instructed to press one of the response buttons at the sound of each tone from the second tone onwards, while they read the sentence at their own pace. The series of button presses began with the button indicated at the beginning of the trial and participants were asked to continue pressing this button if they encountered no contradictory information to the judgement associated with it, or else to switch to the other button. Participants were explicitly trained to synchronise their button presses with the tone series and to perform switches from one side to the other during a practise session. Switches back and forth between the left and right buttons were allowed, provided that participants kept to the rhythm set by the tone series. In each trial, the tone series comprised 17 tones, thus resulting in a total presentation time of 5.59 seconds for each sentence. The assignment of "acceptable" and "unacceptable" to the left and right buttons was counterbalanced across participants.

As in Experiment 1, participants responded to a comprehension question after each trial. If participants had judged a sentence unacceptable in the first task, they were required to decide whether the second sentence was a possible correction of the first or not.

Each participant took part in a single experimental session, which consisted of an intensive training session followed by 8 experimental blocks of 35 trials each. Participants took short breaks between the training session and the experiment proper as well as between the experimental blocks. The entire experimental session lasted approximately 2 hours.

Data Analysis

For the comprehension question, error rates and reaction times were calculated for each condition. Incorrectly answered trials were excluded from the reaction time analysis. The statistical analysis made use of a repeated measures ANOVA with the critical factors ORDER (subject-object vs. object-subject) and VERB (active vs. object-experiencer) and the random factors subjects (F_1) and items (F_2).

With regard to the SAT data, the percentage of correct responses was calculated per subject per lag for all responses falling within ±150 ms of the tone characterising the lag. For each subject and lag, a standard d' measure was calculated (equal variance-Gaussian model) for each condition by scaling the critical (grammatical) conditions against the comparable ungrammatical sentences in (41). Perfect performance in any condition was adjusted to an error rate of 0.01% in order to ensure that d' would be defined (Macmillan & Creelman, 1991; cf. McElree, 1993, for a discussion of the validity of this procedure).

The SAT functions were fit with the exponential in (42) (cf. Chapter 3.1.2) using an iterative hill climbing algorithm (Reed, 1976) similar to Stepit (Chandler, 1969), which minimises the squared deviations of predicted from observed data.

(42) $d'(t) = \lambda\,(1- e^{-\beta\,(t\,-\,\delta)})$, for $t > \delta$, otherwise 0

Differences between conditions were isolated by sets of competitive fits varying the three parameters of (42). The quality of each fit was determined on the basis of three criteria: (a) an adjusted R^2 statistic, which is shown in (43), (b) the consistency of the fits across participants, and (c) an evaluation of whether the fit yielded consistent residual deviations that could be accounted for by more parameters.

The R^2 statistic used, (43), shows the degree of variance accounted for, while considering the number of free parameters *k* (Reed, 1973).

(43)
$$R^2 = 1 - \frac{\sum_{i=1}^{n}(d_i - \hat{d}_i)^2 / (n-k)}{\sum_{i=1}^{n}(d_i - \overline{d})^2 / (n-1)}$$

In (43), d_i represents the observed data values, $\hat{d}$ represents the predicted values, $\bar{d}$ the mean and n the number of data points.

4.2.2 Results

Comprehension question

The statistical analysis for the comprehension question revealed significant effects neither for the error rates (mean error rate: 6.49 %; SD: 3.98) nor for the reaction times (mean reaction time: 1081 ms; SD: 449).

SAT

Figure 7 shows the empirical data (symbols) and best fitting exponential functions (lines) for each of the four critical conditions in Experiment 2.

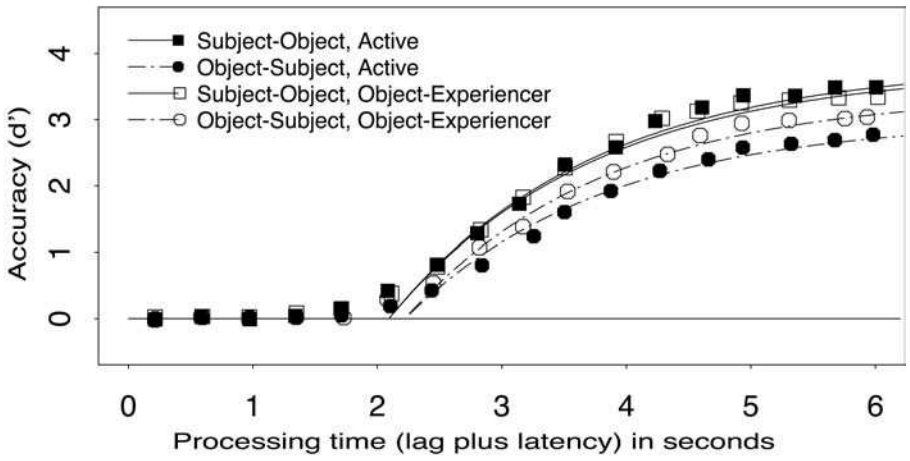

Figure 7. Best fitting SAT functions for each of the four conditions in Experiment 2

In order to ascertain the best fit, we employed a hierarchical model testing schema in which the three parameters of (42) were systematically varied. Models varied from a null case with common intercepts, rates and asymptotes for each of the four conditions to the fully saturated 4λ-4β-4δ model, in which each condition is assigned an individual value for each of the parameters.

The best fit was achieved by a 4λ-1β-2δ model with an R^2 value of .9923. This model estimated differences in asymptote such that subject-initial active structures had the highest asymptotic value (3.85), followed by subject-initial object-experiencer structures (3.78), object-initial object-experiencer structures (3.40) and object-initial active structures (3.00). There was an estimated difference of 190 ms between the intercepts for subject-initial structures (2.03 s) and their object-initial counterparts (2.22 s). In view of the question at hand, i.e. whether the N400 observed for object-experiencer structures in Experiment 1 resulted from dynamical or non-dynamical processing differences, the most important competitor of this model was the comparable model without dynamics differences, i.e. 4λ-1β-1δ, which had an R^2 value of .9911. Values for individual participants are shown in Table 4.

		Participants												
Parameter Estimates	**Av**	1	2	3	4	5	6	7	8	9	10	11	12	13
Asymptotes (λ)														
SO, Active	**3.85**	3.74	3.45	3.06	4.00	4.00	4.00	3.19	3.76	4.00	3.70	3.71	3.29	4.00
OS, Active	**3.00**	3.00	3.00	3.00	2.51	2.27	2.58	3.00	3.00	1.77	3.00	2.36	2.26	3.00
SO, Obj-Exp	**3.78**	3.90	3.90	2.97	3.90	3.90	3.90	3.13	3.66	2.83	3.67	2.56	3.90	3.90
OS, Obj-Exp	**3.40**	3.40	3.26	3.06	3.32	2.55	3.40	2.33	3.402	2.29	3.40	3.40	2.96	3.34
Dynamics														
Common Rate (β)	**0.623**	0.844	0.599	0.917	0.505	0.848	0.870	0.984	1.975	0.913	1.452	0.701	0.949	1.556
SO-Intercept (δ)	**2.029**	2.464	2.257	1.283	3.000	2.627	2.191	2.303	1.909	1.605	2.331	3.000	2.011	2.881
OS-Intercept (δ)	**2.224**	2.737	2.633	1.631	3.000	2.821	2.299	2.375	1.876	1.796	2.289	3.00	2.053	2.735
Adjusted-R^2	**.992**	.956	.964	.977	.923	.977	.961	.986	.977	.964	.954	.931	.978	.961

Table 4. Parameter estimates for individual participants in Experiment 2.

As is apparent from Table 4, the critical intercept difference between subject- and object-initial structures was shown by 10 of the 13 participants. With regard to the asymptote differences, the pattern of the best overall fit was shown by 8 participants, while 3 participants showed a higher asymptotic value for the subject-initial object-experiencer condition than for the subject-initial active condition; one participant showed no differences between the four conditions.

In order to ensure that the parameter differences outlined above are indeed reliable, we calculated a repeated measures ANOVA for the individual

parameter values. With regard to the asymptote values, this analysis revealed a main effect of ORDER ($F(1,12) = 44.46$, $p = .0001$) and an interaction ORDER x VERB ($F(1,12) = 8.41$, $p < .02$). Single comparisons showed significant effects of ORDER for both verb classes (active: $F(1,12) = 34.45$, $p = .0001$; object-experiencer: $F(1,12) = 9.95$, $p < .01$). For the intercept parameter estimates, there was a significant main effect of ORDER ($F(1,12) = 5.73$, $p < .04$). In this way, it is apparent that both the asymptote differences and the intercept differences in the 4λ-1β-2δ model are reliable.

4.2.3 Discussion

Experiment 2 revealed asymptotic differences between all four conditions as well as intercept differences between subject- and object-initial structures. In this way, the results of Experiment 2 indicate that there is a general difference between the processing of ambiguous subject- and object-initial structures such that subject-initial structures are processed more quickly than their object-initial counterparts. This difference in the dynamical parameters confirms the reanalysis perspective on the N400 component observed in the same comparison in Experiment 1, since a condition requiring a reanalysis should always require additional processing time in comparison to a control condition.

It is therefore apparent that, when considered together, Experiments 1 and 2 provide convincing evidence that the N400 in Experiment 1 reflects processes of reanalysis. How is this compatible with the fact that reanalysis processes accompanying the resolution of grammatical function ambiguities are typically associated with positive deflections in the ERP, most typically with the P600? An obvious starting point to approaching this question is to consider the differences between the structures used in the present experiments and those examined in previous studies.

At a first glance, there appear to be two important differences between the structures used in Experiments 1 and 2 and those examined by other studies examining subject-object ambiguities in German subordinate clauses introduced by the complementiser *dass* ('that'). In this regard, consider sentence (44), which is an example of the structures for which Friederici & Mecklinger (1996) and Friederici et al. (2001) observed a P600.

(44) Klaus weiß, dass die Studentin die Freundinnen
Klaus knows that [the student]$_{NOM/ACC.SG}$ [the friends]$_{NOM/ACC.PL}$
besucht haben.
visited have$_{PL}$
'Klaus knows that the friends visited the student.'

The structures used in the present experiment differ from structures such as (44) in that (a) disambiguation is not effected by an auxiliary, but rather by a semantically contentful verb, and (b) the structures involve the assignment of dative case. However, the first of these differences does not appear to be responsible for the appearance of the N400, since beim Graben, Saddy, Schlesewsky, & Kurths (2000) also report a P600 for disambiguation via a semantically contentful verb in structures such as (45).

(45) Welche Studentin besuchten die Freundinnen?
[which student]$_{NOM/ACC.SG}$ visited$_{PL}$ [the friends]$_{NOM/ACC.PL}$
'Which student did the friends visit?'

Thus, it appears unlikely that the N400 in Experiment 1 is a result of the difference in disambiguating elements (auxiliary vs. full verb) between previous studies and Experiment 1.

The possibility remains that the appearance of the N400 is crucially tied to the (nonpreferred) disambiguation of a grammatical function ambiguity in combination with the assignment of dative case. This constellation is reminiscent of an observation by Hopf et al. (1998) that the nonpreferred resolution of accusative-dative ambiguities in German gives rise to an "N400 like" component. Consider the following crucial sentences of their experiment.

(46) a. Dirigenten, die ein schwieriges Werk einstudiert haben,
conductors$_{NOM/ACC/DAT}$ who a difficult opus rehearsed have
kann ein Kritiker ruhig applaudieren.
can [a critic]$_{NOM}$ safely applaud$_{DAT}$
'A critic may safely applaud conductors who have rehearsed a difficult opus.'

b. Musikern, die ein schwieriges Werk einstudiert haben,
musicians$_{DAT}$ who a difficult opus rehearsed have
kann ein Kritiker ruhig applaudieren.
can [a critic]$_{NOM}$ safely applaud$_{DAT}$
'A critic may safely applaud musicians who have rehearsed a difficult opus.'

In (46a), the initial bare plural noun *Dirigenten* ('conductors') is ambiguous between nominative, accusative and dative. Nominative assignment is ruled out when *ein Kritiker* ('a critic') is processed, since this NP is itself unambiguously marked for nominative. The remaining ambiguity between accusative and dative is resolved by the dative-assigning verb *applaudieren* ('to applaud'). In comparison to the control condition (46b), in which the initial noun (*Musikern*, 'musicians') is unambiguously marked for dative case, (46a) elicits a negativity between 300 and 900 ms post onset of the clause-final verb. According to Hopf et al. (1998), case assignment preferences in German proceed in the order Nominative > Accusative > Dative. Thus, in (46a), the preference-based assignment of accusative to the initial noun (which takes place when the subject is processed) must be revised when the verb is encountered. Since accusative and dative objects occupy the same syntactic position, this revision does not involve structural alternations, but only the assignment of a [+dative] feature to the initial argument. As the authors assume that dative is always a lexical case and thereby requires a special type of lexical licensing, they interpret the negativity in (46a) as a reflection of a *lexical reaccess*, which is required in order for the dative assignment to succeed.

Despite the superficial similarity between the revision processes required in the Hopf et al. (1998) study and in the present experiments, it appears unlikely that the N400 in Experiment 1 is amenable to an explanation in terms of lexical reaccess. Firstly, note that the structures used by Hopf et al. are in fact quite different from ours, since they do not involve a subject-object ambiguity: as discussed above, the subject assignment is explicitly ruled before the verb is reached. Now consider the structures used in our experiment. Assuming default case assignment in the sense specified above (Gorrell, 1996; Hopf et al., 1998), NP1 would be assigned nominative and NP2 accusative case. In this way, *all* of the critical conditions in our experiment should involve a lexical reaccess at the position of the verb because dative assignment (which never takes place by default in transitive

structures) must be assigned irrespectively of the word order at this point.[26] Thus, under the lexical reaccess perspective, the fact that the N400 crucially depends on the word order of the clause cannot be derived.

It is therefore apparent that the explanation of the N400 must incorporate dative and verb classes into the word order distinction. In fact, a straightforward solution presents itself if the structure of German is considered a little more closely. Table 5 shows unmarked German word orders, where "unmarked" is generally assumed to entail a non-derived order.[27]

$Type_{active}$	Relation	$Type_{passive}$	Relation	Example
intrans1	NOM		0	*kommen, schlafen*
intrans2	ACC		*	*frieren*
intrans3	DAT		*	*grauen*
trans1	NOM ACC	intrans1	NOM	*sehen*
trans2	NOM DAT	intrans3	DAT	*folgen, vertrauen*
trans3	NOM GEN	intrans4	GEN	*gedenken*
trans4	DAT NOM		*	*gefallen*
ditrans1	NOM DAT ACC	trans4	DAT NOM	*vorstellen, geben*

Table 5. Case patterns in German (following Fanselow 2000, Wunderlich, *in press*).

The table shows that, besides the subject-first order (i.e. nominative before all other arguments) observable in many languages, German also allows a basic order in which an object precedes the (nominative-marked) subject. However, this is only possible if the object bears dative case (cf. trans4 in Table 4; note that there is *no* accusative-nominative pattern; cf. also Chapter 1.1). Thus, since dative-nominative is also a basic (non-derived) word order, reanalysis towards this order may proceed entirely without operations pertaining to the syntactic structure, i.e. all that must take place is an assignment of dative case to the first NP.

[26] An account of these results assuming that dative case may have been assigned by default in our experiment on the basis of an experiment-specific strategy is excluded by Hopf et al.'s findings as well as by the results reported in Kulik (2001). By virtue of the sentences used, these studies should be equally prone as our experiments to a default dative assignment, though both show a clear, preference-based accusative-assignment.

[27] The word order of a sentence is referred to as *unmarked* if this sentence may be felicitously uttered in the absence of any constraining context, with the typical test case being a presumably neutral context such as 'What happened?' (cf. Siewierska, 1988).

This account is also able to derive the verb class dependency of the effect. Note that, in Table 5, the crucial dative-nominative word order is associated with verbs such as *gefallen* ('to be appealing to'), i.e. with exactly the class of object-experiencer dative verbs used in the present experiments. Thus, it is clear how the processing of this particular type of verb may ease the reanalysis process towards an object-initial structure: accessing an object-experiencer verb's lexical entry implies accessing a template requiring a dative-nominative word order, since this allows the thematically higher-ranked argument (the dative Experiencer) to also be positioned higher in the syntactic structure than the second argument (the nominative Theme). In this way, the verb template provides an optimal solution to the processing conflict induced by the agreement mismatch between the first NP and the verb. For active verbs, by contrast, there is no lexical information supporting the case reassignment, which consequently requires more processing effort than the object-experiencer case. However, since the difference between the two object-initial conditions was reflected in a higher asymptote for object-initial sentences with object-experiencer verbs in Experiment 2, rather than in dynamics differences, it appears that the advantage for a reanalysis towards an object-initial structure effected by an object-experiencer verb is due to a higher probability of accessing the object-initial reading in this case, rather than to a faster computation of this analysis.

As a result of the above discussion, we may therefore reach the preliminary conclusion that the 'reanalysis N400' observed in Experiment 1 reflects a reanalysis that does not involve any restructuring operations whatsoever.

Let us now turn to the second question addressed by Experiment 2, namely whether there is independent (i.e. non-ERP) evidence for the simultaneous processing of number agreement and thematic information. Recall that the only difference pertaining to processing dynamics found in Experiment 2 was an intercept difference for subject- vs. object-initial structures. By contrast, no dynamics differences involving different verb classes were apparent. On the basis of these findings, one might be tempted to conclude that number agreement is processed and/earlier or more quickly than thematic information, in contrast to the conclusions drawn from Experiment 1. However, there is an important difference between these two information types in the context of the present experiment, which must be taken into consideration when interpreting its results, namely that there is a preference for one of the two possible number markings of the verb on the basis of the

syntactic preference for subject-initiality, whereas there is no such preference for one verb class over the other. In this way, one should *expect* to find differences in the dynamics of processing between the two information types, even if they are processed within the same time range. In summary, Experiment 2 does not contradict the hypothesis that number agreement information and thematic information are processed within the same time range. Rather, the present findings support the conclusion drawn from Experiment 1 that thematic reanalyses are not observable in sentences with ambiguous case marking, since there were no dynamics differences between sentences with active verbs and sentences with object-experiencer verbs.

4.3 Experiment 3: The global advantage for parallel thematic and syntactic dependencies

Experiments 1 and 2 have provided us with a rather precise impression of the time course of processing for thematic and syntactic information and how these two information types interact during this time. In order to complete the picture, we now require a standard behavioural measure in order to shed light on the way in which the processing of the structures in question is completed, i.e. on the endpoint of processing. To this end, Experiment 3 will examine the same structures as used in Experiments 1 and 2 by means of the speeded acceptability judgement method.

4.3.1 Method

Participants

Twenty-four undergraduate students of the University of Leipzig participated in Experiment 3 (13 female; mean age 23.2 years; age range from 20-28 years). None of the participants had taken part in either of Experiments 1 or 2.

Materials

The critical conditions for Experiment 3 were identical to those used in Experiment 2 (see Table 3). Each participant read 10 sentences per condition and no more than a single condition from one set of lexical items.

The total number of 40 experimental sentences were randomly interspersed with 120 (grammatical and ungrammatical) filler sentences. The fillers were constructed such that the acceptability of a sentence could never be predicted before the appearance of the sentence-final verb.

Procedure

As in Experiment 1, sentences were presented in a phrase-by-phrase manner in the centre of a computer screen (which amounts to a word-by-word presentation for the critical sentences), although with a shorter presentation time of 300 ms per segment with an inter-stimulus interval of 50 ms. After the presentation of the final word, a question mark signalled to participants that they should judge the acceptability of the sentence as quickly as possible. If no response was given within 2000 ms, participants were notified that time had run out. After a pause of 300 ms, participants completed a comprehension task similar to those for Experiments 1 and 2.

Data Analysis

For the statistical analysis, error rates and reaction times for the judgement and comprehension tasks were calculated for each critical condition. Incorrectly answered trials, i.e. “unacceptable” responses in the critical conditions, were excluded from the reaction time analysis. Repeated measures ANOVAs with the critical factors ORDER (subject-object vs. object-subject) and VERB (active vs. object-experiencer) and the random factors subjects (F_1) and items (F_2) were computed.

4.3.2 Results

The percentages of correct answers and mean reaction times for both tasks are presented in Table 6.

CONDITION		ACCEPTABILITY JUDGEMENT		COMPREHENSION TASK	
Verb class	Order	Correct answers (%)	mean reaction times in ms (standard dev.)	correct answers (%)	Mean reaction times in ms (standard dev.)
Active	SO	92.3	634 (184)	89.0	1107 (248)
	OS	84.6	846 (226)	88.7	1333 (275)
Object-Experiencer	SO	86.5	813 (222)	88.9	1161 (280)
	OS	91.7	778 (239)	88.0	1203 (234)

Table 6. Percentages of correct answers and mean reaction times for the acceptability judgement and the comprehension task in Experiment 3.

Acceptability Judgement

For the error rates of the acceptability judgement, a global repeated measures analysis showed neither a significant main effect of ORDER nor of VERB (F_1/F_2 <1). By contrast, the analysis revealed a significant interaction ORDER x VERB ($F_1(1,23) = 7.35$, $p = .01$; $F_2(1,39) = 13.71$, $p < .01$). Resolving this interaction by VERB showed a significant advantage for a subject-object order in sentences involving an active verb ($F_1(1,23) = 5.53$, $p < .05$; $F_2(1,39) = 37.23$, $p < .01$). Sentences with object-experiencer verbs, however, showed a significant advantage for the inverse, i.e. the object-subject order, only in the analysis by items ($F_1(1,23) = 2.48$, $p = 0.1$; $F_2(1,39) = 4.31$, $p < .05$).

The statistical analysis of the reaction times for the acceptability judgement revealed main effects of ORDER ($F_1(1,23) = 11.78$, $p < .01$; $F_2(1,39) = 14.15$, $p < .01$) and VERB ($F_1(1,23) = 6.91$, $p < .02$; $F_2(1,39) = 4.81$, $p < .05$), and a significant interaction ORDER x VERB ($F_1(1,23) = 31.18$, $p < .01$; $F_2(1,39) = 49.07$, $p < .01$). The interaction was again resolved by VERB, thus showing that both main effects resulted from faster reaction times for active sentences with a subject-object order (active: $F_1(1,23) = 31.22$, $p < .01$; $F_2(1,39) = 37.23$, $p < .01$; object experiencer: F_1/ F_2 <1).

Comprehension task

The ANOVA for the error rates showed no significant differences for ORDER, VERB or the interaction of these factors ($F_1/F_2 < 1$).

The statistical analysis of the reaction times revealed a main effect of ORDER ($F_1(1,23) = 19.29$, $p < .01$; $F_2 (1,39) = 12.40$, $p < .01$) and a significant interaction ORDER x VERB ($F_1 (1,23) = 16.95$, $p < .01$; $F_2 (1,39) = 7.80$, $p < .01$). Resolving the interaction by VERB showed a significant subject-first advantage for active sentences ($F_1(1,23) = 49.45$, $p < .01$; $F_2(1,39) = 18.35$, $p < .01$) but no ORDER effect for object experiencer constructions ($F_1 / F_2 < 1$).

4.3.3 Discussion

Experiment 3 confirms the findings of Experiments 1 and 2 in showing that the thematic structure of a sentence crucially influences the way in which word order variations are processed in the disambiguating region of initially ambiguous sentences. Moreover, Experiment 3 supplements the findings of the first two experiments by showing that the global acceptability of object-initial sentences is higher when these sentences contain an object-experiencer verb. In fact, sentences with object-experiencer verbs were tendentiously more acceptable when they were object-initial, thus not only neutralising the general preference for subject-initiality, but even indicating its reversal. This finding surpasses that of the asymptotic accuracy for Experiment 2, in which object-initial sentences with object-experiencer verbs were more acceptable than object-initial sentences with active verbs but still less acceptable than subject-initial sentences with object-experiencer verbs. The contrast between these two experiments perhaps indicates that participants had not entirely reached asymptotic performance at the last lag of Experiment 2.

The present findings thereby indicate that the language processing system has a *global* preference for parallel syntactic and thematic dependencies between arguments. However, the endeavour to establish such a parallelism does not appear to be a driving force during the time course of argument processing; rather, the results of Experiments 1 and 2 indicate that each of the two domains of information attempts to establish internally consistent representations before taking the requirements of the other

domain into account. Thus, the autonomous parallelism between the two types of processing that is characteristic of the argument dependency model is followed by a processing stage in which both domains are mapped onto one another (cf. the function of phase 3 of processing in Friederici's neurocognitive model as outlined in Chapter 3.1.1).

4.4 Summary

By means of an ERP study (Exp. 1), an SAT study (Exp. 2) and a speeded acceptability judgement experiment (Exp. 3), this chapter has provided evidence for the independence of the thematic and syntactic processing routes as well as for their temporal simultaneity. Thus, it is now clear that, in verb-final sentences, the dependencies that are established between sentential arguments before the verb is encountered are either syntactic or thematic in nature, but not both, the crucial deciding factor in this regard being the presence or absence of morphological case marking. When a verb is processed, by contrast, both processing pathways must be pursued, since the lexical entry of a verb inherently contains both information types. In this case, thematic and syntactic processing appear to proceed simultaneously, but relatively autonomously. This autonomy is, however, only of short duration, since both information types interact during reanalysis operations, which, incidentally, may be reflected in an N400 component when they do not involve structural alterations of any kind. Finally, this eventual interaction between syntactic and thematic processing is reflected in the fact that, from a global perspective, it is advantageous for thematic and syntactic dependencies to parallel one another.

Within this quite elaborate view on the relation between syntactic and thematic processing, it appears that there is a discrepancy between the end point of processing, at which a parallelism between syntactic and thematic dependencies seems beneficial, and its time course, during which it appears more desirable for each processing route to generate representations that are maximally unmarked within its own domain. However, in view of the fact that only one of the two processing routes is typically pursued during argument processing, it is not surprising that a parallelism between both is not of primary concern in sentences such as those examined in Experiments 1 – 3. Thus, it appears more important to ask whether the endeavour of attaining such a parallelism may *ever* influence processing within the

individual pathways. In this regard, consider again the difference between nouns and verbs touched upon above: only the latter inherently give rise to both syntactic and thematic processing. Thus, when a verb is processed, the parser essentially has all information available to it that is necessary for striving towards parallel syntactic and thematic dependencies. In this way, the next chapter will be concerned with examining how argument processing is influenced by the availability of verb information, i.e. whether processing preferences in the syntactic domain may be modulated by the desire to parallel thematic dependencies.

Chapter 5
Attaining Parallel Dependencies: On the Interaction between Universal and Specific Information Sources

As outlined in detail at the end of Chapter 4, the present chapter will present an experiment designed to address the apparent divergence between the initial autonomous behaviour of thematic and syntactic processing and the later advantage for parallel syntactic and thematic dependencies. In this way, Experiment 4 will use ERPs to ascertain whether the language processing system endeavours to create parallel syntactic and thematic dependencies under conditions where there is sufficient information for this to be possible.

Specifically, a constellation in which the required type of information should be available is shown in (47).

(47) a. Vielleicht gefällt Maria dem Jungen.
perhaps pleases Maria$_{NOM/ACC/DAT}$ [the boy]$_{DAT}$
'Perhaps Maria is appealing to the boy.'

b. Vielleicht gefällt Maria der Junge.
perhaps pleases Maria$_{NOM/ACC/DAT}$ [the boy]$_{NOM}$
'Perhaps the boy is appealing to Maria.'

In the examples in (47), the verb is processed before its arguments and thereby all of its syntactic and thematic requirements are available when syntactic / thematic integration of the arguments takes place. Thus, if the endeavour to attain parallel syntactic and thematic dependencies may determine processing within the two subsystems during phase 2, there should be an online advantage for structures such as (47b), since here thematic and syntactic dependencies are parallel (i.e. $Arg_{DAT} > Arg_{NOM}$). If, on the other hand, each processing system initially attempts to build up representations which are maximally felicitous with regard to its own type of information, (47a) should be preferred over structures such as (47b) on the basis of the general preference for subject-initiality.

The interaction between verb class differences and word order preferences was touched upon in a previous study by Scheepers, Hemforth, &

Konieczny (2000). These authors examined sentences such as (48) in an eye-tracking experiment.

(48) Vielleicht ängstigte die stille Schülerin der strenge Lehrer ein wenig,
perhaps frightened the$_{NOM/ACC}$ quiet pupil the$_{NOM}$ strict teacher a little
so wurde vermutet.
so was suspected
'It was suspected that the strict teacher perhaps frightened the quiet pupil a little.'

Superficially, there is a close resemblance between (48) and example (47b) discussed above: in both cases, the first argument is ambiguous between a subject- and an object-interpretation in the context of an object-experiencer verb. However, the crucial difference between the two structures is that *ängstigte* ('frightened') is an object-experiencer verb subcategorising for accusative case, whereas *gefällt* ('is appealing to') is a dative object-experiencer verb. It has often been proposed from a theoretical perspective that only dative object-experiencers require a hierarchical thematic ordering between the arguments in which the object outranks the subject, whereas accusative object-experiencers also allow a causative reading in which the nominative argument is thematically highest (e.g. Fanselow, 2000; Primus, 1999; Wunderlich, 1997). In light of these theoretical considerations, it is not entirely surprising that Scheepers et al. (2000) observed a general (i.e. verb class independent) advantage for subject-initiality in first-pass reading times for the position of the (disambiguating) second argument. However, there was also an interaction between word order and verb class in regression path durations for the clause-final adverbial, which indicated that, sentence-finally, object-initial orders were easier to process in the context of an accusative object-experiencer verb. Thus, in view of the fact that accusative object-experiencer verbs do not unequivocally force a reading in which the object is thematically higher-ranked than the subject, these results do not allow us to distinguish between an account assuming that processing firstly proceeds on the basis of general principles applying to the domain of information currently being processed (i.e. syntactic structure, in this case), and the inverse case, i.e. in which there is an early attempt to establish parallel dependencies.

5.1 Experiment 4: ERP evidence for initial thematic and syntactic autonomy and a preference for the universal over the specific

In the spirit of the above discussion, Experiment 4 will use ERPs to investigate whether the human language processing system strives towards parallel syntactic and thematic dependencies even within the early stages of syntactic and thematic processing (i.e. within the two independent processing routes during phase 2 of comprehension). To this end, we will examine whether the subject-preference for ambiguous initial arguments may be influenced by the prior processing of an object-experiencer verb (cf. 47).

However, Experiment 4 will also attempt to answer a further interesting question, which presents itself upon a closer examination of sentences such as (47), namely whether it is possible for general processing principles to be influenced by the specific requirements of a particular verb. In order to be able to examine this without confounding the interaction between lexical and universal processing requirements and that between syntactic and thematic processing, we must examine sentences similar to those in (47), but with two unambiguously case marked arguments. In this way, the processing of a case marked initial argument in the context of a particular verb class will show whether the specific thematic structure of the verb is able to determine the (thematic) processing of arguments, or whether, at least in an initial processing step, arguments are generally processed in accordance with the processing principles assumed by the argument dependency model (cf. Chapter 1.2.4).

