Probabilistic and Prominence-driven Incremental Argument Interpretation in Swedish

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Abstract
This dissertation investigates how grammatical functions in transitive sentences (i.e., ’subject’ and ’direct object’) are distributed in written Swedish discourse with respect to morphosyntactic as well as semantic and referential (i.e., prominence-based) information. It also investigates how assignment of grammatical functions during on-line comprehension of transitive sentences in Swedish is influenced by interactions between morphosyntactic and prominence-based information.

In the dissertation, grammatical functions are assumed to express role-semantic (e.g., Actor and Undergoer) and discourse-pragmatic (e.g., Topic and Focus) functions of NP arguments. Grammatical functions correlate with prominence-based information that is associated with these functions (e.g., animacy and definiteness). Because of these correlations, both prominence-based and morphosyntactic information are assumed to serve as argument interpretation cues during on-line comprehension. These cues are utilized in a probabilistic fashion. The weightings, interplay and availability of them are reflected in their distribution in language use, as shown in corpus data. The dissertation investigates these assumptions by using various methods in a triangulating fashion.

The first contribution of the dissertation is an ERP (event-related brain potentials) experiment that investigates the ERP response to grammatical function reanalysis, i.e., a revision of a tentative grammatical function assignment, during on-line comprehension of transitive sentences. Grammatical function reanalysis engenders a response that correlates with the (re-)assignment of thematic roles to the NP arguments. This suggests that the comprehension of grammatical functions involves assigning role-semantic functions to the NPs.

The second contribution is a corpus study that investigates the distribution of prominence-based, verb-semantic and morphosyntactic features in transitive sentences in written discourse. The study finds that overt morphosyntactic information about grammatical functions is used more frequently when the grammatical functions cannot be determined on the basis of word order or animacy. This suggests that writers are inclined to accommodate the understanding of their recipients by more often providing formal markers of grammatical functions in potentially ambiguous sentences. The study also finds that prominence features and their interactions with verb-semantic features are systematically distributed across grammatical functions and therefore can predict these functions with a high degree of confidence.

The third contribution consists of three computational models of incremental grammatical function assignment. These models are based upon the distribution of argument interpretation cues in written discourse. They predict processing difficulties during grammatical function assignment in terms of on-line change in the expectation of different grammatical function assignments over the presentation of sentence constituents. The most prominent model predictions are qualitatively consistent with reading times in a self-paced reading experiment of Swedish transitive sentences. These findings indicate that grammatical function assignment draws upon statistical regularities in the distribution of morphosyntactic and prominence-based information in language use. Processing difficulties in the comprehension of Swedish transitive sentences can therefore be predicted on the basis of corpus distributions.

Keywords: grammatical functions, Swedish, grammatical function assignment, grammatical function reanalysis, argument prominence, discourse prominence, information structure, event-related brain potentials, self-paced reading, corpus-based modeling, Bayesian surprise, surprisal.

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Abbreviations

The glossing of the examples conforms to the Leipzig Glossing Rules: http://www.eva.mpg.de/lingua/resources/glossing-rules.php. In case of conflict between the Leipzig Glossing Rules and the abbreviations used in my sources, nonstandard abbreviations were substituted with the corresponding standard abbreviations in the Leipzig Glossing Rules. The glossing of the examples was adapted accordingly.

1 first person
2 second person
3 third person
A agent
ABS absolutive
ACC accusative
DEF definite
DET determiner
DIR direct
ERG ergative
F feminine
INDF indefinite
INS instrumental
INV inverse
M masculine
NOM nominative
OBJ object
OBL oblique
OBV obviative
P patient
PASS passive
PL plural
PRF perfective
PRS present
PST past
S single argument of canonical transitive verb
SG singular
STEM verb stem
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1. Introduction

This dissertation is concerned with the grammatical functions of ‘subject’ and ‘direct object’ in transitive sentences in Swedish. In a sentence such as ‘Floyd broke the glass’, the common noun ‘Floyd’ is the grammatical subject, referring to the Actor, the participant who is responsible for the event expressed by the verb ‘break’, and the noun phrase (NP) ‘the glass’ is the direct object, referring to the Undergoer, the thing that is affected in that event. An integral part of comprehending transitive sentences is to determine the grammatical functions of the NP arguments, and thereby resolve which of the two NPs that refer to the Actor and the Undergoer, respectively. This involves assigning grammatical functions to the NP arguments (henceforth called grammatical function assignment).

In most sentences, this is easily done on the basis of unambiguous morphosyntactic information such as case marking or word order. In some cases, however, sentences can be locally ambiguous with respect to their grammatical functions. Consider, for instance, the following sentences in Swedish:

(1.1) (a) Läraren gillar vi inte
    teacher.the like we not
    ‘We don’t like the teacher’

(b) Dig gillar vi inte
    you like we not
    ‘We don’t like you’

In 1.1a, the initial NP consists of a noun. Since nouns lack case marking in Swedish, this NP is ambiguous with respect to its grammatical function. Because the unmarked word order in Swedish transitive sentences is SVO, however, the initial NP is most likely to be interpreted as the subject. The second NP consists of a 1st person subject pronoun and is therefore unambiguous regarding its grammatical function. The initial interpretation of the sentence as subject-initial can therefore not be maintained once the second NP is encountered, and the sentence must be reinterpreted as object-initial. In 1.1b, on the other hand, the initial NP instead consists of an unambiguous object pronoun, and the sentence must be interpreted as object-initial directly. Several studies have shown that sentences like 1.1a that contain such grammatical function ambiguities are harder to comprehend than sentences such as 1.1b (e.g., Bader & Meng 1999; Bornkessel, McElree, Schlesewsky, & Friederici 2004; Casado, Martín-Loeches, Muñoz, & Fernández-Frías 2005; Haupt, Schlesewsky, Roehm, Friederici, & Bornkessel-Schlesewsky 2008; Hörberg, Koptjevskaja-Tamm, & Kallioinen 2013; Matzke, Mai, Nager, Rüsseler, & Münte 2002).

However, language comprehenders not only make use of morphosyntactic information during grammatical function assignment, but also seem to be able to take advantage of other semantic (e.g., animacy) and referential (e.g., definiteness) information types that
at least statistically correlate with grammatical functions. Indeed, grammatical functions correlate with these information types in the frequency distributions in language use. These correlations further appear to condition the grammatical encoding of grammatical functions in several languages in a functionally motivated manner. For instance, overt case marking is in most cases restricted to object NPs that are aprototypical with respect to either semantic or referential properties. In Spanish, only animate NP objects are overtly case marked, and in Swedish, case marking is restricted to 1st, 2nd and 3rd person pronouns. Several experimental studies further show that language comprehenders can benefit from semantic and referential information during on-line grammatical function assignment (Frenzel, Schlesewsky, & Bornkessel-Schlesewsky 2011; Kretzschmar, Bornkessel-Schlesewsky, Staub, Roehm, & Schlesewsky 2012; Mak, Vonk, & Schriefers 2006, 2008; Nieuwland, Martin, & Carreiras 2013; Trueswell, Tanenhaus, & Garnsey 1994; Weckerly & Kutas 1999). Semantic and referential information types therefore seem to work as cues to the grammatical functions of NP arguments that work in concert with morphosyntactic information such as word order and case marking, and this is reflected in the morphosyntactic encoding of grammatical functions across languages. Both semantic and referential as well as morphosyntactic information might therefore function as cues for grammatical function assignment, whose weightings, interplay and availability within a language can be determined on the basis of their distributions in language use.

1.1. Aim, scope and hypotheses

This dissertation investigates grammatical function assignment during on-line comprehension of written transitive sentences, the distribution of NP argument prominence properties across grammatical functions in language use, and whether grammatical function assignment is influenced by the availability of prominence properties during on-line comprehension. The dissertation also addresses the grammatical encoding and functional underpinnings of grammatical functions. The fundamental hypothesis is that both prominence-based and morphosyntactic information function as argument interpretation cues during the on-line comprehension of transitive sentences that are utilized in a probabilistic fashion. More specifically, the dissertation is based upon and aims to test the following hypotheses about grammatical functions and the process of comprehending them:

1. The on-line comprehension of grammatical functions involves the assignment of role-semantic functions to the NP arguments.

2. The encoding of grammatical functions in language use is influenced by a trade-off between the motivation to avoid redundant information and the motivation to provide unambiguous information regarding the argument functions.

3. Morphosyntactic and prominence-based information function as argument interpretation cues whose weightings, interplay and availability vary in systematic ways that are reflected in their distribution in language use.

4. Argument interpretation cues are utilized in an incremental and probabilistic fashion during on-line grammatical function assignment. The distribution of argument
intermediate grammatical function assignment.

These ideas are not new but spring from a wide range of empirical findings and theoretical accounts in functional-typological linguistics as well as in psycho- and neurolinguistics. In this dissertation, I try to bring some of these accounts together. The studies in the dissertation empirically test the hypotheses outlined above. This is done on the basis of corpus-based, psycholinguistic and neurolinguistic studies of the discourse distribution and the comprehension of written transitive sentences in Swedish. In the dissertation, I am also taking into account functional / typological generalizations about grammatical functions. As such, my aim is to investigate grammatical functions using a cross-disciplinary approach (i.e., corpus-based, computational, psycho- / neurolinguistic and typological). An underlying goal of this dissertation is thereby to test the idea that the there exists a close relationship between the distribution of prominence-based and morphosyntactic information in the grammatical encoding and use of grammatical functions, on the one hand, and the processing of grammatical functions during on-line language comprehension, on the other (see Chapter 2).

1.2. Contributions

Some of the empirical findings and contributions of this dissertation are mere replications of earlier studies, others are extensions from other languages to Swedish. A few of them, however, should be considered novel. Some of the main contributions of the dissertation are as follows:

- It contains the first study to provide empirical results on the neurophysiological response to clause-internal grammatical function reanalysis in Swedish\(^1\), thereby complementing many studies in the field of ‘neurotypology’ (Bornkessel-Schlesewsky, Dierdre, & Schlesewsky 2013).

- It provides a comprehensive study of the relationships among grammatical functions, morphosyntactic features, prominence features and verb-semantic features in both subject- and object-initial transitive sentences in written Swedish discourse, and quantifies these features with respect to their ability to predict the sentence word order.

- It suggests a novel way of modeling incremental argument interpretation in transitive sentences on the basis of frequency distributions of morphosyntactic and prominence-based features in language use, and provides initial evidence for this kind of model.

- Finally, and perhaps most importantly, it is cross-disciplinary in nature and therefore brings together a number of empirical findings and theoretical assumptions in diverse fields in linguistics.

\(^1\)As opposed to when the grammatical function of an NP is reanalyzed as the subject argument of the subsequent clause (see Roll & Horne 2011).
1.3. Organization of the dissertation

The dissertation consists of eight chapters, one of which is based upon a journal article that was published in 2013 (i.e., Hörberg et al. 2013). The upcoming chapters of the dissertation are organized in the following way:

**Chapter 2** provides the theoretical background of the dissertation. In this chapter, I give an overview of grammatical functions in the typological perspective, arguing that grammatical functions of transitive sentences express the role-semantic and discourse pragmatic functions of the NP arguments, and that they therefore are correlated with semantic and referential information that are related to these functions. These correlations are manifested in the discourse distributions within individual languages as well as in the grammatical encoding of grammatical functions across languages. I further argue that both morphosyntactic and prominence-based information serve as cues to grammatical functions, and that their interplay and availability is functionally motivated. Overt morphosyntactic information is more frequently resorted to when the NP functions cannot readily be determined on the basis of other information. The encoding of transitive events in language use therefore seems to be influenced by a trade-off between the motivation to reduce the production effort in terms of avoiding redundant information (i.e., the *economy* motivation), on the one hand, and the motivation to be informative enough in terms of providing unambiguous information (i.e., the *iconicity* motivation), on the other. In the course of the chapter, I present evidence for this idea both from corpus-based and experimental studies. I also give an overview of studies that have shown that prominence-based information is used as a cue during grammatical function assignment. I finally present some psycho- and neurolinguistic theories of grammatical function assignment that assume that this process is guided by the availability of prominence features as well as their interplay with morphosyntactic features (e.g., the interaction between animacy and structural ambiguity on the processing of sentences with reduced relative clauses, see Trueswell et al. (1994), among others).

**Chapter 3** gives a summary of the kind of transitive sentences in Swedish that are investigated throughout the dissertation. Since object-initial word order is of particular importance for the dissertation, I also present a short overview of the functional motivations that have been suggested for the object-initial construction in Swedish. The chapter is also concerned with Swedish transitive sentences that are locally ambiguous with respect to the argument functions. In this chapter, I therefore also present an overview of such structures and the kind of information types that disambiguate them. I also summarize a study that investigated whether morphosyntactic information that disambiguates the sentence at hand with respect to its argument functions is used more frequently in potentially ambiguous transitive sentences in Swedish, a question that is further addressed in Chapter 5.

**Chapter 4** presents an ERP experiment that empirically tests the hypothesis that the on-line comprehension of grammatical functions involves the assignment of role-semantic
functions to the NP arguments (Hypothesis 1). This is done on the basis of investigating the ERP-correlate to grammatical function reanalysis, the process by which an initial assumption regarding the grammatical function of an NP argument is revised. The experiment finds that grammatical function reanalysis in Swedish engenders a neurophysiological response (the N400) that has traditionally been seen as a correlate of the (re-)assignment of thematic roles, rather than a response that is believed to correlate with syntactic processing, indicating that grammatical function reanalysis involves a remapping of thematic roles to the NP arguments rather than a revision of the syntactic structure of the sentence.

Chapter 5 presents a corpus study of the distribution of prominence-based, verb semantic and morphosyntactic features in transitive sentences in written Swedish texts. The aim of this study is three-fold. First, it tests and provides additional evidence for the idea that writers are more prone to using formal markers of grammatical functions (i.e., case marking and auxiliary verbs) in transitive sentences where the argument functions cannot be readily determined on other information types, and thereby balance their production efforts in order to accommodate the comprehension of their recipient (Hypothesis 2). Secondly, it investigates the functional motivations for an object-before-subject word order in Swedish transitive sentences, with respect to earlier accounts of Swedish object-before-subject word order. Thirdly, and most importantly, it shows that distributions of prominence features in Swedish follow the systematic patterns found in previous studies, and pattern with the distributions found across languages (Hypothesis 3). This study also quantifies the strength of argument interpretation cues and their interactions in terms of their ability to predict the sentence word order, using logistic mixed effects modeling. The study shows that animacy by far is the strongest cue and, further that this is particularly the case in sentences with volitional or causative verbs, which in many cases require an animate subject argument.

Chapter 6 presents three statistical models of incremental grammatical function assignment that are based on the distribution of morphosyntactic and prominence-based information (that is, argument interpretation cues). These models aim to make predictions regarding the processing difficulties during grammatical function assignment (Hypothesis 4). This is done by modeling the on-line change in the expectation of different grammatical function assignments as a function of the incremental presentation of the sentence constituents (i.e., NP1, the verb, and NP2). Specifically, the models estimate the surprisal of encountering the features of the current constituent, given the features of the previous constituents. The models quantify the change in the expectation of a particular grammatical function assignment at the present constituent with respect to the expectation at the previous constituent in terms of relative entropy. The fundamental characteristics of the three models are the same, but they differ with respect to how the expectations (and thus surprisal) for different grammatical function assignments are estimated and integrated. I then discuss and compare the predictions that the three models make regarding processing difficulties in both locally ambiguous and unambiguous sentences, and discuss potential problems with them. Most importantly, the model predictions motivate the experiment...
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presented in the subsequent chapter.