The critical conditions for Exp. 4 arising as a result of these considerations are shown in Table 7 (on the following page). In order to avoid sentence wrap-up effects at the critical (disambiguating) second NP in the ambiguous conditions, all sentences ended with a prepositional phrase such as *seit der Party* (‘since the party’).

The hypotheses for Experiment 4 are as follows. Essentially, there are three critical positions in the sentences shown in Table 7, i.e. the verb, the first NP and the second NP. We will discuss the predictions for each of these positions in turn in the following.

Condition	Example
A. Ambiguous SO active	Vielleicht droht Stefan dem Regisseur seit ... perhaps threatens Stefan$_{NOM/ACC/DAT}$ [the director]$_{DAT}$ since …
B. Ambiguous OS active	Vielleicht droht Stefan der Regisseur ... perhaps threatens Stefan$_{NOM/ACC/DAT}$ [the director]$_{NOM}$ …
C. Ambiguous SO obj-exp	Vielleicht gefällt Stefan dem Regisseur … perhaps pleases Stefan$_{NOM/ACC/DAT}$ [the director]$_{DAT}$ …
D. Ambiguous OS obj-exp	Vielleicht gefällt Stefan der Regisseur … perhaps pleases Stefan$_{NOM/ACC/DAT}$ [the director]$_{NOM}$ …
E.Unambiguous SO active	Vielleicht droht der Bäcker dem Regisseur ... perhaps threatens [the baker]$_{NOM}$ [the director]$_{DAT}$ …
F. Unambiguous OS active	Vielleicht droht dem Bäcker der Regisseur... perhaps threatens [the baker]$_{DAT}$ [the director]$_{NOM}$ …
G. Unambiguous SO obj-exp	Vielleicht gefällt der Bäcker dem Regisseur … perhaps pleases [the baker]$_{NOM}$ [the director]$_{DAT}$ …
H. Unambiguous OS obj-exp	Vielleicht gefällt dem Bäcker der Regisseur … perhaps pleases [the baker]$_{DAT}$ [the director]$_{NOM}$ …

Table 7. Example sentences for each of the critical conditions in Experiment 4

Verb

In view of the general hypothesis of the argument dependency model that processing differences observed between active and object-experiencer verbs (as in Bornkessel et al., *to appear*, and in Experiment 1) are due to processes of thematic hierarchising that have taken place before the verb is encountered, there should be no differences between the two verb classes at the position of the verb in the present experiment. The findings of Experiment 1 that an early positivity is only observable for object-experiencer verbs in unambiguously case marked sentences also indicates that this should be the case, i.e. that object-experiencer verbs are not processed differently from active verbs in general.

NP1

Processing effects observed for unambiguously case marked arguments at the position of the first NP will serve to shed light on the interaction between

universal and specific (lexical) information in argument processing. The ambiguous conditions, however, will not be examined at this point, since these should not differ from one another until they are disambiguated towards subject- and object-initial structures at the position of NP2.

With regard to the unambiguous conditions (E-H in Table 7), predictions for the position of NP1 are as follows. If the processing of a particular verb class gives rise to a prediction with regard to the thematic status and, hence, the case marking of the following arguments, this prediction should be apparent in the processing of an unambiguously case marked NP1. In this way, an initial active verb should give rise to the prediction of a nominative argument, whereas an initial object-experiencer verb should give rise to the prediction of a dative argument. In the event that a thematic prediction of this type is not borne out, the thematic mismatch thus resulting should give rise to an N400 (cf. Schlesewsky & Frisch, *submitted*). By contrast, if thematic processing in stage 2 proceeds on the basis of universal, rather than specific properties (i.e. if the information of the preceding verb is not taken into account until a later processing stage), the ERP patterns for unambiguously marked initial nominatives and datives should not differ according to the verb class of the preceding verb.

NP2

The critical question for the position of NP2 concerns the interaction between thematic and syntactic dependencies, which should be apparent in the disambiguation of the ambiguous conditions (A-D in Table 7). For the unambiguous sentences, by contrast, all differences related to word order and its interaction with verb class were already apparent at the position of NP1. In this way, we will confine our hypotheses for the position of NP2 to the ambiguous conditions.

If processing within the syntactic and thematic pathways of phase 2 is *not* determined by the endeavour to create parallel syntactic and thematic dependencies between the two domains, there should be a reanalysis for ambiguous dative-initial structures in the disambiguating region (NP2) independently of the type of verb. By contrast, if parallel dependencies are a driving factor behind the relevant processing mechanisms in phase 2, the word order preference should depend on the thematic structure of the verb, i.e. there should be a preference for nominative-initial structures in the case

of active verbs and a preference for dative-initial structures in the case of object-experiencer verbs. In accordance with our interpretation of the findings of Experiment 1, the reanalysis effects observable at this position should manifest themselves in the form of N400 components, since they crucially do not involve operations pertaining to the hierarchical *syntactic* structure of the sentences (cf. Chapter 4.2.3).

5.1.1 Method

Participants

Sixteen undergraduate students of the University of Leipzig participated in Experiment 4 (7 female; mean age 23.5 years; age range: 21 to 31 years). None of the participants had taken part in any one of Experiments 1 to 3.

Materials

The materials for Experiment 4 were constructed on the basis of the materials for Experiment 1. However, seeing that Experiment 4 used main clauses with the verb in second position, all of the particle verbs used in Experiment 1 had to be excluded, for these would not have enabled all of the verb-specific information to be processed before the processing of the arguments. Excluding this change as well as the omission of the ambiguous plural NPs from Experiment 1, the same 80 sets of lexical materials were used, supplemented by a PP for the avoidance of sentence-end effects as described above. The 640 sentences generated from these 80 sets were assigned to 2 lists of 320 critical items (40 per condition) in a counterbalanced manner. Thus, each participant read four sentences from a single set of lexical items, two with ambiguous and two with unambiguous case marking. The sentences were presented to participants in one of two pseudo-randomised orders (for each list).

Procedure

The experimental sentences were presented as in Experiment 1, i.e. in a phrase-by-phrase manner with presentation times of 450 ms for single words, 500 ms for phrases and an ISI of 100 ms. Again as for Experiment 1, participants completed a comprehension task after each sentence, in which they were asked to decide whether a simple declarative sentence correctly

described the content of the preceding experimental sentence or not. The experiment consisted of a short training session followed by 8 experimental blocks of 40 sentences each, between which the participants took short breaks. Including electrode preparation, an entire session lasted approx. 2.5 hours.

The EEG was recorded as for Experiment 1. Grand average ERPs were calculated on the basis of averages per participant per condition from 0 to 1000 ms post onset of each of the critical constituents (verb, NP1, NP2). All averages were aligned to a –200 to 0 ms pre-stimulus baseline relative to the onset of the constituent being averaged. The averaging procedure did not take into account trials for which the comprehension task had not been performer correctly as well as trials containing artefacts (see Exp. 1).

Data Analysis

For the behavioural data, error rates and reaction times were calculated for each condition. Incorrectly answered trials were excluded from the reaction time analysis. We computed a repeated measures analysis of variance (ANOVA) involving the critical factors ambiguity (AMB: ambiguous vs. unambiguous), word order (ORDER: nominative-dative vs. dative-nominative) and verb class (VERB: active vs. object-experiencer) and the random factors subjects (F_1) and items (F_2).

The critical factors for the statistical analysis of the ERP data differed for each of the three positions examined. For the position of the verb, the repeated measure ANOVA involved only the factor verb class (VERB: active vs. object-experiencer), since all other manipulations only became relevant at later points during the processing of the sentence. For NP1, only unambiguous sentences were analysed (since ambiguous sentences did not differ at this point) using the factors word order (ORDER: nominative-dative vs. dative-nominative) and verb class (VERB: active vs. object-experiencer). Also in accordance with the hypotheses for this experiment (see above), only the ambiguous conditions were considered at the position of the second NP, i.e. an analysis involving the factors word order (ORDER: nominative-dative vs. dative-nominative) and verb class (VERB: active vs. object-experiencer) was carried out.

All ANOVAs were calculated for mean amplitude values per time window per condition in six lateral regions of interest (ROIs) as well as for the midline electrodes. Lateral regions of interest were defined as follows: *left-anterior*: F7, F5, F3, FT7, FC5, FC3; *left-central*: T7, C5, C3, TP7, CP5, CP3; *left-posterior*: P7, P5, P3, PO7, PO3, O1; *right-anterior*: F8, F6, F4, FT8, FC6, FC4; *right-central*: T8, C6, C4, TP8, CP6, CP4; *right-posterior*: P8, P6, P4, PO8, PO4, O2. The midline electrodes were analysed in terms of the factor electrode (Elec) with the eight midline electrodes (AFZ, FZ, FCZ, CZ, CPZ, PZ, POZ, OZ) as levels.

5.1.2 Results

Behavioural Data

The statistical analysis of the error rates for the comprehension task showed main effects of ORDER (F_1 (1,15) = 15.43, p <.01; F_2 (1,79) = 40.49, p = .0001) and VERB (F_1 (1,15) = 9.53, p <.01; F_2 (1,79) = 14.90, p <.001). These resulted from higher error rates for object-initial sentences (9.2%) in comparison to their subject-initial counterparts (4.1%) and for sentences with object-experiencer verbs (8.0%) in comparison to sentences with active verbs (5.2%). The main effect of AMB was marginally significant in the analysis by items only (F_2 (1,79) = 3.53, p <.07) and resulted from more errors for unambiguous (7.4%) than for ambiguous sentences (5.9%).

For the reaction times of the comprehension task, there were again main effects of ORDER (F_1 (1,15) = 14.02, p <.01; F_2 (1,79) = 17.03, p = .0001) and VERB (F_1 (1,15) = 18.96, p <.001; F_2 (1,79) = 9.10, p <.01), which resulted from longer reaction times for object-initial (1219 ms) in comparison to subject-initial (1163 ms) sentences and for sentences with object-experiencer (1231 ms) in comparison to sentences with active verbs (1150 ms).

ERP Data

In the following, we will present the ERP results for the three critical positions, i.e. the verb, NP1 and NP2 in turn.

Figure 8 shows grand average ERPs at the position of the verb for active vs. object-experiencer verbs.

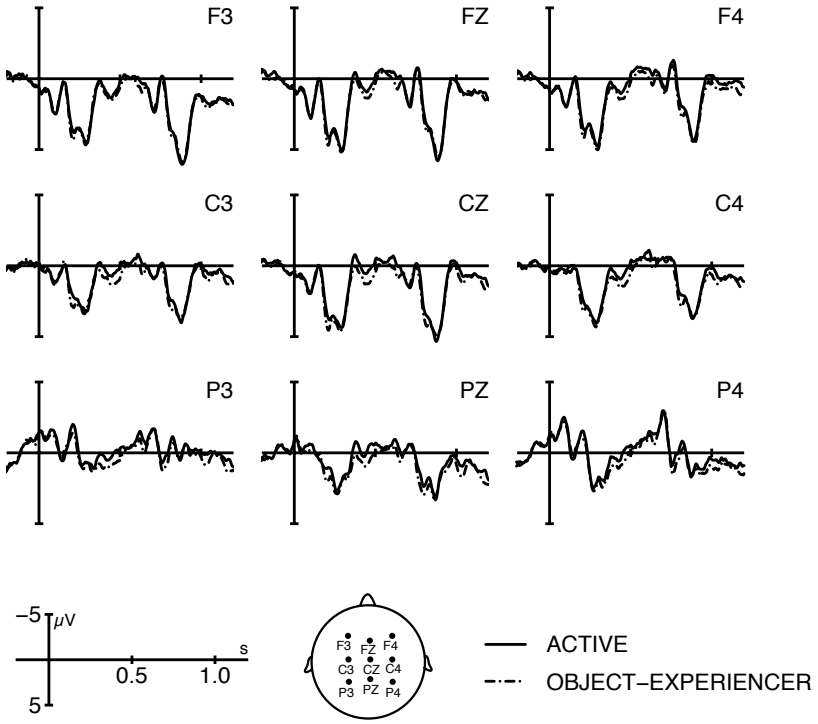

Figure 8. Grand average ERPs for object-experiencer vs. active verbs (onset at the vertical bar) in Experiment 4. Negativity is plotted upwards.

As is apparent from Figure 8, the ERP patterns for the two verb types do not differ from one another. This impression was confirmed by statistical analyses, which revealed no significant effects in the time window 200 – 600 ms, i.e. the time window in which the early positivity for object-experiencer verbs in unambiguous sentences was analysed in Experiment 1.

Grand average ERPs for unambiguous sentences at the position of NP1 are presented in Figure 9 (on the following page). As Figure 9 shows, unambiguous dative-initial sentences elicit a positivity between approximately 300 and 900 ms post onset of the phrase in comparison their unambiguous nominative-initial counterparts. This effect is observable both for sentences with active verbs and for those with object-experiencer verbs, though it appears somewhat more restricted topographically for the latter.

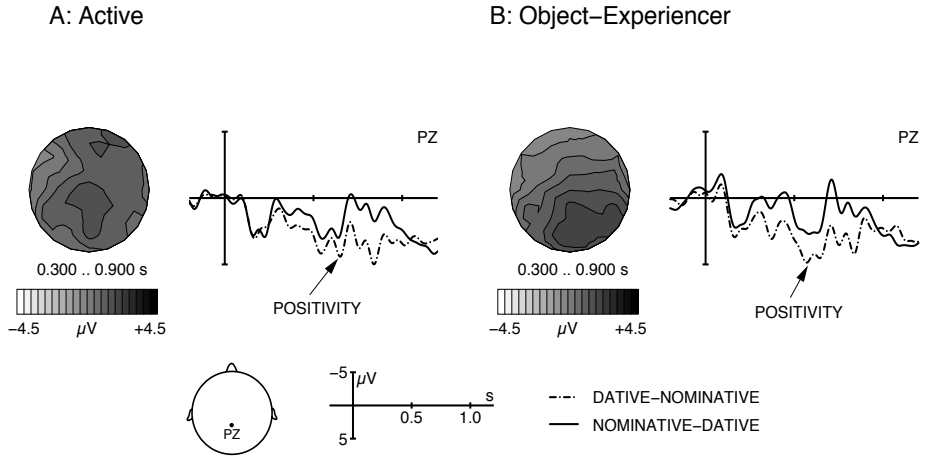

Figure 9. Grand average ERPs for unambiguous dative-initial vs. unambiguous nominative-initial sentences for active (A) vs. object-experiencer verbs (B) at the position of NP1 (onset at the vertical bar) in Experiment 4. Negativity is plotted upwards. The topographical maps indicate the distribution of the voltage differences between dative- and nominative-initial structures.

A repeated measures ANOVA in the time window 300-900 ms revealed the following effects. For the lateral electrodes, there was a significant main effect of ORDER (F (1,15) = 10.12, p < .01) as well as significant interactions ORDER x ROI (F (5,75) = 7.32, p < .001) and ORDER x VERB x ROI (F (5,75) = 3.97, p < .02). Separate analyses for each of the six ROIs, the results of which are shown in Table 8, revealed main effects of ORDER that were significant in the left-posterior, right-central and right-posterior regions and marginal in the left-central region. All of these effects were due to more positive waveforms for object-initial in comparison to subject-initial structures.

ROI	Effect(s)
left-central	ORDER: F (1,15) = 3.58, p < .08
left-posterior	ORDER: F (1,15) = 23.86, p < .001
right-central	ORDER: F (1,15) = 9.67, p < .01
right-posterior	ORDER: F (1,15) = 54.17, p = .0001 ORDER x VERB: F (1,15) = 6.83, p < .02

Table 8. Effects of ORDER and ORDER x VERB in each of the 6 ROIs for the position of the first NP in the time window 300-900 ms in Experiment 4.

As Table 8 indicates, the right-posterior region additionally showed a significant interaction ORDER x VERB, which was subsequently resolved by VERB in order to examine whether and how the processing of the word order variation was differentially affected by verb class. Single comparisons revealed significant effects of ORDER for sentences with both verb classes, though this effect was stronger for sentences with object-experiencer verbs (F (1,15) = 61.45, p = .0001) than for those with active verbs (F (1,15) = 11.43, p < .01). Again, these ORDER effects resulted from a positivity in the object-initial conditions.

The global analysis of the midline electrodes showed a very similar pattern to that of the lateral electrodes, namely a main effect of ORDER (F (1,15) = 28.32, p = .0001) as well as interactions ORDER x ELEC (F (7,105) = 3.86, p < .02) and ORDER x VERB x ELEC (F (7,105) = 4.96, p < .01). In view of the interactions with ELEC, separate analyses were conducted for each of the midline electrodes. These are given in Table 9 (on the following page).

It is apparent from Table 9 that the main effect of ORDER reached significance at each of the individual midline sites except for AFZ, where it was marginal. In all cases, object-initial sentences gave rise to more positive-going ERP signals than subject-initial sentences. With regard to the interaction ORDER x VERB, this reached significance at AFZ and OZ and was marginal at POZ. Single comparisons for each of the verb classes at each of these three electrodes revealed the following. At AFZ, there was a significant main effect of ORDER for active (F (1,15) = 7.21, p < .02) but not for object-experiencer verbs. At POZ and OZ, both active (POZ: F (1,15) = 16.16, p < .01; OZ: F (1,15) = 5.15, p < .04) and object-experiencer (POZ: F (1,15) = 67.34, p = .0001; OZ: F (1,15) = 47.71, p = .0001) verbs showed an ORDER effect. Again, these effects were due to a positivity in the object-initial in comparison to the subject-initial conditions.

Electrode	Effect(s)
AFZ	ORDER: F (1,15) = 4.12, p < .07 ORDER x VERB: F (1,15) = 6.15, p < .03
FZ	ORDER: F (1,15) = 5.25, p < .04
FCZ	ORDER: F (1,15) = 6.58, p < .03
CZ	ORDER: F (1,15) = 13.87, p < .01
CPZ	ORDER: F (1,15) = 25.25, p < .001
PZ	ORDER: F (1,15) = 53.83, p = .0001
POZ	ORDER: F (1,15) = 53.56, p = .0001 ORDER x VERB: F (1,15) = 3.57, p < .08
OZ	ORDER: F (1,15) = 5.15, p < .04 ORDER x VERB: F (1,15) = 8.77, p < .01

Table 9. Effects of ORDER and ORDER x VERB at each of the 8 midline electrodes for the position of the first NP in the time window 300-900 ms in Experiment 4.

Turning now to the second noun phrase, grand average ERPs for ambiguous sentences at this position are shown in Figure 10.

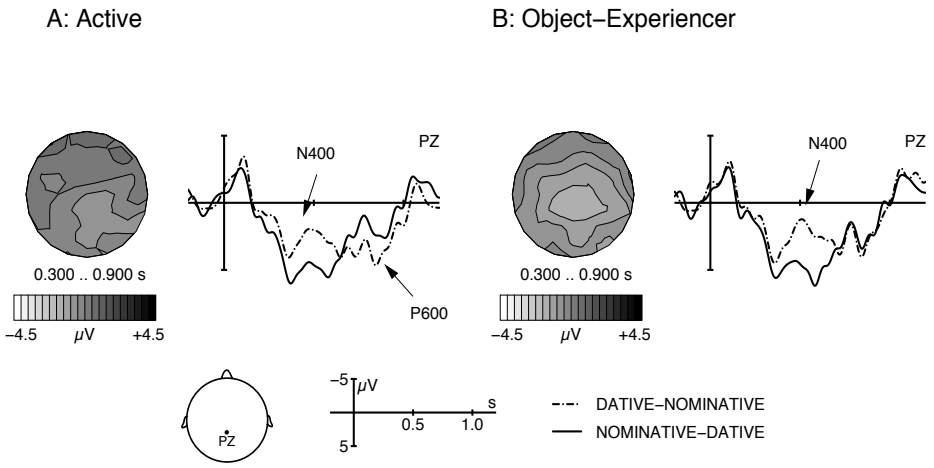

Figure 10. Grand average ERPs for ambiguous dative-initial vs. ambiguous nominative-initial sentences for active (A) vs. object-experiencer verbs (B) at the position of NP2 (onset at the vertical bar) in Experiment 4. Negativity is plotted upwards. The topographical maps indicate the distribution of the voltage differences between dative- and nominative-initial structures.

It is clear from Figure 10 that, at the position of NP2, initially ambiguous dative-initial sentences show an N400-like negativity irrespectively of whether they commenced with an active or an object-experiencer verb. For sentences with active verbs, the object-initial structures additionally elicit a small P600 in comparison to their subject-initial counterparts. In view of these two components, the statistical analysis for NP2 was conducted in two time windows, namely 350-600 ms for the N400 and 800-1000 ms for the P600.

Time window 1: 350-600 ms

The analysis of the lateral electrodes in the first time window showed a main effect of ORDER (F (1,15) = 13.57, p < .01) and an interaction ORDER x ROI (F (5,75) = 4.46, p < .02). The results of separate analyses for each of the six ROIs are shown in Table 10.

ROI	Effect(s)
left-anterior	ORDER: F (1,15) = 4.83, p < .05
left-central	ORDER: F (1,15) = 9.96, p < .01
left-posterior	ORDER: F (1,15) = 12.28, p < .01
right-anterior	ORDER: F (1,15) = 6.95, p < .02
right-central	ORDER: F (1,15) = 15.14, p < .01
right-posterior	ORDER: F (1,15) = 17.83, p < .001

Table 10. Effects of ORDER in each of the 6 ROIs for the position of the second NP in the time window 350-600 ms in Experiment 4.

All of the effects shown in Table 10 resulted from more negative ERP responses to dative-initial in comparison to nominative-initial structures.

For the midline electrodes, the statistical analysis revealed a main effect of ORDER (F (1,15) = 18.42, p < .001) and an interaction ORDER x ELEC (F (1,15) = 5.45, p < .01). The latter was resolved by ELEC, as the results of the planned comparisons for each of the midline electrode sites in Table 11 show.

Electrode	Effect(s)
AFZ	ORDER: F (1,15) = 4.72, p < .05
FZ	ORDER: F (1,15) = 12.82, p < .01
FCZ	ORDER: F (1,15) = 12.77, p < .01
CZ	ORDER: F (1,15) = 21.33, p < .001
CPZ	ORDER: F (1,15) = 23.53, p < .001
PZ	ORDER: F (1,15) = 16.10, p < .01
POZ	ORDER: F (1,15) = 16.06, p < .01
OZ	ORDER: F (1,15) = 10.29, p < .01

Table 11. Effects of ORDER at each of the 8 midline electrodes for the position of the second NP in the time window 350-600 ms in Experiment 4.

All of the ORDER effects shown in Table 11 resulted from more positive waveforms for object-initial sentences in comparison to their subject-initial counterparts.

Time window 2: 800-1000 ms

Although the interaction ORDER x VERB did not reach significance in this time window[28], separate analyses were conducted for each verb class on the basis of the hypothesis that only object-initial sentences with active verbs show a positivity in comparison to their subject-initial counterparts.

For active verbs, the analysis of the lateral electrodes revealed a marginal interaction ORDER x ROI (F (5,75) = 2.46, p <.07). Resolving this interaction by ROI showed a significant main effect of ORDER at left-posterior sites (F (1,15) = 7.56, p <.02) and marginal effects of ORDER in the left-central (F (1,15) = 3.58, p <.08) and right-posterior (F (1,15) = 4.47, p <.06) regions. In each case, ERP responses to object-initial sentences were more positive than those to subject-initial sentences. The global analysis of the midline electrodes, by contrast, revealed no significant effects.

For sentences with object-experiencer verbs, there were no significant effects either at lateral or midline electrode sites.

[28] Note, however, that the interaction ORDER x VERB was marginally significant in the time window 800-900 ms (F (1,15) = 3.24, p = .09).

5.1.3 Discussion

Experiment 4 revealed the following findings. Firstly, the processing of active and object-experiencer verbs preceding their arguments did not differ, thereby providing further evidence that previously reported differences between the processing of active and object-experiencer verbs crucially depend on processes of thematic hierarchising applying between the arguments. Secondly, at the position of the first NP, unambiguously marked dative arguments elicited a positivity between 300 and 900 ms post onset of the phrase, irrespectively of the verb class of the preceding verb. This positivity had a right-posterior focus for object-experiencer verbs and was more broadly distributed for active verbs. Finally, at the position of the second NP, disambiguation towards a dative-nominative word order generally gave rise to an N400 effect. For initially ambiguous dative-initial sentences with active verbs, there was additionally a left-posterior P600 effect at this position. These findings provide clear evidence both with regard to the question of whether the parser strives towards parallel syntactic and thematic dependencies during phase 2 of processing and to what extent universal and specific (lexical) information sources interact in this processing phase. We will discuss both of these points in turn in the following.

In contrast to the findings of Experiment 3 that parallel syntactic and thematic dependencies (e.g. in the form of an object-initial word order in a sentence with an object-experiencer verb) are eventually advantageous for comprehension, the results of Experiment 4 show that the initial establishment of syntactic dependencies is not guided by the endeavour to attain such a parallelism, even if sufficient information is available for such an attempt to be undertaken. This was shown by the fact that the disambiguation towards a dative-initial structure gave rise to an N400 irrespectively of whether the arguments were processed in the context of an active or of an object-experiencer verb. An account assuming an early influence of parallel dependencies, by contrast, predicts that the word order preference in sentences in which the verb precedes its arguments should mirror the thematic structure of that verb.

In this way, the present results replicate the finding of an N400 for a reanalysis towards a dative-nominative structure in Experiment 1, thereby supporting the interpretation advanced in Chapter 4 that this component

may reflect a reanalysis that does not require any alterations to the syntactic structure of the sentence. Interestingly, the N400 effects did not differ according to verb class in the present experiment, in contrast to Experiment 1, where the effect was more pronounced for active in comparison to object-experiencer verbs. Recall that, for Experiment 1, this difference was interpreted as indicating a higher likelihood of accessing the correct, object-initial interpretation when disambiguation was effected by an object-experiencer verbs on the basis of asymptotic differences between the two object-initial conditions in the SAT measures used in Experiment 2. In this way, the absence of such a difference in the present experiment suggests that the effectiveness of the verb class based cue for reanalysis towards an object-initial order may be dependent on the crucial information being part of the disambiguating constituent itself. In other words, this finding may be taken as a further piece of evidence that this type of 'intra-sentential context' is not taken into account until after stage 2 of processing is complete (see below for further corroborating evidence in this regard).

A further interesting difference between the present findings and those of Experiment 1 is that here, the disambiguation towards an object-initial order also gave rise to a P600 effect for sentences with active verbs. The observation of such an effect provides additional support for interpreting the 'reanalysis N400' as reflecting a reanalysis that does not involve any modifications of the syntactic structure of the clause being reanalyse, since a dative-nominative word order may, in fact, only be unmarked as a passivised form of a ditransitive verb or with an object-experiencer verb (cf. Chapter 4.2.4). In this way, a dative-nominative structure might be expected to also require a syntactic reanalysis (in the form of a P600) in sentences with active verbs.

Yet the question arises of why a P600 component should have been elicited for object-initial orders with active verbs in Experiment 4 but not in Experiment 1. One tentative explanation for this may be that the structures used in both experiments may not have provided the same conditions for (syntactic) reanalysis: whereas the sentences used in Experiment 1 involved subordinate clauses introduced by the complementiser *dass* ('that'), the sentences in Experiment 4 were main clauses. Thus, it cannot be excluded that these two sentence types differ with respect to their syntactic properties in some way, despite the fact that the critical manipulation encompassed the

theoretically defined German 'middlefield' in both cases.[29] In fact, an interesting parallel to this proposed difference may be found in previous results on the processing of clause medial word order variations in German. Thus, while dative-marked arguments at the left edge of the middlefield were shown to elicit a fronto-central negativity in comparison to initial nominatives in main clauses such as (49a) (Rösler et al., 1998; Schlesewsky, Bornkessel, & Frisch, *in press*), no differences were observable between the ERP responses to initial datives vs. initial nominatives in subordinate clauses such as (49b) (Bornkessel et al., 2002*)*.

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

b. Maria glaubt, dass dem Lehrer der Gärtner hilft.
Maria believes that [the teacher]$_{DAT}$ [the gardener]$_{NOM}$ helps.
'Maria believes that the gardener is helping the teacher.'

Bornkessel et al. (2002) account for this apparent discrepancy by appealing to the possible unmarked continuations of a dative-initial sentence fragment. Thereby, while the fragment *dass* + Arg_{DAT} may be completed to form a canonically ordered passive clause (*dass dem Lehrer geholfen wurde* – 'that [the teacher]$_{DAT}$ helped was') or an unmarked dative-nominative structure with an object-experiencer verb (cf. Chapter 4.2.3), the auxiliary *hat* ('has') precludes such a continuation in sentences such as (49a), since it excludes a passive clause as well as most dative object-experiencer verbs (which typically require *sein*, 'to be'). However, the present data suggest that the difference between the two sentence types in (49) may, in fact, be somewhat more principled than assumed by Bornkessel et al. (2002). Thus, the fact that a P600 indicative of a syntactic reanalysis for dative-nominative word orders with active verbs is only apparent in main clauses suggests that the restriction with regard to unmarked word orders may be stricter in the case of (verb-second) main clauses in comparison to subordinate clauses introduced by a complementiser.

[29] The German middlefield is defined as the region of the German clause following the complementiser or the finite verb in second position and preceding a participle or particle at the end of the clause (cf. Wöllstein-Leisten, Heilmann, Stepan, & Vikner, 1997).

In fact, the difference between verb-second clauses and clauses introduced by a complementiser also constitutes an important aspect of the second major question examined in Experiment 4, namely whether the processing mechanisms in phase 2 should be described as operating solely on the basis of universal requirements (i.e. those of the universal syntactic and thematic hierarchies) or whether verb-/event-specific information may also influence this processing stage. Recall that, in the present experiment, the processing patterns elicited at the position of the first NP by the unambiguously case marked conditions were designed to shed light on this question. Most generally, the finding of a verb class independent positivity between 300 and 900 ms for initial dative-marked arguments indicates that verb specific information cannot induce a local preference for an initial non-nominative argument, even if only a single processing pathway (i.e. the thematic pathway in this particular case) is involved. More specifically, however, the nature of the component thus elicited is rather intriguing and deserves some discussion.

As discussed above and in Footnote 19, clause medial word order variations in German typically give rise to a fronto-central negativity at the position of the non-canonically placed constituent (e.g. Rösler et al., 1998; Schlesewsky et al., *in press*). This component has been interpreted as reflecting a mismatch between a predicted position and the properties of the constituent encountered in that position (Friederici, Schlesewsky, & Fiebach, *in press*; Schlesewsky et al., *in press*). As discussed above, initial dative-marked arguments need not elicit a 'scrambling-negativity' if the possibility of an unmarked continuation of the sentence remains (Bornkessel et al., 2002). On the basis of these considerations, it may appear somewhat surprising that unambiguously marked dative-initial constructions in the present experiment should have elicited a *positivity* (i.e. rather than a negativity or no difference to initial nominatives). However, there is an interesting parallel between these results and findings on the processing of German relative clauses reported by Friederici et al. (1998). These authors observed a P600 for a relative pronoun unambiguously marked for accusative (50b) in comparison to a relative pronoun unambiguously marked for nominative (50a).

(50) a. Das ist der Direktor, der …
this is the director who$_{NOM}$

b. Das ist der Direktor, den …
this is the director who$_{ACC}$

As argued by Friederici et al. (*in press*), the crucial difference between the sentences in (50) – in which an accusative relative pronoun elicits a P600 – and word order variations in the German middlefield – in which an initial accusative elicits a negativity – is that an accusative relative pronoun may be integrated into the same position as a nominative relative pronoun, whereas an accusative-initial word order in the middlefield requires the creation of an additional position. This difference in the nature of the integrative processes having to be performed is reflected in the difference in components elicited by the two constructions. This generalisation suggests a possible solution to the problem of why initial dative arguments should have elicited a positivity in the present experiment: as has been argued theoretically (cf. Chapter 4.2.3) and as the results of Experiment 1, for example, suggest, dative-nominative is a possible unmarked word order in German. Thereby, an initial dative and an initial nominative may be integrated into the same position, though the language processor will, of course, clearly prefer to integrate a nominative under most circumstances. In this way – and thus we return to the differences between verb-second clauses and subordinate clauses discussed above – it may be the case that a full verb gives rise to the projection of a more fully specified syntactic structure than the processing of an auxiliary or a complementiser does. Consequently, a constellation very similar to that in the sentences in (50) arises: an initial dative may be integrated into a predicted structural position, though it does not fulfil the prediction in an ideal way, thereby giving rise to a positivity. Why this positivity has a shorter latency in the present experiment in comparison to previous studies, however, must remain an open question at present.[30] In any case, the proposed account of this component supports

[30] One possibility which cannot be excluded at present is that the positivity between 300 and 900 ms post onset of NP1 in fact consists of two subcomponents, an early positivity and a P600. Such a pattern might be taken to suggest that the processing of a full verb leads to the projection of a thematic structure in a similar manner to the projection of a syntactic structure outlined above, with an unexpected constituent then eliciting a thematic reanalysis. Since there is no difference in this component according to verb class, such a projection would also have to be viewed as universal rather than specific in nature. Unfortunately, it is at present quite difficult to dissociate between a single component and

the predictions of the argument dependency model, since it requires a specification of both the thematic and the syntactic processing dimensions upon the processing of a verb. However, it is clear that, despite this specification, processing initially takes place with respect to universal preferences and strategies only, rather than on the basis of the specific lexical information provided by a particular verb.

In summary, Experiment 4 has provided consistent evidence for the preferential application of universal, rather than specific processing strategies during the establishment of syntactic and thematic dependencies during stage 2 of comprehension. Thus, each of the two (i.e. syntactic and thematic) processing routes initially operates without reference to existing dependencies of the other type. Both types of information then interact during later processing stages. Similarly, universal processing strategies are preferred even when specific information from the same domain is available, though these strategies do appear to depend on the particular linguistic environments in which they apply.

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several subcomponents (but see Friederici et al., 2001, for an example of such a dissociation).

Chapter 6
The Argument Dependency Model Revisited

The experiments presented in Chapters 4 and 5 have provided evidence for a number of the key assumptions of the argument dependency model that were presented at the beginning of this thesis. Furthermore, the findings of Experiments 1-4 have also shed light on some further aspects of processing that were not discussed in detail when the argument dependency model was introduced. In this way, before pressing on to the last two experiments to be reported as a part of this thesis, we shall make use of the present chapter to recapitulate the findings presented so far and, more importantly, to discuss their significance for the general processing architecture of the argument dependency model. In this way, it is the aim of this chapter (a) to summarise the evidence that the experiments presented so far have provided in favour of the original conception of the model, and (b) to discuss the findings that shall now allow us to elaborate upon some more fine-grained details of the model's processing architecture.

Experiment 1 confirmed the assumed distinction between syntactic and thematic processing by showing that thematic hierarchising between arguments only takes place if the arguments are unambiguously case marked. For unambiguously case marked arguments, on the other hand, the word order of the clause does not impact upon the thematic dependencies that are established (cf. also Bornkessel et al., *to appear*).

In this way, it is apparent that, with regard to the processing of arguments, only one of the two pathways available within phase 2 of processing is pursued.

In contrast to this distinction with regard to the processing of arguments, verbs must be processed both syntactically and thematically, since they inherently carry both types of information within their lexical entries. Whereas for thematic structure this means that the hierarchical dependencies between arguments must be checked (or established) when the verb is reached, with regard to syntactic processing it should suffice to check agreement for the arguments giving rise to agreement in the particular language being processed, rather than to check all hierarchical dependencies.

Even when both information types are processed for a particular lexical item, however, the interaction between both processing domains proceeds in accordance with several architectonic restrictions. Thus, it is apparent that there is an initial stage of processing (during phase 2) in which both processing routes do not interact, as shown, for example, by the fact that the LAN reflecting the mismatch between the thematic and the syntactic hierarchy in Experiment 1 only obtained for subject-initial structures with object-experiencer verbs but not for object-initial structures with active verbs. This interpretation is supported by the results for ambiguous structures in Experiment 4, which indicate that this (syntactic or thematic) processing in this initial stage proceeds exclusively with the goal of producing maximally felicitous representations for the domain of information currently being processed, i.e. processing is *not* driven by the desire to attain parallel syntactic and thematic dependencies, for example.

Interestingly, it also appears that the processing mechanisms in this initial stage operate on the basis of universal preferences, rather than sentence-internal (verb-specific) considerations even if these information sources are both thematic (or, by analogy, syntactic) in nature. This was shown by the processing patterns for unambiguously case marked sentences in Experiment 4, in which initial dative-marked arguments elicited a positivity in comparison to their nominative counterparts independently of the class of the verb preceding this argument.

At a later processing stage, by contrast, both information types interact, as the influence of verb class on the reanalysis N400 observed for object-initial structures in Experiment 1 indicates. Interestingly, this interaction between thematic and syntactic information in reanalysis parallels the interaction between syntactic and semantic information observable in the P600 component (cf. Chapter 3.1.1). In light of the fact that the interaction between the two information types should take place at some stage beyond phase 2 of processing, while the temporal properties of the N400 component observed as a reflex of this reanalysis are more compatible with a classification of this processing step as lying within phase 2, we shall assume that the types of reanalyses reflected in an N400, i.e. reanalyses which do not bear upon the hierarchical structure of the clause in any way, are situated on the borderline between phases 2 and 3, i.e. within phase 2a.

These observations with regard to the fine-grained structure of processing within the argument dependency model are captured in Figure 11 (on the following page). Even though the basic architecture of this revised version of the model is very similar to that introduced in Chapter 1.2 (cf. Figure 4), several details have been added. In addition to providing evidence for the distinction between syntactic and thematic processing, Experiments 1-4 have indicated that the thematic and syntactic processing subsystems operate independently from one another during phase 2. The interaction between these two systems is delayed until phase 2a, in which syntactic reanalyses, for example, are influenced by thematic information (Experiment 1). By contrast, interactions with other information types (e.g. semantics, lexical context, etc.) are apparently delayed until phase 3 of processing, as suggested by the finding that the facilitation of a reanalysis towards an object-initial word order via the (lexically specified) thematic structure of an object-experiencer verb may be observed in phase 2 when the reanalysis is initiated by the verb itself (cf. the reduced N400 for these constructions in Experiment 1) but is delayed until phase 3 when this information is borne by an element preceding the disambiguating region, i.e. when the relevant information is part of the 'lexical context' of the critical input item (cf. the fact that only active verbs elicited a P600 for the disambiguation towards an object-initial order in Experiment 4). In this way, phase 3 involves a 'generalised mapping' process, in which the various information types are mapped onto one another (cf. Friederici, 1999, 2002).

This formulation of the argument dependency model makes the strong prediction that the thematic and syntactic processing routes within phase 2 (shaded box in Figure 11) do not receive input from other domains of information during this processing stage. In this way, all interaction with semantics, world knowledge and discourse should be postponed until phases 2 and 2a of processing have been completed. By contrast, we do not wish to exclude information flow from thematic or syntactic processing to semantics, for example.

The remaining experiments to be presented in this thesis will test the prediction outlined above, namely that the thematic and syntactic processing routes in phase 2 are 'inert' with respect to outside influences. In particular, we will examine this prediction with regard to the thematic processing route.

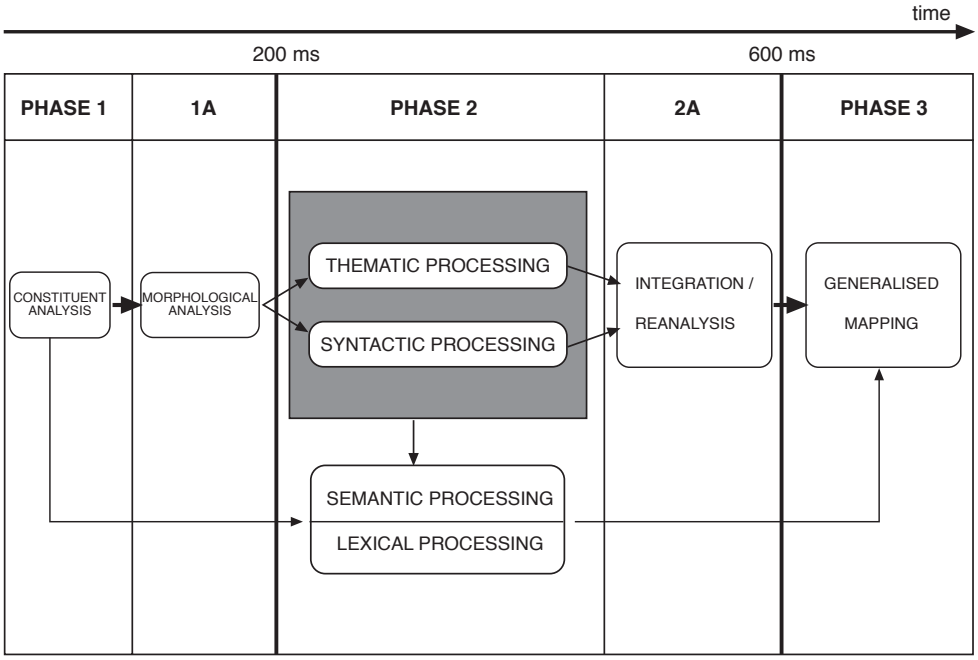

Figure 11. Schematic representation of the extended processing architecture assumed by the argument dependency model in view of the results of Experiments 1-4

In this way, Experiment 5 (Chapter 7) will be concerned with the question of whether thematic hierarchising operations may be influenced by discourse information, while Experiment 6 (Chapter 8) will examine whether hierarchical thematic relations may be assigned on the basis of world knowledge / plausibility information.

Chapter 7
On the Context-Insensitivity of Thematic Hierarchising

Many psycholinguistic approaches pertaining to the role of thematic information within sentence comprehension have assumed that thematic processing interacts with contextual factors in one way or another (e.g. Altmann, 1999; Rayner et al., 1983; Tanenhaus et al., 1989). Whereas Rayner et al. (1983) consider the thematic grids associated with a verb as the locus of interaction with discourse, pragmatic plausibility and general world knowledge, Tanenhaus et al. (1989) and Altmann (1999), amongst other authors, argue that thematic assignments may be determined by the context.

For example, Altmann (1999) argues for context-based influences on thematic assignments on the basis of two experiments using the stop-making-sense task, one of which involved short passages such as (51) and (52).

(51) A car was driving downhill when it suddenly veered out of control. In its path were some pigeons and a row of bollards.
It injured / missed …

(52) A car was driving downhill when it suddenly veered out of control. In its path were some dustbins and a row of bollards.
It injured / missed …

Participants read each of the first two sentences of these passages in their entirety, while the third was presented in a word-by-word fashion in response to the participants' button presses. The crucial condition is that in which context (52) is completed by a sentence beginning with *It injured …*, since the verb *to injure* requires an animate Patient despite the fact that no adequate referent for this role is provided by the context. Indeed, Altmann (1999) observed significantly more 'no' responses at the position of the verb *injured* in contexts such as (52) than in contexts such as (51). He therefore argues that thematic role assignments may be driven by the context.

From the perspective on thematic processing presented in the present thesis, the question of whether context information may guide thematic assignments must be rephrased to whether context factors can influence thematic hierarchising. In terms of the argument dependency model, such an influence is not excluded, but appears rather unlikely in view of the fact that even various sentence-internal factors (e.g. parallelism of syntactic and thematic structure) are apparently not taken into account during the individual processing routes in phase 2 (cf. the results of Experiment 4). Thus, since both the syntactic and the thematic processing routes appear to operate autonomously in an initial stage of processing (i.e. when thematic hierarchising takes place), the finding that discourse-based considerations should be taken into account within this initial stage would be quite surprising.

In view of this question, Experiment 5 will use ERPs to examine whether thematic hierarchising may be influenced by contextual information.

7.1 Experiment 5: ERP responses to the processing of accusative object-experiencer verbs in context

A possible means of testing whether thematic processing in the sense of the argument dependency model is influenced by context or discourse factors is to examine whether a constraining context may be used to resolve a thematic ambiguity. In this regard, consider the following sentences.

(53) Klaus sagt, …
Klaus says, ...

a. … dass der Mönch den Bischof <u>besucht</u>.
… that [the monk]$_{NOM}$ [the bishop]$_{ACC}$ visits
'… that the monk visits the bishop.'

b. … dass der Mönch den Bischof <u>ängstigt</u>.
… that [the monk]$_{NOM}$ [the bishop]$_{ACC}$ frightens
'… that the monk frightens the bishop.'

The examples in (53) illustrate active (53a) and object-experiencer (53b) German verbs subcategorising for *accusative* objects. In contrast to their

dative counterparts, however, accusative object-experiencers do not show an early positivity indicative of thematic reanalysis in sentences such as (53b) (Bornkessel, 2001). This difference between dative and accusative verbs may be accounted for in terms of the theoretical distinction between these verb classes: whereas dative object-experiencer verbs *require* a reading in which the dative-marked argument thematically dominates the nominative-marked argument, accusative object-experiencer verbs also allow a causative reading in which the nominative argument (the Causer) is still thematically higher-ranked than the accusative argument (the Experiencer) (e.g. Fanselow, 2000; Primus, 1999; Wunderlich, 1997). Thus, since a reversal of the hierarchical thematic relations between arguments is not required for accusative object-experiencer verbs, there is no early positivity indicative of thematic reanalysis. With regard to the negativity observed for accusative object-experiencer verbs, a possible account of this component is to assume that it reflects the lexical ambiguity associated with these verbs on account of their multiple thematic structures (cf. Hagoort & Brown, 1994, for the finding that lexically ambiguous word elicit negativities in comparison to unambiguous controls).

Thus, in view of the question at hand, we may capitalise upon the observation that accusative object-experiencer verbs are ambiguous between a 'true' object-experiencer reading, in which the accusative argument thematically dominates the nominative argument, and a causative reading, in which the nominative argument thematically dominates the accusative argument (cf. Scheepers et al., 2000, and the discussion of this study in Chapter 5). If it is the case that context information is taken into account by initial processes of thematic hierarchising, a context ruling out the causative reading of the object-experiencer verb, or at least rendering this reading quite unlikely, should force the thematic processing system to compute the true object-experiencer reading. Under these circumstances, accusative object-experiencer verbs should then show a thematic reanalysis, as reflected in an early positive component, in the same way as dative object-experiencers.

An example of the contextual manipulation that we have in mind is given in (54) together with the corresponding target sentences in (55).

(54) a. Causative context
Der Patient hatte schon wieder alles verwüstet, als der Arzt das Zimmer betrat.
'The patient had once again devastated everything when the doctor entered the room.'

b. Non-causative context
Der Patient lag noch immer im Koma, als der Arzt das Zimmer betrat.
'The patient was still in a coma when the doctor entered the room.'

(55) a. Active verb
Es war klar, dass der Patient den Arzt bemerkte und ...
It was apparent that [the patient]$_{NOM}$ [the doctor]$_{ACC}$ noticed and ...
'It was apparent that the patient noticed the doctor.'

b. Object-experiencer verb
Es war klar, dass der Patient den Arzt beunruhigte und ...
It was apparent that [the patient]$_{NOM}$ [the doctor]$_{ACC}$ disconcerted and ...
'It was apparent that the patient disconcerted the doctor.'

Whereas the context in (54a) implies activity (and thereby potential causation) on the part of the object of the target sentences in (55), this is not the case for the context in (54b). Thus, if contextual information can influence the establishment of hierarchical thematic dependencies during phase 2 of processing, the knowledge that the participant instantiating the object of the target sentence cannot plausibly be assumed to play a causative role in the event described by the verb of the target sentence should be able to force a non-causative reading for accusative object-experiencer verbs (55b). If this occurs, i.e. if a 'true' object-experiencer reading is established for these verbs on the basis of contextual information, this should require the initiation of a thematic reanalysis as for dative object-experiencer verbs. Thus, we should observe an early positivity at the position of the verb in (55b) in comparison to (55a). By contrast, if the context cannot influence thematic hierarchising, accusative object-experiencer verbs should elicit a negativity in comparison to their active counterparts irrespectively of the context.

7.1.1 Method

Participants

Sixteen undergraduate students of the University of Leipzig participated in Experiment 5 (9 female; mean age 24.9 years; age range 19-29 years).

Materials

Forty sets of contexts and target sentences such as in (54) and (55) were constructed. Each target sentence was completed by a verb coordination as shown in (56) in order to avoid confounding critical effects at the position of the verb with sentence wrap-up effects.

(56) Es war klar, dass der Patient den Arzt beunruhigte und bedrückte.
It was apparent that the patient the doctor disconcerted and troubled

In view of the difficulty associated with obtaining a larger number of adequate contexts, participants read all four versions of each set. However, to ensure that this mode of presentation would not allow participants to anticipate target sentences on the basis of the contexts, the 160 critical context-target pairs were embedded among 560 unrelated filler context-target pairs. In view of the acceptability judgement task performed by participants (see below), both grammatical and ungrammatical filler sentences were included. The presentation of the 720 experimental sentences thus resulting took place in two sessions (see below), with the assignment of sentences to sessions varied across participants in a counterbalanced manner.

Procedure

Context sentences were presented as a whole in the centre of a computer screen. Participants read each context at their own pace and pushed a button to initiate the presentation of the ensuing target sentence. Before the presentation of the target sentence began, an asterisk was presented for 300 ms followed by a blank screen for 300 ms in order to fixate participants' eyes at the centre of the screen and to alert them to the upcoming presentation of the sentence. Target sentences were presented in a phrase-by-phrase manner, with individual words presented for 450 ms and phrases

for 500 ms. The ISI was 100 ms. Following the presentation of the target sentence, participants were required to judge the acceptability of the target sentence *in the context of the context sentence*, i.e. they were instructed explicitly to read the sentence pairs as a unit and to then judge the acceptability of the second sentence. In addition to the acceptability judgement task, participants completed a probe detection after each trial, in which they decided whether a single word had been presented as part of either the context or the target sentence in the previous trial. For each of the two tasks, the maximal decision time allowed was 2000 ms. Participants were asked to avoid movements and not blink their eyes during the presentation of the target sentences.

The experiment was divided into two sessions, which were separated by at least 7 days. Each session began with a short practise block followed by 8 experimental blocks of 45 context-target pairs. Between the blocks, participants took short breaks. Including electrode preparation, a single session lasted approx. 3 hours.

The EEG recording took place as described for Experiment 1, though for this experiment all channels were amplified using Twente Medical Systems DC amplifiers and no low-pass filter was operative during the recording.

Grand average ERPs were calculated on the basis of averages per condition per participant from the onset of the verb to 1000 ms post onset. In this experiment, averages were aligned to a baseline from –100 to 100 ms relative to the critical stimulus onset. Trials for which the probe detection task was not performed correctly were excluded from the averaging procedure as were trials containing other artefacts (see Experiments 1 and 4).

Data Analysis

For both behavioural tasks, we calculated error rates and reaction times per condition, with incorrectly answered trials excluded from the reaction time analysis. For the statistical analysis of the behavioural data, repeated measures ANOVAs were computed with the critical factors CONTEXT (causative vs. non-causative) and VERB (active vs. object-experiencer) and the random factors subjects (F_1) and items (F_2).

For the ERP data, mean amplitude values per time window per condition were also analysed statistically with a repeated measures ANOVA involving the critical factors listed above. Topographical regions of interest were defined as for Experiment 4 and the data analysis proceeded in the same manner as described for Experiment 1.

7.1.2 Results

Behavioural Data – Acceptability Judgement

The analysis of the error rates for the acceptability judgement task showed a main effect of CONTEXT that was significant in the analysis by items and marginal in the analysis by subjects (F_1 (1,15) = 3.95, p < .07; F_2 (1,39) = 96.76, p = .0001) and a main effect of VERB that reached marginal significance only in the subjects analysis (F_1 (1,15) = 4.23, p < .06). Furthermore, there was an interaction CONTEXT x VERB which was also marginal by subjects and significant by items (F_1 (1,15) = 4.31, p < .06; F_2 (1,39) = 12.06, p < .01). Resolving this interaction by CONTEXT showed that the error rates for sentences involving active and object-experiencer verbs differed only for non-causative contexts (F_1 (1,15) = 9.42, p < .01; F_2 (1,39) = 10.22, p < .01). These differences were due to higher error rates for object-experiencer verbs in a non-causative context (19.8%) than for active verbs in a non-causative context (14.2%). In comparison, the mean error rate for object-experiencer verbs in a causative context was 7.5% and that for active verbs 9.1%.

The reaction times for the acceptability judgement task showed significant effects only in the analysis by items. Here, there was a main effect of CONTEXT (F_2 (1,39) = 17.94, p = .0001), which was due to longer mean reaction times for non-causative (608 ms) than for causative contexts (563 ms).

Behavioural Data – Probe Detection

With regard to the probe detection task, the statistical analysis of the error rates showed a main effect of VERB, which only reached significance in the subjects analysis (F_1 (1,15) = 6.60, p < .03). This effect was based on higher error rates for object-experiencer (8.9%) than for active verbs (6.6%).

The analysis of the reaction times for the probe detection task showed only a marginal interaction CONTEXT x VERB in the subjects analysis (F_1 (1,15) = 3.71, p < .08). Resolving this interaction by CONTEXT showed that there was an effect of VERB for non-causative contexts (F_1 (1,15) = 4.98, p < .05) but not for causative contexts, which resulted from longer reaction times for object-experiencer (902 ms) in comparison to active verbs (870 ms).

ERP Data

Figure 12 shows grand average ERPs for active and object-experiencer verbs in causative (A) and non-causative contexts (B).

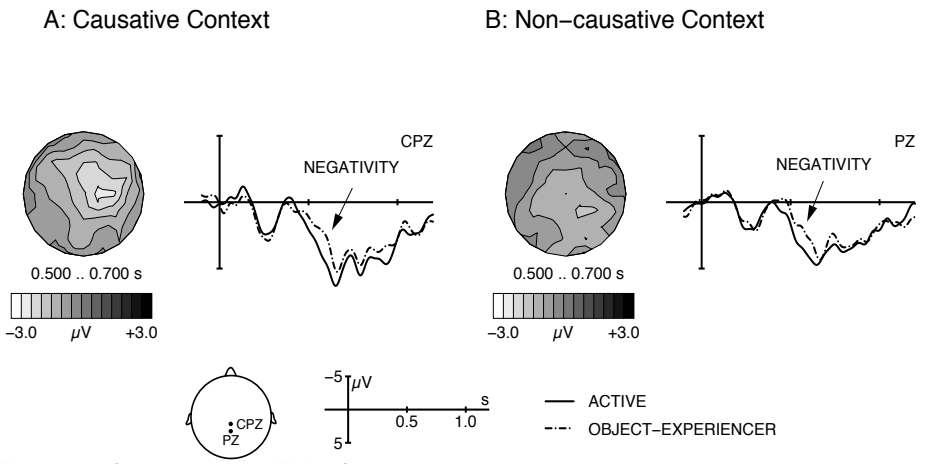

Figure 12. Grand average ERPs for accusative active vs. object-experiencer verbs (onset at the vertical bar) in causative (A) and non-causative contexts (B). Negativity is plotted upwards. The topographical maps indicate the distribution of the voltage differences between object-experiencer and active verbs.

As Figure 12 shows, object-experiencer verbs elicit a negativity between approx. 450-700 ms in comparison to their active counterparts independently of the context. However, for the non-causative contexts, this negativity appears to begin a little earlier (approx. 400 ms post onset of the verb) than for causative contexts (approx. 500 ms post onset) and its topographical focus is a little more posterior.

In order to quantify the latency differences between the negativities in the two contexts, two time windows were chosen for the statistical analysis: 400-500 ms and 500-700 ms.

Time window 1: 400-500 ms

For the first time window, the only effect approaching marginal statistical significance in the global analysis of the lateral electrodes was an interaction CONTEXT x VERB x ROI (F (5,75) = 2.61; p = .08). In order to test the hypothesis that object-experiencer verbs in a non-causative context give rise to a negativity in comparison to object-experiencer verbs in a causative context in this time window, we computed planned comparisons for each ROI. These revealed a marginal interaction CONTEXT x VERB (F (1,15) = 3.93; p < .07) in the right-posterior region. Planned comparisons for each of the two verb classes in this region showed an effect of CONTEXT for object-experiencer verbs (F (1,15) = 4.25; p = .05; non-causative contexts more negative) but not for their active counterparts.

The analysis of the midline electrodes revealed no significant or marginally significant effects.

Time window 2: 500-700 ms

In the second time window, the global statistical analysis revealed a main effect of VERB for both the lateral (F (1,15) = 7.11; p < .02) and the midline electrodes (F (1,15) = 13.79; p < .01). In each case, object-experiencer verbs elicited more negative waveforms than active verbs.

7.1.3 Discussion

In contrast to the predictions of accounts assuming that context may influence thematic hierarchising (e.g. Altmann, 1999; Tanenhaus et al., 1989) the results of Experiment 5 showed no indication that a constraining context may force the non-causative reading for accusative object-experiencer verbs. Rather than giving rise to an early positivity indicative of a thematic reanalysis in a non-causative context, as the choice of the non-causative reading would require, these verbs showed a centrally distributed negativity irrespectively of the context in which they appeared. This

component had a shorter onset latency of approx. 100 ms in a non-causative context.

The finding of a negativity for accusative object-experiencer verbs in comparison to their active counterparts replicates previous findings (Bornkessel, 2001). As described above, this negativity may be seen as reflecting the ambiguity inherent in accusative object-experiencer verbs. The earlier onset of the negativity in a non-causative context, by contrast, may be an index of the incompatibility between the contextual information and the 'dominant reading' (i.e. the preferred thematic structure) of these verbs. This interpretation is supported by the (descriptive) observation that the negativity for object-experiencer verbs has a more parietal distribution for non-causative in comparison to causative contexts, a finding that is in line with the results of an ERP study on lexical ambiguity reported by Hagoort & Brown (1994). While these authors observed typical N400 effects for the disambiguation of a lexically ambiguous word towards its subordinate meaning, with regard to the negativity observed for ambiguous words themselves (in comparison to unambiguous controls), they note that "the distribution of the effect over the scalp does not fit with the standard topography observed for N400 effects" (p. 54). The authors describe this latter component as more frontal and lateralised than an N400, as, indeed, is also the case for the negativity observed in a causative context in the present experiment.

Furthermore, the assumption that the negativity in a non-causative context observed here is a reflection of a mismatch between the contextual requirements and the (strongly) preferred thematic structure of accusative object-experiencer verbs is supported by the acceptability judgement data of this experiment. Here, it was apparent that sentences with object-experiencer verbs are less acceptable than sentences with active verbs only in non-causative contexts, thus indicating that the requirement of these verbs to realise a causative structure is very strong.

In this way, since both the behavioural data and the ERPs for Experiment 5 show that the contextual manipulation employed in this experiment was able to influence processing, the present data indicate that contextual considerations are not taken into account during the establishment of hierarchical thematic dependencies.

However, we of course cannot exclude that the non-causative reading of accusative object-experiencer is generally inaccessible (i.e. the causative reading is always dominant). If this were the case, our results would simply reflect the fact that there can be no contextual manipulation that is adequate to force the non-causative reading of these verbs, thereby rendering our conclusions with regard to the possible influence of context on thematic hierarchising invalid. Yet, there are several points that speak against this possibility, which we will discuss in turn in the following.

Firstly, if the non-causative reading of accusative object-experiencer verbs were generally subordinated to such a degree that it is never accessible, it is not clear why these verbs should differ from their active counterparts in terms of ERP measures. Thus, this difference in itself speaks in favour of the assumption that accusative object-experiencers *are* ambiguous, whereby ambiguity is understood as entailing the possibility of expressing all alternative readings. Consequently, the apparent ambiguity of accusative object-experiencer verbs leads one to expect the unpreferred reading to manifest itself at some point, since otherwise it is not clear why these verbs should remain ambiguous.

Secondly, recall from the discussion in Chapter 5 that Scheepers et al. (2000) found an interaction of verb class and word order in regression path durations at the clause-final adverbial in sentences in which the first NP argument was case ambiguous and was preceded by either an (accusative) subject-experiencer or object-experiencer verb. Thus, while the processing of an accusative object-experiencer verb did not influence the preference for subject-initiality, these verbs *did* serve to diminish the processing difficulties associated with object-initial sentences clause-finally. In this way, it is apparent that the non-causative reading of accusative object-experiencer verbs *is* able to influence processing, thereby indicating the manipulation chosen in the present experiment is a valid one.

Finally, the findings of Experiment 5 are also compatible with the results reported by Altmann (1999). While the present data provide evidence that (hierarchical) thematic assignments cannot be determined by contextual information, they do suggest that there is a rapid integration between contextual information and the thematic information provided by a verb. This is shown by the shorter latency and slightly more posterior distribution of the negativity for object-experiencer verbs in a non-causative context in

comparison to a causative context. The search process for potential arguments that is, thereby, apparently initiated by the processing of the verb is somewhat reminiscent of the immediate search for an antecedent that takes place when a pronoun is processed (Osterhout & Mobley, 1995), i.e. of the fact that, whenever additional contextual information is required, it is rapidly sought. However, these interactions with contextual information may be thought of as operating entirely within the lexical / semantic processing system within phase 2 of the argument dependency model (cf. Figure 11 in Chapter 6), since thematic dependencies (‘assignments’) may, of course, be conveyed to this processing system although no information flow in the reverse direction is possible. In this way, these previous findings provide no evidence against the autonomy of thematic processing during stage 2 of comprehension.