Chapter 7 presents a self-paced reading experiment that sets out to test the most prominent predictions of the incremental models presented in the previous chapter (Hypothesis 4). The experiment tests whether the processing of transitive sentences is influenced by the availability of both morphosyntactic and prominence-based cues to grammatical function assignment during incremental language comprehension. The results of the experiment are qualitatively in line with the predictions of the incremental models and therefore provide evidence for Hypothesis 4.

Chapter 8 concludes the dissertation by summarizing the results of the individual studies and relating them to the theoretical assumptions presented in Chapter 2. The following main conclusions are drawn. The results of the ERP experiment presented in Chapter 4 speaks in favor of the hypothesis that the on-line comprehension of grammatical functions involves the assignment of role-semantic functions to the NP arguments. The corpus distributional data investigated in Chapter 5 provides evidence for the idea that writers adopt their productions in order to accommodate the understanding of their recipients by more frequently providing formal markers of grammatical functions in potentially ambiguous transitive sentences. This corpus distributional data is also in line with the functions of the object-topicalized construction in Swedish that have been suggested in the literature. It is also concluded that the statistical models presented in Chapter 6 together with the self-paced reading experiment presented in Chapter 7 provide evidence for the assumption that the process of grammatical function assignment is based upon statistical regularities in the distribution of morphosyntactic and prominence-based information in language use. Processing difficulties during the comprehension of Swedish transitive sentences can therefore be predicted on the basis of the distributions of morphosyntactic and prominence-based information in corpora.
2. Background and Theoretical Assumptions

In this dissertation, I investigate how morphosyntactic information interacts with semantic and referential (i.e., prominence-based) information both in the grammatical encoding as well as in the comprehension of grammatical functions in Swedish transitive sentences. The fundamental hypothesis is that both referential and semantic information, on the one hand, and morphosyntactic information, on the other, function as argument interpretation cues during the on-line comprehension of transitive sentences. These cues are utilized in a probabilistic fashion, and their weightings, interplay and availability are reflected in their distribution in language use and can therefore be quantified on the basis of corpus data. This hypothesis is investigated using a cross-disciplinary approach, drawing on corpus-based, computational and psycho- / neurolinguistic methods and data.

I further assume that the hypothesized relationship between the distribution of prominence features and their utility as argument interpretation cues is functionally motivated. In line with the view of grammatical functions advocated in the functional / typological perspective, I assume that grammatical functions express role-semantic (e.g., Actor or Undergoer) and discourse-pragmatic (e.g., Topic and Focus) functions of the NP arguments, and that these functions are highly correlated with prominence-based information in language use within individual languages. Across languages, these correlations also condition the grammatical encoding of grammatical functions. Morphosyntactic cues to grammatical functions are more frequently required when they serve to unambiguously differentiate between the functions of the NP arguments, but are, on the other hand, less frequently required when the functions can be determined on other information types, and therefore are redundant. These patterns are further in line with the more general idea that language structure is in part shaped or at least constrained by competing cognitive constraints that underlie efficient language use and communication.

This work is therefore to a large extent motivated by findings and assumptions of the functional-typological and usage-based perspectives of linguistics. This is not to say, however, that this work is inconsistent with more formal approaches to language. It is also consistent with the Optimality Theoretic (OT) framework, in which grammatical structures are selected on the basis of the ranking of a set of constraints, as well as recent developments in minimalism generative grammar, which recognizes that language structure is partly shaped by cognitive constraints that underlie language use and processing (see Chomsky 2005; Fitch, Hauser, and Chomsky 2005; Hauser, Chomsky, and Fitch 2002 and Golumbia 2010 for a review). As such, the theoretical assumptions underlying this work are based upon a wide range of empirical findings and theoretical accounts from different linguistic disciplines.

In this chapter, I start out (Section 2.1) by presenting grammatical functions from the functional / typological perspective, arguing that grammatical functions express role-
semantic and discourse-pragmatic functions. In Section 2.2, I then go on to argue that grammatical functions correlate with semantic and referential properties that are related to these functions. These correlations manifest themselves both in the grammatical encoding of grammatical functions across languages, as well as in the discourse distributions of prominence properties across grammatical functions in individual languages. In Section 2.3, I discuss the functional underpinnings of these correlations and argue that both morphosyntactic and prominence-based information function as cues to grammatical functions, whose weightings, availability and interplay is in part shaped or at least constrained by the competing motivations of avoiding redundant morphosyntactic information (i.e., the economy motivation), on the one hand, and ensuring that the message is unambiguous (i.e., the iconicity motivation), on the other. In Section 2.4, I then go on to present experimental studies that have shown that prominence-based information is indeed utilized during on-line grammatical function assignment. I also present some theoretical accounts of the comprehension of grammatical functions that are consistent with the idea that both prominence-based and morphosyntactic information function as cues during on-line comprehension that are utilized in a probabilistic fashion. In Section 2.5, I summarize these findings and accounts, and unite them with the general hypotheses of this dissertation.

2.1. Grammatical functions in the typological perspective

Grammatical functions pertain to the alignment of core arguments into sets on the basis of restrictions in the grammatical encoding of the arguments. These involve morphosyntactic encoding restrictions (e.g., word order, case marking or agreement), on the one hand, and co-reference restrictions in syntactic constructions, on the other (e.g., conjunction reduction, raising or relativization constructions) (Bickel 2010; Bickel and Nichols 2009; Dixon 1994:8-18; Van Valin and LaPolla 1997:250).

The traditional notions ‘subject’ and ‘direct object’ designate grammatical functions that align the sole argument of an intransitive sentence, often referred to as the S argument, with the most agent-like argument of a transitive sentence, referred to as the A argument, in contrast to the most patient-like argument of a transitive sentence, called the P argument, on the basis of their grammatical encoding (cf., e.g., Bickel 2010; Bickel and Nichols 2009; Croft 2003:142-144; Dixon 1994:6-8, for a further description of the S-, A- and P- arguments). In English, for example, the S and A arguments are encoded alike in terms of syntactic position, case marking and agreement in contrast to the morphosyntactic encoding of the P argument. The S and A arguments are also differentiated from the P argument in the sense that they are targeted by co-reference restrictions in many syntactic constructions and therefore constitute a syntactic pivot (see, e.g., Dixon 1994; Evans & Levinson 2009; Foley 2007) in English. In control constructions, for instance, the controlled argument of the infinitival complement must be either S (Example 2.1a) or A (Example 2.1b):

(2.1)  
(a) Susani wants __i to sing.  
(b) Susani wants __i to kiss Jack.  
(c) *Susani wants Jack to kiss __i.
2.1 Grammatical functions in the typological perspective

(d) Susan wants to be kissed by Jack.

Example 2.1c is ungrammatical because it is the P argument that is the controlled argument in the complement. Instead a passive construction must be used in the complement so that the controlled argument is realized as S, such as in Example 2.1d. The S and A arguments therefore constitute the alignment set that makes up the traditional subject grammatical function, whereas the P argument constitutes the direct object grammatical function.

But languages differ with respect to the type of alignment sets they possess. In ergative languages, for instance, the grammatical encoding of core arguments instead align the S and P arguments into a set that is contrasted against the A argument (e.g., Dixon 1994). Many languages also have more than one alignment set. In Nepali, for example, verb agreement follows accusative alignment whereas case marking is based upon ergative alignment (Bickel 2010), and in Jacaltec, the pivot of various constructions operate on the basis of five different alignment sets (Van Valin 1981; Van Valin & LaPolla 1997:284-285). Grammatical functions are therefore ultimately construction-specific (Bickel 2010; Van Valin 1981; Van Valin & LaPolla 1997:282-285). The fact that alignment patterns vary so much across and, in some cases even, within languages, makes it difficult to consider the traditional notions of ‘subject’ and ‘direct object’ as universal categories. In this dissertation, however, I use ‘subject’, on the one hand, and ‘direct object’, or simply ‘object’, on the other, to exclusively refer to A- and P-arguments of transitive sentences.

Following Foley (2007) and Andrews (2007), among others, I further assume that grammatical functions are limited to two functions: they either express the participant roles of the argument NPs or the pragmatic status of the arguments. Languages differ with regard to whether their grammatical functions primarily concern role semantic properties, discourse pragmatic properties, or a combination of the two. In English and Swedish, both role-semantic and discourse-pragmatic properties are of importance. In many languages, the grammatical encoding of grammatical functions is also conditioned or restricted by semantic and referential properties of the NP arguments. These properties, in turn, relate to the role-semantic and discourse-pragmatic status of the arguments, and their influence on the encoding of grammatical functions is therefore functionally motivated. In the following, I discuss grammatical functions with respect to participant roles, on the one hand, and discourse pragmatic properties, on the other.

2.1.1. Participant roles

Grammatical functions express the participant roles of the NP arguments in transitive sentences. Participant roles refer to the kind of involvement that the NP argument refersents of a transitive event have. For example, in the sentence ‘Floyd broke the glass’, the subject ‘Floyd’ refers to the participant responsible for the breaking and the direct object ‘the glass’ to the thing that was broken. The degree to which the participant roles are associated with agent or patient properties depend on the kind of event that is expressed by the main verb. Participant roles can be seen as the set of semantic properties that are shared by one of the arguments of a group of verbs (e.g. Dowty 1991; Primus 2006). For example, the subjects of the predicates ‘x murders y’, ‘x nominates y’ and ‘x interrogates y’ all share the property that x does a volitional act. In any given event, the participants
will be differentiated from each other in terms of possessing the most agent and patient properties, respectively. Participant roles can therefore be subsumed under two general categories, the Actor and the Undergoer role (referred to as, e.g., protoroles Ackerman and Moore 2001; Dowty 1991; Primus 2006, macroroles Foley and Valin 1984; Valin 2005; Valin and LaPolla 1997; hyperroles Kibrik 1997, or generalized semantic roles Bickel 2010; Bornkessel and Schlesewsky 2006; Bornkessel-Schlesewsky and Schlesewsky 2009c). The extent to which an NP argument functions as the Actor or the Undergoer depends on the number of agent or patient properties that the verb at hand assigns to that argument. Proto-role membership is therefore a matter of degree. In a transitive sentence, the Actor role is expressed by the subject argument, and the Undergoer role by the object argument.

Prototypical Actors are volitional, sentient and/or causers / causes of events. Participants that possess such properties tend to be human or at least animate. Volitional and experiencer verbs even require an animate or human Actor argument. Undergoers, on the other hand, do not require these properties to the same extent and therefore generally do not need to be animate. Animate and human referents are therefore more likely to function as Actor participants than inanimates (Dahl 2008; Dixon 1994:84; Naess 2007:180-181; Valin and LaPolla 1997:305). The relationship between proto-roles and animacy results in a correlation between grammatical functions and animacy: subjects are more frequently animate than objects because subjects express the Actor role of transitive events, and objects express the Undergoer role of such events.

2.1.2. Discourse pragmatic properties

Grammatical functions also serve to determine the prominence of the arguments in terms of their information and discourse status. The information conveyed by individual sentences in natural discourse is pragmatically structured in a way that accommodates the understanding of the addressees (Chafe 1976; Erteschik-Shir 2007:3-4; Foley 2007; Vallduví and Engdahl 1996). Individual sentences are typically about some entity that is presupposed and therefore assumed to be known by the addressees. This entity is referred to by the topic NP of the sentence. The sentence at hand expresses some information, a comment, about this entity (e.g., Erteschik-Shir 2007; Foley 2007; Gundel & Fretheim 2004; Krifka 2007; Lambrecht 1994; Vallduví & Engdahl 1996). Most sentences further contain some new information that is provided against a background of presupposed information that is assumed to be known by the addressees. This new information is called the focus (Foley 2007; Lambrecht 1994:213) of the sentence. Individual sentences therefore contain both a topic structure and a focus structure. Most commonly, the focus of the sentence is part of or makes up the whole comment. Topical arguments most commonly refer to entities that have been introduced into the discourse at an earlier stage (Ariel 1990; Erteschik-Shir 2007:20; Gundel and Fretheim 2004; Gundel, Hedberg, and Zacharski 1993; Lambrecht 1994:166). Topical referents therefore tend to be maintained through longer stretches of discourse through the use of anaphoric expressions (i.e., topic-chaining or topic-continuity, see Engdahl and Lindahl 2014; Erteschik-Shir 2007:44-45; Givón 1983, and Example 2.2 below).

Although topical arguments most frequently refer to presupposed entities that have
been introduced into the discourse at an earlier stage, in a few cases, the topic of the sentence provides new information. In such instances, topic and focus coincide (see Lambrecht 1994:213 for an example). It is therefore useful to distinguish between sentence topics, topics of individual sentences, on the one hand, and discourse topics, topics in longer stretches of discourse, on the other: Only the former can in some instances be discourse new, whereas the latter, by definition, are given and presupposed in the discourse.

In syntactically accusative languages such as English and Swedish, the sentence topic of a transitive sentence is prototypically expressed with the pivot argument, that is, the subject (e.g., Erteschik-Shir 2007; Foley 2007; Lambrecht 1994). In an unmarked, transitive sentence, the subject therefore not only refers to the Actor participant of the event, but also by default expresses the sentence topic. Pivots in languages such as English and Swedish can be seen as ‘syntacticized topics’ (Foley 2007:417) that serve to track topical referents throughout the discourse (Van Valin & LaPolla 1997:285-287). If some NP argument other than the subject is to be realized as the sentence topic, an alternative construction (e.g., topicalization, left dislocation or passivization, see Foley 2007) needs to be used. The passive construction allows for the promotion of non-pivot arguments to pivot status (Foley 2007; Van Valin & LaPolla 1997:294), thereby realizing the Undergoer argument as sentence topic. Thus in a multi-clause sentence such as Example 2.2, the topic referent of the NP ‘the man’ is maintained in the conjoined clauses by virtue of being realized as pivot, independent of its semantic role:

\[(2.2) \text{The man}_1 \text{ shot the victim and } \varnothing_1 \text{ ran away, but } \varnothing_1 \text{ was caught by the police on the run.}\]

The fact that the subject is the unmarked choice for expressing the sentence topic seems to be functionally motivated. Actors are more likely to be topical and more discourse prominent than Undergoers, which, on the other hand, more commonly are part of the focus and introduce new referents into the discourse (e.g., Du Bois 2003a; Erteschik-Shir 2007:44; Lambrecht 1994:262, and see also Cooreman 1988 for evidence from an ergative language). The Actor participant therefore tends to be the discourse topic, and it is therefore functionally motivated to collapse these functions in unmarked transitive sentences.

Whereas sentence topics most commonly refer to highly discourse prominent entities, arguments that are part of the sentence focus, on the other hand, often introduce new referents into the discourse (e.g., Erteschik-Shir 2007:27ff; Lambrecht 1994:262). There is therefore a correlation between the pragmatic function of arguments (i.e., topic or focus) and their discourse prominence in terms of givenness, that is, the degree to which the argument referents are given and accessible in the discourse model (Ariel 1990; Gundel & Fretheim 2004; Gundel et al. 1993; Vallduví & Engdahl 1996). Further, the forms of referring expressions correspond to different degrees of givenness or accessibility, forming a hierarchy from zero anaphoric to indefinite NPs (e.g., Ariel 1990:69ff; Givón 1983; Gundel et al. 1993; Lambrecht 1994:105ff). There is therefore a correlation between the form of a referential expression and the givenness/accessibility of its referent in the discourse, as estimated on the basis of, for example, the proximity to the previous mention of that referent (i.e., referential distance) (see Givón 1983, and the studies in that volume). By extension, there is also a corresponding correlation between grammatical functions and
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the NP forms: subjects are more frequently definite and pronominal than objects, because subjects tend to be topical and therefore more discourse prominent than objects.