Chapter 8
On the Independence of Thematic Relations from Semantic / World Knowledge Information

Whereas Experiment 5 provided evidence that the mechanisms within the thematic processing route in phase 2 apply independently of contextual information, there is a potential interaction of information types that is perhaps even more central to the core architecture of the argument dependency model. Thus, since the internal structure of comprehension in phase 2 is characterised by the simultaneous processing of syntactic, thematic and semantic information, the interaction between these three information types is particularly interesting to examine. Recall that Friederici's (1999,2002) neurocognitive model of language processing assumes autonomy of processing with regard to syntactic and semantic information in this phase, since previous studies have shown that the distinct ERP components elicited by these two types of processing (i.e. the LAN and the N400, respectively) are not modulated by manipulations pertaining to the other information type (Gunter et al., 1997, 2000). Furthermore, the results of Experiment 1 in the present thesis indicate that thematic and syntactic processing also proceed autonomously from one another. In this way, a single logical combination of the processing pathways in Phase 2 remains, namely the interaction of thematic and semantic processes.

Evidently, an examination of the interrelationship between thematic and semantic / world knowledge / plausibility information and how these information sources are processed far surpasses a simple combinatory possibility in importance, since various researchers have proposed – generally in the context of constraint-based models of sentence processing – that thematic information (a) is conceptually contentful in the sense that it includes general semantic / world knowledge information (Ferretti et al., 2001; McRae et al., 1997), and (b) may be *assigned* via semantic / world knowledge information (e.g. McRae et al., 1997; Tanenhaus et al., 1989). For a detailed discussion of this view of thematic processing, see Chapter 2.2.

The argument dependency model, by contrast, assumes that any interaction between thematic and syntactic processing during Phase 2 is restricted to

an information flow from thematic to semantic information. Thus, semantic information crucially *cannot* influence thematic processing within this phase. Rather, thematic processing may only be influenced by a small set of thematically relevant features such as animacy. It is the aim of this chapter to provide evidence for this not uncontroversial view of thematic information and thematic processing.

In order to provide empirical support for the autonomous view of thematic processing assumed by the argument dependency model, we must show that thematic hierarchising is not affected by the semantic plausibility or world knowledge related status of a particular hierarchical thematic ordering (as, indeed, hierarchical syntactic assignments appear to be independent of these types of influences, cf. for example Mecklinger et al., 1995; Schriefers et al., 1995). A promising paradigm for the purpose of this enterprise is that used by Frisch & Schlesewsky (2001) to demonstrate the influence of animacy on thematic processing. Recall from Chapter 3.2.1 that these authors examined double case violations elicited by two identically case marked arguments that were either both animate or of which one was animate and the other inanimate. The critical examples in (33) are repeated here as (57).

(57) a. *… welcher Mönch der Bischof begleitete.
… [which monk]$_{NOM}$ [the bishop]$_{NOM}$ accompanied

b. *… welcher Mönch der Zweig streifte.
… [which monk]$_{NOM}$ [the twig]$_{NOM}$ brushed

Whereas (57a) showed the typical ERP signature for double case ungrammaticalities, namely a biphasic N400-P600 pattern, (57b) only elicited a P600. This finding shows that a violation resulting from the impossibility of hierarchising two identically case marked arguments with respect to one another thematically may be circumvented if the two arguments differ in animacy (for a more detailed discussion, cf. Chapter 3.2.1).

Even though the study reported by Frisch & Schlesewsky (2001) insightfully demonstrates that the thematic hierarchising process may be influenced by interpretative features, its results cannot be interpreted as showing that semantic / world knowledge based information is drawn upon to this

purpose. Rather these findings are also compatible with the view that thematic dependencies are established exclusively on the basis of a small set of thematically relevant features (Dowty, 1991; Primus, 1999). As was discussed in detail in Chapter 1.1, many researchers have argued for a strong influence of animacy in this regard (Primus, 1999; for further evidence regarding the potent influence of animacy cf., for example, Billings & Rudin, 1996; Comrie, 1981; Tomlin, 1986). In this way, the question of whether thematic hierarchising takes place with reference to a restricted domain of information (i.e. morphological case and animacy information, for present purposes) or on the basis of all interpretationally relevant information available within the crucial time range. Experiment 6 will address this question by means of extending the paradigm of the Frisch & Schlesewsky (2001) study.

8.1 Experiment 6: ERP evidence for the independence of thematic and semantic information

Experiment 6 will examine whether double case violations may be influenced by varying the degree of plausibility of (Proto-) Agent and (Proto-) Patient assignments to the two arguments in a transitive relation. If thematic hierarchising is influenced by plausibility / world knowledge, the difficulties associated with the processing of two identically case-marked arguments should be alleviated, at least to some degree, when one of the two possibilities of hierarchising the arguments with respect to one another is markedly more plausible than the other.

To this end, we will make use of a plausibility manipulation as illustrated in (58).

(58) a. neutral plausibility
Welchen Prüfer amüsierte der Bastler auf der Party?
[which examiner]$_{ACC}$ amused [the tinkerer]$_{NOM}$ at the party
'Which examiner did the tinkerer amuse at the party?'

b. ideal plausibility
Welchen Prüfer amüsierte der Komiker auf der Party?
[which examiner]$_{ACC}$ amused [the comedian]$_{NOM}$ at the party
'Which examiner did the comedian amuse at the party?'

c. implausible
Welchen Prüfer amüsierte der Langweiler auf der Party?
[which examiner]$_{ACC}$ amused [the bore]$_{NOM}$ at the party
'Which examiner did the bore amuse at the party?'

The crucial variation in the sentences in (58) concerns the second argument. Whereas this argument is neutral with respect to the plausibility of it being a [-dep] argument of the verb *amüsierte* ('amused') in (58a), the same relation is ideally plausible in (58b) and implausible in (58c). In order to ensure that all effects of the plausibility manipulation would be confined to the second argument, the first argument was always neutral with respect to the plausibility of it being a [+dep] argument of the verb. Furthermore, since plausibility preferences for (Proto)-Agents (or [-dep] arguments) are apparently more potent than those for (Proto-)Patients ([+dep] arguments) (McRae et al., 1997), we chose to vary the nominative-marked rather than the accusative-marked arguments in this experiment. The combination of these constraints yielded the accusative-nominative structures in (58) and their critical ungrammatical counterparts with two accusative NPs. The latter are illustrated in (59).

(59) a. neutral plausibility
*Welchen Prüfer amüsierte den Bastler auf der Party?
[which examiner]$_{ACC}$ amused [the tinkerer]$_{ACC}$ at the party

b. ideal plausibility
*Welchen Prüfer amüsierte den Komiker auf der Party?
[which examiner]$_{ACC}$ amused [the comedian]$_{ACC}$ at the party

c. implausible
*Welchen Prüfer amüsierte den Langweiler auf der Party?
[which examiner]$_{ACC}$ amused [the bore]$_{ACC}$ at the party

The hypotheses for this study are clear-cut. Essentially there are two different influences on the processing of the second NP: the case marking of this NP, which determines the grammaticality or ungrammaticality of the sentence, and the plausibility manipulation induced by this NP. For the grammatical structures, the plausibility manipulation should modulate the N400, with ideal structures expected to elicit the smallest N400, implausible structures the largest N400, and neutral structures an N400 that lies

between these two extremes (Kutas & Hillyard, 1980). With regard to the neutral ungrammatical structures, we expect to observe an N400-P600 pattern in accordance with previous findings on double case ungrammaticalities in German (e.g. Frisch & Schlesewsky, 2001). With regard to the biased ungrammatical structures, however, there are two possibilities. If there is a semantic / world knowledge component to (hierarchical) thematic knowledge, a plausibility bias with regard to the relation between the two arguments should serve to alleviate the difficulties encountered when processing a double case ungrammaticality, since this information should allow a hierarchisation of the arguments to one another to take place.[31] In this way, there should be a reduction of the N400 component, in accordance with Frisch & Schlesewsky's (2001) findings with regard to animacy, i.e. there should be an interaction of the factors grammaticality and plausibility. By contrast, if thematic hierarchising takes place independently of world knowledge, the two processing aspects should vary independently of one another.

8.1.1 Norming Study

In order to ensure that the plausibility variation required in Experiment 6 would indeed be valid, we conducted a norming study, the results of which were then used to select the critical experimental items for the ERP study.

This study made use of the rating technique described in McRae et al. (1997), i.e. participants were asked to rank the likelihood of particular nouns being the Agent or Patient of a particular verb on a 7-point scale. An example of the presentation to participants is shown in (60) and (61) for Agent and Patient ratings, respectively.

[31] Note, however, that this prediction is essentially restricted to the ideal structures, since the implausible structures only have an implausible Agent, not a plausible Patient and thereby need not necessarily provide sufficient information in this regard.

(60) Wie wahrscheinlich ist es, dass ein
how likely is it that a

Bastler (*tinkerer)* _____
Pförtner (*doorman)* _____
Komiker (*comedian)* _____
Prüfer (*examiner)* _____
Langweiler (*bore)* _____
Zuschauer (*spectator*) _____

jemanden amüsiert?
amuses someone

(61) Wie wahrscheinlich ist es, dass ein
how likely is it that a

Bastler (*tinkerer)* _____
Pförtner (*doorman)* _____
Komiker (*comedian)* _____
Prüfer (*examiner)* _____
Langweiler (*bore)* _____
Zuschauer (*spectator*) _____

von jemandem amüsiert wird?
is amused by someone

Participants

76 undergraduate students of the University of Leipzig and the University of Potsdam volunteered to take part in the rating study.

Materials

The materials for the rating study were created on the basis of 120 verb plus 6 noun septuplets. Of the six nouns, there was one designated ideal Agent, one implausible Agent and one plausible Patient (to ensure a full range of ratings for the Patient questions) as well as 3 supposedly neutral Agents/Patients. From these sets, 3 active and 3 passive versions were

generated. The order of noun phrase presentation varied between versions in order to ensure that participants could not follow a rating strategy on the basis of most plausible Agents/Patients always being in a certain position. The 720 blocks thus created were subdivided into 12 lists of 60 blocks (each made up of 30 active, 30 passive blocks) such that each list contained a single verb only once, i.e. either in the active or in the passive voice. The lists were randomly assigned to participants and each list was rated approximately equally often.

Procedure

Participants rated sets of nouns of the form illustrated in (60) and (61) above in a written questionnaire. The instructions asked for ratings to be as quick and intuitive as possible. The completion of the questionnaire took approximately 15-20 minutes.

Results

The results of the rating study will be presented only for the critical items selected for the ERP study (see below).

8.1.2 ERP study: Method

Participants

Sixteen undergraduate students of the University of Leipzig participated in Experiment 6 (8 female; mean age 24.1 years; age range 21 – 31 years).

Materials

On the basis of the rating study, 50 verb plus 4 noun quintuplets were selected. Of the four nouns, one was an ideal Agent (generally indexed by a mean Agent rating of ≥ 6), one an implausible Agent (generally, a mean Agent rating of ≤ 2), one a neutral Agent (generally, a mean Agent rating between 3 and 5), and the fourth (the designated NP1) was chosen to be neutral with respect to both agent- and patienthood. The mean ratings and standard deviations for all chosen materials are shown in Appendix A.

Due to the difficulty associated with obtaining a larger number of suitably biased items, participants read all six versions of a single sentence (though, of course, the NP-V-NP relation was identical in only two of these). Since the experiment was carried out in two sessions, only three sentences from the same set were read in each session; it was ensured that only one of the two sentences with an identical NP-V-NP relation was presented during the course of one session. The randomisation of the material was varied across participants, as was the assignment of particular sentences to sessions 1 and 2.

Procedure

The experimental sentences were presented in a phrase-by-phrase manner, with presentation times of 450 ms for single words and 500 ms for phrases (ISI: 100 ms). As for Experiment 5, participants completed an acceptability judgment task and a probe detection task after the presentation of each sentence. Participants were explicitly instructed to judge a sentence as "unacceptable" if it was ill-formed, implausible or both. The experiment consisted of two sessions, each of which comprised a short training session followed by 6 experimental blocks of 40 sentences each, between which the participants took short breaks. An entire session (including electrode preparation) lasted approximately 2.5 hours.

The EEG recording took place as described for Experiment 1. Average ERPs were calculated per condition per participant from the onset of the second noun phrase to 1000 ms post onset of this phrase, before grand-averages were computed over all participants. Averaging took place relative to a baseline interval from –200 to 0 ms before the onset of the second noun phrase. Trials for which the probe detection task was not performed correctly were excluded from the averaging procedure, as were trials containing other artefacts (see Experiment 1).

Data Analysis

For the behavioural data, error rates and reaction times were calculated for each condition for both the acceptability judgement and the probe detection tasks. Incorrectly answered trials were excluded from the reaction time analysis. Repeated measures analyses of variance (ANOVAs) involving the critical factors grammaticality (GRAMM: grammatical vs. ungrammatical)

and plausibility of the second NP being the subject/Agent (PLAUS: ideal vs. neutral vs. implausible) and the random factors subjects (F_1) and items (F_2) were computed.

For the statistical analysis of the ERP data, repeated measures ANOVAs involving the critical factors grammaticality (GRAMM: grammatical vs. ungrammatical) and plausibility of the second NP being the subject/Agent (PLAUS: ideal vs. neutral vs. implausible) were calculated for mean amplitude values per time window per condition in six regions of interest (ROIs). Regions of interest were defined as for Experiment 4 and the data analysis proceeded in accordance with the procedure outlined for Experiment 1.

8.1.3 ERP study: Results

Behavioural Data – Acceptability Judgement

The statistical analysis of the error rates for the acceptability judgement task revealed a significant main effect of GRAMM (F_1 (1,15) = 18.90, $p < .001$; F_2 (1,49) = 90.86, $p = .0001$), which was due to higher error rates for ungrammatical structures (23.3%) than for grammatical structures (9.7%). The main effect of PLAUS was marginal in the analysis by subjects (F_1 (2,30) = 2.98, $p < .08$) and significant in the analysis by items (F_2 (2,98) = 5.05, $p < .01$). Pairwise comparisons for the three levels of the factor PLAUS showed significant differences between ideal and implausible structures in both the analysis by subjects and the analysis by items (F_1 (1,15) = 11.80, $p < .01$; F_2 (1,49) = 9.60, $p > .01$), whereas the difference between ideal and neutral structures reached significance only in the items analysis (F_2 (1,49) = 5.36, $p < .03$). These differences were due to higher error rates for implausible (17.9%) in comparison to neutral (17.1%) and ideal structures (14.5%).

With regard to the reaction times, there was again a main effect of PLAUS (F_1 (2,30) = 4.72, $p < .02$; F_2 (2,98) = 4.10, $p < .02$) and a main effect of GRAMM, though this was only significant in the items analysis (F_2 (1,49) = 12.13, $p < .01$), with grammatical structures giving rise to longer reaction times (608 ms) than grammatical structures (577 ms). Pairwise comparisons between the individual levels of the factor PLAUS revealed a difference between ideal and implausible structures only

(F_1 (1,15) = 7.56, p < .02; F_2 (1,49) = 9.40, p < .01), with implausible sentences giving rise to longer reaction times (622 ms) than ideal sentences (587 ms).

Behavioural Data – Probe Detection

For the error rates of the probe detection task, a repeated measures ANOVA showed a main effect of GRAMM (F_1 (1,15) = 9.93, p < .01; F_2 (1,49) = 6.00, p < .02), which resulted from higher error rates for ungrammatical (6.25 %) than grammatical structures (4.33%), and an interaction GRAMM X PLAUS (F_1 (2,30) = 4.22, p < .03; F_2 (2,98) = 3.19, p < .05). Planned comparisons for each of the two levels of GRAMM revealed an effect of PLAUS only for ungrammatical structures (F_1 (2,30) = 6.23, p < .01; F_2 (2,98) = 3.03, p < .06); pairwise comparisons between the three levels of PLAUS for the ungrammatical sentences showed a reliable difference between ideal and implausible sentences (F_1 (1,15) = 14.49, p < .01; F_2 (1,49) = 5.32, p < .03) due to more errors for implausible (7.88%) in comparison to ideal sentences (4.63%).

The reaction times for the probe detection task showed a main effect of GRAMM (F_1 (1,15) = 31.81, p = .0001; F_2 (1,49) = 21.65, p = .0001), which resulted from longer reaction times for ungrammatical (806 ms) than for grammatical (765 ms) sentences, as well as a main effect of PLAUS that was significant in the analysis by subjects (F_1 (2,30) = 3.91, p < .04) and marginal in the analysis by items (F_2 (2,98) = 2.88, p < .07). The interaction GRAMM x PLAUS was significant only in the analysis by subjects (F_1 (2,30) = 4.66, p < .02). Resolving this interaction by GRAMM revealed an effect of PLAUS for grammatical (F_1 (2,30) = 7.05, p < .01) but not for ungrammatical structures. This effect resulted from a difference between neutral and ideal structures (F_1 (1,15) = 10.99, p < .01) as well as between neutral and implausible structures (F_1 (1,15) = 6.34, p < .03). In both cases, neutral structures elicited longer reaction times (784 ms) than ideal (751 ms) or implausible (759 ms) structures.

ERP Data

Figure 13 shows grand-average ERPs for ungrammatical vs. grammatical structures at the critical position of the second noun phrase, irrespectively of plausibility.

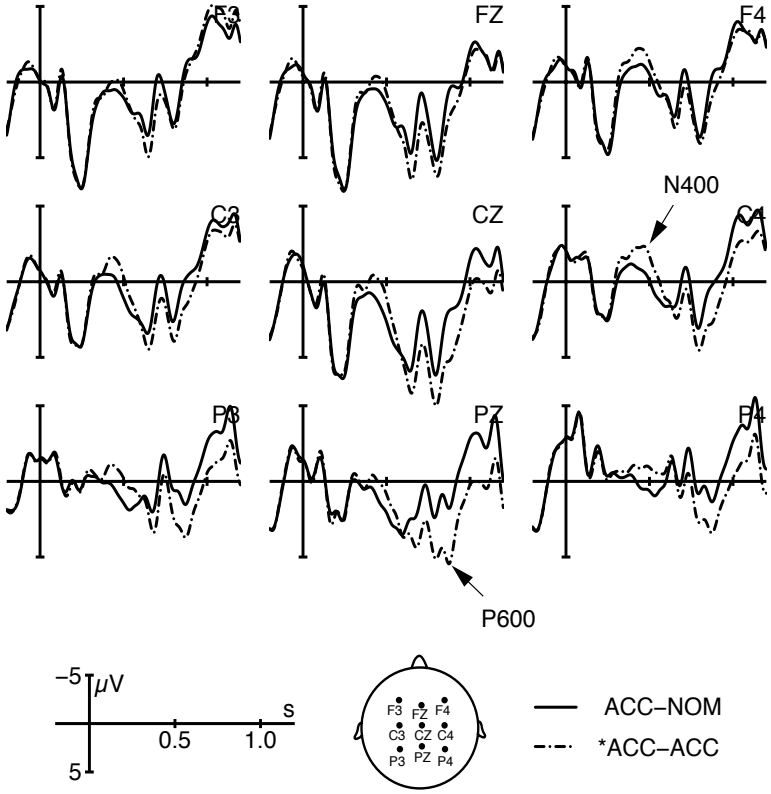

Figure 13. Grand average ERPs elicited by ungrammatical (accusative-accusative) and grammatical (accusative-nominative) structures at the position of the second NP (onset at the vertical bar) in Experiment 6. Negativity is plotted upwards.

In accordance with previous findings (Frisch 2000; Frisch & Schlesewsky, 2001), double case ungrammaticalities elicit a biphasic N400-P600 pattern in comparison to their grammatical counterparts. Of greater interest for present purposes, however, is the interaction of this basic pattern with the plausibility of the NP-NP-Verb relation. With regard to the impact of the plausibility, Figure 14 (on the following page) shows grand average ERPs for the three levels of plausibility for grammatical sentences.

As is evident from Figure 14, ERPs elicited by implausible grammatical sentences were more negative than those elicited by ideal and neutral grammatical sentences between approx. 300 and 500 ms post onset of NP2. Neutral grammatical sentences, by contrast, appear to differ from their ideal counterparts between approx. 500 and 700 ms post noun phrase onset such that the former give rise to a negativity in comparison to the latter.

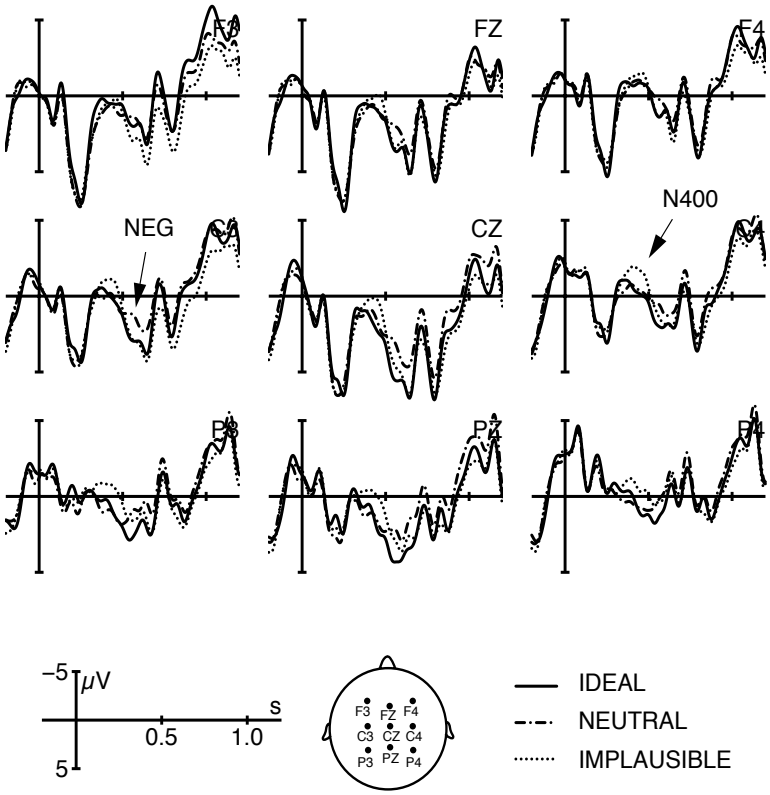

Figure 14. Grand average ERPs elicited by ideally plausible, neutral and implausible grammatical sentences at the position of the second NP (onset at the vertical bar) in Experiment 6. Negativity is plotted upwards.

The contrasts between ungrammatical and grammatical structures of one degree of plausibility are shown in parts A, B and C of Figure 15 (on the following page) for ideal, neutral and implausible structures, respectively. As Figure 15 clearly shows, ungrammatical structures elicit a biphasic N400-P600 response in comparison to their ungrammatical counterparts, irrespectively of their plausibility.

For the statistical analysis of the ERP data, we chose the following three time windows: (a) 300-500 ms for the analysis of the N400 elicited by ungrammatical sentences and the difference between implausible and plausible grammatical sentences; (b) 500-700 ms for an analysis of the difference between neutral and ideal grammatical sentences; (c) 700-900 ms for an analysis of the P600 effects.

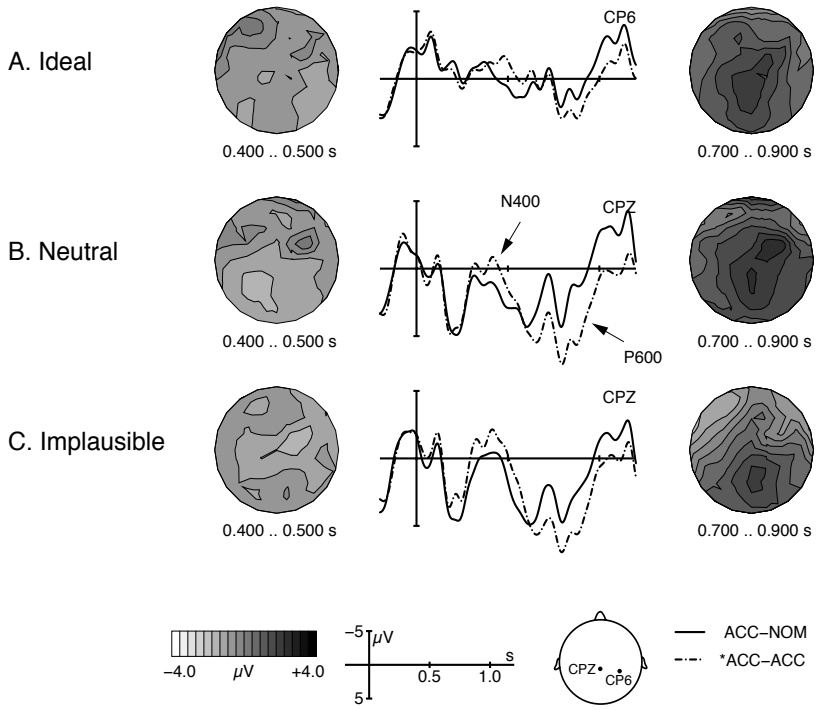

Figure 15. Grand average ERPs for ungrammatical (accusative-accusative) vs. grammatical (accusative-nominative) structures for ideally plausible (A), neutral (B) and implausible (C) sentences at the position of NP2 (onset at the vertical bar) in Experiment 6. Negativity is plotted upwards. The topographical maps indicate the distribution of the voltage differences between ungrammatical and grammatical structures.

Time window 1: 300-500 ms

In the first time window, a repeated measures ANOVA for the lateral electrodes revealed main effects of GRAMM (F (1,15) = 10.52, p < .01; ungrammatical structures more negative) and PLAUS (F (2,30) = 6.77, p < .01). Pairwise comparisons for the three levels of PLAUS showed significant differences between neutral and implausible (F (1,15) = 8.37, p < .02; implausible structures more negative) as well as between ideal and implausible structures (F (1,15) = 16.66, p < .01; implausible structures more negative).

For the midline electrodes, there were again significant main effects of GRAMM (F (1,15) = 10.94, p < .01; ungrammatical structures more negative) and PLAUS (F (2,30) = 8.18, p < .01), as well as a marginal interaction PLAUS x ELEC (F (14,210) = 2.21, p < .08). The effects of

PLAUS for each of the eight midline electrodes are shown in Table 12 (on the following page), as are the results of the pairwise comparisons between the individual levels of PLAUS when the main effect reached significance or was marginal. All differences in pairwise comparisons in Table 12 were due to more negative ERP waveforms for implausible in comparison to either neutral or ideal sentences.

Time window 2: 500-700 ms

In the second time window, the statistical analysis for the lateral electrodes showed a significant interaction ROI x GRAMM x PLAUS (F (10,150) = 2.92, p < .02). This interaction was resolved by ROI, thus revealing an interaction GRAMM x PLAUS in the left-anterior (F (2,30) = 3.67, p < .04) and right-anterior regions (F (2,30) = 3.79, p < .04). When both of these interactions were resolved by GRAMM, no significant effects of PLAUS were apparent.

In the analysis of the midline electrodes, the main effect PLAUS (F (2,30) = 4.14, p < .03) reached significance, though this effect was modulated by a marginal interaction GRAMM x PLAUS x ELEC (F (14,210) = 2.29, p < .08). Since planned comparisons for each of the electrodes revealed no effects of GRAMM x PLAUS at any of the electrode positions, we conducted global pairwise comparisons for the individual levels of PLAUS. These revealed a difference between neutral and ideal sentences (F (1,15) = 10.78, p < .01), which resulted from more negative waveforms for neutral sentences in this time window.

Electrode	Effect of PLAUS	Pairwise comparisons (if applicable)
AFZ	---	---
FZ	$F(2,30) = 3.18$, $p < .06$	neutral vs. implausible: $F(1,15) = 3.93$, $p < .07$ ideal vs. implausible: $F(1,15) = 7.06$, $p < .02$
FCZ	$F(2,30) = 4.41$, $p < .03$	neutral vs. implausible: $F(1,15) = 5.20$, $p < .03$ ideal vs. implausible: $F(1,15) = 11.55$, $p < .01$
CZ	$F(2,30) = 8.95$, $p < .01$	neutral vs. implausible: $F(1,15) = 7.03$, $p < .02$ ideal vs. implausible: $F(1,15) = 31.63$, $p = .0001$
CPZ	$F(2,30) = 11.85$, $p < .001$	neutral vs. implausible: $F(1,15) = 15.10$, $p < .01$ ideal vs. implausible: $F(1,15) = 28.04$, $p = .0001$
PZ	$F(2,30) = 9.68$, $p < .001$	neutral vs. implausible: $F(1,15) = 9.62$, $p < .01$ ideal vs. implausible: $F(1,15) = 21.72$, $p < .001$
POZ	$F(2,30) = 7.59$, $p < .01$	neutral vs. implausible: $F(1,15) = 7.19$, $p < .02$ ideal vs. implausible: $F(1,15) = 21.86$, $p < .001$
OZ	$F(2,30) = 6.92$, $p < .01$	neutral vs. implausible: $F(1,15) = 5.43$, $p < .04$ ideal vs. implausible: $F(1,15) = 14.19$, $p < .01$

Table 12. Main effects of PLAUS and pairwise comparisons where applicable for each of the midline electrodes in the time window 300-500 ms in Experiment 6.

Time window 3: 700-900 ms

The analysis of the lateral electrodes in time window 3 showed a main effect of GRAMM (F (1,15) = 5.10, p < .04), which arose from a positivity for ungrammatical structures in comparison to their grammatical counterparts. Additionally, there were significant interactions GRAMM x PLAUS (F (2,30) = 3.77, p < .05) and ROI x GRAMM x PLAUS (F (10,150) = 2.86, p < .02) as well as a marginal interaction ROI x GRAMM (F (5,75) = 2.92, p < .08). In view of the interactions with ROI, we conducted separate analyses for each of the six regions of interest. The results of these are given in Table 13.

ROI	Effect(s)
left-anterior	GRAMM x PLAUS: F (2,30) = 5.65, p < .01
left-central	GRAMM: F (1,15) = 5.36, p < .04
left-posterior	GRAMM: F (1,15) = 10.15, p < .01
right-anterior	GRAMM x PLAUS: F (2,30) = 6.30, p < .01
right-central	GRAMM: F (1,15) = 5.40, p < .04
right-posterior	GRAMM: F (1,15) = 7.01, p < .02

Table 13. Effects of GRAMM and GRAMM x PLAUS in each of the 6 ROIs for the time window 700-900 ms in Experiment 6.

All of the main effects of GRAMM shown in Table 6 resulted from more positive ERP patterns for the ungrammatical structures. The interactions GRAMM x PLAUS in both of the anterior regions were resolved by GRAMM: whereas there was no significant effect of PLAUS for either grammatical or ungrammatical structures in the right-anterior region, single comparisons for the left-anterior region revealed an effect of PLAUS for grammatical structures only (F (2,30) = 5.52, p < .01). Pairwise comparisons for each of the levels of PLAUS showed significant differences between neutral and implausible (F (1,15) = 6.57, p < .03) as well as between ideal and implausible (F (1,15) = 10.14, p < .01) structures. In each case, implausible structures elicited the more positive waveforms of the two conditions.

With regard to the midline electrodes, there was a significant main effect of GRAMM (F (1,15) = 11.41, p < .01; ungrammatical structures more positive) as well as an interaction PLAUS x ELEC (F (11,210) = 2.44, p < .05).

Planned comparisons for each electrode position revealed only a marginal effect of PLAUS at PZ (F (2,30) = 3.31, p < .06).