2.2. Prominence properties and grammatical functions

As discussed in the previous section, because grammatical functions are concerned with the role semantic and information structural functions of the NP arguments, they correlate with semantic and referential properties that are related to these functions. Since subjects express the Actor role and are more commonly topical than objects, subjects tend to be more prominent than objects in terms of animacy, referentiality and definiteness (Bornkessel-Schlesewsky and Schlesewsky 2009c; Comrie 1989:128; de Hoop and Malchukov 2008; Dixon 1994:83-85). In other words, subjects tend to possess properties at the higher ends of the animacy, person, referentiality and definiteness hierarchies (Croft 2003:130 on the basis of the nominal hierarchy first introduced by Silverstein 1976), whereas objects commonly have properties at the lower ends:

- Animacy: human < animate < inanimate
- Person: first, second < third
- Referentiality: pronoun < proper name < common noun
- Definiteness: definite < specific indefinite < unspecific indefinite

These correlations manifest themselves in the grammatical encoding of grammatical functions across languages. In many languages, the morphological marking or syntactic behavior of NP arguments is influenced by whether one or both arguments are aprototypical (i.e., typologically marked in the sense of Croft 2003) in terms of some prominence property or set of properties, given their functions. The correlations are also reflected in the discourse distributions of prominence properties across NP arguments in individual languages. In unmarked transitive constructions, subjects occur more frequently with properties at the high end of the prominence hierarchies, and objects more frequently with properties at the low end. In alternative constructions such as object topicalization constructions, objects instead tend to be high in prominence. This is because such constructions are used to signal that the pragmatic status of the NP arguments is marked somehow, such as when the Undergoer argument is the discourse topic.

In the following section (Section 2.2.1), I present examples from some languages of how the encoding of grammatical functions is conditioned by argument prominence properties. In section (Section 2.2.2), I then give an overview of corpus studies that have investigated relationships between grammatical functions and argument prominence in the discourse distributions of individual languages. In Section 2.2.3, I present results of studies that have investigated the discourse distribution of prominence properties in marked constructions, such as passives or object-topicalization constructions, and that show that the Undergoer arguments of such constructions tend to be high in discourse prominence.
2.2.1. Prominence properties and grammatical encoding

In many languages, the grammatical encoding of grammatical functions is conditioned by the prominence properties of the NP arguments. Overt morphological object marking is, for example, often restricted to objects that are highly ranked on a prominence hierarchy, and therefore marked in terms of prominence (i.e., differential object marking and differential object indexation, see Aissen 2003; Iemmolo 2010a, 2010b; Malchukov 2008; Malchukov & de Swart 2009). In Tigrinya, only definite objects are overtly case marked and indexed on the verb, as shown in 2.3a in comparison to 2.3b (Kifle 2007):

(2.3) Tigrinya (Afro-Asiatic, Semitic, Ethiopian) (Kifle 2007)

(a) ɣiːt-a lami n-āt-i ʔiːrəjə
DET-3SG.F cow.SG.F OBJ-DET-3SG.M bull.SG.M
riʔiy-a-to
see.PRF-3SG.F-OBJ.3SG.M
‘The cow saw the bull’

(b) lami ʔiːrəjə riʔiy-a
cow.SG.F bull.SG.M see.PRF-3SG.F
‘A cow saw a bull’

In languages with splits between alignment sets, arguments that are marked in terms of prominence are often mapped into a structurally marked alignment set (Bickel and Witzlack-Makarevich 2008; Dixon 1994:58-63; Silverstein 1976) such as the accusative or ergative set: Whereas low prominent subjects display ergative alignment (rather than nominative), highly prominent objects show accusative alignment (rather than absolutive). In Dyirbal, such a split is conditioned by the person hierarchy such that 1st and 2nd person pronouns pattern accusatively, and all other arguments pattern ergatively (Dixon 1994:10-14):

(2.4) Dyirbal (Australian, Pama-Nyungan, Dyirbalic) (Dixon 1994:10-14)

(a) ɣaːbu-rjgu ʔu-ra-n
father.ABS mother-ERG see-PRS
‘Mother saw father’

(b) ʔu-na nyuːra-na ʔu-ra-n
1PL.NOM 2PL-ACC 2PL-ERG see-PRS
‘We saw you’

Subjects that consist of 3rd person pronouns, as in 2.4a, and 1st and 2nd person objects, as in 2.4b, are therefore structurally marked: They occupy the second argument position and are overtly case marked in the ergative and accusative, respectively. The opposite situation holds for 1st and 2nd person subjects, on the one hand, and 3rd person objects, on the other. Arguments that are marked in terms of prominence are therefore also overtly marked in such languages.

The encoding of grammatical functions can also depend on whether the relative prominence of the arguments is marked such that the object outranks the subject on a prominence hierarchy, rather than on the prominence of individual arguments. For instance, in
languages such as Fore (Scott 1986) and Awtuw (Feldman 1986), overt case marking is conditioned by the relative positioning of the arguments on the animacy hierarchy (see Silverstein 1976 on local versus global case marking). In Fore, the subject receives ergative marking only when it is less animate than the object (Scott 1986):

(2.5) Fore (Trans-New Guinea, Kainantu-Goroka, Gorokan) (Scott 1986)
   (a) Yaga: wá aegüye
       pig man 3SG-hit-3SG
       ‘The man attacks the pig’
   (b) Yaga:-ma wá aegüye
       pig-ERG man 3SG-hit-3SG
       ‘The pig attacks the man’

Thus in 2.5a, the human NP ‘wá’ (‘man’) has to be interpreted as the Actor, independent of the word order of the arguments. The less animate NP ‘yaga:’ (‘pig’) can only function as the Actor when it bears ergative case marking, as in 2.5b. Without overt case marking, the relative animacy of the arguments is therefore decisive in determining the argument roles. A similar situation is found in Lakhota, in which the word order of NP arguments only is of importance when both arguments are animate. When the Actor is animate and the Undergoer inanimate, the Actor can either precede (as in 2.6a) or follow (as in 2.6b) the Undergoer (Van Valin 1985):

(2.6) Lakhota (Siouan-Catawban, Mississippi Valley Siouan, Dakota) (Van Valin 1985)
   (a) Wičháša ki ix٢э́ óta wą-∅-yąke
       man DEF rock many STEM-3SG.A-see
       ‘The man saw many rocks’
   (b) Ix٢э́ óta wičháša ki wą-∅-yąke
       rock many man DEF STEM-3SG.A-see
       ‘The man saw many rocks’

The relative prominence of the arguments is also a determining factor in languages with inverse marking. In such languages, an inverse suffix on the verb is used to signal that ‘the direction of action is unusual’ (Mithun 1999:224) in the sense that the object outranks the subject in terms of prominence (Croft 2003:171; Dahl 2000). In Ojibwa, the verb takes the direct suffix when the subject outranks the object in terms of pronominality or topicality (i.e., 3rd person proximative, see Mithun 1999:222-223) as expected (Example 2.7a). The inverse suffix is used in the opposite situation where the object is the higher ranking argument (Example 2.7b) (Mithun 1999:224):
2.2 Prominence properties and grammatical functions

Finally, there are languages in which a transitive construction can only be used when the subject outranks or is equally ranked with the object on a prominence hierarchy. In Navajo (Dahl & Fraurud 1996) and Lakhota (Van Valin 1985) this restriction is conditioned by the animacy hierarchy. In Lakhota, inanimate Actors can only be realized as oblique arguments, marked with an instrumental postposition (Van Valin 1985:367):

(2.8) Lakhota (Siouan-Catawban, Mississippi Valley Siouan, Dakota) (Van Valin 1985:367)

\[
\text{Ixé } \text{ki } \text{hená } \text{μ } \text{hokšila } \text{wq } a-∅-∅-phé }
\]
rock DEF those INS boy INDF STEM-3SG.P-3SG.A-hit

‘Those rocks hit a boy’ / ‘He hit a boy with those rocks’ / ‘A boy hit him with those rocks’

In Lummi (Bresnan, Dingare, & Branning 2001) and Picurìs (Mithun 1999:227), person is the determining factor: In Picuris, the passive construction must be used when the object outranks the subject on the person hierarchy (as in 2.9a), but not when the subject is equal to or higher than the object on the hierarchy (as in 2.9b) (Zaharlick 1982):

(2.9) Picuris (Kiowa-Tanoan, Tanoan) (Zaharlick 1982)

(a) \text{ta-ṃn-miaʔqn } \text{sənene-pa}
1SG-see-PASS-PST man-OBL
‘The man saw me’

(b) \text{sənene-pa } \text{ti-ṃn-ʔqn}
man 1SG-see-PST
‘I saw the man’

2.2.2. Prominence properties in language use

Plenty of corpus studies also show that grammatical functions correlate with prominence properties in the frequency distributions of language use within individual languages. Subjects with properties at the high end of the prominence hierarchies are preferred over subjects with properties at the low ends at the hierarchies, and objects with properties at the low ends are preferred over objects at the high ends.

Whereas subjects most frequently are high in animacy, objects are more frequently inanimate, and sentences in which the object outranks the subject in animacy are extremely rare. Dahl and Fraurud (1996) and Dahl (2000) found a strong relationship
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between argument functions and animacy in both spoken and written Swedish discourse. Subjects were most frequently animate, both in written and spoken spoken discourse, and animate objects were highly dispreferred. Sentences in which the object outranked the subject in animacy was extremely rare. The grammaticalized constraints of languages in which the subject is required to be animate (e.g., Lakhota) or at least not less animate than the object (e.g., Fore) are therefore ‘approximated statistically’ (Dahl & Fraurud 1996:54) in Swedish discourse. Similar results have been found in, for instance, written German (Kempen & Harbusch 2004), spoken Dutch (Bouma 2008), and written Norwegian (Ovrelid 2004).

Many studies have further found strong relationships between discourse prominence (i.e., in terms of person, referentiality or definiteness / givenness) and grammatical functions. Bouma (2008) found it preferable for subjects in transitive sentences of spoken Dutch to be highly discourse prominent, whereas are more frequently low in discourse prominence. He also found transitive sentences with the object outranking the subject in discourse prominence to be extremely infrequent. Similar results were again found by Ovrelid (2004) for written Norwegian: Subjects were definite more frequently than objects, and were more or equally as discourse prominent as the object of the same sentence in a majority of all cases.

Other studies have also found a strong tendency to avoid new (and therefore lexical) subjects in the natural discourse of various languages (see, e.g., Ashby and Bentivoglio 1993 for French and Spanish; Matsumoto 2000 for Japanese; Du Bois 1987 for Sapulteko; England 1988 for Mam; Payne 1987 for Papago; Scancarelli 1985 for Chamorro, and Du Bois 2003b for a review). New discourse referents are more frequently realized as objects. For instance, Du Bois (1987) investigated distributional differences in the referential status and givenness of core arguments in narratives in Sapulteko. Almost all subjects in the corpus were realized as pronominal or zero anaphoric (i.e., cross-referenced at the verb), reflecting their high preponderance for being given. Almost half of the objects, on the other hand, were realized as lexical NPs, and about a quarter of them were classified as new.

Dahl (2000) found subjects in transitive sentences in both spoken and written Swedish to consist of 1st and 2nd personal pronouns in more than half of all sentences. On the other hand, 1st and 2nd person objects were highly infrequent. In particular, Dahl (2000) found 1st and 2nd person subjects to be highly frequent in sentences with verbs of perception and cognition. He suggested that since such verbs tend to express private knowledge and subjective experiences (e.g. verbs such as ‘know’, ‘think’, ‘see’ or ‘feel’), they are more likely to be used from the perspective of the speaker. They therefore more frequently occur with subjects that are 1st and 2nd personal pronouns, that is, that are speech act participants and therefore take on the perspective of the interlocutors.

2.2.3. Discourse prominence and marked constructions

Results such as those presented in the previous section show that there is also a correlation between grammatical functions and prominence properties in the frequency distributions of language use within languages. It is preferable for subjects to be high in prominence and objects more frequently lower than subjects in prominence. This correlation stems from
2.2 Prominence properties and grammatical functions

the fact that Actor referents most often are highly discourse prominent. However, in some cases the relationship between the participant role of the argument and its discourse status is not met, such as when the Undergoer is the discourse topic, is in contrastive focus, or when the Actor is new (which can be emphasized by topicalization of the object). In such cases, a marked construction or word order (such as passivization, object topicalization, left dislocation or scrambling) is often used to signal the aprototypical information status of the referents (Foley 2007). This is also reflected in the discourse distribution of prominence properties across subjects and objects in such marked constructions.

For example, several studies have shown that passive constructions in English are more frequent when the Undergoer outranks the Actor on the person and referentiality hierarchies (e.g., Dingare 2001; Estival & Myhill 1988; Svartvik 1966). This pattern reflects the grammatical constraint of languages that require passivization (e.g. Picuris) or a structurally marked transitive construction (e.g., Ojibwa) when the object outranks the subject in person or referentiality. On the basis of such observations, Bresnan et al. (2001) have argued that constraints that are grammaticalized in some languages (i.e., ‘hard constraints’) are reflected in statistical tendencies in other languages (i.e., ‘soft constraints’). In their view, grammars constitute ‘a continuum of conventionalization’ (Bresnan et al. 2001:14) that span from usage preferences to categorical grammatical constraints, in line with the assumptions of this dissertation.

Other studies have further shown that the ordering of subjects and objects is affected by their relative prominence in terms of person or referentiality. For instance, the relative ordering of subjects and objects in the middlefield in German and Dutch verb final clauses has been assumed to be influenced by discourse prominence such that NP arguments that are pronominal or definite are more prone to be ordered before arguments that are lexical or indefinite (Bouma 2008; Uszkoreit 1986:53-57). In line with this, Kempen and Harbusch (2004) found subjects to always precede lexical objects in transitive complement clauses in written German, but pronominal objects to precede lexical subjects in about a third of all cases in their corpus. In the same type of German sentences, Bader and Häussler (2010) found definite objects to more frequently precede the subject when it was indefinite in comparison to when it was definite. In other words, when the object is marked in terms of being more discourse prominent than the subject, there is a tendency to signal this by reversing the ordering of the subject and the object in the middlefield.

Several studies have further found that the positioning of arguments in the sentence-initial position is related to discourse prominence. Bouma (2008) found the sentence-initial position of mono- and ditransitive sentences in spoken Dutch to be strongly preferred for discourse prominent arguments, independent of their function. More than two-thirds of all pronominal NP arguments were positioned sentences initially, followed by about half of all definite arguments, but only about one-fifth of the indefinite arguments. Almost all objects in object-initial sentences were pronominal or definite, whereas only about half of the objects in subject-initial sentences were pronominal or definite. In Weber and Müller’s (2004)’s corpus data of transitive main clauses in spoken German, objects are significantly more often given and definite in the initial position than in the final position1. Similar

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1In all, 44.1% of all initial objects are given and 60.8% are new, in comparison to 35.7% and 48.6% of the objects positioned in their canonical positions, both p:s < .01. Weber and Müller (2004) did not present this analysis themselves, but it was easily done on the basis of the data they present.
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results were found by Øvrelid (2004) in written Norwegian. She found objects to outrank subjects in definiteness in about half of all object-initial sentences, in comparison to one-tenth in her whole corpus. Snider and Zaenen (2006) found both topicalized and left-dislocated NP arguments in spoken English to more frequently be discourse prominent than arguments positioned in their canonical positions. These results are in line with the assumption that an object-initial word order, scrambling or left dislocation is used to signal that the object is marked in terms of being highly discourse prominent.

However, although the object generally is highly discourse prominent in object-initial sentences, there is some evidence suggesting that the preference for the subject to outrank the object in discourse prominence is maintained. As mentioned above, Bouma (2008) found objects outranking the subject in discourse prominence to be extremely infrequent. Using logistic regression modeling (see Chapter 5), he could show that both the discourse prominence of the object as well as the relative difference in discourse prominence between the subject and the object, with the former outranking the latter in prominence, significantly predicts object-before-subject word ordering. That is, the object-initial word order was found to be preferred in cases where the object was highly prominent but equally or not as prominent as the subject. Results such as these show that discourse prominent objects are preferably positioned sentence-initially but also that the subject of such constructions is often highly discourse prominent and therefore highly predictable.

In short, there is much evidence from language use in different languages that indicates that marked constructions or word orderings (i.e., passivization, object topicalization, left dislocation or scrambling) are used to signal that the Undergoer of an transitive event is high in discourse prominence.

2.3. Competing motivations and grammatical functions

The assumptions and empirical findings discussed in the previous section can be summarized as follows. Grammatical functions serve to express role-semantic properties of the argument referents as well as their pragmatic status. In pivot languages with voice constructions such as English and Swedish, grammatical functions of transitive sentences are associated with either the Actor or the Undergoer role. In the unmarked case, that is, in prototypical transitive sentences, the Actor argument is also the sentence topic. If instead the Undergoer argument is to function as the topic, a marked construction such as the passive or the object-topicalization construction must be used.

Because grammatical functions are concerned with the role-semantic and pragmatic functions of the NP arguments, they correlate with semantic and referential properties that are related to these functions. Prototypical Actors are in control, volitional and sentient, and predicates that assign such properties therefore require an animate or human Actor argument. Undergoers do not require these properties to the same extent and therefore generally do not need to be animate. Actor participants, and by extension subject arguments, are therefore more frequently animate and human than Undergoer participants, that is, object arguments in regular transitive sentences (Dahl 2008; Dixon 1994:84; Naess 2007:180-181; Van Valin and LaPolla 1997:305). Subjects are also more likely to be topical and more discourse prominent than objects, which on the other hand are more commonly part of the focus and introduce new referents into the discourse (e.g.,
Du Bois 2003a; Erteschik-Shir 2007:44; Lambrecht 1994:262). Subjects are therefore more likely to be pronominal and definite by virtue of their high degree of givenness: they are either anaphoric or deictic, or assumed to be known by the addressee. Subjects are also more likely to be expressed with 1st and 2nd person pronouns than objects, because they more frequently refer to the participants in the conversation. This is because the information structuring in natural conversations tends to be done from the perspective of the speakers (Dahl 2000; DeLancey 1981; Dixon 1994:84): We talk about our own thoughts, feelings or actions to a greater extent than those of others. The speaker or the addressee is therefore often the discourse topic of the conversation and is consequently often expressed with the subject argument.

The correlations between grammatical functions and argument prominence properties are reflected both in the grammatical encoding of grammatical functions across languages, as well as in the discourse distributions of prominence properties across subjects and objects in language use. Across languages, the encoding of grammatical functions is conditioned or restricted by whether one or both of the arguments are aprototypical in terms of referential properties, given their functions. Transitive constructions in which the subject is either low in prominence or is outranked by the object on some prominence hierarchy are in some languages either structurally marked in some way (e.g., Fore, see Example 2.5) or are outright ungrammatical in others (e.g., Lakhota, see Example 2.8). Within individual languages, subject arguments more frequently possess properties at the higher end of the prominence hierarchies than object arguments. Subjects are for example more frequently animate and definite than objects, and prototypical transitive sentences in which the object outranks the subject in animacy or definiteness are extremely rare.

Taken together, these observations suggest that both prominence-based and morphosyntactic information work as cues to the grammatical functions of NP arguments in transitive sentences. The interplay and availability of these cues seems to some extent to be functionally motivated. As evidenced by, for instance, differential object marking patterns, morphosyntactic cues are more frequently required when they serve to unambiguously differentiate between the argument functions, but are, on the other hand, less frequently required when the functions can be determined by prominence information, and therefore are redundant. These patterns are further in line with the more general idea that language structure is in part shaped or at least constrained by competing cognitive constraints that underlie efficient language use and communication (e.g. Beckner et al. 2009; Chater & Christiansen 2010; Christiansen & Chater 2008; Gibson et al. 2013; Hawkins 2003, 2007; Ibbotson 2013; Jaeger 2013; Jaeger & Tily 2011; MacDonald 2013; Piantadosi, Tily, & Gibson 2012). More specifically, the encoding of transitive events in language use seems to be influenced by the competing motivations of keeping the message length short by avoiding redundant morphosyntactic information, while at the same time ensuring that the message contains enough information in order to be unambiguous. The use of overt morphosyntactic information regarding the argument functions entails that the message must contain additional information, and therefore take up a longer time duration of the speech signal. The exclusion of redundant morphosyntactic information is therefore economically motivated (e.g., Haiman 1983): it allows for a shortening of the message length, thereby reducing the amount of information that needs to be processed during language comprehension, as well as reducing the articulatory effort during language
production (e.g., Hawkins 2003; Lindblom 1990:38). At the same time, the message must contain enough information for the listener to be able to unambiguously determine the argument functions. It is therefore motivated to use overt morphosyntactic information regarding the argument functions when they cannot be readily determined on the basis of other information, by keeping the form-to-meaning relationships isomorphic (i.e., one unique form for each function, see Haiman 1980), a motivation that often goes under the more general term *iconicity* or the *iconic motivation* (Croft 2003:102-103; Haiman 1980, 1983).

### 2.3.1. Competing motivations in language use

Several corpus-based as well as experimental studies provide evidence for the hypothesis that the encoding of transitive events is influenced by a competition between economy and iconicity. For instance, there is some evidence that the animacy difference between subjects and objects is more pronounced in object-initial sentences. This indicates that the object-initial word order is preferred when the argument functions can be inferred on the basis of animacy. In Bouma’s (2008) data, objects are somewhat more frequently inanimate in object-initial sentences than in subject-initial sentences. Subjects, on the other hand, are somewhat more frequently animate in object-initial sentences than in subject-initial sentences. Using regression modeling, Bouma (2008) also found that both the animacy of the object as well as the relative animacy between the subject and the object (the former again outranking the latter) significantly predicted the object-initial word order. Similarly, Snider and Zaenen (2006) found inanimacy of the object to be predictive of object topicalization in spoken English. Bader and Häussler (2010) found objects to be more frequently inanimate and subjects to be more often animate in object-initial versus subject-initial sentences in written German main clauses, and Øvrelid (2004) found similar results in her corpus of written Norwegian. The results of these studies indicate that animacy can function as a robust cue to argument interpretation, and, further, that speakers are more prone to using the object-initial word order in cases where the argument functions can be reliably determined on the basis of animacy (cf. Bouma 2008:256-257).

There is also some evidence that speakers are more prone to using morphological information regarding the argument functions in situations where they cannot readily be inferred on the basis of referential or semantic information. In Korean, overt realization of morphological case marking is optional in colloquial speech (H. Lee 2006). Taking advantage of this fact, H. Lee (2006) investigated whether prominence in terms of animacy, person and referentiality correlated with the preponderance for omission of case marking (i.e., *case ellipsis*) in spoken Korean. Strikingly, the frequency of case omission was found to correlate with the extent to which both subjects and objects were prototypical in prominence, given their functions. That is, whereas nominative case omission occurred more frequently on subjects high in animacy, person or referentiality, accusative case omission was more frequent for objects that were low in animacy, person and referentiality. Importantly, this pattern of language use in Korean mirrors the differential case marking

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2 In all, 95% of all initial objects are inanimate in comparison to 87.6% of all canonically positioned objects. Subjects, on the other hand, are animate in 99.6% of all object-initial sentences, but in 95.3% of the subject-initial sentences. Both of these differences are significant (both $p < .0001$). Again, Bouma (2008) himself did not provide this analysis, but it is easily performed on the basis of his data.
patterns observed across languages. This is thus yet another example where statistical tendencies or ‘soft constraints’ within a particular language (e.g., the preference for passivization when the Undergoer outranks the Actor in referentiality in English) reflect the grammatical restrictions or ‘hard constraints’ of other languages (e.g., the requirement of passivization when the Actor is outranked in referentiality in languages such as Picuris) (see Section 2.2.3).

Similar results were recently obtained experimentally by Kurumada and Jaeger (2015). In three sentence recall experiments, they investigated whether Japanese speakers’ choice of overt case marking was influenced by the availability of disambiguating semantic and plausibility information. As in Korean, case marking is optional in conversational Japanese and is often omitted in causal speech (Kurumada & Jaeger 2015). In the experiments, participants heard pairs of transitive sentences with SOV word order that they were prompted to recall. Participants were more prone to overtly express object case marking during recall in sentences in which both arguments were animate (Experiment 1) as well as in semantically implausible sentences (in sentences such as ‘The criminal arrested the police officer’, in Experiments 2 and 3), independently of whether case marking had been overtly expressed in the stimulus sentences. In other words, participants were more prone to use overt object case marking when the function of the object was harder to infer on the basis of animacy or plausibility information. Kurumada and Jaeger (2015) interpreted these results to reflect ‘a trade-off between production ease and the goal to be understood’ (p. 13) during language production. In other words, language production is influenced by a competition between economy (i.e., minimizing the message form by omitting the case marker) and iconicity (i.e., unambiguously expressing the argument function by using the case marker).

Generally, all of these results indicate that speakers and writers are more prone to using unambiguous information in the encoding of transitive events that are potentially ambiguous. Speakers and writers seem to be inclined towards balancing their production efforts by avoiding redundant information in order to reduce production and processing costs, while at the same time providing unambiguous information in order to facilitate comprehension (a view commonly referred to as ambiguity avoidance, see, for instance, Hawkins 2003; Haywood, Pickering, and Branigan 2005; MacDonald 2013; Snedeker and Trueswell 2003; Temperley 2003).

2.3.2. Competing motivations in language learning

Fedzechkina and colleagues have found compelling evidence that language learning of transitive sentences is also influenced by a competition between economy and iconicity, thereby providing some first insights into the mechanisms of how a competition between these motivations helps reshape language structure (Fedzechkina, Jaeger, & Newport 2011, 2013, 2012). In a series of studies using miniature artificial language learning (see Fedzechkina, Newport, and Jaeger in press for an overview), they investigated how the competition between functional pressures of production ease (i.e., economy) and informativity (i.e.,
iconicity) shapes the encoding of argument structure over the course of learning\(^3\). In their experiments, participants learned and were subsequently tested on transitive sentences of an artificial language that varied across groups of learners with respect to some property of interest. Fedzechkina et al. (2011) found that language learners of a language with varying word order were more prone to regularize the word order over the course of learning when the language lacked case marking in comparison to when it contained case markers. In other words, when an unambiguous cue to the argument functions was unavailable, learners showed a stronger tendency to make the word order of the language more rigid in order to reduce its inherent uncertainty regarding the argument functions. In a subsequent study, Fedzechkina et al. (2012) used a language with varying word order, but that also used both animate and inanimate objects, as well as optional case marking that was equally probable for all objects, independent of their animacy. Case marking was used more frequently on animate (and therefore ambiguous) objects than on inanimate (and therefore unambiguous) objects, as well as in the less frequent OSV sentences than in the more frequent SOV sentences. In other words, learners showed a stronger tendency to provide unambiguous information such as case marking when the uncertainty about the argument functions was higher. Fedzechkina et al. (2013) and Fedzechkina, Newport, and Jaeger (2016) used two variants of a language with animate nouns only and optional case marking on the object. These differed with respect to whether the word order was fixed (SOV only) or flexible (SOV or OSV). They found that learners of the fixed word order variant used less case marking, but learners of the flexible word order variant instead used more case marking. In other words, learners seem to be biased towards balancing the information provided by the word order and case marking cues regarding the argument functions. When the word order provides reliable information about the argument functions, case marking becomes redundant and is therefore used less frequently. When the word order is unreliable, on the other hand, case marking is of greater importance and therefore used more often.

These results indicate that not only language use, but also language learning is shaped by the competing pressures of production ease / economy, on the one hand, and informativity / iconicity, on the other. If learners were motivated by production ease only, they would not display an increased use of unambiguous information (such as word order regularization or case marking) in potentially ambiguous situations. If they were motivated by informativity only, on the other hand, the change in the use of case marking would not depend on the extent to which other cues (i.e., animacy or fixed word order) were available. Learners would instead generalize case marking to all sentences.

Overall, the studies presented in this section provide evidence for the view that the grammatical encoding of transitive events in language use is influenced by the prominence of the participants, and that it in part is shaped by competing functional motivations such as production ease / economy, on the one hand, and informativity / iconicity, on the other. The studies of Fedzechkina and colleagues further indicate that language learning is also influenced by such a competition, thereby providing some insights into how functional pressures can reshape language structure over the course of learning across generations.

\(^3\)As noticed by a reviewer of an earlier draft of this chapter, it should be pointed out that the miniature language learning paradigm is likely to resemble second language learning. Second language learning most likely differs from first language acquisition with respect to its impact in language evolution.
2.4. Argument interpretation in language comprehension

As discussed in the previous section, a multitude of both corpus-based and experimental studies indicate that the grammatical encoding of transitive events is influenced by argument prominence in terms of a trade-off between production ease and informativity: morphosyntactic cues regarding the argument functions are more frequently resorted to in cases where prominence cues are not readily available. For instance, across languages, animate objects are more frequently case marked than inanimate ones. There is also some evidence that language learning, and therefore, presumably, language change across generations of learners, is influenced by this trade-off as well. For example, language learners appear to be more prone towards word order regularization when the grammatical functions cannot easily be determined on the basis of other information types (such as case marking or animacy). The occurrence and interplay between these information types therefore seem to be influenced by their utility as cues for determining the argument functions, both synchronically (i.e., as seen in the discourse distributions within individual languages) as well as diachronically (i.e., as seen in the encoding of grammatical functions across languages, as well as regularization patterns in artificial language learning). This account is based upon the assumption that prominence information is informative with respect to determining the argument functions. In other words, it assumes that the cognitive processes underlying the comprehension of transitive sentences is influenced by and efficiently makes use of prominence-based information. This section provides an overview of studies that have found evidence for this and present some models of language comprehension that are consistent with this view.

On-line language comprehension is a highly incremental process in the sense that comprehenders aim to maximize their interpretations on the basis of the information available at each successive step in time (Bornkessel & Schlesewsky 2006; Crocker 1994; Hawkins 2003, 2007) as well as generate predictions about upcoming material (e.g., Kuperberg & Jaeger 2016; Kutas, DeLong, & Smith 2011). For instance, Hawkins (2003:51) argues that language comprehension operates on the basis of a maximization principle according to which the set of properties assignable to linguistic items (e.g., semantic and pragmatic functions) are maximized during on-line comprehension. The functions of grammatical functions (e.g., Actor and topic) are therefore assigned to core argument NPs as soon as possible on the basis of the information available, even before the verb is encountered.