8.1.4 Discussion

Most generally, Experiment 6 replicated the findings of previous studies in that sentences with two accusative marked arguments elicited a biphasic N400-P600 pattern. Furthermore, neither of these two components was attenuated by the presence of explicit world knowledge information, i.e. information which could have served to disambiguate the relationship between the two arguments. By contrast, grammatical sentences showed clear effects of the plausibility manipulation as reflected by a larger negativity for implausible vs. neutral and ideal sentences between 300 and 500 ms and a larger negativity for neutral vs. ideal sentences between 500 and 700 ms.[32]

These results clearly indicate that plausibility / world knowledge information is not drawn upon to solve a thematic hierarchising conflict (at least not during processing phases 2 and 3), a conclusion that appears valid in view of the fact that the plausibility manipulation *was* able to modulate the ERP patterns for the grammatical structures. Thus, the present findings are not compatible with world knowledge based views of thematic information as advocated by McRae et al. (1997) and Ferretti et al. (2001).

Recall from Chapter 2.4 that, in light of previous results pertaining to argument processing in German, one of the primary points of critique with regard to the view of thematic processing advocated by McRae and colleagues is that this type of processing is entirely head-based. Thus, since these authors assume that thematic information crucially incorporates experience based information with regard to the participants that are typically involved in the event described by a particular verb, there are two

[32] These differential responses to implausible vs. neutral/ideal and neutral vs. ideal sentences indicate that the N400 effects generally observed for words that are implausible in a particular sentence context or that have a low cloze probability in this context may reflect a number of distinct subprocesses. Thus, one might speculate on the basis of the present data that a semantic expectation with regard to an upcoming constituent is specified as to exclude very unlikely (implausible) candidates only, with differences between ideal and neutral candidates then arising as a consequence of additional inference processes.

possibilities for the processing of verb-final sentences: either thematic analysis is delayed until the verb is reached, or a second, verb-independent type of thematic information must be drawn upon in order for successful processing of the arguments to take place. Clearly, the first of these possibilities is not a feasible option in light of the experimental evidence for thematic hierarchising prior to the verb in unambiguously case marked structures (Bornkessel et al., *to appear*, and Experiment 1 of the present thesis).

Of course, the fact that thematic processing may take place independently of the processing of a verb does not provide unequivocal evidence that verb-specific information *cannot* contribute to the establishment of thematic relations. Rather, such findings show that thematic processing *may* take place without a verb having been processed. In the context of a world knowledge based approach to thematic processing, this might be accounted for by appealing to the second possibility outlined above, i.e. by assuming an additional aspect of thematic processing that is more general than that described by McRae et al. (1997) and Ferretti et al. (2001), such as, for example, the thematic dependencies assumed in the context of the argument dependency model. If this were the case, we should expect processing to rely on the general type of thematic information when no verb information is available, with the more elaborate, verb-based information being used in those cases when it is accessible. However, this prediction is clearly not borne out, as the present experiment shows. Thus, there does not seem to be much leeway for reconciling the processing approach assumed by McRae and colleagues with the findings on German.

An obvious question arising in this regard is how the data McRae et al. (1997) and Ferretti et al. (2001) present in support of their view of thematic processing may be accounted for in terms of the present approach. These findings may, in fact, be derived quite readily by assuming that, in addition to thematic prototypes, there exist more general conceptual ("semantic") prototypes, which, however, impact upon language processing in quite a different manner to their thematic counterparts. In this way, it is not surprising that participants are able to judge that noun A is a better Agent / Patient for a particular verb than noun B (McRae et al., 1997), since all conceptual information, world knowledge etc. available to a participant may be readily employed in making such a judgement. As for the single word priming of Agents, Patients etc. reported in Ferretti et al. (2001), it is not at

all clear in what way these findings differ from standard semantic priming, i.e. why the knowledge responsible for these effects should be anything other than higher-level conceptual in nature.

With regard to the question of how thematic information should be delimited and, thereby, whether the types of results presented by McRae and colleagues should be viewed as pertaining to a characterisation of thematic information and thematic processing, McRae et al. (1997) assume the following stance: "if this type of knowledge is used immediately to aid the assignment of noun fillers to their roles, then it is appropriate to view it as thematic role knowledge" (p. 160). However, as we have seen, precisely this prediction does not appear to be borne out, neither in the present experiment nor, indeed, in the reading time study reported by McRae et al. (1997). Recall from Chapter 2.2 that the authors compared sentences such as in (19), which are repeated here as (62), for convenience.

(62) a. The young naïve gambler (who was) manipulated
by the dealer had bid more than he could afford to lose.

b. The shrewd heartless gambler (who was) manipulated
by the dealer had bid more than he could afford to lose.

In contrast to the findings by Trueswell et al. (1994), who demonstrated that the difficulty associated with the resolution of a main verb / reduced relative ambiguity in favour of the latter reading is only observable if the head noun is animate but not when it is inanimate, McRae et al. (1997) did not find such an immediate influence of the manipulation in (62), since reading times for the segment *manipulated* + *by* were significantly higher for reduced relative clauses in comparison to unreduced controls independently of whether the head noun of the relative clause was a 'good Agent' or a 'good Patient' in terms of their rating studies.[33] Rather, the reduced reading times for (62a) in comparison to (62b) at the position of *the dealer* may simply be a reflection of the better semantic fit of the former in comparison to the latter. In any case, this study provides no evidence that the *initial* assignment of roles (and grammatical functions) in (62) is driven by the

[33] A potential point of critique with regard to the procedure of the McRae et al. (1997) study is that the disambiguating information (*by*) was presented in the same segment as the ambiguous region (*manipulated*).

world knowledge based manipulation employed by McRae et al. (1997), thus rendering the characterisation of the type of knowledge referred to by these authors as ‘thematic’ highly questionable even with regard to their own classificational standards. By contrast, since the results of the Trueswell et al. (1994) and Frisch & Schlesewsky (2001) studies show that animacy *may* influence thematic processing, it appears that thematic information should be classified in terms of a small set of well defined features (e.g. animacy) rather than in terms of all available conceptual information.

Chapter 9
General Discussion

In the preceding chapters, we have described a neurocognitive model of incremental argument processing (the argument dependency model) and presented experimental evidence in its favour. A schematic outline of the model's processing architecture is recapitulated in Figure 16.

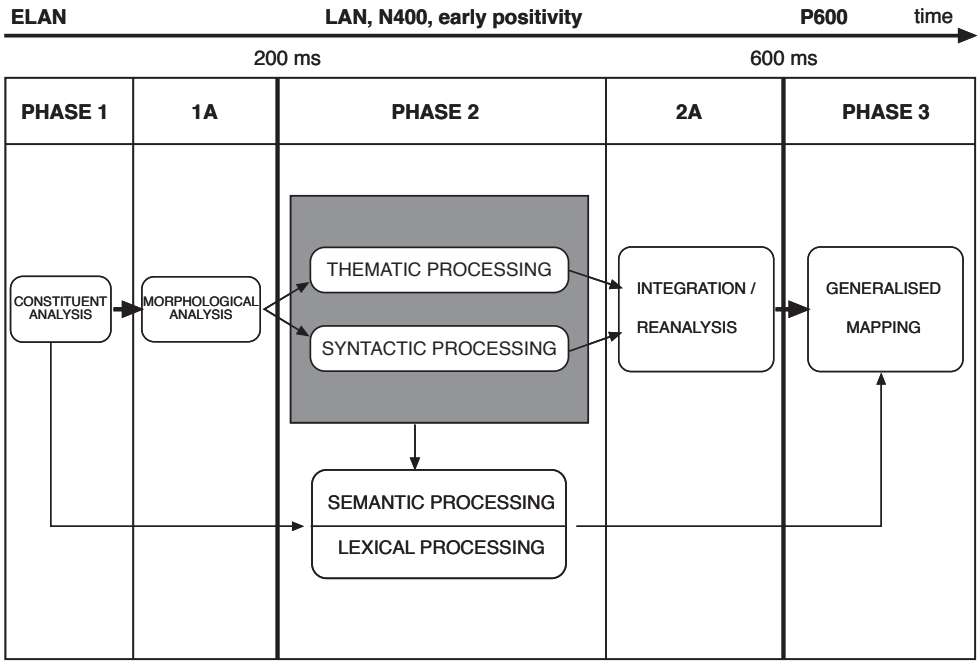

Figure 16. The processing architecture of the argument dependency model.

The central claim of the argument dependency model is that sentential arguments may be processed incrementally in one of two ways, namely via the establishment of either *syntactic* or *thematic* dependencies (cf. the distinction between syntactic and thematic processing in phase 2 in Figure 16). Which of these two processing pathways is pursued for a given argument crucially depends on whether this argument bears unambiguous morphological case marking or not, as is determined by the hypothesised morphological analyser in phase 1a of processing. Both the syntactic and the thematic processing routes in phase 2 are thought to operate by establishing hierarchical dependencies between arguments on the basis of

three basic processing principles: *Economy* (dependencies are minimised), *Dependency* (dependencies must be created between all arguments of a sentence), and *Distinctness* (dependencies must be established as to ensure maximal distinctness between arguments). Importantly, this initial establishment of (syntactic and thematic) dependencies cannot be influenced by any other types of information (e.g. semantic information, world knowledge, discourse context etc.) and the first period of interaction between syntactic and thematic information (phase 2a) also excludes all of these other potential influences. In this way, an interaction between all available pieces of linguistic information is delayed until phase 3, in which 'generalised mapping' processes are thought to set in.

9.1 Summary of the experimental evidence in support of the argument dependency model

The argument dependency model's conception of online sentence comprehension is supported by the findings of the six experiments reported in this thesis. Experiment 1, an ERP study, indicated that the morphological case marking borne by a sentential argument is indeed crucial with regard to how this argument will be processed. Thus, unambiguously case marked arguments (e.g. *der Direktor*, 'the$_{NOM}$ director') are thematically hierarchised with respect to one another even before the verb is processed, as is shown by the finding of an early positivity indicative of thematic reanalysis for unambiguous sentences concluded by a dative object-experiencer verb. In the absence of unambiguous case marking, however, there are no differences in the ERP responses to clause-final active and object-experiencer verbs, thus indicating that arguments with ambiguous case marking (e.g. *Maria*, 'Maria$_{NOM/ACC/DAT}$' / *die Direktorin*, 'the$_{NOM/ACC}$ director') do not give rise to such incremental (hierarchical) thematic processing.

In contrast to the processing of arguments, the processing of verbs requires the pursuit of both processing pathways, since the lexical entry of a verb encodes both thematic and syntactic information. This assumption is supported by the observation that a mismatch between the preferred syntactic and the preferred thematic hierarchisation of the sentential arguments elicited a LAN at the position of the verb in Experiment 1 when it was not clear from the arguments themselves which of the two orderings was correct. Finally, the finding of this LAN effect in itself as well as the

simultaneous appearance of an N400 for ambiguous object-initial sentences provides evidence for the simultaneous accessibility – and application – of the thematic and syntactic processing pathways during the processing of a verb. Since the N400 was less pronounced when the disambiguation towards an object-initial order was effected by an object-experiencer verb, it appears that thematic and syntactic information may interact in a processing stage that is post phase 2, but precedes the generalised mapping in phase 3, thereby motivating the assumption of phase 2a.

The conclusions drawn from Experiment 1 were confirmed by Experiment 2, which examined the ambiguous sentences used in Experiment 1 by means of the multiple-response SAT technique. Firstly, the slower dynamics of processing for object-initial in comparison to subject-initial structures provides convincing evidence that the N400 observed in Experiment 1 should indeed be viewed as a reflection of reanalysis. Furthermore, object-initial sentences with object-experiencer verbs showed a higher asymptote than their active counterparts, thus indicating that the N400 difference observed between these structures in Experiment 1 resulted from a higher likelihood of accessing (or computing) the correct, object-initial reading in the case of a disambiguation via an object-experiencer verb. The combined findings of Experiments 1 and 2 led to the conclusion that the reanalysis N400 observed in Experiment 1 is a reflection of reanalysis processes that require no structural alterations whatsoever. Additionally, since there were no general dynamics differences between sentences with active verbs and sentences with object-experiencer verbs, the findings of Experiment 2 support the conclusion that thematic reanalysis effects are not elicited in sentences with ambiguously case marked arguments.

The speeded acceptability-judgement study reported here as Experiment 3 provided further evidence for a late interaction between the thematic and syntactic processing routes. Thus, the acceptability ratings in this study show that parallel thematic and syntactic dependencies are ultimately preferred, since the well-known acceptability decrease for object-initial sentences in comparison to their subject-initial counterparts was not only neutralised, but tendentiously even reversed in the case of sentences with object-experiencer verbs.

However, this ultimate advantage of parallel thematic and syntactic dependencies does not guide the initial establishment of these relations, as

Experiment 4 showed. Using ERPs, this experiment examined whether, in verb-second sentences where the verb precedes both of its arguments, the processing of a dative object-experiencer verb may lead to an object-preference for an initial case ambiguous argument. This was not the case, i.e. there was a general reanalysis effect (again in the form of an N400) for object-initial structures at the position of the second NP independently of the type of the preceding verb. Additionally, there was a P600 effect for object-initial sentences with active verbs only, which we interpret as reflecting the additional structural reanalysis required for dative-nominative word orders with these types of verbs. These results are a strong piece of evidence that, even when both information types are available, thematic and syntactic processing proceeds independently from one another during an initial processing stage (i.e. the initial part of phase 2). An interaction between the two processing routes is therefore delayed until phase 2a in terms of the argument dependency model. The further general finding of a positivity for unambiguous dative-initial sentences in Experiment 4 provides evidence for an initial preference towards universal rather than specific processing strategies, even within one particular domain of information.

Finally, Experiments 5 and 6 provided ERP evidence for the independence of thematic processing – in the sense of the establishment of hierarchical thematic dependencies – from contextual and plausibility / world knowledge information, respectively. In this way, Experiment 5 demonstrated that context information cannot lead to the dispreferred alternative of two possible thematic hierarchisations being adopted, i.e. accusative object-experiencer verbs in German cannot be brought to elicit an early positivity indicative of a thematic reanalysis even in a non-causative context. Perhaps even more strikingly, the results of Experiment 6 show that a thematic hierarchising conflict cannot be resolved by means of plausibility information. Thus, there were *no* differences in the N400-P600 pattern elicited by the second of two identically case marked arguments depending on whether the argument-argument-verb relation provided a strong plausibility-based cue as to which of the two arguments should be interpreted as the [-dep] (nominative-marked) argument. This finding stands in stark contrast to the demonstration that a difference in animacy between two identically case marked arguments may completely eliminate the N400 effect (Frisch & Schlesewsky, 2001). It is therefore clear that the establishment of thematic dependencies only draws upon a small, clearly defined set of features, while not considering more general information

sources such as context and plausibility, a finding that is not compatible with many constraint-based approaches to thematic processing (e.g. Ferretti et al., 2001; McRae et al., 1997; Tanenhaus et al., 1989).

In summary, the present experiments provide strong support for the view of phase 2 processing advocated by the argument dependency model. Specifically, they have motivated the distinction between the thematic and syntactic processing routes for the processing of arguments and shown that, when both pathways are pursued during the processing of a single constituent (i.e. for verbs), each type of processing proceeds simultaneously but independently during the initial period of phase 2. An interaction between the two types of information may then take place in phase 2a. By contrast, interactions with all other information types (e.g. world knowledge) are delayed until the generalised mapping processes that set in during phase 3 of processing. This autonomy of syntactic and thematic processing from other information types is indicated by the shaded box in Figure 16. Whereas evidence for the independence of the thematic route was provided here, similar findings with regard to the syntactic route have been reported in the literature (e.g. Ferstl & Friederici, 1997; Mecklinger et al., 1995).

9.2 Consequences of the argument dependency approach

The view of incremental interpretation proposed as part of the argument dependency model has several important consequences for language processing in general. Firstly, the model's processing architecture implies that processing differs qualitatively for sentential arguments with unambiguous morphological case marking and those with ambiguous case marking such that the former are processed by means of the establishment of *thematic* dependencies, while the latter only give rise to the building of hierarchical *syntactic* relations. While we have assumed that this distinction results from the fact that the information required to establish thematic dependencies may only be accessed via morphological case marking, a further intuitive reason for why the thematic route should be pursued whenever possible is that only thematic processing allows for incremental interpretation to be maximised. Recall from Chapter 1.1 that thematic dependencies of the type assumed here are inherently interpretative in nature (and, indeed, this was the reason for assuming that these dependencies should be universal). Syntactic dependencies, by contrast,

are purely formal and therefore only constitute a prerequisite for ultimately attaining a sentence-level interpretation, which may be achieved by mapping these dependencies onto some interpretative form. Thematic dependencies are therefore inherently much more informative with regard to interpretation than syntactic dependencies, thereby leading to an incremental processing advantage.

This general distinction between sentences with unambiguously case marked arguments and those involving ambiguous case marking is of course also not without consequence for language processing from a cross linguistic perspective. Thus, processing differences are to be generally expected between case marking languages (e.g. German) and languages that are essentially caseless (e.g. English). For the latter, one would certainly predict that only the syntactic processing pathway is available for the processing of an argument, since the arguments themselves convey very little thematic information on account of their lack of case marking. Note, however, that this assumption does not contradict the findings of earlier studies on English such as that of Trueswell et al. (1994), in which the animacy of the initial noun phrase crucially determined whether a reduced relative clause reading of an ensuing verb would lead to processing difficulties or not (cf. Chapter 2). In this study – and, crucially, in all other studies showing similar results in English – the verb was available when the critical parsing decision needed to be made, thereby providing all relevant syntactic *and* thematic information.

Interestingly, from this perspective it does not appear necessary to assume the use of thematic hierarchy based strategies for languages such as English, since, in this language, all of the information used to establish thematic dependencies is provided by the verb. In this way, as no thematic dependencies are built up between the arguments in the absence of the verb and the processing of the verb then provides all verb-specific information about the semantic status of the arguments (i.e. 'verb-specific semantic roles' in the terminology of Van Valin (1999) such as 'hitter' and 'hittee' for the verb *to hit*), the utility of such strategies seems minimal, at least from a processing perspective. However, under these assumptions, it remains to be specified whether the lexical entries of verbs are structured differently between languages such as English and German: while there is at present no evidence that an explicit thematic grid is required for German and it may therefore be more plausible to assume a hierarchically arranged

argument structure with no individual thematic role labels (cf. Grimshaw's (1990) A-structure), whether this type of approach is also amenable to English remains an open question.

How wide-ranging the consequences of a language processing strategy making use of hierarchical thematic dependencies may be is indicated by a further intriguing finding. Thus, recall from the results of Experiment 4 that, in German, explicit (verb-specific) thematic information is *not* used to establish hierarchical dependencies, irrespectively of whether these are thematic or syntactic in nature, even when such specific information is available. Partly, this finding indicates that the language processing system has a strong tendency to employ generally applicable strategies during the earlier stages of processing, before specifying the specific properties of a particular input at a later point. Additionally, though, the result that verb-specific information is *not* drawn upon to establish thematic or syntactic dependencies stands in contrast to the predictions of theories which assume that German clause structure and, in particular, unmarked German argument orders are verb-class specific (e.g. Haider, 1993). Under such an account, verbs of particular types (e.g. active vs. object-experiencer verbs) are assumed to project their specific argument structures into verb-class specific syntactic structures, thereby giving rise to the prediction that the processing of a dative object-experiencer verb in the second position of a German clause should lead to a general preference for object-initiality with regard to the arguments subsequently encountered. Yet, this prediction is not borne out, as Experiment 4 showed, thereby indicating that the online processing of arguments in German at least is driven by general (thematic or syntactic) considerations, rather than by verb-class specific information. Interestingly, the early autonomy and late interaction of syntactic and thematic processing suggested by the present experiments indicates that the theoretically assumed dependence of word order regularities on specific verb classes reflects a rather late stage of online processing only.

More generally, the experiments reported here are of important consequence for the general definition of 'thematic' information. Thus, while previous studies (e.g. Bornkessel et al., *to appear*; Frisch & Schlesewsky, 2001) as well as Experiment 1 of the present thesis have indicated that thematic relations must crucially make reference to verb-independent information (i.e. they cannot be defined as entirely verb-specific), Experiments 5 and 6 of the present thesis showed that the establishment of

thematic relations is not driven by context information or world knowledge / plausibility even when these information sources are available. In this way, it appears that thematic relations should be described as an independent domain of linguistic information, which draws upon a small set of well defined features (e.g. morphological case, animacy) only.

In view of the fact that thematic information is apparently defined with reference to such a highly specific set of features only, one may wonder about the nature of this restrictive form of information. Thus, the definition of a 'thematic feature' might be entirely language-based, or, alternatively, it could result from a (domain general) conceptual abstraction over events. The restrictiveness of thematic information in itself in combination with the observation that, when applicable, thematic dependencies determine the basic interpretation of a sentence (i.e. "who is doing what to whom") in a strikingly autonomous fashion, appears to indicate that thematic relations should be considered language specific. On the other hand, thematic relations are of course also closely related to more general conceptual information, as the definition of thematic dependencies in Chapter 1.1 shows. In this way, one may uncover a further – albeit speculative – parallelism between the thematic and the syntactic processing pathways, since syntactic information as the quintessential type of linguistic information to often be considered language specific may also be related to more general rule abstraction and sequencing abilities.[34]

Finally, the present findings shed new light on several aspects of the neurophysiology of language comprehension. Firstly, the finding of Experiments 1 and 4 that a reanalysis of a subject-object ambiguity may be reflected in an N400 when this reanalysis does not require any alterations to the syntactic structure of the sentence indicates that the interpretation of the N400 component must be extended. Thus, it is apparent from these results that the N400 may crucially reflect processes involved in computing a particular interpretation in addition to the various lexical-semantic mismatches that this component is typically associated with. Perhaps these

[34] This characterisation of thematic information as a very restricted domain leads to the interesting question of how this type of information may be acquired by children. If it is the case that the set of thematically relevant features delimited here truly results from a gradual abstraction process, children should process unambiguously case marked sentences in languages such as German in a very different manner to adults, since, in contrast to adults, they will initially have to rely upon syntactic and/or plausibility-based information to interpret these sentences.

different N400 ‘types’ should also be viewed as neurophysiologically distinct subcomponents of the greater N400 component family, but this question will have to be addressed in further research.

Secondly, the results of Experiment 1 clearly show that a LAN component may result from a mismatch between two linguistic hierarchies, i.e. specifically between the thematic and the syntactic hierarchy. Although this finding nicely parallels the more typical interpretation of the LAN as a reflex of (formal) feature mismatches, it also suggests that the class of functional mismatches which elicit this component is broader than previously assumed. Hence, the LAN is not only sensitive to ‘local’ mismatches as may result from a failure of specifier-head agreement, for example, but also to global mismatches between distinct, but mutually contradictory information types. The consequences of this observation are, in fact, quite far-reaching in nature, since it is thereby clear that LAN effects are not exclusively a reflex of a single processing pathway in phase 2 of comprehension, but may also take simultaneously accessible information from distinct pathways into account.

Thirdly, the formulation of the argument dependency model has resulted in several elaborations upon the basic processing architecture of Friederici’s (1999, 2002) neurocognitive model. In addition to the more fine-grained description of the internal structure of phase 2 of processing (i.e. the distinction between syntactic, thematic and semantic processing), we have also introduced two new processing phases, namely phases 1a and 2a. Phase 2a as the locus of the first interaction between the syntactic and thematic processing routes is well motivated on the basis of the present experiments, as the consistent finding of a ‘reanalysis N400’ showed. Interestingly, the architectonic changes thus resulting support the basic assumption of Friederici’s neurocognitive model that the processing of different information types initially proceeds autonomously, but interacts at a later processing stage. In the present approach, however, this interaction is also assumed to be hierarchically structured, with an interaction exclusively between syntactic and thematic processing (phase 2a) preceding a more general interactive processing stage (phase 3).

With regard to the ‘morphological analyser’ that is thought to constitute phase 1a of processing, the present data strongly suggest the existence of such a processing step, though the postulation of ‘phase 1a’ as a means of

accommodating it is, admittedly, somewhat more speculative. Clearly, since the distinction between the thematic and syntactic routes during phase 2 of processing crucially depends on the morphological marking borne by an argument, morphological processing must take place at some point in time before phase 2 commences. Additionally, since the applicability of this analysis differs between nominal constituents and verbs, we must assume that it is preceded by a basic constituent (word category) analysis.[35] In this way, the postulation of phase 1a appears a plausible solution to these requirements pending further investigations into the fine-grained structure of the processes preceding phase 2.

9.3 Open questions and outlook

Clearly, several open questions with regard to and, indeed, arising from the argument dependency model's processing architecture remain. We will discuss some of these in the following.

Firstly, it is important to specify exactly how the 'constituent analysis' in phase 1 is distinct from the 'syntactic processing' that is assumed to take place in phase 2, since classical structure-based approaches to sentence processing would assume that the establishment of hierarchical syntactic relations immediately follows from a basic word category analysis (e.g. Frazier, 1978). However, in the argument dependency framework, this can be the case only to a limited degree, since the well-motivated distinction between the establishment of thematic and syntactic dependencies in phase two (see above) could then not be upheld.

How then, may the processes operating within phase 1 be characterised? Recall firstly that these processes must minimally be sufficiently elaborate to

[35] The distinction between the processing of arguments and the processing of verbs within the argument dependency model (i.e. the fact that only the latter are thought to require the processing of *both* syntactic and thematic information) is supported by the results of two ERP studies reported by Friederici & Frisch (2000). In these studies, a violation of the type of subcategorised case (i.e. sentences with a dative-marked object and an accusative-assigning verb or vice versa) elicited a LAN and a P600 when this violation was realised via the position of the verb, but a P600 only for the realisation of the same type of violation via an argument position. This contrast shows that a functional mismatch (during phase 2 of processing) is only elicited by the verb, as is to be expected if only the verb requires an additional pursuit of the syntactic processing route, while an unambiguously case marked argument does not.

elicit an ELAN, i.e. they must involve at least basic knowledge regarding possible phrase structure organisation. On the other hand, they should not have access to too much of this knowledge either, since otherwise it should be possible to establish fully fledged syntactic structures in phase 1, which is difficult to reconcile with the finding that hierarchical syntactic structure is simply ignored in sentences with unambiguous case marking.[36] Thus, one possibility of combining both of these insights is to assume that the structure building which takes place in phase 1 is strictly local in nature, i.e. the processes operating in this phase determine the word category of an input item and subsequently structure these items into phrases (e.g. noun phrases, prepositional phrases etc.). The hierarchical structuring of these phrases in relation to another, however, is then accomplished during phase 2 of processing. This point of view, however, makes the explicit prediction that ELAN effects should always result from local mismatches, i.e. mismatches within a single maximal projection, rather than as a result of more global processes. Although this prediction does not appear to be contradicted by existing experimental findings, it should clearly be addressed by further research.

A further important question that is beyond the scope of this thesis concerns the neural basis of the processes assumed within the argument dependency model. Thus, while numerous studies have examined this question with regard to syntactic processing (cf. Friederici, 1999, 2002 for an interpretation of these findings within her neurocognitive model of language processing), there are as yet no results that may be seen as evidence for which brain regions subserve the thematic processing pathway in phase 2 of the argument dependency model. Moreover, in view of the very specific and unique properties of thematic processing discussed above, it appears difficult to make concrete predictions as to where the 'thematic processor' should be localised. Therefore, further investigations in this regard should serve to complement the argument dependency model's description of the time course and functional characteristics of thematic processing.

[36] It is, of course, possible that a complete phrase structure is always built up in phase 1, but then subsequently disregarded in the face of more informative evidence (e.g. unambiguous case marking). How this should be implemented, though, is less clear, one possibility being the establishment of two independent (syntactic and thematic) representations, of which the former has a much lower degree of activation.

Finally, the distinction between the establishment of thematic and syntactic dependencies assumed by the argument dependency model opens up a wide range of possibilities for cross linguistic explorations of incremental argument processing. While it was discussed in the last section that there should certainly be differences between the processing of languages with and without morphological case, additional distinctions between languages which employ morphological case marking are also possible. Thus, while we have assumed that the ability to make use of hierarchical thematic information during language processing crucially depends on the presence of morphological case marking, the way in which these hierarchical dependencies are employed may depend on the specific properties of the language under consideration. For example, there are languages with morphological case marking that is explicit enough to warrant an association of arguments with more specific thematic assignments than may be captured by the three alternative values of the feature [dep] in the present approach. In this regard, consider the following example sentences from the Daghestanian language Avar (Blake, 1994):

(63) a. Agent : Inssu-cca j-as j-écc-ula
father-erg fem-child-abs fem-praise-pres
'Father praises the girl.'

b. Experiencer: ínssu-je j-as j-ól'-ula
father-dat fem-child fem-love-pres
'Father loves the girl.'

c. Perceiver: ínssu-da j-as j-íx-ula
father-loc fem-child fem-see-pres
'Father sees the girl.'

d. Possessor: inssu-l j-as j-ígo
father-gen fem-child fem-be
'Father has a daughter.'
(lit: Of father is a girl.)

As is evident from the sentences in (63), Avar employs distinct morphological marking for Agents, Experiencers, Perceivers and Possessors, i.e. for individual thematic roles which are all subsumed by the [-dep] thematic status or the Proto-Agent role (cf. Chapter 1.1). In this way, it

appears plausible to assume that, in languages with case marking as thematically differentiating as that of Avar, much more detailed thematic dependencies than those assumed here for German may be established even before the verb is processed.

In this way, the relationship between hierarchical thematic dependencies and generalised thematic roles is highlighted. While we have assumed, following Primus (1999), that generalised roles are solely defined on the basis of hierarchical thematic dependencies, this raises the question of how such a hierarchy-based processing approach may be extended to languages such as Avar. An obvious possibility is, of course, to simply make use of more elaborately specified hierarchies, though these will certainly be more difficult to code by means of a single feature and will also prove more difficult to integrate into a universal thematic hierarchy. Alternatively, it may be the case that Avar's thematic hierarchy is not more elaborate than that drawn upon by German, but that an additional specification of the arguments marked by a certain value of [dep] may be undertaken incrementally. Such a strategy, however, appears much closer to an approach making use of individual thematic roles than to one operating in terms of generalised thematic roles.

In other words, the use of generalised thematic roles (in the hierarchically defined sense used here) with regard to processing may – speculatively – be a phenomenon that is limited to the class of languages which employ morphological case marking to a limited degree (e.g. German). Specifically, the case morphology in these languages is thematically informative to a certain degree (i.e. it provides more information than may be drawn from arguments in a language without case marking), but not explicit enough to allow for a distinction between individual thematic roles or alternative instantiations of one generalised role. The generalisation of which types of languages might be assumed to make use of generalised roles is illustrated in Figure 17 (on the following page).