Studies from various languages using measurements of event-related brain potentials (ERPs) indicate that the initial NP argument is directly interpreted as the Actor even in the absence of unambiguous information that is provided by, for instance, a subsequent verb or second argument NP (see, e.g., Demiral, Schlesewsky, and Bornkessel-Schlesewsky 2008 for evidence from Turkish; Hörberg et al. 2013 for Swedish; and Wang, Schlesewsky, Bickel, and Bornkessel-Schlesewsky 2009 for Mandarin Chinese). Thus there is overwhelmingly strong evidence for a subject-first preference from a variety of languages, even in ergative ones (Bornkessel-Schlesewsky, Choudhary, Witzlack-Makarevich, & Bickel 2008)4, as well as in languages in which subject drop is very common (Demiral et al. 2008). In the absence of unambiguous information, the initial NP argument is preferably interpreted

4Ergative languages presumably lack the traditional subject category because they lack a \{S, A\} alignment set (see Section 2.1).
as the subject of the sentence, thereby filling the Actor role or being the sole argument of the verb. This preference has been argued to depend on a preference for keeping the NP arguments as distinct as possible (Bornkessel-Schlesewsky & Schlesewsky 2009a), to stem from an asymmetric dependency between Undergoers and Actors (the former being interpretively dependent on the latter, see Section 2.4.3 below) (Hawkins 2007), and to be rooted in a preference for structuring interpretations of actions and events with respect to agents, that is, volitional instigators of actions (Bornkessel-Schlesewsky & Schlesewsky 2014), possibly modeled on the self (Dahl 2008), or, finally, to be based upon a preference for positioning highly predictable and ‘informationally low’ words and constituents early in the sentence, in order to keep the information flow as constant as possible throughout the sentence (Fenk-Oczlon 2001; see also e.g. Jaeger 2010). As will become apparent in Chapters 4 and 6, the subject-first preference is the utmost importance in this dissertation.

Many experimental studies using both offline (i.e., post-presentation judgments, see E. Bates, McNew, MacWhinney, Devescovi, and Smith 1982; and speeded sentence-picture verification tasks, see Kempe and McWhinney 1999; MacWhinney, Bates, and Kliegl 1984) and online measurements (e.g., event-related brain potentials, see Frisch and Schlesewsky 2001, Philipp, Bornkessel-Schlesewsky, Bisang, and Schlesewsky 2008, Roehm, Bornkessel-Schlesewsky, Rösler, and Schlesewsky 2004, Weckerly and Kutas 1999 and Bornkessel-Schlesewsky and Schlesewsky 2009c for a review) have further shown that both morphosyntactic and prominence-based information guide the assignment of functions to core arguments during sentence comprehension. These studies indicate that grammatical function assignment (henceforth GF assignment) initiates directly when an argument is encountered (i.e., on the basis of the subject-preference in the absence of evidence to the contrary). This process draws upon both morphosyntactic and prominence-based information. In the following, I present an overview of studies that have shown that GF assignment is influenced by animacy, on the one hand, and referential properties, on the other.

### 2.4.1. Animacy influences on argument interpretation

A multitude of studies have showed, in particular, the importance of animacy in GF assignment. Some studies have shown, for example, that the comprehension of locally ambiguous reduced relative clauses is facilitated when the initial noun that heads the relative clause is inanimate in comparison to when it is animate. In reduced relative clauses such as 2.10a and 2.10b below, the initial verb ‘examined’ is morphologically ambiguous between a past tense and past participle reading. Under the former reading, the initial NP is interpreted as the subject of an active clause, and is accordingly assigned the Actor role. Under the latter reading, on the other hand, the initial NP is interpreted as the subject of a passivized relative clause, and is therefore assigned the Undergoer role. At the prepositional phrase ‘by the lawyer’, 2.10a and 2.10b are disambiguated toward the latter reading, and the initial interpretation must potentially be revised. In 2.10b, however, the initial noun is inanimate and therefore cannot take on the Actor role. A main clause reading of 2.10b is therefore semantically implausible.
2.4 Argument interpretation in language comprehension

(2.10) (a) The defendant examined by the lawyer turned out to be unreliable.
(b) The evidence examined by the lawyer turned out to be unreliable.
(c) The defendant who was examined by the lawyer turned out to be unreliable.
(d) The evidence that was examined by the lawyer turned out to be unreliable.

In an eye-tracking experiment, Trueswell et al. (1994) found longer reading times at the disambiguating region in locally ambiguous sentences with initial animate nouns such as 2.10a in comparison to locally unambiguous controls such as 2.10c. This indicates that participants were required to revise their initial interpretations towards the relative clause interpretation in 2.10a but not in 2.10c. No reading time differences were found between ambiguous and unambiguous sentences with initial inanimate nouns, such as 2.10b and 2.10d, however, indicating that participants opted for the relative clause reading directly (but see F. Ferreira and Clifton 1986 for results that did not show any differences between animate and inanimate sentences). Using similar sentences, Just and Carpenter (1992) found similar results but for high-span readers only, and Clifton et al. (2003) found faster reading times for both ambiguous and unambiguous sentences with inanimate nouns in comparison to animate nouns. These results indicate that the animacy of the initial noun can guide the interpretation of an ambiguous sentence directly toward the correct reading, at least for proficient readers, or at a minimum facilitate the argument interpretation process.

A multitude of studies using both self-paced reading (e.g., Gennari & MacDonald 2008; Jackson & Roberts 2010; Mak, Vonk, & Schriefers 2002; Mak et al. 2006), eye-tracking (e.g., Traxler, Morris, & Seely 2002; Traxler, Williams, Blozis, & Morris 2005), fMRI (Chen, West, Waters, & Caplan 2006) as well as EEG (Weckerly & Kutas 1999) further indicate that animacy also guides the structural interpretation of unambiguous object relative clauses, and thereby facilitates GF assignment to relative clause argument NPs (Mak et al. 2002, 2006). In particular, Weckerly and Kutas (1999) found a so-called N400 effect for an inanimate (versus animate) sentence-initial noun, which headed a subsequent object relative clause (such as in ‘The movie that the novelist praised...’) and therefore functioned as the (head of) the subject in the matrix clause. This was also the case for an inanimate (versus animate) noun, which functioned as the subject of the object relative clause (such as in ‘The novelist that the movie inspired...’). The N400 effect is a negative shift in the ERP wave with a centro-parietal scalp distribution, peaking around 400 ms after presentation of the critical stimulus item. It is generally assumed to correlate with increased semantic integration costs (e.g., Kutas & Federmeier 2000, 2011), and problems in assigning thematic roles to the NP arguments (e.g., Frenzel et al. 2011; Frenzel, Schlesewsky, & Bornkessel-Schlesewsky 2015; Frisch & Schlesewsky 2005). More recent studies in German (Roehm et al. 2004) and Mandarin Chinese (Philipp et al. 2008) have found a similar effect in main clauses with an object-initial word order. These studies found that an unambiguous inanimate subject that followed an object engendered an N400 effect. These N400 effects have been interpreted to reflect violations of the expectation of an animate and therefore highly prominent subject (Bornkessel-Schlesewsky & Schlesewsky 2009c; Weckerly & Kutas 1999).

More recently, Nieuwland et al. (2013) investigated the interaction between case marking and animacy of the objects in subject-initial transitive sentences in Spanish. Spanish
has differential object marking conditioned by animacy: definite objects that are animate objects take the particle ‘al’, and inanimates take the particle ‘el’. Inanimate objects that were incorrectly marked with ‘al’ engendered an N400 effect in line with the previously mentioned studies. Nieuwland et al. (2013) interpreted this N400 to reflect a violation of the expectation of an animate object, set up by the preceding particle.

Frenzel et al. (2011) investigated the ERP response to case violations at the second NP in English subject-initial sentences that varied with respect to animacy of the initial noun (for example, ‘The pilot took she to paradise’). As predicted, the second NP (‘she’) engendered a *P600* effect, a centro-parietally distributed positive shift in the ERP wave peaking around 600 ms following stimulus presentation. This ERP-component, called the *P600* effect or the syntactic positive shift (SPS), is elicited by syntactic anomalies such as agreement, case or phrase structure violations (Coulson, King, & Kutas 1998b; Hagoort, Brown, & Groothuysen 1993; Osterhout, McKinnon, Bersick, & Corey 1996), syntactic ambiguities (Friederici & Mecklinger 1996; Friederici, Mecklinger, Spencer, Steinhauser, & Donchin 2001; Friederici, Steinhauser, Mecklinger, & Meyer 1998; Osterhout & Holcomb 1992, 1993; Osterhout, Holcomb, & Swinney 1994) as well as syntactically dispreferred or marked structures (see, e.g., Fiebach, Schlesewsky, & Friederici 2002; Frisch & Schlesewsky 2005; Haupt et al. 2008; Roll, Horne, & Lindgren 2010; Schlesewsky & Bornkessel 2006) that are restricted to certain linguistic contexts (Siewierska 1988). Importantly, however, the second NP also engendered an N400 effect. The N400 was interpreted as reflecting competition for the Actor role between the NP arguments. Whereas the sentence-initial position speaks in favor of an Actor interpretation of the initial argument, the nominative case marking of the second NP speaks against this interpretation. Importantly however, the N400 effect was absent in sentences where the initial noun was inanimate (for example ‘The plane took she to paradise’) (see also Frisch and Schlesewsky 2001, 2005 for similar results in German). This suggests that the inanimacy of the initial argument functioned as an additional cue to argument interpretation, rendering the assignment of the Actor role to the initial NP less likely, thereby reducing the competition for the Actor role between the NPs.

Finally, a few studies have found an increased N400 effect in active English sentences engendered either by an inanimate (versus an animate) sentence-initial subject (Kuperberg, Sitnikova, Caplan, & Holcomb 2003; Nakano, Saron, & Swaab 2010) or an animate (versus an inanimate) post-verbal object (Paczynski & Kuperberg 2011). That is, both a subject or an object that is aprototypical and therefore marked in terms of animacy with respect to its role engenders an N400 effect, suggesting that the assignment of an argument role is directly impeded when that argument is aprototypical in terms of prominence, given its role. In a second study, Paczynski and Kuperberg (2011) failed to find a difference in the N400 effect engendered by animate post-verbal objects in sentences with action verbs (e.g., ‘penalized’) in comparison to sentences with object-experiencer verbs (e.g., ‘pleased’). On the basis of this, they argued that it is the linearization animate-before-inanimate that aids interpretation rather than the association between inanimacy and the Undergoer role. They reasoned that since the latter set of verbs assign the experiencer role to the object, and the experiencer role requires an animate argument, an animate object should be expected and therefore not hamper GF assignment, as in sentences with action verbs. The N400 amplitude should therefore be significantly higher in
action verb sentences than in object-experiencer verb sentences. However, since all the action verbs that were used also required an animate object and, importantly, the Stimulus or Cause role of an object-experiencer verb is assumed to outrank the Experiencer role in terms of involvement (cf. Primus 2006:61) these verbs do not differ with respect to the assignment of the Actor and Undergoer roles, and a differential N400 effect cannot be predicted on such basis.

2.4.2. Discourse prominence and argument interpretation

Several studies have also investigated the influence of discourse prominence on GF assignment and language comprehension more generally. Some studies have found that the processing of object relative clauses is facilitated when the subject of the relative clause is high in referentiality (Gordon, Hendrick, & Johnson 2001; Kaan 2001; Mak et al. 2008; Warren & Gibson 2002). Using self-paced reading, Gordon et al. (2001) and Warren and Gibson (2002) found unambiguous object relative clauses in English to be easier to process when the subject in the relative clause either was pronominal (e.g., ‘the reporter who you attacked’) or a proper noun (e.g., ‘the reporter who Ben attacked’) in comparison to being lexical (e.g., ‘the reporter who the senator attacked’). Kaan (2001) and Mak et al. (2008) found similar results in self-paced reading experiments containing sentences with locally ambiguous object relative clauses, such as in Example 2.11:

(2.11) (a) Ongerust kijkt de hardloper, die de wandelaars in het park
groet hebben...

‘The jogger, whom the strollers have greeted in the park, looks worried...’

(b) Ongerust kijkt de hardloper, die jullie in het park
groet hebben...

‘The jogger, whom you have greeted in the park, looks worried...’

Since both the relative pronoun ‘die’ and the NP arguments (‘die wandelaars’ in Example 2.11a and ‘jullie’ in 2.11a) are case ambiguous, both sentence types are ambiguous with respect to the argument functions up until the presentation of the sentence-final verb, which disambiguates the sentences through agreement. The studies found faster reading times at and beyond the disambiguating verb when the subject of the relative clause was pronominal (Example 2.11b) in comparison to when it was lexical (Example 2.11a). Mak et al. (2008) even found reading times to be faster in object relative clauses with pronominal subjects than in the corresponding subject relative clauses.

These results indicate that referentiality (and therefore discourse prominence) also guides the GF assignment to relative clause argument NPs, in parallel to animacy. The interpretation of an object relative clause is facilitated when the subject is highly discourse prominent (or high in ‘topic-worthiness’, see Mak et al. 2008). This interpretation was confirmed in a subsequent study by Mak et al. (2008) in which the givenness (in terms
of being previously mentioned) of the subject in the object relative clauses was instead manipulated. Reading times in the ambiguous region were again faster when the subject of the relative clause was given in comparison to when it was new.

In parallel to the finding that more discourse prominent arguments are frequently ordered before less prominent arguments in the German middlefield (see Bader and Häussler 2010; Kempen and Harbusch 2004 and the discussion in Section 2.2.3), Kretzschmar et al. (2012) found an effect of relative discourse prominence on the comprehension of locally ambiguous transitive complement clauses in German, using eye-tracking. More specifically, they found faster reading times and fewer regressions at and beyond the position of the disambiguating verb in object-initial sentences, when the object outranked the subject in referentiality (rather than the opposite). In other words, the disambiguation towards the dispreferred object-initial word order was less costly when the relative referentiality of the arguments spoke in favor of an object-initial interpretation. Thus GF assignment in complement clauses also appears to draw upon referentiality.

Other studies have further shown that both givenness and topicalization can facilitate on-line language comprehension. Self-paced reading and sentence acceptability studies conducted in Finnish (Kaiser & Trueswell 2004), Russian (Slioussar 2011) and Danish (Kristensen, Engberg-Pedersen, & Poulsen 2014) have shown faster reading times (Kaiser & Trueswell 2004; Slioussar 2011) or higher acceptability ratings (Kristensen et al. 2014) for sentences with non-canonical word orders (e.g., object-before-subject word order) when the object is given by virtue of being introduced in the preceding context. For instance, Kaiser and Trueswell (2004) found reading times of sentences with an object-before-subject word order to be faster when the object had been established in the previous context and therefore was given. Post-verb reading times of object-initial sentences were in fact equally as fast as in canonical subject-initial sentences when the object was given. When it was new, reading times were instead slower than in subject-initial sentences throughout the presentation of the sentence.

Several ERP studies have provided further insights into how givenness and topicalization interact in sentence and discourse comprehension. Burkhardt (2006) found additional processing costs at the NP argument in intransitive sentences in German when that NP was new (not previously mentioned) or inferred (implied in the previous sentence) in comparison to when it was given (mentioned in the previous sentence). New NPs engendered an increased N400 effect in comparison to given, assumed to index discourse integration costs, as well as a late positivity effect, assumed to reflect processes of discourse updating (see also Burkhardt and Roehm 2007 and Hirotani and Schumacher 2011 for similar findings in Japanese). In a subsequent study, Schumacher and Hung (2012) found no late positivity of an inferred versus a given object in transitive German sentences when that object was positioned in the sentence-initial position, thereby signaling that it is the sentence topic. They interpreted these findings as indicating that processes of discourse updating are less costly for sentence topics, because they serve as the starting points for information storage in the discourse representation (see also Hung and Schumacher 2012, 2014 for related results in Chinese and Wang and Schumacher 2013 for Japanese). These findings were corroborated by Burmester, Spałek, and Wartenburger (2014). They found the processing of topicalized object-initial arguments in German transitive sentences to be more costly, in terms of engendering an enhanced late positivity, when the referent of the
topical argument had not been established as a topic in the previous discourse.

In sum, these studies indicate that both inherent properties of NPs related to discourse prominence such as referentiality, as well as the actual discourse prominence of NP referents in terms of givenness, can influence both GF assignment and sentence comprehension in discourse.

2.4.3. Models of argument interpretation

As discussed in the previous sections, argument interpretation is a highly incremental process that draws upon both morphosyntactic (e.g., word order, case marking and agreement) and prominence-based (e.g., animacy, referentiality and givenness) information. In line with this, several models of language comprehension assume that GF assignment is done on the basis of both morphosyntactic and prominence-based cues in a dynamic manner such that an initial tentative interpretation is done immediately upon encountering the initial core argument.

In constraint-based and probabilistic models of language comprehension, incremental language comprehension is assumed to involve some kind of selection among possible alternative interpretations or continuations of a sentence. As the sentence unfolds over time, more information about the sentence structure becomes available. Alternative interpretations are thereby constrained by the additional information, whose strengths or weights are determined probabilistically on the basis of statistical regularities in the language input. Models differ with respect to what kind of information types they draw upon, which structures they apply to, and how the selection among alternatives is done. Constraint-based models (MacDonald 2015; MacDonald & Christiansen 2002; MacDonald, Pearlmutter, & Seidenberg 1994; MacDonald & Seidenberg 2006; McRae, Spivey-Knowlton, & Tanenhaus 1998; Trueswell & Tanenhaus 1994) usually assume competition between alternative interpretations, where alternative interpretations are represented in a connectionist or activation-based network. The alternative that surpasses some activation threshold ‘wins’, and is selected. Processing demands are on this view related to prolonged competition between alternatives. More probabilistically oriented models (e.g., Hale 2001, 2003; Jurafsky 1996; Levy 2008, 2011, 2013; Martin 2016) instead assume that alternative syntactic continuations are weighted or ranked with respect to how probable they are in the current syntactic context. As new words become available, alternative continuations are constrained, resulting in a re-ranking of possible continuations. The ranking of possible continuations can be described in terms of a probability distribution over possible parses. The alternative which finally accrues the highest probability mass or is the only possible interpretation is the one that is finally selected. The processing cost of a word in probabilistic models is related to, for instance, the degree to which that word disconfirms alternatives that previously comprised a great amount of probability (Hale 2001), the degree to which the probability distribution over alternatives is updated (Levy 2008), or the reduction in entropy of the distribution over alternatives (Hale 2003). The incremental models of argument interpretation presented in Chapter 6 are based upon the probabilistic model proposed by Levy (2008). A fundamental assumption of this dissertation is that incremental argument interpretation is constraint-based and probabilistic in nature, and draws upon statistical regularities in the distribution of morphosyntactic and
prominence-based cues found in language use.

As such, the assumptions of this dissertation are highly consistent with those of the competition model (E. Bates & MacWhinney 1981, 1982; MacWhinney 2005; MacWhinney & Bates 1989a), one of the precursors to the constraint-based perspective (MacDonald & Seidenberg 2006). In the competition model, morphosyntactic and prominence-based cues are activated in parallel in an interactive fashion in order to assign functions (e.g., topic and agent) to core arguments during on-line comprehension. Cues can either converge on or compete for alternative mappings between argument NPs and functions, and the activation of alternative mappings is dynamically updated as cues are made available during on-line processing. The strengths of the available cues differ across languages, and, importantly, can be estimated on the basis of frequency distributions in natural discourse, in line with the assumptions of the present work. Cue strengths are proportional to the validity of those cues. Cue validity is in turn (in part) determined on the basis of the reliability and availability of the cues in natural discourse (Kempe & McWhinney 1999; MacWhinney & Bates 1989a). Cue reliability is the proportion of times an available cue signals the correct interpretation for an argument NP, and cue availability the proportion of times that a cue is present.

Many studies indicate that cue validity is an important determinant of cue strength in argument role assignment. In these studies, subjects have to choose which NP of a transitive sentence refers to the Actor. The relevant cues are systematically varied across sentences in order to put them in competition with each other (e.g. ‘the pencil a horse kicks’ in which the animacy cue is in competition with the word order cue). Cue strength is estimated using both ‘off-line’ measurements of the proportion of times a given cue is consistent with the NP choice at hand (i.e., the degree to which the cue ‘wins’ over the others), and ‘on-line’ measurements of the average response latency, relative to the start of sentence presentation, that a cue is associated with. Differences in cue strength in terms of these measurements across languages correlate with estimations of the validity of the cues as based upon knowledge of informal language use (see E. Bates et al. 1982 for a comparison between Italian and English; Hernandez, Bates, and Avila 1994 for English and Spanish; Kail 1989 for French and Spanish; Li, Bates, and MacWhinney 1993 for Chinese; MacWhinney et al. 1984 for English, German and Italian; MacWhinney, Csaba, and Bates 1985 for Hungarian and Mimica, Sullivan, and Smith 1994 for Croatian), on the one hand, and frequency counts in sample texts (e.g., Kempe and McWhinney 1999 for a comparison between German and Russian and Sokolov 1989 for Hebrew), on the other. For example, MacWhinney et al. (1984) showed that choice responses in English, German and Italian quite consistently correlated with estimations of cue validity of word order, agreement and animacy. English speakers overwhelmingly made their choice on the basis of word order, Italians showed a consistent reliance on agreement information, and Germans made use of a combination of agreement and animacy, in line with the predictions made from estimations of the validity of the respective cues (see MacWhinney et al. 1984). Kilborn (1989) found differences in response latencies between English and German that paralleled these results. Whereas the speed with which the English speakers gave their response primarily depended on word order (i.e., whether the sentence had a noun-verb-noun word order), the response latencies of the German speakers were influenced by both agreement and animacy (i.e. whether the verb agreed with the initial noun, on the one
hand, and whether the initial noun was animate and the final noun inanimate, on the other).

Kempe and McWhinney (1999) used a connectionist model to simulate the performance of argument interpretation in German and Russian in terms of incremental cue interaction. Using a recurrent cascaded back-propagation network (Elman 1990; McClelland 1979; Rumelhart, Hinton, & Williams 1986), their model simulated the incremental activation of alternative mappings between argument roles and NPs as a function of the interaction of word order, animacy and case marking cues that become available in a sequential fashion. Cue strengths were set on the basis of cue validity estimations that were based upon frequency distributions in sample texts in the respective languages. The model showed a very good fit to experimental data that was obtained in a speeded picture-sentence verification task conducted in German and Russian, similar to the paradigm described above. The model was able to accurately simulate both the choice responses (i.e., in terms of asymptotic activation level) and the response latencies (i.e., the number of cycles taken to reach asymptotic activation level) of the experiment.

A more recent model that is at least in part consistent with the assumptions of this dissertation is the extended Argument Dependency (eADM) Model (Bornkessel & Schlesewsky 2006; Bornkessel-Schlesewsky et al. 2008; Bornkessel-Schlesewsky & Schlesewsky 2009b, 2009c, 2013). In the eADM model, morphosyntactic and prominence-based cues guide the mapping of Actor and Undergoer roles to the core arguments. Following Primus (2006), the eADM assumes that the relationship between the Actor and the Undergoer role is asymmetric (Bornkessel-Schlesewsky & Schlesewsky 2014). The extent to which an argument functions as the Actor or the Undergoer of a transitive sentence depends on the degree and kind of involvement (Primus 2006:54) of the participant in the event described by the verb. However, Undergoers have no defining involvement properties of their own. These are determined on the basis of their dependence on the involvement of the Actor. For instance, whereas the Actor can be in volitional control or sentient, the Undergoer is reciprocally under control, or the object of sentience. Because of this asymmetry, NP arguments of transitive sentences are assumed to ‘compete’ for the Actor role. Since morphosyntactic and prominence-based information correlates strongly with the Actor role (e.g., the Actor is highly prominent, sentence-initial and case marked in the nominate), these information types guide the assignment of the Actor role to one of the NP arguments (and by extension, the assignment of the Undergoer role to the other NP). This process initiates immediately upon encountering the first NP so that an initial assumption regarding the confidence of the first NP to function as the Actor is computed directly. This initial assumption might be incompatible with upcoming information provided by, for instance, the case marking of the subsequent NP or the agreement of the verb, leading to reassignment of the Actor role to the other NP (cf. Haupt et al. 2008; Hörberg et al. 2013).

Although the competition and the eADM model share many similarities, they also differ in many respects. Firstly, whereas the competition model is a cognitive model, the eADM aims to model aspects of the neurobiology in language. As such, it makes rather specific claims about the time course and the neurophysiological and neuroanatomical correlates of the processes that underlie incremental argument interpretation (cf. Bornkessel-Schlesewsky and Schlesewsky 2013 and Chapter 4). Secondly, it is also not
clear if the eADM model assumes that frequency distributions determine language specific cue strengths, although the model acknowledges that cue strengths qualitatively differ between languages (see, e.g., Bornkessel-Schlesewsky & Schlesewsky 2013:70). Bornkessel-Schlesewsky and Schlesewsky have in fact argued against frequency as a determining factor in language comprehension (Bornkessel, Schlesewsky, & Friederici 2002b). Despite this, the model is highly compatible with the assumptions of this dissertation. In Chapter 4, some of the assumptions of the model are tested against a structurally oriented account of GF assignment.

Alday and colleagues have formulated a computational implementation of aspects of the eADM model that aims at modeling the competition for the Actor role between two arguments (Alday, Schlesewsky, & Bornkessel-Schlesewsky 2014). The total prominence of each argument is represented by a vector of binary features which code for the individual prominence and morphosyntactic features of animacy, person, number, definiteness, case and position. The language specific strengths of these features are represented by a vector of weightings. However, these weights were not determined on the basis of, for instance, estimations of the validity of the features in natural discourse (as done by e.g. Kempe & McWhinney 1999). Instead, weights were determined on the basis of the relative ranking of the cues found in Kempe and McWhinney (1999), although measures of cue availability and reliability as estimated on corpus frequencies are readily available. Cue rankings were scaled so that each subsequent rankings differed by one order of magnitude (i.e. 1000 > 100 > 10 > 1). The competition for the Actor role between the NP arguments was then quantified as either the unweighted or the weighed summed distance between the prominence features of the NP arguments. High values essentially reflected the extent to which the final NP outweighed the initial NP in prominence.

These measures of competition were subsequently evaluated in an ERP experiment. In the experiment, participants read German sentences with either an SVO or an OVS word order that varied with respect to whether the initial NP was unambiguously case marked or not, and whether it outranked the second argument in prominence in terms of referentiality (lexical vs. pronominal). In line with previous results (see, e.g., Haupt et al. 2008; Hörberg et al. 2013 and Chapter 4), the final NP engendered an N400 effect in the ambiguous sentences in comparison to the unambiguous sentences, presumably reflecting the reanalysis toward the object-initial word order. Importantly, both the unweighted and weighted measures of NP competition were found to significantly correlate with the N400 amplitude in the ambiguous sentences: When the competition between the arguments was high in terms of the positioning of the initial NP being inconsistent with the disambiguating information of the final NP (i.e., by virtue of being highly prominent), the N400 amplitude was higher. This correlation was also found to be significantly stronger for the weighted than for the unweighted competition measure. These results suggest that processing difficulty of GF assignment is causally related to the degree of competition between the NP arguments, as determined on the basis of their prominence-based and morphosyntactic features.

In Chapter 6, I will present three models of incremental argument interpretation that share some similarities to the model proposed by Alday et al. (2014). They, too, provide

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5For prominence features \( i \), the unweighted distance was \( \sum_i |NP_2i - NP_1i| \), and distance weighted by vector \( w \) was \( \sum_i w_iNP_2i - \sum_i w_iNP_1i \).
2.5 Summary

The fundamental hypothesis of this dissertation is that referential and semantic information (i.e., prominence-based information), on the one hand, and morphosyntactic information, on the other, function as cues during the on-line comprehension of transitive sentences that are utilized in a probabilistic fashion, and whose weightings, interplay and availability are reflected in their distribution in language use.

The relationship between the distribution of prominence features in language use and their utility as argument interpretation cues is functionally motivated. As discussed in Section 2.1, grammatical functions express role-semantic (e.g., Actor or Undergoer) and discourse-pragmatic functions (e.g., Topic and Focus) of the NP arguments. These functions correlate with prominence properties of the NP arguments in transitive sentences. On the one hand, subjects are more frequently animate than objects. This is because Actors often are volitional, in control and/or sentient, and therefore tend to be human or at least animate. On the other, subjects are also more discourse prominent than objects in terms of definiteness, person and pronominality. This is because Actor participants are more frequently discourse topics and therefore are more commonly given in the discourse than objects. In cases where the object argument is instead the sentence topic or the sentence is marked in terms of its information structure in some other way, a marked construction such as a passive, a left dislocation or topicalization construction is required.

As discussed and exemplified in Section 2.2, the correlations between prominence features and grammatical functions manifest themselves both in the grammatical encoding of grammatical functions across languages, as well as in the frequency distributions of language use within individual languages. Across languages, the morphological marking or syntactic behavior of NP arguments is often influenced by whether one or both NP arguments are aprototypical in terms of some prominence property or set of properties, given their functions. In the discourse distributions within individual languages, subjects
are more frequently high in prominence than objects are, in unmarked transitive sentences. In alternative constructions such as object topicalization constructions, objects instead tend to be high in prominence.

Both prominence-based and morphosyntactic information seem to work as cues to grammatical functions, whose interplay and availability to some extent is influenced by competing cognitive constraints in a functionally motivated manner. As discussed in Section 2.3, many studies indicate that unambiguous morphosyntactic cues are used more frequently in potentially ambiguous transitive sentences in which the argument functions cannot be readily determined on the basis of prominence information. Also, the learning of morphosyntactic regularities seems to be influenced by their utility as cues to the argument functions. Over the course of learning, word order regularization and the frequency of overt case marking are influenced by whether these cues are required in order to determine the argument functions. When no other cues are available, learners tend to regularize the word order or use overt case marking more frequently, in comparison to when other cues are available. In other words, learners seem to be biased toward balancing the information provided by both morphosyntactic and prominence cues concerning the argument functions. Both the use and the learning of transitive structures therefore seem to be influenced by competing motivations for keeping the message length short by avoiding redundant morphosyntactic information (i.e., the economy motivation), while at the same time ensuring that the message contains enough information in order to be unambiguous (i.e., the iconicity motivation).

As discussed in Section 2.4, grammatical function assignment during on-line comprehension of transitive sentences is a highly incremental process that commences directly when the initial NP argument is encountered. In the absence of evidence to the contrary, sentence-initial NPs are preferably interpreted as the subject of the sentence directly when encountered. A multitude of studies have also found support for the idea that prominence information functions as a cue to grammatical function assignment. Argument prominence properties such as animacy, referentiality and givenness are utilized during on-line grammatical function assignment by either facilitating or impeding the comprehension process. In line with findings such as these, constraint-based and probabilistic theories of language comprehension assume that language comprehension is a highly incremental process that draws upon a multitude of information types, such as prominence information, whose strengths and weightings depend on their availability in the previous linguistic experience of the comprehender. Such models are generally consistent with the view advocated in this thesis. In Chapter 6, I will present a probabilistic and prominence-based model of GF assignment, which is based upon some of the assumptions of such models. In Section 2.4, I also more specifically focused on the competition and the extended Argument Dependency Model (eADM) models, which are primarily concerned with grammatical function assignment during language comprehension. These models assume that GF assignment is a highly incremental and interactive process that draws upon both prominence-based and morphosyntactic cues, and that, in particular, is concerned with the assignment of argument functions to the NP arguments. As such, the assumptions of these models are highly consistent with those advocated in this dissertation. In Chapter 4, I present an ERP study that tests the assumption of the eADM model and this dissertation that GF assignment during on-line language comprehension of transitive sentences involves the assignment of
role-semantic functions to the NP arguments.