Thus, as Figure 17 shows, the tentative prediction from the perspective of the argument dependency model is that the use of generalised roles in

incremental comprehension may be restricted to those languages which case mark their arguments morphologically to a limited degree.[37]

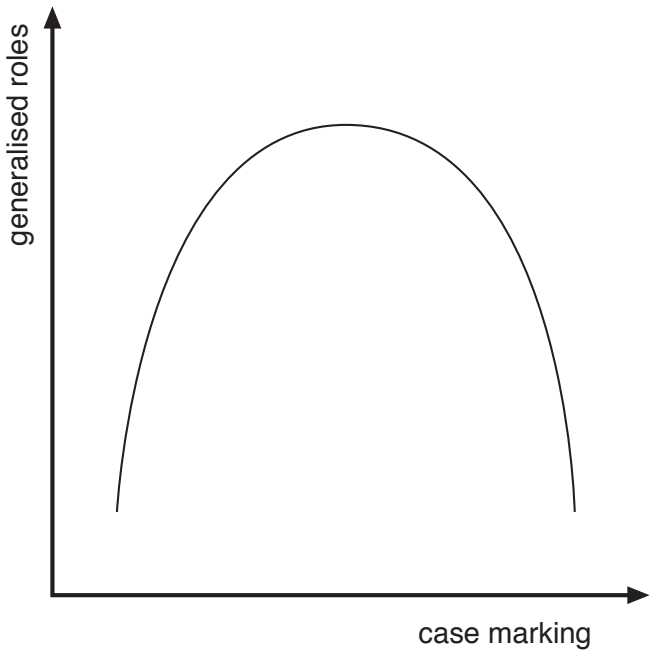

Figure 17. The hypothesised relationship between the explicitness of morphological case marking and the applicability of generalised thematic roles.

While the above discussion has focused primarily on the question of how languages are processed, the considerations in question of course also bear upon the more general question of how these languages should be characterised theoretically. Thus, the experimental findings presented here support the assumption of an intimate relationship between thematic relations and morphological case, as has been proposed in the theoretical literature (Primus, 1999). Furthermore, the present data also provide evidence in favour of generalised hierarchy approaches to language for both

[37] One possible counterargument to this view might draw upon the observation discussed above that German makes use of universal (i.e. generalised role) strategies even when more specific information is available. However, this may in part be dependent on the fact that, in the particular constellation examined here, a processing strategy based the specific information would have required drawing on the properties of a preceding element, rather than only on the properties of the current input item.

the thematic and the syntactic domains, since one recurring finding has been the preference of the universal over the specific. Certainly, one should also expect the more intricate properties of the processing architecture proposed here (e.g. the fact that thematic processing takes priority over syntactic processing whenever possible) to be reflected in more general linguistic regularities (e.g. unmarked word orders). However, to what extent this prediction is actually borne out will become clear only on the basis of further investigations, specifically with a cross linguistic focus.

9.4 Conclusion

The argument dependency model constitutes a new perspective on the incremental processing of obligatory sentential constituents. In particular, the model elucidates the role of hierarchical thematic relations in incremental sentence processing, with particular focus on the independence of thematic information from other (linguistic and extralinguistic) information types and the close relationship between thematic dependencies and morphological case marking. In this way, the model provides a framework which should prove especially fruitful in the investigation of cross linguistic similarities and differences with regard to incremental language comprehension.

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Appendix A
Sentence Materials

1. Materials for Experiments 1-4

The materials are listed here in the exact form used for Experiment 1. All modifications undertaken for Experiments 2-4 are listed in the relevant *Materials* sections. The critical sentence constituents are listed in the order:

$NP_{SG.AMB}$ / $NP_{PL.AMB}$ / $NP_{SG.UNAMB}$ / $NP_{PL.UNAMB.NOM}$ / $NP_{PL.UNAMB.DAT}$ / $V_{ACTIVE.SG/PL}$ / $V_{OEXP.SG/PL}$

01 Christian / Pastorinnen / Kommissar / Pförtner / Pförtnern / abrät / abraten / auffällt / auffallen

02 Kerstin / Studentinnen / Busfahrer / Pfarrer / Pfarrern / antwortet / antworten / behagt / behagen

03 Reinhold / Autorinnen / Trompeter / Dichter / Dichtern / applaudiert / applaudieren / einfällt / einfallen

04 Lisa / Poetinnen / Erpresser / Kläger / Klägern / berichtet / berichten / entfällt / entfallen

05 Lena / Probandinnen / Wanderer / Geiger / Geigern / dankt / danken / entgeht / entgehen

06 Stefan / Schwimmerinnen / Regisseur / Bäcker / Bäckern / droht / drohen / gefällt / gefallen

07 Heike / Läuferinnen / Reporter / Gärtner / Gärtnern / entflieht / entfliehen / behagt / behagen

08 Rudolf / Präsidenten / Gutachter / Wächter / Wächtern / folgt / folgen / missfällt / missfallen

09 Karin / Agentinnen / Ingenieur / Sportler / Sportlern / hilft / helfen / einfällt / einfallen

10 Wolfgang / Käuferinnen / Zuschauer / Schüler / Schülern / gratuliert / gratulieren / passt / passen

11 Erwin / Patientinnen / Physiker / Sprecher / Sprechern / huldigt / huldigen / passt / passen

12 Birgit / Journalisten / Betreuer / Trainer / Trainern / nachgibt / nachgeben / gefällt / gefallen

13 Thomas / Professoren / Senator / Mieter / Mietern / nachschaut / nachschauen / missfällt / missfallen

14 Peter / Soldatinnen / Hausierer / Sammler / Sammlern / nachsieht / nachsehen / auffällt / auffallen

15 Ines / Terroristen / Besucher / Forscher / Forschern / opfert / opfern / gefällt / gefallen

16 Sandra / Kolleginnen / Aufseher / Händler / Händlern / widerspricht / widersprechen / entfällt / entfallen

17 Roland / Prinzessinnen / Psychiater / Bettler / Bettlern / winkt / winken / entgeht / entgehen

18 Jürgen / Richterinnen / Detektiv / Förster / Förstern / zusieht / zusehen / einfällt / einfallen

19 Anja / Kandidaten / Betrüger / Winzer / Winzern / zustimmt / zustimmen / behagt / behagen

20 Karsten / Diplomaten / Handwerker / Schreiner / Schreinern / zuwinkt / zuwinken / auffällt / auffallen

21 Nadine / Intendanten / Entführer / Klempner / Klempnern / abrät / abraten / passt / passen

22 Norbert / Klientinnen / Direktor / Pfleger / Pflegern / antwortet / antworten / entfällt / entfallen

23 Martha / Reiterinnen / Schauspieler / Diener / Dienern / applaudiert / applaudieren / missfällt / missfallen

24 Ludwig / Dirigenten / Sekretär / Jäger / Jägern / berichtet / berichten / entgeht / entgehen

25 Astrid / Dozentinnen / Hausmeister / Maurer / Maurern / dankt / danken / gefällt / gefallen

26 Alfred / Doktoranden / Verkäufer / Meister / Meistern / droht / drohen / entgeht / entgehen

27 Kirsten / Diplomanden / Bildhauer / Priester / Priestern / entflieht / entfliehen / entfällt / entfallen

28 Frieda / Artistinnen / Geldgeber / Tänzer / Tänzern / folgt / folgen / einfällt / einfallen

29 Wilhelm / Astronauten / Radfahrer / Turner / Turnern / gratuliert / gratulieren / behagt / behagen

30 Inge / Kameraden / Techniker / Maler / Malern / hilft / helfen / auffällt / auffallen

31 Anne / Räuberinnen / General / Kellner / Kellnern / huldigt / huldigen / auffällt / auffallen

32 Josef / Floristinnen / Arbeiter / Rentner / Rentnern / nachgibt / nachgeben / behagt / behagen

33 Anke / Bäuerinnen / Musiker / Sänger / Sängern / nachschaut / nachschauen / einfällt / einfallen

34 Günther / Sängerinnen / Chemiker / Makler / Maklern / nachsieht / nachsehen / entfällt / entfallen

35 Paula / Pilotinnen / Zigeuner / Schmuggler / Schmugglern / opfert / opfern / entgeht / entgehen

36 Martin / Lehrerinnen / Redakteur / Künstler / Künstlern / widerspricht / widersprechen / gefällt / gefallen

37 David / Künstlerinnen / Bewohner / Lehrer / Lehrern / winkt / winken / missfällt / missfallen

38 Christa / Leserinnen / Kassierer / Schneider / Schneidern / zusieht / zusehen / missfällt / missfallen

39 Sascha / Schneiderinnen / Briefträger / Leser / Lesern / zustimmt / zustimmen / passt / passen

40 Hanna / Kellnerinnen / Einbrecher / Richter / Richtern / zuwinkt / zuwinken / passt / passen

41 Detlef / Bürgerinnen / Verleger / Väter / Vätern / abrät / abraten / behagt / behagen

42 Sonja / Passantinnen / Designer / Bläser / Bläsern / antwortet / antworten / einfällt / einfallen

43 Vincent / Fahnderinnen / Leibwächter / Witwer / Witwern / applaudiert / applaudieren / entfällt / entfallen

44 Britta / Mörderinnen / Manager / Pendler / Pendlern / hilft / helfen / missfällt / missfallen

45 Christoph / Schmugglerinnen / Bankräuber / Schwager / Schwagern / berichtet / berichten / gefällt / gefallen

46 Tina / Siegerinnen / Berater / Boxer / Boxern / dankt / danken / passt / passen

47 Johann / Masseurinnen / Passagier / Brüder / Brüdern / droht / drohen / auffällt / auffallen

48 Silke / Stewardessen / Minister / Ringer / Ringern / folgt / folgen / entgeht / entgehen

49 Erich / Nachbarinnen / Gastgeber / Kenner / Kennern / entflieht / entfliehen / einfällt / einfallen

50 Annett / Fälscherinnen / Hotelier / Schaffner / Schaffnern / gratuliert / gratulieren / auffällt / auffallen

51 Heiner / Ordnerinnen / Verwalter / Tüftler / Tüftlern / nachgibt / nachgeben / passt / passen

52 Susann / Anwältinnen / Inspektor / Wähler / Wählern / nachschaut / nachschauen / behagt / behagen

53 Jochen / Touristinnen / Offizier / Herrscher / Herrschern / nachsieht / nachsehen / entgeht / entgehen

54 Grete / Cellistinnen / Preisträger / Denker / Denkern / huldigt / huldigen / missfällt / missfallen

55 Werner / Zauberinnen / Entdecker / Ritter / Rittern / opfert / opfern / entfällt / entfallen

56 Marga / Enkelinnen / Anwohner / Ober / Obern / winkt / winken / gefällt / gefallen

57 Siegfried / Helferinnen / Archivar / Hexer / Hexern / widerspricht / widersprechen / behagt / behagen

58 Marlies / Chirurginnen / Begleiter / Leiter / Leitern / zuwinkt / zuwinken / entgeht / entgehen

59 Simon / Notärztinnen / Verbrecher / Gegner / Gegnern / zustimmt / zustimmen / einfällt / einfallen

60 Antje / Juristinnen / Legionär / Trommler / Trommlern / zusieht / zusehen / passt / passen

61 Markus / Zöllnerinnen / Missionar / Zeichner / Zeichnern / abrät / abraten / entfällt / entfallen

62 Gabi / Rednerinnen / Prediger / Schäfer / Schäfern / antwortet / antworten / auffällt / auffallen

63 Axel / Kanzlerinnen / Heimkehrer / Taucher / Tauchern / applaudiert / applaudieren / gefällt / gefallen

64 Judith / Bastlerinnen / Schriftsteller / Kuppler / Kupplern / berichtet / berichten / missfällt / missfallen

65 Wolfram / Hehlerinnen / Kapitän / Fischer / Fischern / dankt / danken / einfällt / einfallen

66 Ilse / Königinnen / Liebhaber / Kanzler / Kanzlern / droht / drohen / behagt / behagen

67 Burkhard / Pilgerinnen / Befreier / Enkel / Enkeln / folgt / folgen / entfällt / entfallen

68 Edith / Flötistinnen / Financier / Pächter / Pächtern / entflieht / entfliehen / auffällt / auffallen

69 Bertram / Surferinnen / Nichtraucher / Jogger / Joggern / gratuliert / gratulieren / missfällt / missfallen

70 Maren / Ketzerinnen / Kritiker / Bürger / Bürgern / hilft / helfen / passt / passen

71 Birte / Dompteurinnen / Statiker / Fälscher / Fälschern / nachgibt / nachgeben / entgeht / entgehen

72 Robert / Siedlerinnen / Bauzeichner / Räuber / Räubern / nachschaut / nachschauen / gefällt / gefallen

73 Tanja / Fleischerinnen / Staatsanwalt / Zöllner / Zöllnern / nachsieht / nachsehen / behagt / behagen

74 Gerhard / Pächterinnen / Zuhörer / Segler / Seglern / widerspricht / widersprechen / einfällt / einfallen

75 Gertrud / Kaiserinnen / Professor / Siedler / Siedlern / huldigt / huldigen / gefällt / gefallen

76 Willi / Seglerinnen / Vermieter / Surfer / Surfern / winkt / winken / entfällt / entfallen

77 Waltraud / Anglerinnen / Besitzer / Bastler / Bastlern / zusieht / zusehen / auffällt / auffallen

78 Friedrich / Gönnerinnen / Empfänger / Kaiser / Kaisern / opfert / opfern / passt / passen

79 Dagmar / Fahrerinnen / Bewerber / Fleischer / Fleischern / zustimmt / zustimmen / entgeht / entgehen

80 Hubert / Spielerinnen / Urlauber / Ketzer / Ketzern / zuwinkt / zuwinken / missfällt / missfallen

2. Materials for Experiment 5

For each set of materials, the two contexts (non-causative and causative) are listed before their corresponding target sentences (sentences with object-experiencer and active verbs, respectively).

Der Gärtner saß in der Ecke und weinte, als der Jäger zur Tür herein kam. /
Der Gärtner lief wie ein Verrückter mit einem Messer in der Wohnung herum, als der Jäger herein kam.

Es war offensichtlich, dass der Gärtner den Jäger ängstigte und verstörte.
Es war offensichtlich, dass der Gärtner den Jäger beobachtete und musterte.

Der Patient lag noch immer im Koma, als der Arzt das Zimmer betrat. /
Der Patient hatte schon wieder alles verwüstet, als der Arzt das Zimmer betrat.

Es war klar, dass der Patient den Arzt beunruhigte und bedrückte.
Es war klar, dass der Patient den Arzt bemerkte und wahrnahm.

Der Schüler lag auf dem Sofa und schien zu schlafen, als der Rentner vorbeikam. /
Der Schüler spielte ein lautes Computerspiel, als der Rentner vorbeikam.

Es war zu sehen, dass der Schüler den Rentner störte und entnervte.
Es war zu sehen, dass der Schüler den Rentner ignorierte und auslachte.

Der Redner beachtete den Künstler nicht, als dieser ihm eine Frage stellte./
Der Redner begrüßte den Künstler sehr freundlich, als dieser ihm eine Frage stellte.

Alle bemerkten, dass der Redner den Künstler animierte und anregte.
Alle bemerkten, dass der Redner den Künstler unterschätze und verachtete.

Der Kanzler lud den Dekan anlässlich eines Jubiläums zum Kaffee ein. /
Nach der unglücklichen Pressemitteilung fragte der Kanzler den Dekan, ob dieser den Ruf der Universität ruinieren wollte.

Eine Sekretärin glaubte, dass der Kanzler den Dekan verunsicherte und begeisterte.
Eine Sekretärin glaubte, dass der Kanzler den Dekan bedrohte und blamierte.

Der Cellist hatte noch nicht zu spielen angefangen, als der Kritiker den Proberaum betrat. /
Der Cellist spielte gerade sein Paradekonzert, als der Kritiker den Proberaum betrat.

Alle bemerkten, dass der Cellist den Kritiker beeindruckte und entzückte.
Alle bemerkten, dass der Cellist den Kritiker begrüßte und anlachte.

Der Bankier war ein sehr unauffälliger Mensch, den der neue Anwalt kaum wahrnahm. /
Der Bankier war ein sehr extrovertierter Mensch, den der neue Anwalt nur schwer einschätzen konnte.

Eine Rezeptionistin erkannte, dass der Bankier den Anwalt schockierte und entrüstete.
Eine Rezeptionistin erkannte, dass der Bankier den Anwalt anlächelte und ansprach.

Der Kommissar wartete geduldig auf seinen Bus, als der Fleischer ihn begrüßte. /
Der Kommissar schaute in die andere Richtung, als der Fleischer ihn begrüßte.

Es war zu erkennen, dass der Kommissar den Fleischer ärgerte und beleidigte.
Es war zu erkennen, dass der Kommissar den Fleischer sah und ignorierte.

Der Ingenieur stand mit seinem Rollstuhl hilflos vor der Treppe, als der Pförtner herunterkam. /
Der Ingenieur raste mit seinem Rollstuhl direkt auf den Pförtner zu.

Es schien, dass der Ingenieur den Pförtner verängstigte und erschreckte.
Es schien, dass der Ingenieur den Pförtner kannte und mochte.

Der Reporter schaffte es nach zwei Jahren immer noch nicht, seine kleine Tochter zu wickeln, wie der Angler bemerkte. /
Der Reporter drohte mit einem weiteren bitterbösen Artikel, als der Angler ihn ansprach.

Keiner sah, dass der Reporter den Angler entmutigte und beängstigte.
Keiner sah, dass der Reporter den Angler fürchtete und verdächtigte.

Der Architekt konnte sich mit seinem Gipsfuß kaum bewegen, als der Meister ihn zu Hause aufsuchte. /
Der Architekt wollte sich gerade auf den Weg zum Golfplatz machen, als der Meister ihn zu Hause aufsuchte.

Die Haushälterin glaubte, dass der Architekt den Meister erzürnte und verschreckte.
Die Haushälterin glaubte, dass der Architekt den Meister missverstand und unterschätzte.

Der Bildhauer lag schon wieder mit einem Hexenschuss im Bett, als der Kritiker ihn einladen wollte. /
Der Bildhauer ließ gerade seine ganze Wut an einem Steinblock aus, als der Kritiker ihn einladen wollte.

Es war zu beobachten, dass der Bildhauer den Kritiker verärgerte und befremdete.
Es war zu beobachten, dass der Bildhauer den Kritiker bemitleidete und schätzte.

Der Trompeter war schon wieder betrunken, so erschien es dem Sänger. /
Der Trompeter hatte erneut seine Virtuosität bewiesen, so erschien es dem Sänger.

Das Publikum glaubte, dass der Trompeter den Sänger motivierte und ermutigte.
Das Publikum glaubte, dass der Trompeter den Sänger bewunderte und idealisierte.

Der Zuschauer saß mit großen Augen still auf seinem Platz, während der Preisträger seine Rede hielt. /
Der Zuschauer nickte zustimmend, während der Preisträger seine Rede hielt.

Es schien, dass der Zuschauer den Preisträger interessierte und faszinierte.
Es schien, dass der Zuschauer den Preisträger verwechselte und missdeutete.

Der Trainer gab sich trotz seiner Höhenangst große Mühe, dem Hausmeister bei der Reparatur des Daches zu helfen. /
Der Trainer weigerte sich auf die Leiter zu steigen, obwohl der Hausmeister ihn inständig darum bat.

Es war offensichtlich, dass der Trainer den Hausmeister enttäuschte und bekümmerte.
Es war offensichtlich, dass der Trainer den Hausmeister mochte und achtete.

Der Lehrling lag fast vollständig unter dem Wagen, da der Inhaber ihm eine schwierige Reparatur aufgetragen hatte. /
Der Lehrling wollte auf dem Betriebsfest unbedingt mit allen auf das Wohl des Inhabers anstoßen.

Es war zu sehen, dass der Lehrling den Inhaber erboste und irritierte.
Es war zu sehen, dass der Lehrling den Inhaber veralberte und bloßstellte.

Seitdem der Chemiker sich wieder verliebt hatte, konnte der Winzer ihn kaum noch erreichen. /
Seitdem sie sich kannten, hatte der Chemiker dem Winzer immer die neuesten Gerüchte erzählt.

Es wurde offensichtlich, dass der Chemiker den Winzer amüsierte und betrübte.
Es wurde offensichtlich, dass der Chemiker den Winzer vergaß und ignorierte.

Der Priester kniete vor dem Altar und betete, als der Bischof die Kirche betrat. /
Der Priester machte einen theatralischen Freudensprung, als der Bischof die Kirche betrat.

Keiner sah, dass der Priester den Bischof belustigte und verblüffte.
Keiner sah, dass der Priester den Bischof hasste und betrauerte.

Der Hotelier beugte sich verzweifelt über einen Brief, als der General sich beschweren wollte. /
Der Hotelier frisierte sich gerade für den großen Empfang, als der General sich beschweren wollte.

Ein Zimmermädchen sah, dass der Hotelier den General anwiderte und ekelte.
Ein Zimmermädchen sah, dass der Hotelier den General beneidete und begünstigte.

X

Der Bettler war vor Hunger und Kälte zu schwach zum Sprechen, als der Zöllner ihn befragen wollte. /
Der stadtbekannte Bettler stellte sich dumm, als der Zöllner ihn befragen wollte.

Es schien, dass der Bettler den Zöllner aufregte und erschütterte.
Es schien, dass der Bettler den Zöllner durchschaute und erkannte.

Der Maler hatte zwei Nächte lang durchgearbeitet und konnte sich kaum auf den Beinen halten, als der Schneider mit ihm ein Bier trinken wollte. /
Der Maler war plötzlich wie verändert und starrte den Schneider mit weit aufgerissenen, blutunterlaufenen Augen an.

Es war zu sehen, dass der Maler den Schneider ängstigte und bedrückte.
Es war zu sehen, dass der Maler den Schneider reinlegte und unterschätzte.

Obwohl er sich große Mühe gab, war der Anwalt offenkundig nicht in der Lage, den Käufer vernünftig zu verteidigen. /
Der Anwalt hatte sich offenkundig nicht auf die Verteidigung des Käufers vorbereitet.

Es schien, dass der Anwalt den Käufer verärgerte und erschreckte.
Es schien, dass der Anwalt den Käufer bedauerte und verdächtigte.

Der abgemagerte und verwahrlost aussehende Physiker war vollkommen in seiner Arbeit vertieft und blickte nicht einmal auf, als der Techniker den Raum betrat. /
Der Physiker legte demonstrativ die Füße auf den Tisch und nahm sich eine Zeitung, als der Techniker ihn sprechen wollte.

Ein Doktorand bemerkte, dass der Physiker den Techniker schockierte und befremdete.
Ein Doktorand bemerkte, dass der Physiker den Techniker anschrie und bloßstellte.

Der Student wirkte sehr interessiert und stellte dem Schauspieler viele Fragen. /
Der Student erzählte dem Schauspieler Geschichten über einige ihrer gemeinsamen Bekannten.

Alle sahen, dass der Student den Schauspieler amüsierte und verblüffte.
Alle sahen, dass der Student den Schauspieler anhimmelte und idealisierte.

Der Dozent suchte laut fluchend nach einer Urkunde, während der Onkel daneben saß. /
Der Dozent drohte dem Onkel mit den fürchterlichsten Dingen, falls dieser die Urkunde nicht wiederfände.

Es war zu sehen, dass der Dozent den Onkel beunruhigte und verstörte.
Es war zu sehen, dass der Dozent den Onkel anlächelte und veralberte.

Der Wanderer hatte seine Schuhe ausgezogen und auf einer Bank ein Picknick ausgebreitet, als der Pförtner zur Arbeit kam. /
Der Wanderer betrat mit seinen matschigen Stiefeln das Pförtnerhäuschen, als er den Pförtner entdeckte.

Eine Passantin beobachtete, dass der Wanderer den Pförtner störte und beleidigte.
Eine Passantin beobachtete, dass der Wanderer den Pförtner ansprach und befragte.

Der Betreuer saß bei dem Empfang für den Senator gelangweilt in der Ecke. /
Der Betreuer attackierte den Senator wegen der Giftmülldeponie.

Man konnte erkennen, dass der Betreuer den Senator verunsicherte und irritierte.
Man konnte erkennen, dass der Betreuer den Senator ablehnte und musterte.

Der Fischer glaubte nicht mehr, dass er an diesem Tag auch nur einen Fisch verkaufen würde, als der Schreiner ihn besuchte. /
Der Fischer prahlte mit seinem hervorragenden Fang, als der Schreiner ihn besuchte.

Es schien, dass der Fischer den Schreiner ärgerte und ekelte.
Es schien, dass der Fischer den Schreiner brauchte und schätzte.

Der Inspekteur zeigte offen sein Desinteresse, was die Werke des Erfinders angingen. /
Der Inspekteur machte dem Erfinder extravagante Versprechungen, als er dessen jüngstes Werk sah.

Es schien, dass der Inspekteur den Erfinder animierte und anspornte.
Es schien, dass der Inspekteur den Erfinder musterte und anlachte.

Der junge Detektiv war in seinem Fall noch nicht weiter gekommen, als er den Forscher befragte. /
Der junge Detektiv prahlte dem Forscher gegenüber von seinen Forschritten im aktuellen Fall.

Es war klar, dass der Detektiv den Forscher beeindruckte und anregte.
Es war klar, dass der Detektiv den Forscher verdächtigte und missdeutete.

Der Bewohner des kleinen Einfamilienhauses starrte den Kassierer schon seit Jahren auf dem Weg zur Arbeit an. /
Der Bewohner des verwahrlosten Einfamilienhauses beschimpfte den Kassierer jedesmal, wenn dieser an seinem Grundstück vorbeikam.

Nur die Wenigsten wusste, dass der Bewohner den Kassierer verängstigte und verschreckte.
Nur die Wenigsten wusste, dass der Bewohner den Kassierer kannte und respektierte.

Der Spieler betrank sich mit niedergeschlagener Miene an der Bar, als der Kellner zur Arbeit kam. /
Der Spieler fing an, von der katastrophalen neuen Arbeitslosenquote im Gaststättengewerbe zu erzählen, als er den Kellner zur Arbeit kommen sah.

Eine Köchin sah, dass der Spieler den Kellner entmutigte und erschütterte.
Eine Köchin sah, dass der Spieler den Kellner umarmte und auslachte.

Der Offizier war ganz auf seine Arbeit fixiert und begegnete dem Kuppler freundlich aber gelangweilt. /
Der Offizier hatte für die Absichten des Kupplers nichts übrig und sagte diesem gehörig die Meinung.

Alle wussten, dass der Offizier den Kuppler erzürnte und entrüstete.
Alle wussten, dass der Offizier den Kuppler tolerierte und verachtete.

Nach langen Diskussionen ließ sich der Ketzer von dem Prediger zu dessen Glauben bekehren. /
Schließlich ließ sich der Ketzer von dem Prediger bekehren, aber hauptsächlich um diesem einen Gefallen zu tun.

Es war abzusehen, dass der Ketzer den Prediger motivierte und faszinierte.
Es war abzusehen, dass der Ketzer den Prediger einlud und begünstigte.

Weil er so lange im Urlaub gewesen war, hatte der Masseur dem Hautarzt seine Fähigkeiten noch gar nicht unter Beweis stellen können. /
Der Masseur versprach dem Hautarzt, dass dieser nach einer Massage von ihm nie wieder unter Rückenschmerzen leiden würde.

Es schien, dass der Masseur den Hautarzt interessierte und erfreute.
Es schien, dass der Masseur den Hautarzt beschummelte und ablehnte.

Der Boxer würde aufgrund seines Gesundheitszustandes seine Karriere beenden müssen, wie der Ringer im Radio hörte. /
Der Boxer erzählte dem Ringer, dass er nach der verlorenen Meisterschaft einfach keine Lust zum Boxen mehr hätte.

Es war offensichtlich, dass der Boxer den Ringer enttäuschte und entnervte.
Es war offensichtlich, dass der Boxer den Ringer belog und zurückwies.

Der alte Passagier döste in einem Liegestuhl während der Enkel zu seinen Füßen spielen wollte. /
Der alte Passagier sagte dem Enkel, dass dieser sich auch mal alleine beschäftigen müsste.

Der Steward sah, dass der Passagier den Enkel erboste und enttäuschte.
Der Steward sah, dass der Passagier den Enkel verwöhnte und mochte.

Der Regisseur war dem Gutachter als ruhiger Mensch bekannt, der keiner Fliege etwas zuleide tun konnte. /
Der Regisseur präsentierte dem Gutachter ein äußerst unterhaltsames, humorvolles Konzept.

Alle Mitarbeiter bemerkten, dass der Regisseur den Gutachter belustigte und ermutigte.
Alle Mitarbeiter bemerkten, dass der Regisseur den Gutachter überzeugte und befriedigte.

Der Sänger lag zur Verwunderung des Redakteurs am Ende des dritten Aktes regungslos auf der Bühne. /
Der Sänger stilisierte zur Verwunderung des Redakteurs seinen Tod am Ende des dritten Aktes zu einem fast biblischen Ereignis.

Dabei schien es, dass der Sänger den Redakteur anwiderte und beängstigte.
Dabei schien es, dass der Sänger den Redakteur anschaute und wahrnahm.

Der Förster war sehr ruhig und gefasst, als er nach dem Unfall mit dem Notarzt sprach. /
Der Förster war gar nicht zu beruhigen and schrie wild um sich, als der Notarzt nach dem Unfall mit ihm sprechen wollte.

Eine Polizistin bemerkte, dass der Förster den Notarzt aufregte und entrüstete.
Eine Polizistin bemerkte, dass der Förster den Notarzt beleidigte und blamierte.

3. Materials for Experiment 6

The following table lists all of the critical materials for Experiment 6 as well as the relevant Agent/Patient ratings from the norming study. For NP1, both Agent (active) and Patient (passive) ratings are listed, whereas for the three NP2 variants only Agent ratings are given.