In the next chapter, however, I will first give an overview of the kind of transitive sentences in Swedish that are investigated throughout this dissertation. In this chapter I also discuss the functional motivations for the object-initial word order in Swedish, and also give an account of Swedish transitive sentences that are locally ambiguous with respect to the argument functions.
3. The Structure of Transitive Sentences in Swedish

Before going on to present the empirical studies of this thesis, I start out by presenting the structure of transitive sentences in Swedish. This chapter therefore serves as a background for the upcoming studies, in which the kind of sentences that are investigated in this dissertation are introduced (Section 3.1). As such, this chapter is by no means intended to provide a comprehensive overview of the variety of transitive structures that is found in Swedish.

As will become apparent in this as well as in the upcoming chapters, transitive sentences with an object-initial word order are of particular importance throughout this dissertation. In Section 3.2, I therefore present a short overview of the functional motivations that have been suggested for the object-initial word order in Swedish. Since the literature regarding object topicalization in Swedish is rather sparse, this section is mainly based upon the account of object topicalization found in the Grammar of The Swedish Academy (‘Svenska Akademiens Grammatik’ Teleman, Hellberg, & Andersson 1999). In Chapter 5, I will return to these issues and investigate whether differences in the distribution of prominence properties between object- and subject-initial sentences are in line with these accounts.

Transitive sentences that are locally ambiguous with respect to the argument functions are also of great importance throughout this dissertation. Following up on the presentation of the structure of Swedish transitive sentences in Section 3.1, in Section 3.3, I therefore provide an overview of transitive sentences that are locally ambiguous with respect to the argument functions, as well as an overview of the kind of morphosyntactic cues that are available for GF assignment.

As discussed in Section 2.3.1, several studies have found that speakers and writers are more prone to use unambiguous morphosyntactic information regarding the argument functions in cases where these functions cannot be readily determined on the basis of other information types (such as animacy). Results such as these indicate that speakers and writers are inclined to avoid ambiguities in order to make their message easily interpretable for their addresses (e.g., Hawkins 2003; Haywood et al. 2005; MacDonald 2013; Snedeker & Trueswell 2003; Temperley 2003). In Section 3.4, I present the results of a study of Rahkonen (2006) that, among other things, tested this hypothesis on transitive sentences in Swedish. In particular, Rahkonen (2006) investigated whether writers are more likely to use disambiguating morphosyntactic information regarding the argument functions in transitive sentences that are semantically ambiguous with respect to the argument roles. In Chapter 5, I will follow up on Rahkonen’s (2006)’s study, and further test the ambiguity avoidance hypothesis on Swedish transitive sentences.
3.1. Transitive sentences in Swedish

3.1.1. Word order variation

As discussed in Chapter 2, the grammatical encoding of argument functions found in accusative pivot languages such as Swedish is functionally motivated by the correlation between role semantic prominence and discourse prominence. The Actor is in the prototypical case highly discourse prominent, and the Undergoer is low in discourse prominence and high in informational content in terms of being (part of) the focus. In less prototypical cases, however, the Undergoer is pragmatically marked in terms of either being topical or expressing contrastive focus. In such cases, a marked construction such as a passive (thereby realizing the Undergoer as pivot) or a topicalization construction must be used in order to signal the marked status of the Undergoer. Variations from the prototypical SVO word order are therefore quite common in Swedish transitive sentences. Since Swedish is considered to be a verb-second (V2) language, only one constituent must precede the finite verb in declarative main clauses (Teleman et al. 1999:4:688, but see Josefsson 2012 for exceptions). As exemplified in 3.1, the sentence-initial constituent can therefore be, for example, the subject (Example 3.1a), the direct object (Example 3.1b), or an adverbial phrase (Example 3.1c) (see Teleman et al. 1999:4:412ff).

(3.1) (a) Barnen äter glass innan middagen.
    children.the eat ice-cream before dinner
    ‘The children eat ice cream before dinner.’

(b) Glass äter barnen innan middagen.
    ice-cream eat children.the before dinner
    ‘The children eat ice cream before dinner.’

(c) Innan middagen äter barnen glass.
    before dinner eat children.the ice-cream
    ‘The children eat ice cream before dinner.’

In sentences in which the direct object is positioned in the sentence-initial position (Example 3.1b), the sentence word order is OVS, and when an adverbial phrase is sentence-initial (Example 3.1c), it is VSO.

In Swedish, sentential adverbials such as the negation ‘inte’ are treated differentially from other types of adverbials in that they tend to either precede or follow the finite verb of the clause. There is, however, a great deal of word order variation depending on whether the sentence at hand contains auxiliary verbs and whether it is a main or an embedded clause. The word ordering is therefore more complex in sentences with auxiliary verbs, a sentence adverbial and / or a verb particle, in terms of allowing for alternations. Sentences can contain several auxiliary verbs in addition to the main verb\( ^1 \) (see Teleman et al. 1999:3:278ff). In subject-initial transitive sentences, the direct object follows all the verbs, the sentential adverbial and the verb particle (see examples 3.2). If the direct object or an adverbial phrase instead occupies the sentence-initial position, the subject precedes

\(^1\) With ‘main verb’ I refer to the most semantically prominent verb of the verb phrase that denotes the action or event of the verb phrase, such as ‘eat’ in ‘will eat’.
3.1 Transitive sentences in Swedish

the non-finite verb(s) and the verb particle (as in Example 3.3 and 3.4) (see Teleman et al. 1999:39-40).

(3.2) canonical subject-initial transitive clauses

(a) Barnen får inte äta upp all glass innan middan.
children.the can not eat up all ice-cream before dinner
‘The children can’t eat all the ice cream before dinner.’

(b) barnen inte får äta upp all glass innan middan.
children.the not can eat up all ice-cream before dinner
‘the children can’t eat all the ice cream before dinner.’

(3.3) object-initial transitive clauses

(a) All glass får barnen inte äta upp innan middan.
all ice-cream can children.the not eat up before dinner
‘The children can’t eat all the ice cream before dinner.’

(b) All glass får inte barnen äta upp innan middan.
all ice-cream can not children.the eat up before dinner
‘The children can’t eat all the ice cream before dinner.’

(3.4) transitive clauses with initial adverbial phrase

(a) Innan middan får barnen inte äta upp all glass.
before dinner can children.the not eat up all ice-cream
‘The children can’t eat all the ice cream before dinner.’

(b) Innan middan får inte barnen äta upp all glass.
before dinner can not children eat up all ice-cream
‘The children can’t eat all the ice cream before dinner.’

Sentences can also vary with respect to the positioning of a sentential adverbial. In canonical subject-initial transitive sentences, the adverbial phrase follows the finite verb in main clauses (Example 3.2a) but precedes it in subordinate clauses (Example 3.2b) (Teleman et al. 1999:4:7). A sentential adverbial therefore normally precedes the final NP in subject-initial main clauses. Their relative positioning may, however, be shifted when the NP argument is highly discourse prominent and unstressed, a phenomenon called ‘object shift’ (Andréasson 2010, 2013; Andréasson, Bentzen, & Engdahl 2013; Holmberg 1986). In Example 3.5a below, for instance, the positioning of the direct object and the sentential adverbial has been shifted. This is not permissible in sentences such as Example 3.5b, however, in which the direct object consists of an indefinite NP.

(3.5) (a) Barnen äter den inte innan middagen.
children.the eat it not before dinner
‘The children do not eat it before dinner.’

(b) *Barnen äter en glass inte innan middagen.
children.the eat a ice.cream not before dinner
‘The children do not eat ice cream before dinner.’
In sentences with either the direct object or an adverbial phrase in the sentence-initial position, the sentence adverbial either follows the subject NP (Example 3.4a and 3.3a) or precedes it (Example 3.4b and 3.3b). In spoken language, the latter word order is not permissible if the subject NP is pronominal and unstressed (Teleman et al. 1999:4:94), suggesting that the position is used to signal contrastive focus (Andréasson 2013; Andréasson et al. 2013).

3.1.2. Case marking

Swedish lacks noun case marking and verb agreement, but has nominative and accusative forms for personal pronouns that differentiate between subjects and objects (Teleman et al. 1999:2:296). The paradigm is illustrated in Table 3.1. Whereas the nominative and accusative forms of the 1st and 2nd person pronouns are consistently used to distinguish between NP arguments in the subject and the object functions, the use of the nominative form of the masculine 3rd person for NPs in the object function is acceptable in both spoken and written informal language. This is also the case for the corresponding feminine form in some dialects. Recently, the gender neutral 3rd person ‘hen’ was officially accepted in Swedish (i.e., as evidenced by its recent inclusion in the glossary of the Swedish Academy, SAOL 2015). However, whether or not ‘hen’ should be considered as a pronoun of its own on par with other personal pronouns has been hotly debated, as the pronoun first and foremost has been introduced in the context of a debate regarding gender inequalities, and in particular, as a step towards a more gender neutral language use. The generic pronouns ‘man’ and ‘folk’, finally, are only used in the subject function and therefore unequivocally identify the subject.

<table>
<thead>
<tr>
<th>Table 3.1. Personal pronouns in Swedish, differentiating between nominative and accusative forms.</th>
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<tbody>
<tr>
<td>1st pers.</td>
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<tr>
<td>Nom.</td>
</tr>
<tr>
<td>sg.</td>
</tr>
<tr>
<td>pl.</td>
</tr>
<tr>
<td>Acc.</td>
</tr>
</tbody>
</table>

3.2. The functional motivation for the object-initial word order

As mentioned in the previous section (Section 3.1), marked constructions such as the passive or the topicalization construction are used in Swedish to signal that the sentence at hand is pragmatically marked in terms of its information structure. In this section, I discuss some of the functional motivations that have been suggested for both the object as well as the adverbial-initial word orders, and in particular those found in the Grammar of The Swedish Academy (‘Svenska Akademiens Grammatik’ Teleman et al. 1999).

The positioning of a constituent in the sentence-initial position is primarily determined by the information structure of the sentence itself and its immediate discourse context (Rahkonen 2006; Teleman et al. 1999:4:431). Typically, the sentence-initial argument expresses the theme or the topic of the sentence, which in most cases is high in referentiality and therefore highly given. The sentence word order is also in many cases
conditioned by the discourse or situational context, in that the sentence-initial argument often refers to something in the immediate context. The sentence-initial argument in such contexts therefore very commonly consists of a highly given NP argument such as a pronoun (Rahkonen 2006; Teleman et al. 1999:4:432). In many cases, such pronouns are anaphoric and refer back to a referent or a proposition in the previous discourse context. In particular, the preposing of pronominal objects very often involves focus/rheme-topic chaining, in which the antecedent of the anaphoric object is (part of) the focus of the previous clause, or topic-topic chaining, in which the antecedent is a discourse topic (Engdahl & Lindahl 2014). Topicalization of the object occurs very frequently when the object is more prominent than the subject (Rahkonen 2006). Rahkonen (2006) found a very strong relationship between the givenness of the object and the sentence word order. Whereas 73.7% of all definite and anaphoric objects occurred in sentence-initial position, only 23.2% of the non-anaphoric and indefinite objects were located in sentence-initial position. Rahkonen (2006) further found that object topicalization seems to be particularly frequent when the object consists of a neuter pronominal or demonstrative object (i.e., ‘det’ and ‘detta’ - ‘that’) that refers back to a proposition in the immediate left context. In Example 3.6, for instance, the sentence-initial pronominal object ‘det’ refers back to the proposition of the previous sentence.

(3.6) Samtidigt som vi andas måste vi nämligen spänna ett antal småmuskler i svalget för att slemhinnorna inte ska dras in och förminska luftkanalen. Det kan man visa genom ett enkelt experiment. ‘At the same time as we breathe, we have to flex a number of small muscles in the throat, in order for the mucosa not to get pulled in and diminish the air duct. That one can show through a simple experiment.’

Such objects will henceforth be referred to as a text deictic, since their meanings are determined by the immediate left context in the text. Rahkonen (2006) found that text deictic objects more frequently occur in sentence-initial position than post-verbal position. A sentence-initial argument can also refer to something in the situational context, rather than the discourse context per se.

In sentences in which the sentence-initial object instead is the focus, that is, the new information in the sentence, the remainder of the sentence meaning tends to be highly predictable, so that the comprehender in many cases can infer it already upon hearing or reading the initial constituent (Teleman et al. 1999:4:432). The meaning of Example 3.7 would, for example, be highly predictable in the context of packing for a vacation, so that its meaning could be inferred already by the presentation of the sentence-initial object:

(3.7) Extra handduk eller handdukar får man väl ha med sig. ‘An extra towel or towels one surely must bring’
A common function of positioning a focused object in sentence-initial position is to signal that it is contrastive (cf. Teleman et al. 1999:4:432). That is, it is contrasted against a limited set of alternatives (e.g., Erteschik-Shir 2007; Gundel & Fretheim 2004). In Example 3.8, for instance, a woman named ‘Åsa’ is contrasted against some other individual(s) (such as, e.g., a woman named ‘Sandra’):

(3.8) Åsa är jag mycket förtjust i (men inte Sandra)
    ‘Åsa I am very fond of (but not Sandra)’

In many cases, finally, the sentence-initial argument expresses the background (cf. Teleman et al. 1999:4:432), or what Krifka (2007) refers to as a frame setter: an expression, in many cases an adverbial phrase, that limits the situational frame or domain for which the event described by the sentence is applicable. The frame setter typically expresses a time, a place or a condition under which the event may take place (Teleman et al. 1999:4:432). In transitive sentences with initial adverbials, such as the example sentences 3.4, the initial adverbial functions as a frame setter. In 3.4 the adverbial phrase ‘innan middan’ (‘before dinner’) sets up a temporal domain under which the circumstances described by the sentence (i.e. the prohibition of the children’s eating of the ice cream) is valid.

To sum up the previous discussion, word order variations in Swedish transitive sentences, and in particular the object-before-subject order, are motivated by information-structural and discourse pragmatic considerations. In most cases, the positioning of the object in sentence-initial position is motivated by the need to signal that the object is the sentence topic, that is, what the sentence is about. When this is the case, the object very often refers to something that is highly prominent in the discourse context. Topicalized objects are therefore very commonly anaphoric, referring back to entities in the previous discourse, that have either been introduced in the previous sentence (i.e., focus/topic chaining), or are discourse topics (i.e., topic/topic chaining). Object topicalization is especially frequent when the object is text deictic, referring back to a proposition introduced by the previous clause. Topicalized objects are for these reasons highly given, in most cases. As observed by Rahkonen (2006), there is a very strong relationship between object givenness and object word order. In cases where a sentence-initial object is focused, it often is contrastive, as in Example 3.8. In such sentences, the information following the initial object, and in particular the post-verbal subject, tends to be predictable and therefore highly given. In adverbial-initial sentences, finally, the adverbial phrase functions as a background or a frame setter that limits the domain for which the event described by the sentence is applicable.

3.3. Locally ambiguous sentences

Swedish transitive sentences hold the potential to be locally ambiguous with respect to the function of the initial NP argument (see Rahkonen 2006). In particular, this is the case in object-initial sentences in which the initial NP does not consist of a personal pronoun and therefore lacks case marking. In Example 3.9a below, for instance, there is a mismatch between word order and case marking, in the sense that the sentence word order speaks
in favor of interpreting the initial NP as the subject, but the case marking of the final NP renders such an interpretation impossible. In Example 3.9b, on the other hand, the initial NP is a personal pronoun. It is therefore case marked and must be interpreted as an object, despite its sentence-initial position.