Verb	**NP 1** Active / Passive (SD) / (SD)	**NP2 - ideal** Active (SD)	**NP2 - neutral** Active (SD.)	**NP2 - implausible** Active (SD)
amüsiert	Prüfer 1.94 / 2.79 (1.44) / (1.36)	Komiker 6.56 (1.50)	Bastler 3.44 (2.16)	Langweiler 1.31 (0.60
bedroht	Bengel 3.58 / 4.00 (1.46) / (1.67)	Mafiosi 6.33 (0.90)	Geschäftsmann 3.80 (1.52)	Winzer 1.80 (1.15)
befördert	Sekretär 2.16 / 4.50 (1.38) / (1.82)	Admiral 6.11 (1.29)	Angestellte 2.47 (1.31)	Maurer 1.41 (0.77)
beklaut	Kriminologe 1.74 / 2.24 (0.81) / (1.25)	Dieb 6.95 (0.23)	Tourist 3.17 (1.62)	Bischof 1.68 (1.00)
bekleidet	Turner 1.50 / 4.65 (0.86) / (1.73)	Schneider 6.78 (0.55)	König 2.89 (1.88)	Nudist 1.56 (1.15)
belästigt	Großvater 2.34 / 3.50 (1.25) / (1.61)	Betrunkener 6.00 (1.52)	Ober 2.71 (1.31)	Schüchterne 1.43 (0.60)
benotet	Diener 1.35 / 4.63 (0.49) / (2.03)	Dozent 6.88 (0.33)	Autor 3.00 (1.06)	Schüler 2.24 (1.35)
berät	Zeuge 2.54 / 4.11 (1.59) / (2.47)	Fachmann 6.96 (0.21)	Passagier 2.54 (1.22)	Laie 1.76 (1.18)
beschützt	Bäcker 1.52 / 2.53 (0.68) / (1.43)	Ritter 6.67 (0.97)	Schaffner 3.48 (1.94)	Mörder 1.19 (0.40)
beschwichtigt	Senator 4.92 / 4.00 (1.32) / (1.73)	Freund 6.46 (0.78)	Kritiker 3.08 (1.38)	Choleriker 1.85 (1.68)
bestellt	Kameramann 6.17 / 5.17 (1.10) / (1.89)	Arzt 5.30 (2.25)	Begleiter 2.71 (1.35)	Sklave 1.14 (0.65)
denunziert	Frisör 2.33 / 2.00 (1.76) / (0.97)	Spitzel 5.20 (1.42	Junge 3.67 (1.72)	Zahnarzt 1.71 (0.91)
durchsucht	Empfänger 2.44 / 1.82 (1.56) / (1.33)	Wächter 6.20 (1.08)	Präsident 2.60 (1.80)	Läufer 1.32 (0.56)

empfängt	Entdecker 2.43 / 5.57 (1.60) / (1,34)	Direktor 6.33 (0.97)	Angestellter 3.70 (1.45)	Eremit 1.76 (1.45)
enterbt	Fotograf 2.33 / 1.95 (1.19) / (1.24)	Großonkel 6.00 (1.53)	Berater 2.33 (1.24)	Neffe 2.39 (1.29)
ermutigt	Flieger 3.5 / 3.57 (2.11) / (1.44)	Notarzt 5.73 (1.55)	Mieter 2.05 (1.21)	Pessimist 1.10 (0.30)
erschießt	Passant 2.71 / 3.50 (1.61) / (1.43)	Mörder 6.72 (0.57)	Trauernder 3.39 (1.94)	Babysitter 1.72 (0.96
fängt	Schelm 2.47 / 3.11 (1.58) / (1.81)	Jäger 6.05 (1.75)	Anhänger 2.63 (1.57)	Flüchtiger 1.31 (0.79)
fasst	Aufseher 2.39 / 5.00 (1.61) / (1.62)	Fahnder 6.60 (0.68)	Soldat 4.90 (1.52)	Turner 1.75 (0.91)
fesselt	Reporter 2.05 / 4.44 (1.24) / (1.98)	Kidnapper 6.90 (0.30)	Schwindler 3.33 (1.91)	Bankier 1.43 (0.93)
feuert	Betreuer 3.63 / 2.59 (1.64) / (1.66)	Arbeitgeber 6.50 (1.15)	Gutachter 3.65 (2.12)	Arbeitnehmer 1.13 (0.34)
findet	Experte 3.85 / 4.32 (2.03) / (1.96)	Detektiv 6.10 (1.68)	Sammler 4.75 (1.83)	Träumer 2.10 (1.21)
grüßt	Masseur 4.39 / 3.92 (1.85) / (1.93)	Bürgermeister 5.61 (1.61)	Imker 3.78 (1.83)	Griesgram 1.56 (0.98)
instruiert	Kanzler 5.39 / 4.90 (1.72) / (1.67)	Trainer 6.33 (1.03)	Informatiker 4.11 (1.60)	Anfänger 1.28 (0.67)
interviewt	Verursacher 2.15 / 4.65 (1.23) / (1.87)	Reporter 6.70 (1.34)	Helfer 3.45 (1.73)	Pilot 2.15 (1.23)
jagt	Pauker 2.10 / 3.00 (0.97) / (1.94)	Polizist 6.65 (0.75)	Verbrecher 3.75 (2.12)	Philosoph 1.75 (0.72)
knebelt	Bürgermeister 1.67 / 3.45 (1.17) / (1.84)	Entführer 6.96 (0.21)	Bürge 1.73 (1.20)	Leidende 1.57 (0.90)
pflegt	Koch 2.71 / 2.15 (1.49) / (1.14)	Tierarzt 6.35 (0.93)	Vater 5.47 (1.23)	Mafiosi 1.73 (0.96)
rettet	Musikant 2.06 / 3.47 (1.06) / (1.60)	Notarzt 6.89 (0.32)	Detektiv 5.17 (1.58)	Pathologe 2.00 (1.37)
schleust	Animateur 1.56 / 1.93 (0.86) / (0.96)	Schmuggler 6.79 (0.54)	Kumpel 4.00 (1.73)	Notar 1.67 (1.14)
sucht	Ketzer 2.88 / 5.35 (2.34) / (2.11)	Kommissar 6.65 (1.00)	Finder 4.24 (2.54)	Preisträger 2.17 (1.89)

tadelt	Erfinder 3.09 / 3.07 (1.78) / (1.58)	Betreuer 6.04 (1.02)	Onkel 4.57 (1.44)	Praktikant 1.78 (1.04)
terrorisiert	Jäger 3.62 / 2.79 (1.50) / (1.47)	Erpresser 6.81 (0.60)	Gefangener 3.86 (1.82)	Leser 1.95 (1.20)
testet	Terrorist 3.00 / 3.20 (1.93) / (1.99)	Psychologe 6.74 (0.69)	Kapitän 4.00 (1.72)	Proband 1.35 (0.65)
überfällt	Richter 1.21 / 4,62 (0.54) / (1.53)	Gauner 6.74 (0.56)	Zimmermann 2.37 (1.57)	Bankdirektor 1.37 (0.68)
überprüft	Maler 2.25 / 3.44 (1.44) / (1.92)	Boss 6.06 (0.85)	Ober 3.06 (1.53)	Auszubildend er 1.69 (0.85)
betrügt	Förster 2.32 / 3.08 (1.17) / (1.85)	Schummler 6.87 (0.63)	Adliger 3.91 (1.41)	Pastor 2.00 (1.13)
überwacht	Hortner 5.35 / 2.92 (1.93) / (1.61)	Ermittler 6.40 (1.35)	Physiker 3.30 (2.20)	Verdächtiger 2.20 (1.64)
überwältigt	Prinz 2.71 / 3.50 (1.23) / (2.15)	Leibwächter 6.76 (0.44)	Fußballer 4.33 (1.80)	Schwächling 1.14 (0.36)
untersucht	Kraftfahrer 2.00 / 3.62 (1.03) / (1.85)	Pathologe 6.14 (2.15)	Makler 2.20 (1.47)	Verletzter 1.50 (0.71)
verfolgt	Lehrer 2.14 / 2.35 (1.31) / (1.11)	Killer 6.76 (0.62)	Taxifahrer 3.71 (1.59)	Faulenzer 1.38 (0.86)
verführt	Chemiker 2.33 / 2.50 (1.59) / (1.29)	Casanova 6.90 (0.30)	Leibwächter 2.86 (1.65)	Alkoholiker 2.62 (1.56)
verjagt	General 5.48 / 3.56 (1.42) / (1.26)	Nachtwächter 6.68 (0.78)	Tänzer 2.09 (1.12)	Flüchtling 1.17 (0.39)
verklagt	Nachbar 4.53 / 4.56 (1.42) / (1.26)	Prominenter 5.59 (1.18)	Drängler 3.65 (1.90)	Bettler 1.71 (0.77)
vernimmt	Bankier 1.83 / 3.80 (1.15) / (1.86)	Inspektor 6.30 (1.55)	Pathologe 2.22 (1.70)	Schornstein-feger 1.39 (0.79)
versorgt	Hausherr 4.81 / 4.95 (2.06) / (2.09)	Butler 6.24 (1.14)	Aufseher 3.52 (1.57)	Langweiler 1.86 (0.85)
verteidigt	Priester 4.11 / 2.95 (1.52) / (1.40)	Anwalt 6.63 (1.38)	Pädagoge 3.84 (1.54)	Klient 1.53 (0.96)
verurteilt	Chef 5.00 / 3.18 (1.49) / (1.42)	Richter 6.68 (1.38)	Eigner 3.21 (1.75)	Gärtner 1.84 (1.26)

verwundet	Bademeister 1.78 / 2.63 (0.65) / (1.59)	Geiselnehmer 6.29 (0.99)	Optiker 2.11 (1.28)	Bischof 1.61 (0.98)
weckt	Häftling 2.44 / 5.70 (1.29) / (1.53)	Aufseher 5.96 (1.27)	Mitarbeiter 2.92 (1.53)	Langschläfer 1.24 (0.52)

Appendix B
Supplementary ERP Figures

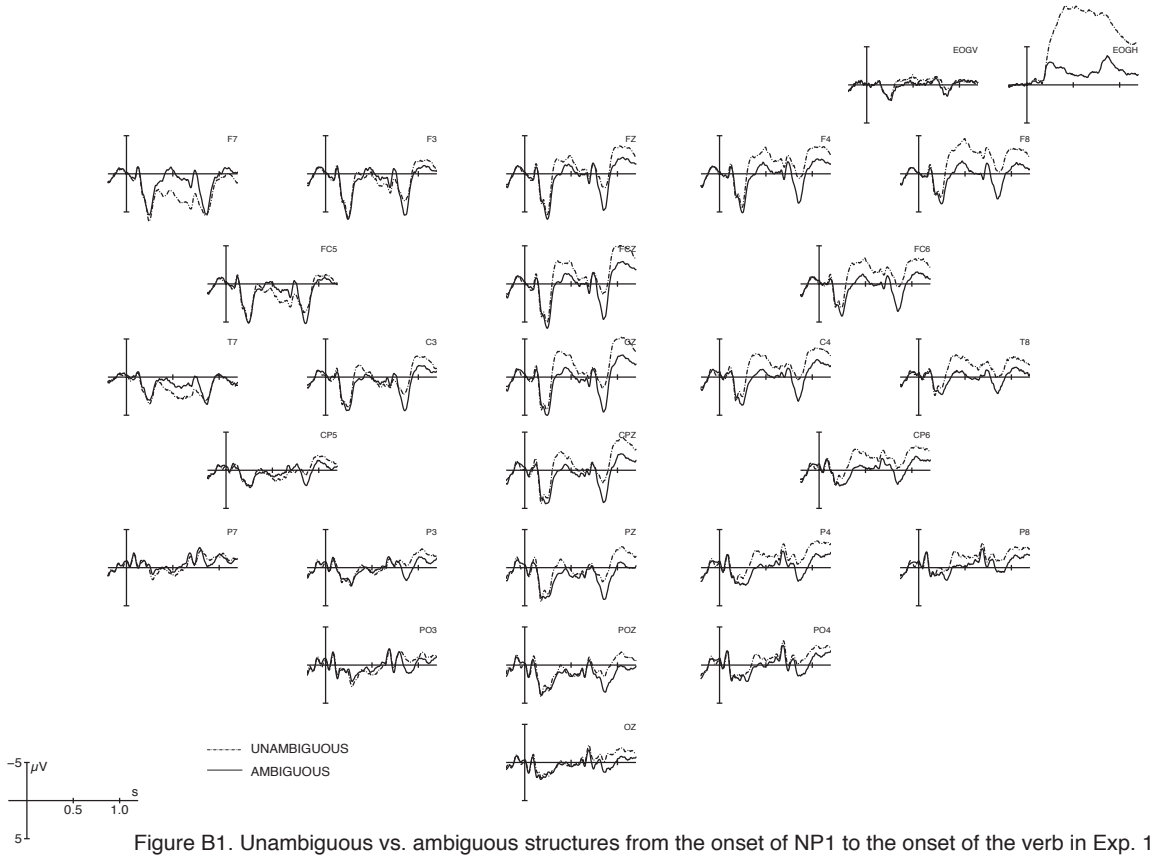

Figure B1. Unambiguous vs. ambiguous structures from the onset of NP1 to the onset of the verb in Exp. 1

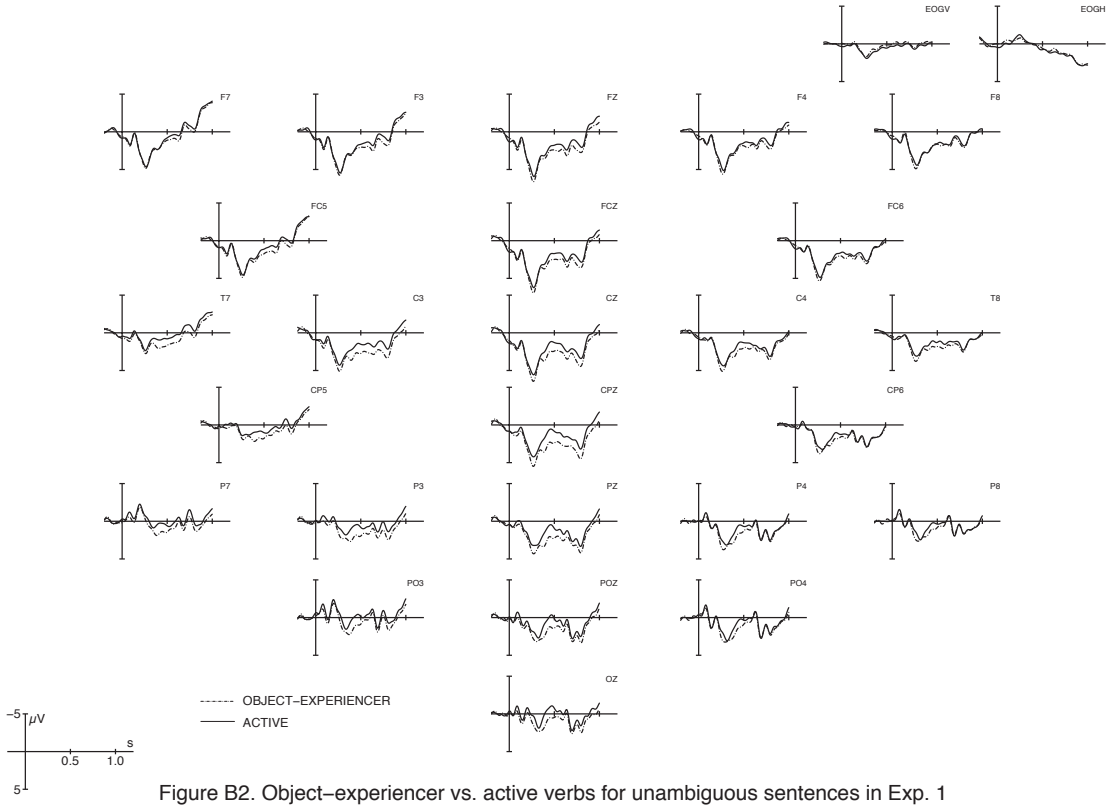

Figure B2. Object–experiencer vs. active verbs for unambiguous sentences in Exp. 1

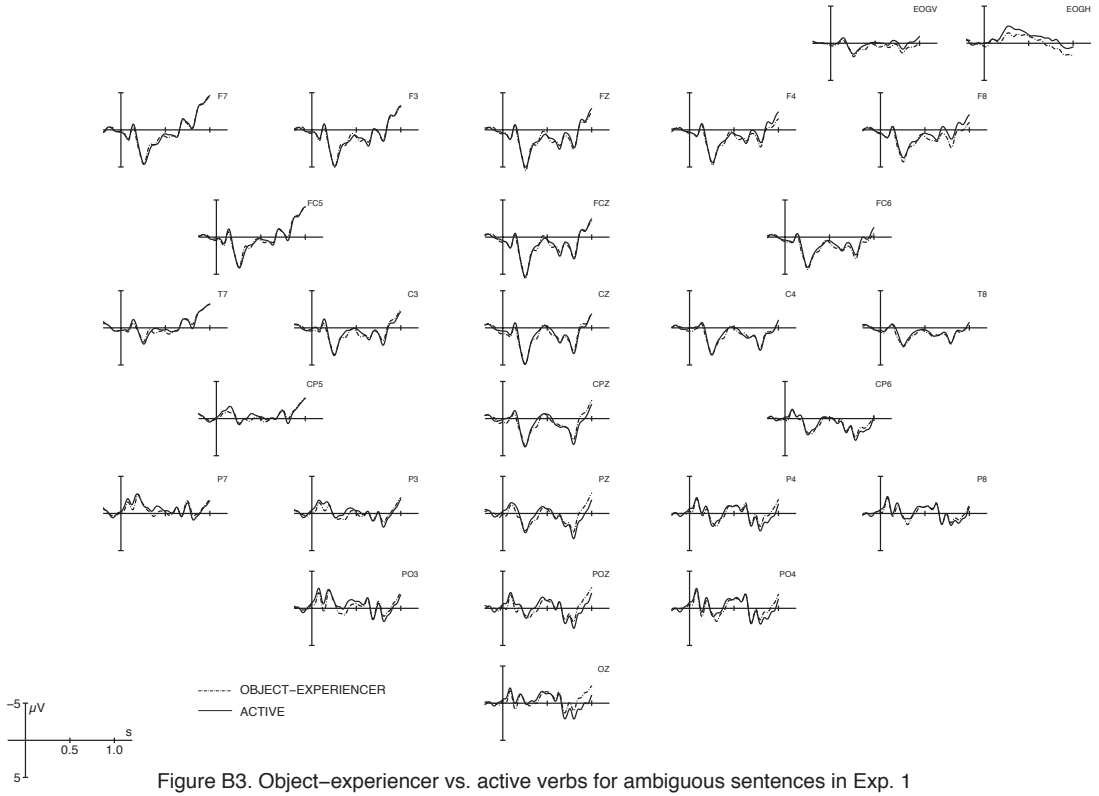

Figure B3. Object–experiencer vs. active verbs for ambiguous sentences in Exp. 1

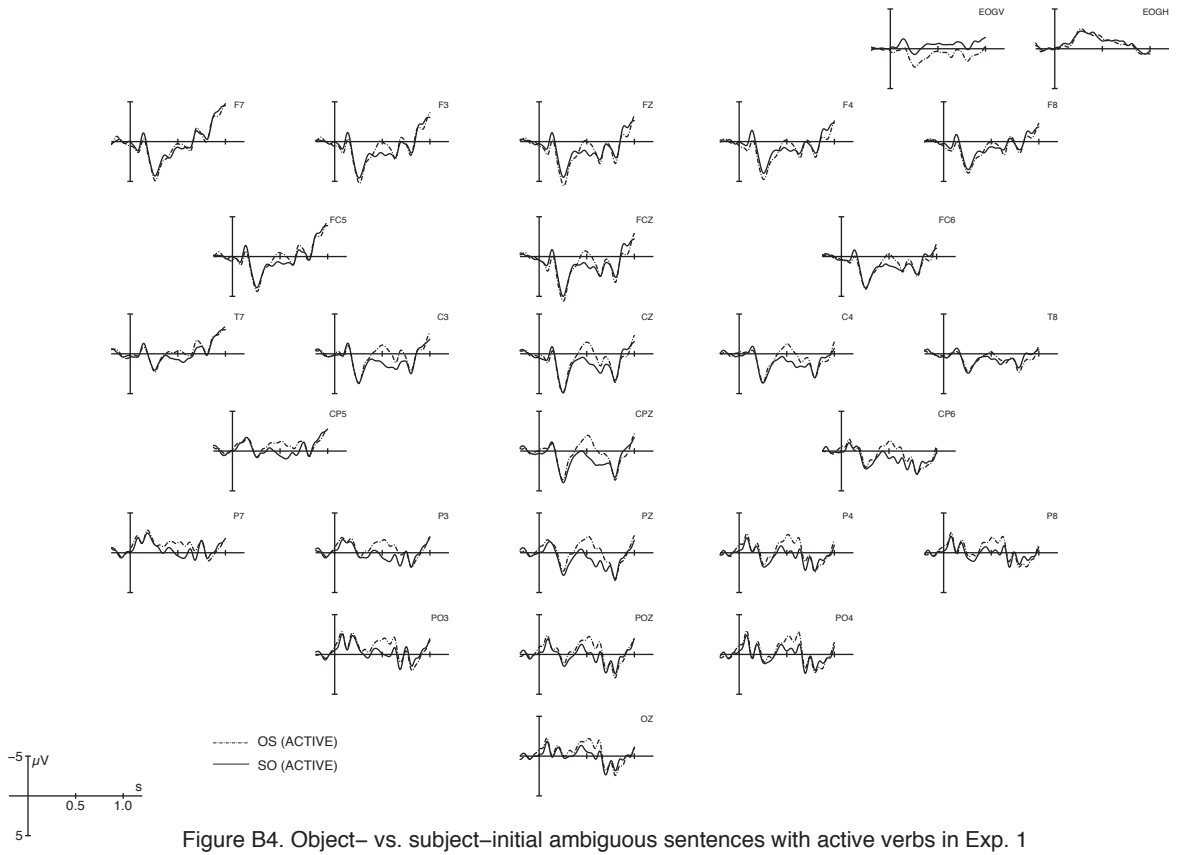

Figure B4. Object– vs. subject–initial ambiguous sentences with active verbs in Exp. 1

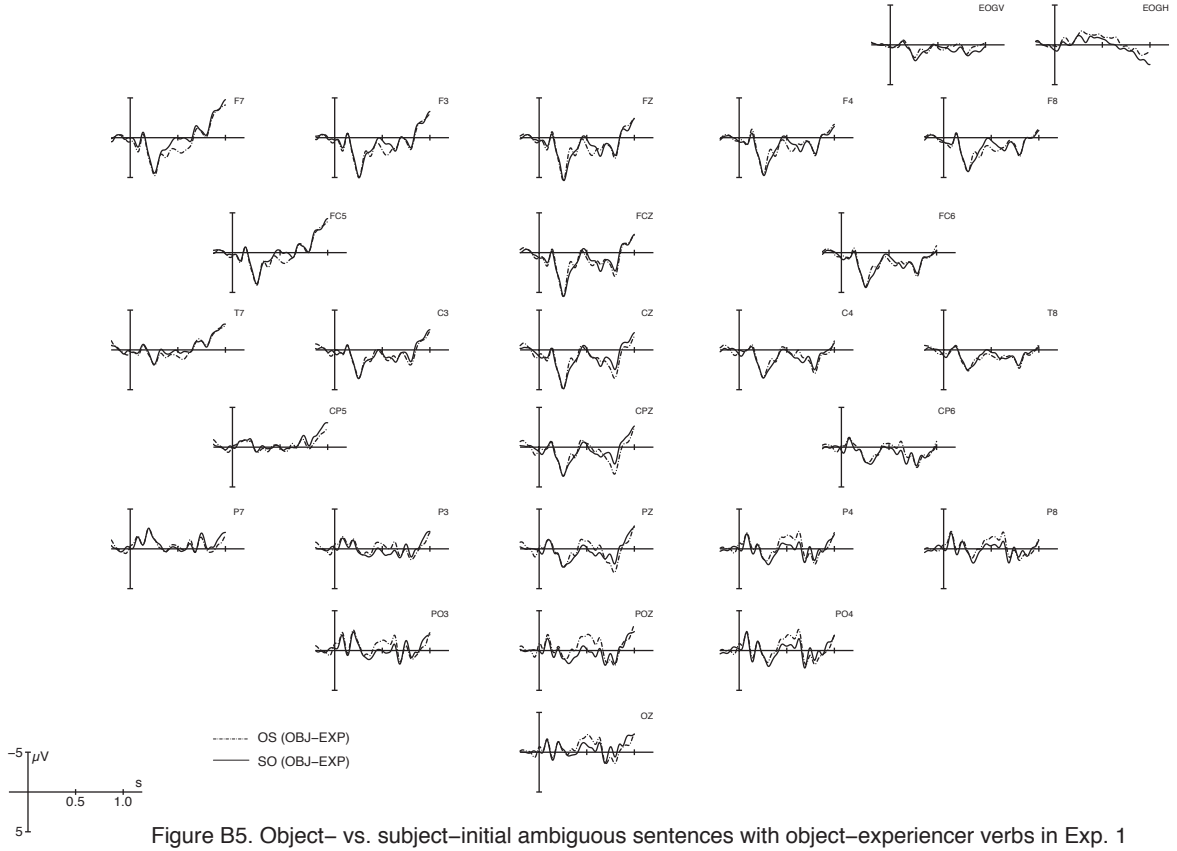

Figure B5. Object– vs. subject–initial ambiguous sentences with object–experiencer verbs in Exp. 1

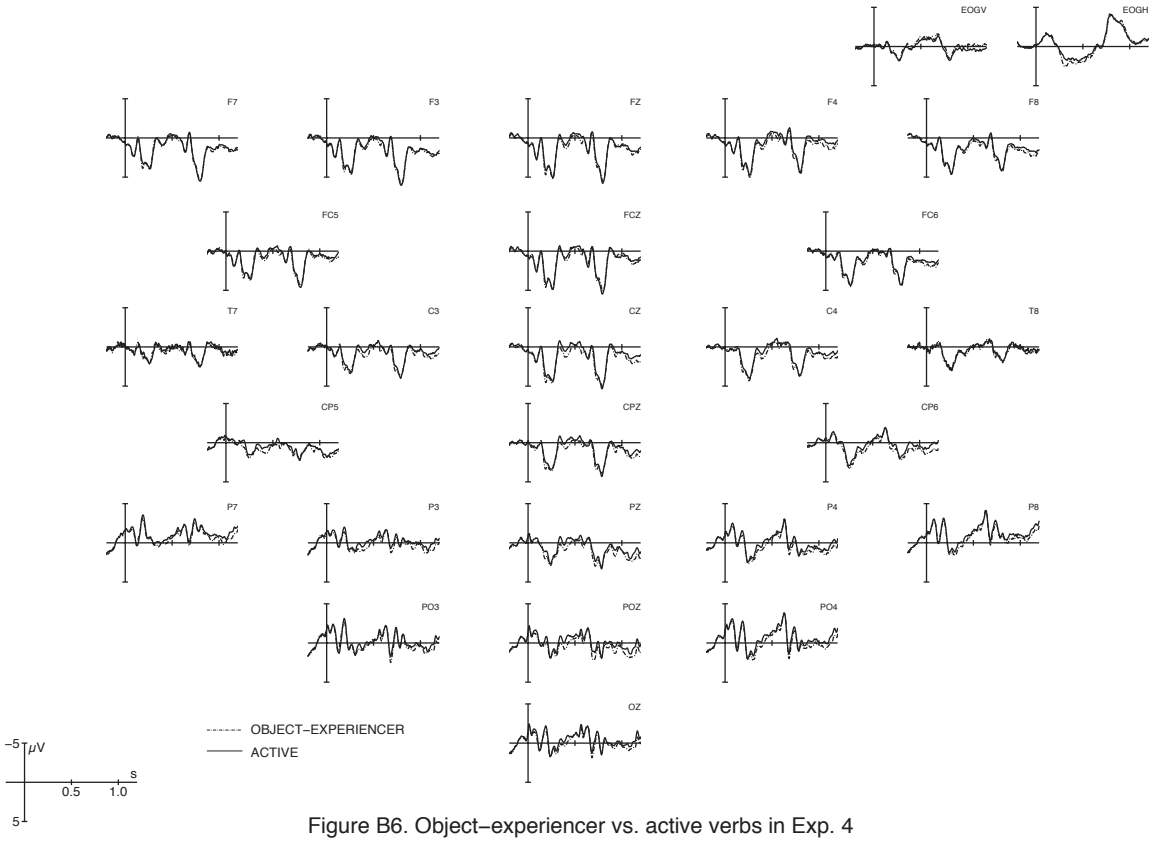

Figure B6. Object–experiencer vs. active verbs in Exp. 4

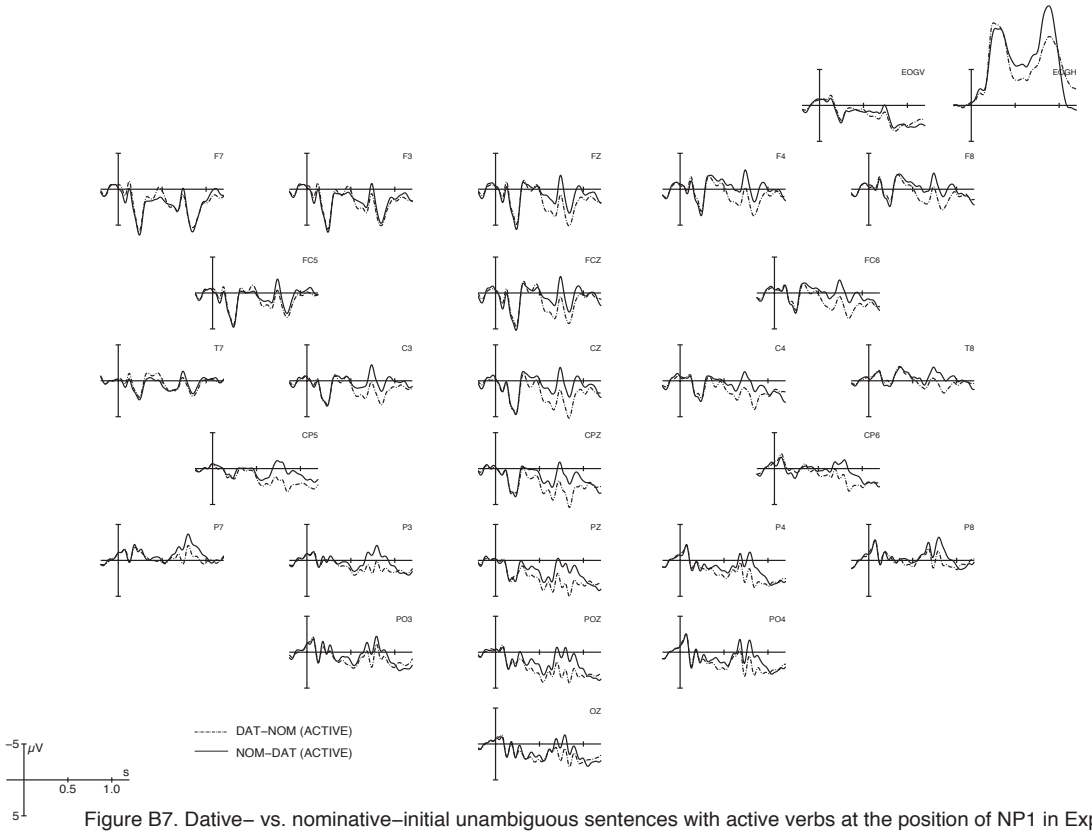

Figure B7. Dative– vs. nominative–initial unambiguous sentences with active verbs at the position of NP1 in Exp. 4

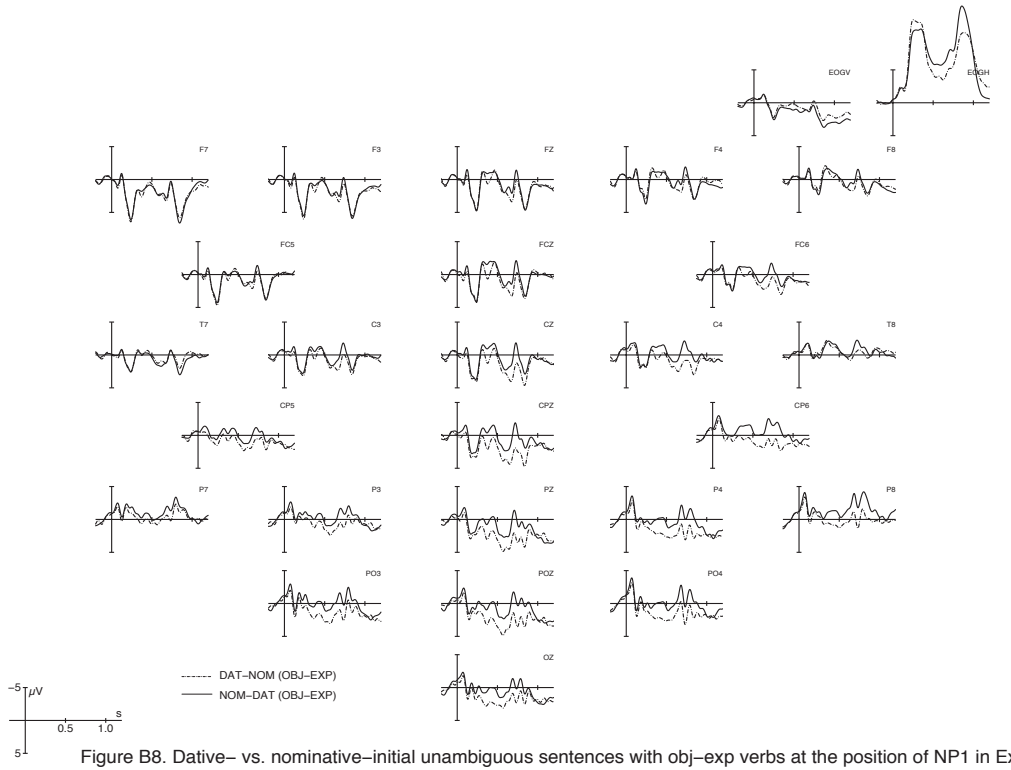

Figure B8. Dative– vs. nominative–initial unambiguous sentences with obj–exp verbs at the position of NP1 in Exp. 4

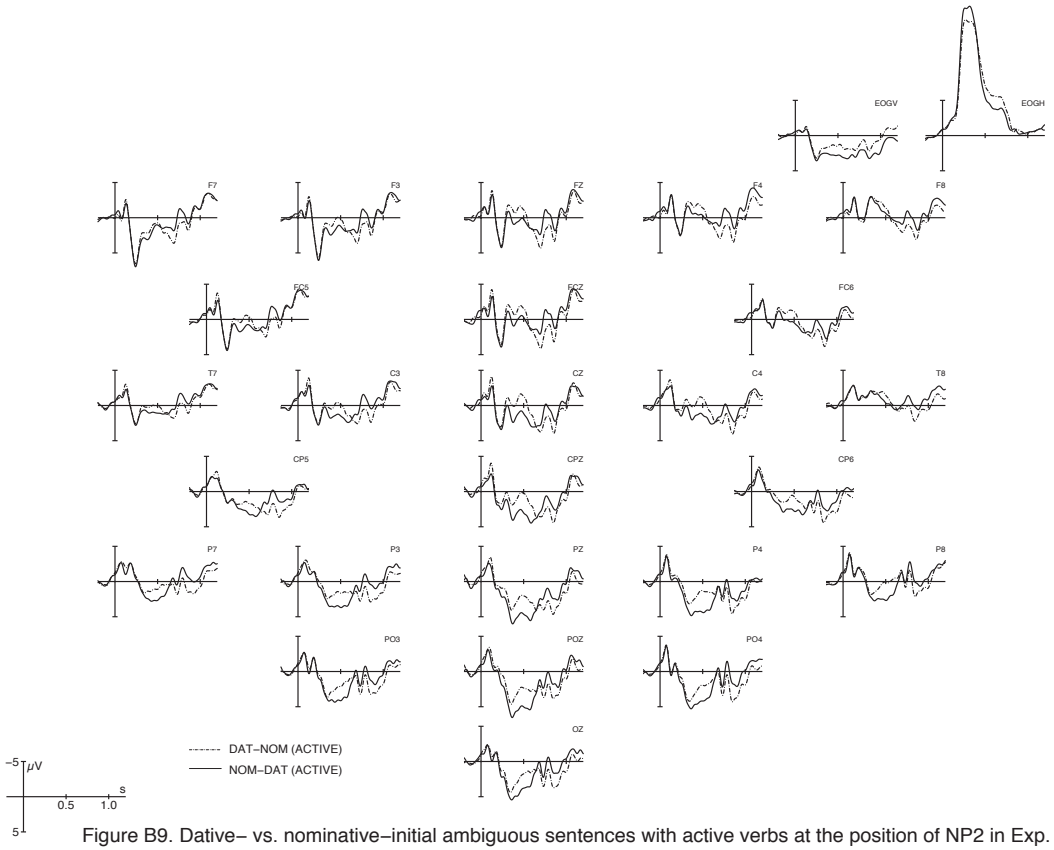

Figure B9. Dative– vs. nominative–initial ambiguous sentences with active verbs at the position of NP2 in Exp. 4

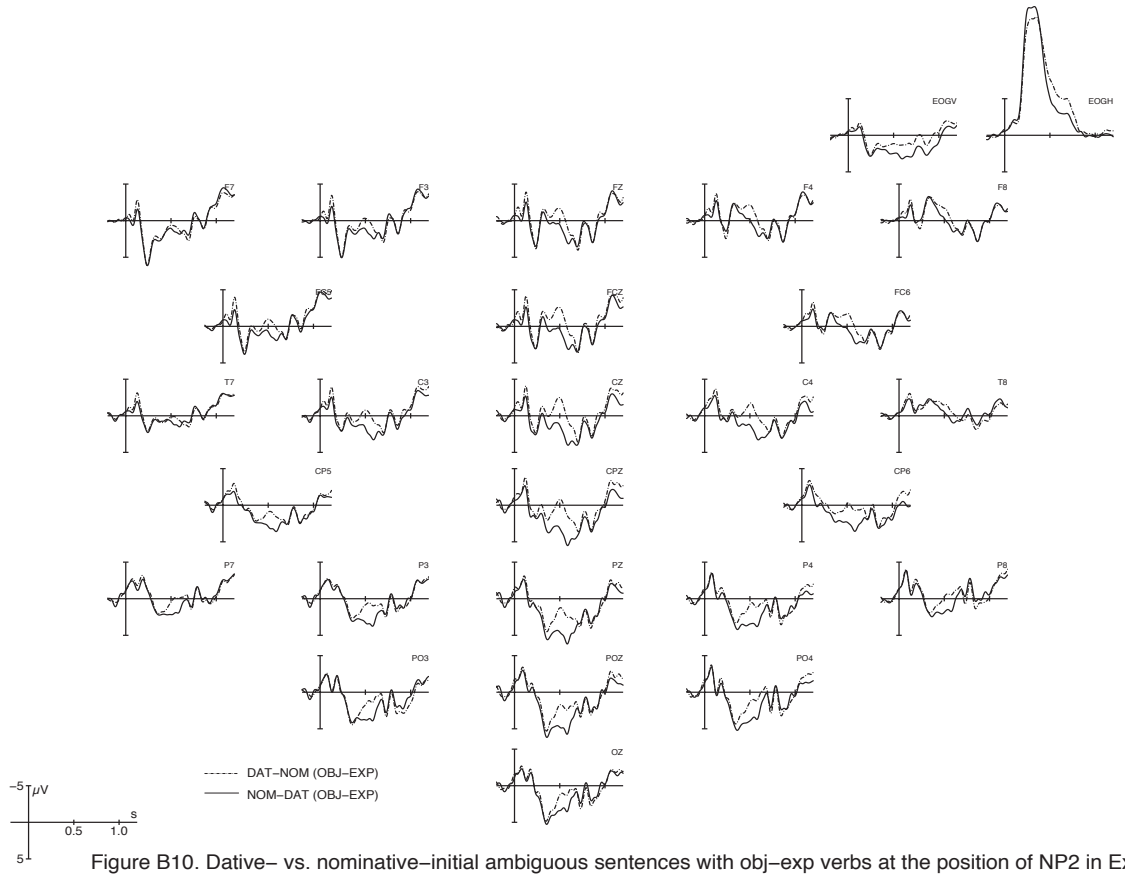

Figure B10. Dative– vs. nominative–initial ambiguous sentences with obj–exp verbs at the position of NP2 in Exp. 4

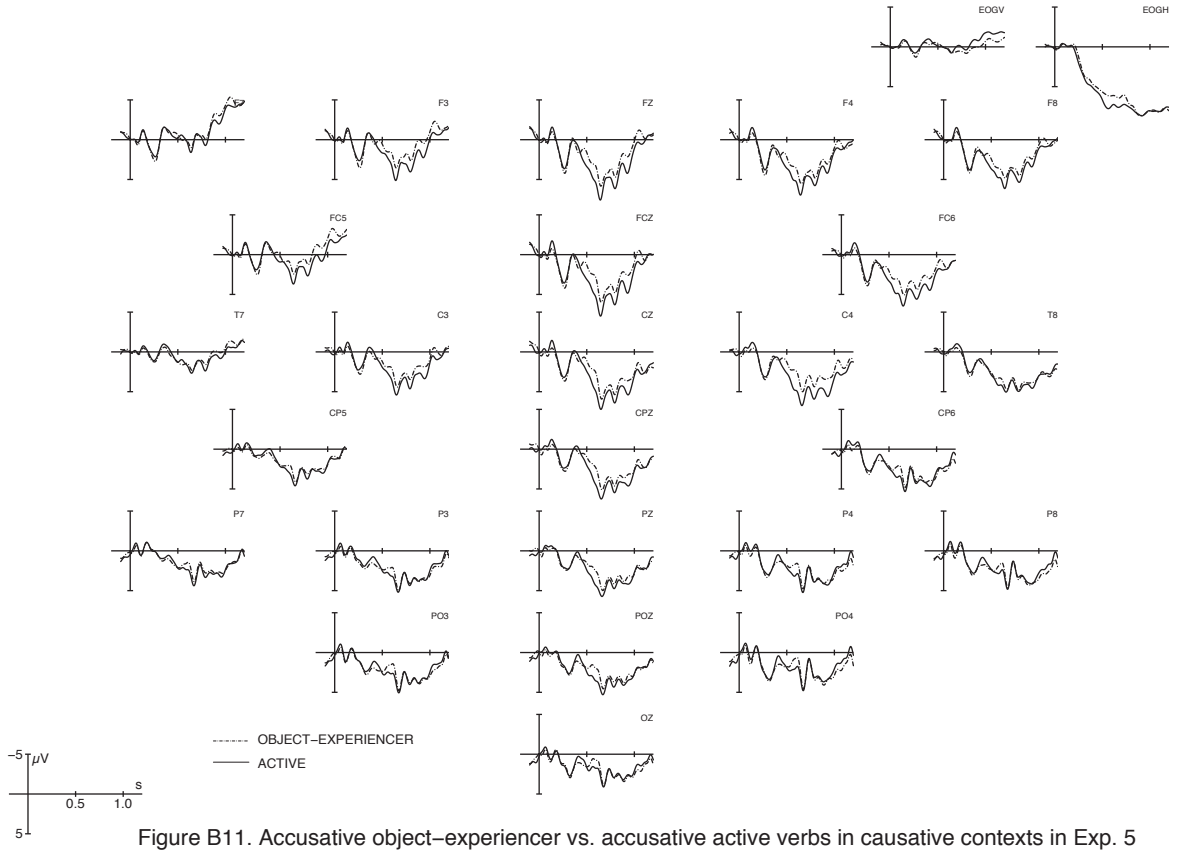

Figure B11. Accusative object–experiencer vs. accusative active verbs in causative contexts in Exp. 5

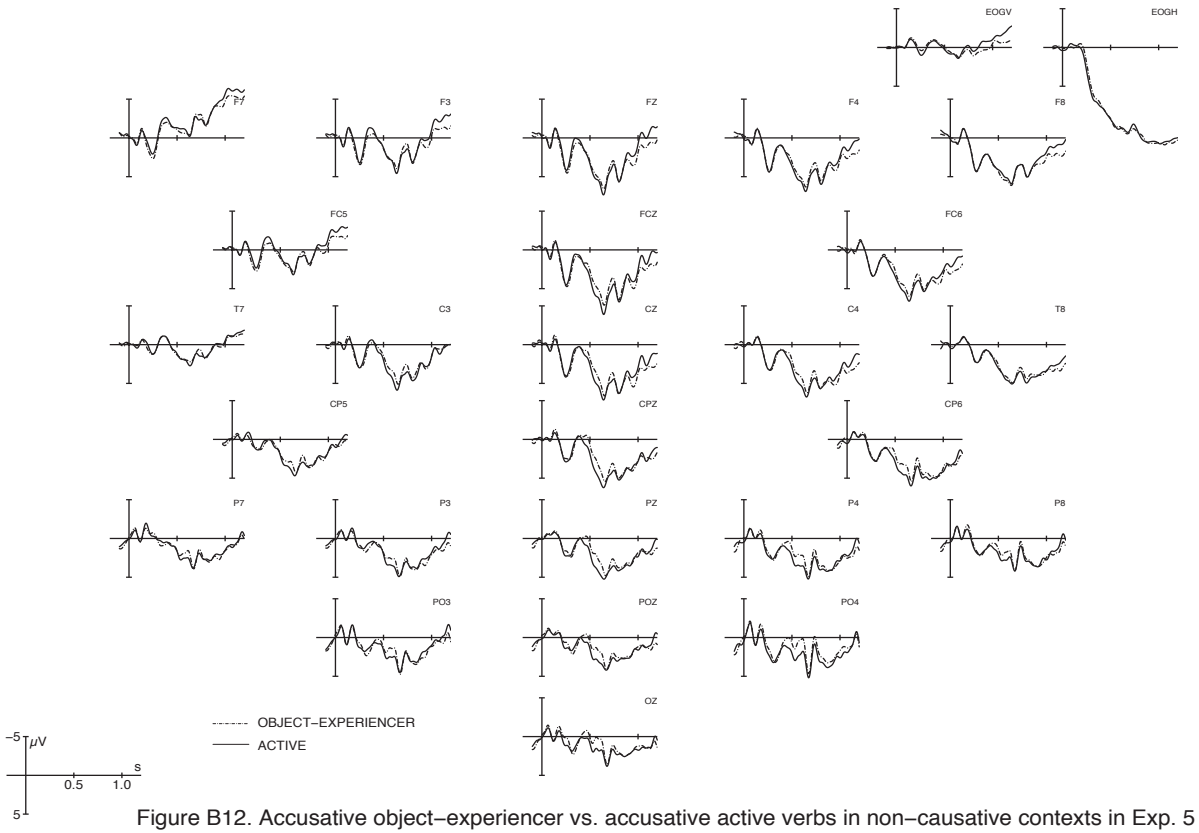

Figure B12. Accusative object–experiencer vs. accusative active verbs in non–causative contexts in Exp. 5

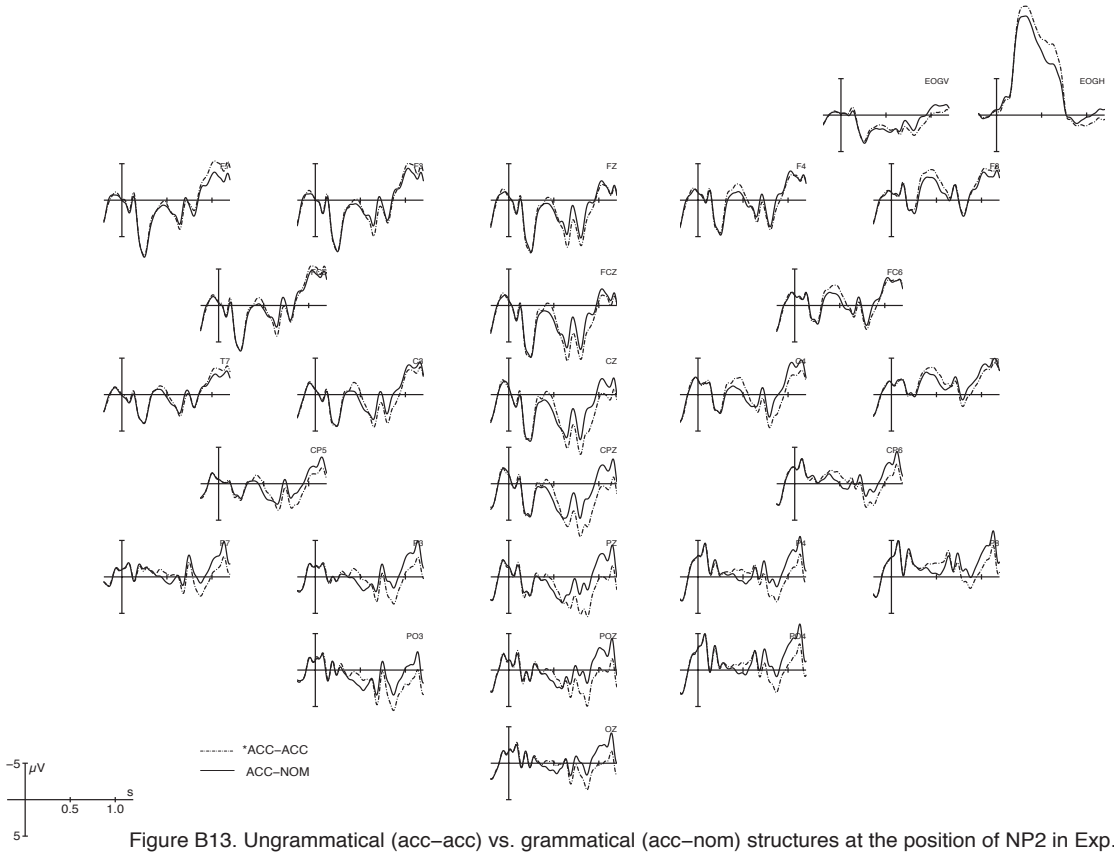

Figure B13. Ungrammatical (acc–acc) vs. grammatical (acc–nom) structures at the position of NP2 in Exp. 6

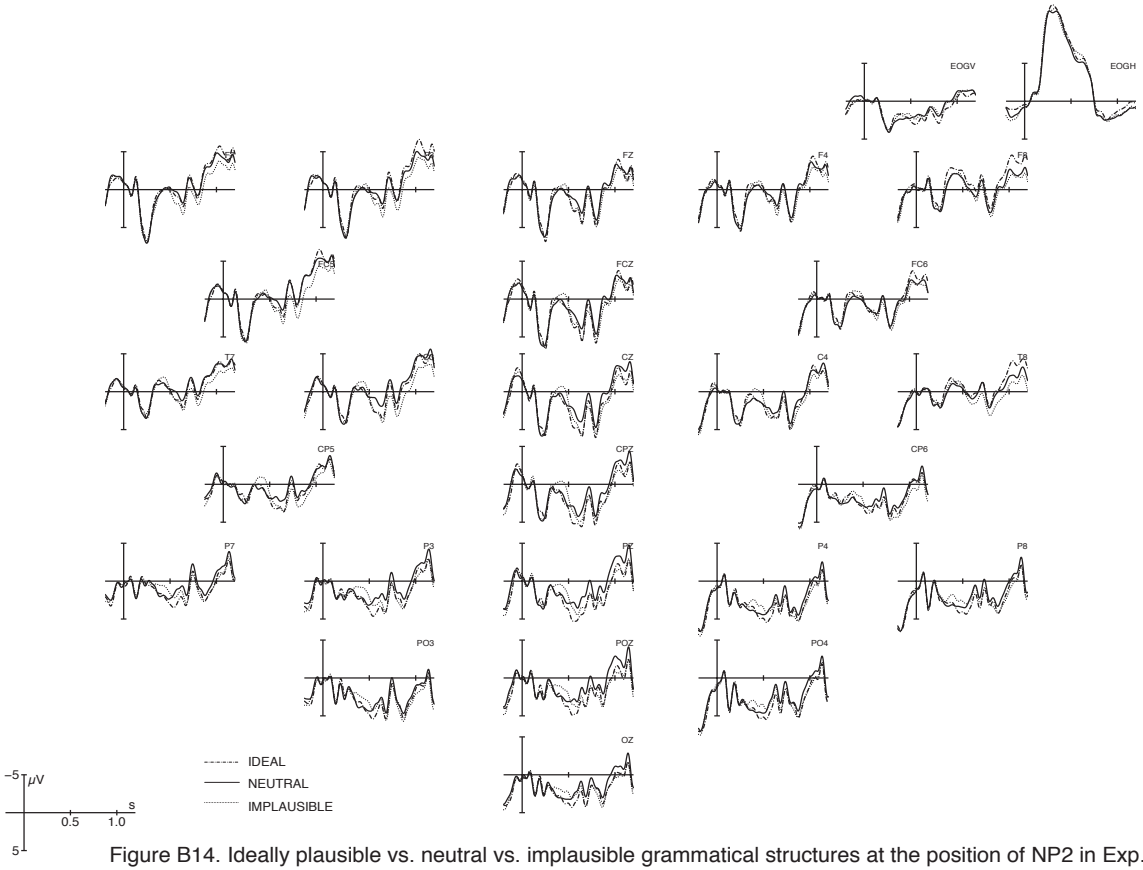

Figure B14. Ideally plausible vs. neutral vs. implausible grammatical structures at the position of NP2 in Exp. 6

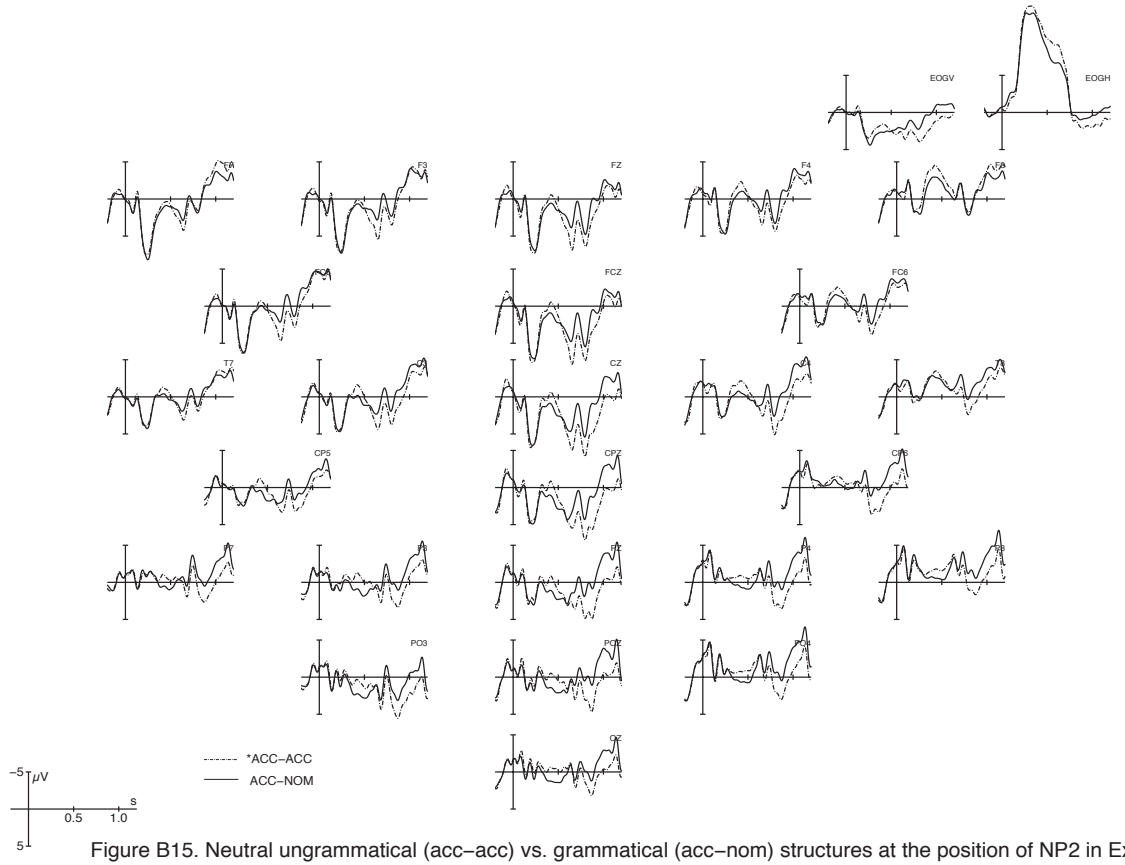

Figure B15. Neutral ungrammatical (acc–acc) vs. grammatical (acc–nom) structures at the position of NP2 in Exp. 6

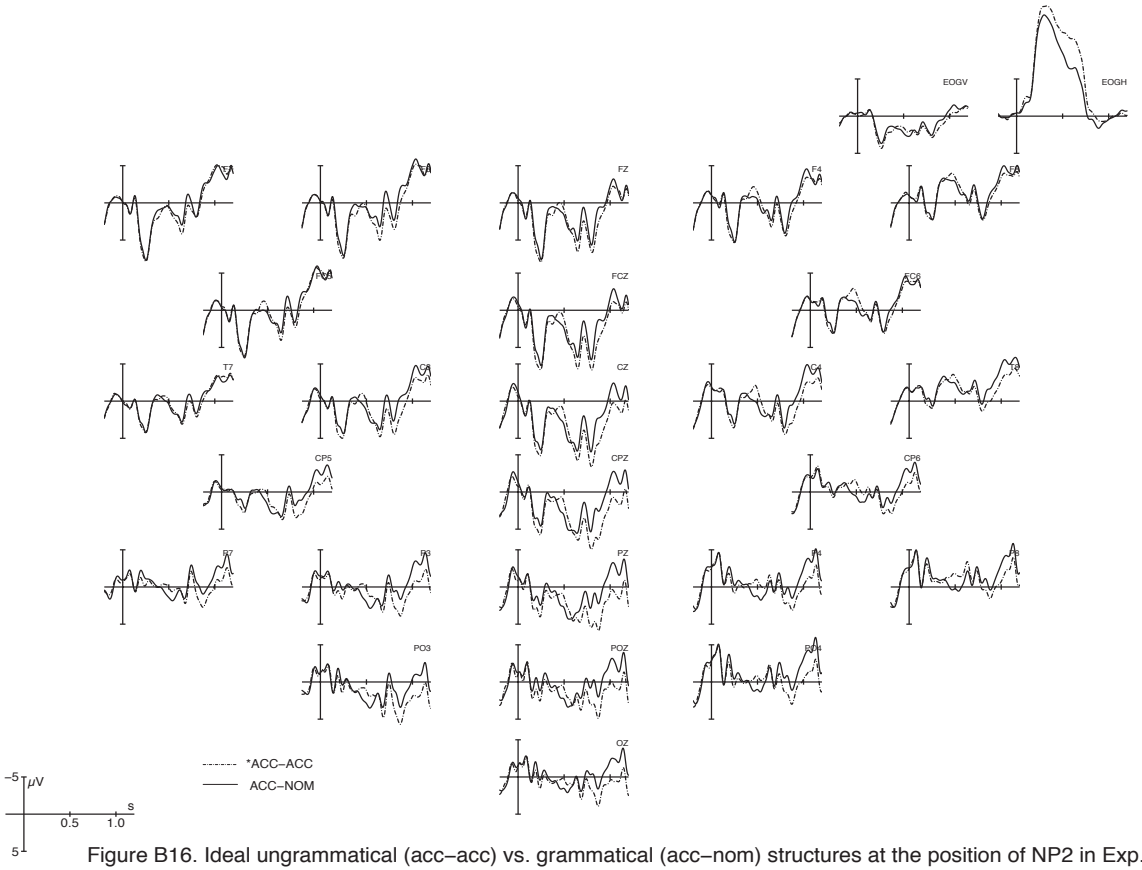

Figure B16. Ideal ungrammatical (acc–acc) vs. grammatical (acc–nom) structures at the position of NP2 in Exp. 6

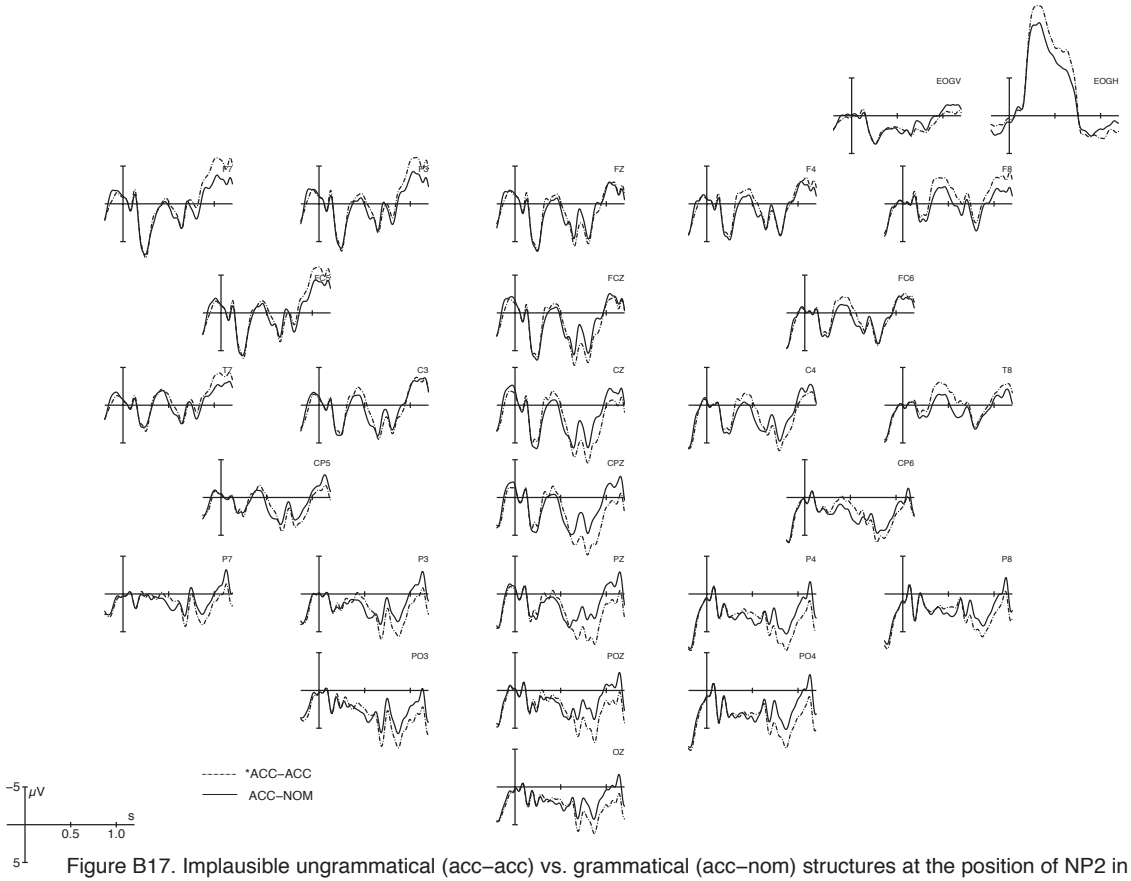

Figure B17. Implausible ungrammatical (acc–acc) vs. grammatical (acc–nom) structures at the position of NP2 in Exp. 6

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