(3.9) (a) *Flickan gillar vi inte*

  girl.the like we not  
  ‘The girl we don’t like’

(b) *Henne gillar vi inte*

  her like we not  
  ‘Her we don’t like’

It is not only the case marking on pronouns and the SO-word order that provides disambiguating information, but also other word orderings (see also Rahkonen 2006). In sentences with auxiliary verbs, verb particles, and/or sentential adverbials, word order may provide unambiguous information regarding the NP functions. In Example 3.10, taken from Rahkonen (2006), the NP arguments are ambiguous both in terms of morphology (i.e., both are unmarked) and semantics (i.e., both can fill the Actor role of the verb) with respect to their argument functions. Their functions are, however, unambiguously determined on the basis of the relative word ordering between the main verb and the final NP. In sentence 3.10a, the initial NP must function as the subject, because the final NP follows the main verb, whereas in Example 3.10b, it must instead be the object, because the final NP precedes the main verb.

(3.10) (a) *Den äldsta av rävarna försökte lura jägaren*

  the oldest of foxes.the tried cheat hunter.the  
  ‘The oldest of the foxes tried to cheat the hunter’

(b) *Den äldsta av rävarna försökte jägaren lura*

  the oldest of foxes.the tried hunter.the cheat  
  ‘The oldest of the foxes the hunter tried to cheat’

In a similar manner, in sentences such as 3.11a and 3.11b, also taken from Rahkonen (2006), the NP functions are unambiguously determined on the basis of the relative ordering between the final NP and the verb particle, which precedes the final NP in subject-initial sentences (such as in Example 3.11a) but follows it in object-initial sentences (as in Example 3.11b).

(3.11) (a) *En av gästerna kastade ut värden*

  one of customers.the threw out inkeeper.the  
  ‘One of the customers threw out the inkeeper’

(b) *En av gästerna kastade värden ut*

  one of customers.the threw inkeeper.the out  
  ‘The inkeeper threw out one of the customers’
The functions of the NP arguments can in some cases be determined also on the basis of the relative positioning between the final NP and a sentential adverbial (Rahkonen 2006). In subject-initial main clause sentences, a final NP that is either stressed or lexical (and therefore low in discourse prominence), may not shift (see above) and therefore must follow a sentential adverbial. In object-initial sentences, on the other hand, the final NP can either follow or precede the adverbial. When the final NP of transitive clause is lexical and precedes a sentential adverbial, as in Example 3.12 (again from Rahkonen (2006)), the sentence at hand must be object-initial. The argument functions can therefore be determined on the basis of the relative positioning between the final NP and the adverbial in such sentences.

(3.12) Den stora björnen såg bilisten inte
the big beer.the saw driver.the not
‘The driver did not see the big beer’

3.4. Ambiguity avoidance

An important question that arises, which is of great significance for this dissertation, is whether speakers and writers are more prone to using disambiguating morphosyntactic cues in potentially ambiguous transitive sentences, thereby tailoring their language use in order to accommodate the understanding of their recipients (i.e. ambiguity avoidance, see Section 2.3.1, and, for instance, MacDonald 2013). This question was addressed in a corpus study by Rahkonen (2006). Rahkonen (2006) distinguishes between formal means of disambiguating sentences, such as word order and morphology as discussed above, and semantic means, such as when an NP argument is semantically unfit to fill the Actor or the Undergoer role of the verb.

Focusing on the prevalence of formal disambiguators, Rahkonen (2006) first investigated whether potentially ambiguous OVS sentences are more prone to contain formal disambiguators than SVO sentences, in which the argument functions are assigned on the basis of word order dominance, as well as object relative clauses with an OSV word order (e.g., ‘Flickan som vi inte gillar’ - ‘The girl who we don’t like’), which are unambiguous with respect to the argument functions. He found that subject NPs are more frequently case marked in potentially ambiguous OVS sentences in comparison to both SVO sentences and OVS object relative clauses. Rahkonen (2006) also found a strong dispreference for realizing the Actor argument of passivized transitive sentences with a case marked personal pronoun. These results indicate that writers indeed are more prone to use the potentially ambiguous OVS structure when the subject referent can be expressed with a case marked and therefore unambiguous NP. An alternative to OVS word order would be to use the passive construction. As with OVS sentences, passivization can be used in cases where the object is to be promoted on grounds of information structure or discourse pragmatics (see Section 2.1.2). Importantly, however, passive sentences are, in contrast to OVS sentences, unambiguous with respect to the argument functions, and there is no need to provide extra disambiguating information regarding the argument functions. If a writers’ choice between the passive construction and the OVS structure is influenced by a

2 The initial head noun must refer to the object of the relative clause.
motivation to avoid ambiguities, the OVS structure can therefore be expected to be used more frequently than the passive in cases when a case marked subject can be used.

Rahkonen (2006) himself argues against this interpretation, however. According to him, the observed prevalence of the unambiguous subjects in OVS sentences in comparison to SVO and OSV sentences is instead a consequence of the general dispreference for using case marked Actor arguments in passive constructions *per se*. In his view, writers resort to the OVS structure in order to avoid passivization when the subject is a highly prominent personal pronoun. However, he does not present any arguments for why there is a dispreference for realizing the Actor argument as a personal pronoun in passivized transitives in the first place. This dispreference does seem to be functionally motivated by the ambiguity avoidance perspective, however: the unambiguous passive construction is more frequently resorted to when the argument functions cannot be determined on the basis of case marking, and the alternative OVS structure therefore would result in an ambiguity.

Rahkonen (2006) also investigated whether formal disambiguators are preferred in semantically ambiguous sentences in comparison to semantically unambiguous sentences. This was done by investigating whether subjects are more frequently case marked in ‘semantically reversible’ OVS sentences with two animate referents that can fill both roles of the verb (such as in Example 3.12), in comparison to ‘semantically irreversible’ OVS sentences with an animate subject but a text deictic pronominal object (see Section 3.2). Since such pronouns have neuter gender, they are necessarily inanimate. They either refer back to a proposition in the immediate left context or an inanimate entity. They can therefore only fill the Undergoer role of most verbs, thereby ensuring that the sentence at hand is unambiguous with respect to the argument functions. Rahkonen (2006) found that case marked subjects indeed are somewhat more frequent in ‘semantically reversible’ OVS sentences in comparison to ‘semantically irreversible’ OVS sentences. This suggests that writers are more likely to use an unambiguous form for the subject in OVS sentences when the sentence at hand is semantically ambiguous with respect to the NP functions. This interpretation was again rejected by Rahkonen (2006), however, who argued that although OVS sentences might be semantically ambiguous with respect to their argument functions outside of their discourse context, this is very seldom the case in context. The argument functions of the semantically ambiguous sentences can therefore in most cases be determined on the basis of contextual information, and considering such sentences as semantically ambiguous might therefore be incorrect. However, the interpretation of local structure on the sentence level is in some accounts assumed to temporarily precede the interpretation of global structure on the discourse level during language comprehension (see, e.g., Bornkessel & Schlesewsky 2006; Bornkessel-Schlesewsky & Schlesewsky 2009c, 2013, 2014; Friederici 2011). Although the argument functions might be determined on the basis of contextual information during the final stage of language comprehension, the comprehension process is therefore still likely to be hampered at an earlier stage during

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3 More specifically, Rahkonen (2006) states that ‘the high frequency of the [personal pronoun subjects] in OVS declaratives can be explained as the tendency of writers to prefer an active OVS clause where the use of its passive counterpart would have resulted in an undesired pronominal [prepositional] phrase’ (p. 32).

4 Apart from object experiencer verbs such as ‘please’ or ‘offend’, but with the majority of verbs, these pronouns can only fill the Undergoer role.
local structure building. Consequently, the use of formal markers in potentially ambiguous OVS sentences is motivated by the need to facilitate language comprehension during local structure building, independent of whether those sentences are unambiguous in the discourse context.

In sum, Rahkonen (2006) finds some evidence that writers indeed tailor their texts in a manner that accommodates the understanding of the reader, by providing, to a greater extent, disambiguating information in sentence structures that are potentially ambiguous with respect to the argument functions. In Chapter 5, I will again test these predictions on the basis of the corpus data of the present study. More specifically, I will further investigate whether formal disambiguators appear to be more common in OVS sentences in comparison to SVO sentences, on the one hand, and whether they occur more frequently in semantically ambiguous OVS sentences in comparison to their semantically unambiguous counterparts, on the other.
4. The Neurophysiological Status of Grammatical Relations

This chapter has been reformatted from:

4.1. Introduction

The on-line comprehension of transitive sentences involves assignment of grammatical functions to the NP arguments. This is necessary in order to determine which of the argument referents is responsible for the event expressed by the verb, and which is affected by that event. In other words, the comprehension of grammatical functions, that is, GF assignment, is in part concerned with determining the role-semantic properties of the NP arguments. As discussed in Chapter 1 and 2, a fundamental hypothesis in this dissertation is that this process draws upon a systematic interplay between both morphosyntactic and prominence-based information, and that these information types work as cues for the grammatical functions of the NPs and thereby for their semantic protoroles (i.e., the Actor-Undergoer distinction). These assumptions are in line with those of the Competition and eADM models of argument interpretation. In structurally oriented approaches to the comprehension of transitive sentences, on the other hand, grammatical function assignment is instead assumed to primarily involve interpretation of the phrase structure of the sentence. This is because these approaches assume that grammatical functions causally depend on the positioning of the NP arguments in the phrase structure representation of the sentence at hand. These two different views, henceforth referred to as the functional and structural account, respectively, make different predictions regarding the neurophysiological response to grammatical function reanalysis, as measured on the basis of event-related brain potentials (ERPs). It is therefore possible to pit them against each other empirically. To this end, the study presented in this chapter investigates the EPR response to grammatical function reanalysis in transitive Swedish sentences such as Example 1.1 presented in Chapter 1.

In the following Section (4.1.1), I present grammatical function reanalysis and the competing theoretical accounts of whether this kind of reanalysis involves revision at the syntactic (as predicted by the structural account) or thematic (as predicted by the functional account) level of representation. In sections 4.1.2 and 4.2, I then present the predictions and the method of the study in detail. In Section 4.3, the results of the experiment are presented, and in Sections 4.4 and 4.5, I discuss these results with respect to the more general theoretical aspects of this dissertation.
4.1.1. Grammatical function reanalysis

As discussed in Section 2.4, real-time language comprehension is assumed to proceed incrementally, in the sense that comprehenders aim at maximizing their interpretations on the basis of the information available, as well as generating predictions regarding upcoming information (Bornkessel & Schlesewsky 2006; Crocker 1994; Hawkins 2003, 2007). Comprehenders commit to initial interpretations even when the linguistic information at hand is ambiguous. Such tentative interpretations need in some cases to be revised, or reanalyzed, once the disambiguating information is encountered. This is also true for GF assignment, which is the basis for determining the thematic roles of the arguments (i.e., who is doing what to whom). Sentences can occasionally be locally ambiguous with respect to the grammatical functions of their arguments. Because of the general preference for a subject-initial word order (i.e., the subject-first preference, see Section 2.4), initial arguments that are ambiguous with regard to their grammatical functions are initially interpreted as subjects, an interpretation which may need to be revised once subsequent disambiguating morphological (or, in some cases semantic) information is encountered. This type of reanalysis has been called grammatical function reanalysis (Haupt et al. 2008).

In behavioral studies, grammatical function reanalyses are reflected by either lower acceptabilities or longer reading times for sentences that are ambiguous with respect to the grammatical function of an initial non-subject argument in comparison to unambiguous controls (Bader & Meng 1999; de Vincenzi 1991; Frazier & Flores D’Arcais 1989; M.-W. Lee 2004; Meng & Bader 2000). In studies involving measurements of event-related brain potentials (ERP:s), information that disambiguates the interpretation of ambiguous sentences towards an object-initial reading elicit ERP responses that are assumed to reflect grammatical function reanalysis (for evidence from German, see Bornkessel, McElree, et al. 2004; Friederici et al. 1998; Frisch, Schlesewsky, Saddy, and Alpermann 2002; Haupt et al. 2008; Matzke et al. 2002; Münte et al. 2001; Schlesewsky and Bornkessel 2006; for Spanish, see Casado et al. 2005; for Turkish, see Demiral et al. 2008; for Mandarin Chinese, see Wang et al. 2009; and for Basque, see Erdocia, Laka, Mestres-Missé, and Rodriguez-Fornells 2009). Although the phenomenon of grammatical function reanalysis is well-established in the literature, there are competing views on the nature of the underlying processing mechanisms. Crucially, these views differ with respect to whether these mechanisms involve revision processes at the syntactic or the thematic level of representation. With the aim of providing further evidence for one of these accounts, this study investigates the ERP-correlate of grammatical function reanalysis in Swedish. In the following, these competing accounts are presented, and then the study is described.

**The structural account of Grammatical Function Reanalysis**

Most ERP studies on grammatical function reanalysis, that is, subject-object word order ambiguities, have assumed that the reanalysis processes triggered by the disambiguating information involves a revision of the syntactic structure of the sentence. As the grammatical functions of subject and direct object are assumed to be determined on the basis of structural positioning (Chomsky 1981, 1986; Chomsky & Lasnik 1993; Engdahl 2012; Holmberg 1986; Holmberg & Platzack 1995; Platzack 1998, 2010), the derivation of sentences with object-initial word orders is assumed to involve movement of the object argument. The syntactic structure
of object-initial sentences is therefore syntactically more complex than that of canonical sentences, as they require an additional structural dependency between the permuted object argument and its base position (see, e.g., Bornkessel, Fiebach, and Friederici 2004; Friederici and Mecklinger 1996 for examples). A common assumption is therefore that the subject-first-preference stems from a general preference for assuming syntactic interpretations without dependencies between moved constituents and structural positions, or with as few or as short dependencies as possible (de Vincenzi 1991; Frazier and Flores D’Arcais 1989; Gibson 1998, among others). Such accounts of the subject-first-preference entail that all types of subject-direct object reanalyses involve a reinterpretation of the syntactic structure of the sentence toward a dispreferred structural representation and do not qualitatively differ from other syntactic reanalyses (but see Hagoort, 2003, 2005 for an alternative account on the processing of syntactic ambiguities).

Evidence for this view comes from a number of ERP studies that have shown that the neurophysiological response to grammatical function ambiguities does not differ from the ERP response elicited by other kinds of syntactic ambiguities. As mentioned in Section 2.4.1, syntactic ambiguities have been shown to engender a P600 effect, occurring between 500 and 1000 ms following the presentation of either the disambiguating information (Friederici & Mecklinger 1996; Friederici et al. 2001, 1998; Osterhout & Holcomb 1992, 1993; Osterhout et al. 1994) or the syntactically ambiguous element itself (Frisch et al. 2002). The P600 has primarily been seen as a correlate of syntactic repair or reanalysis processes, or, alternatively, as a response to a competition between alternative mappings or unification links between syntactic frames (Hagoort 2003, 2005). Other ERP studies have shown that the P600 is also engendered by grammatical function reanalyses. Matzke et al. (2002) examined grammatical function ambiguities in German, a language in which grammatical functions are primarily determined on the basis of case morphology rather than word order, using visual, word-by-word sentence presentation of object-topicalized sentences of the following kind:

(4.1) Die 
\textit{begabte Sänger(in)} entdeckte der \textit{talentierte Gitarrist}

'The talented guitar player the gifted singer discovered'

In Example 4.1, the initial direct object NP is ambiguous with respect to its grammatical function because its feminine gender (‘die’) is case ambiguous, whereas the subject NP following the verb has masculine gender, which is case unambiguous, and therefore disambiguates the sentence towards an object-initial interpretation. Matzke et al. (2002) found that the determiner of the subject NP (‘der’), which provides the disambiguating information, elicited a posterior positive deflection with a late onset of approximately 600 ms (i.e., a P600 effect) in comparison to unambiguous control sentences. Frisch et al. (2002) replicated these findings using similar stimulus materials, and Casado et al. (2005) found similar results for Spanish, also using sentences with either an SVO or an OVS word order. Several studies (Bornkessel, McElree, et al. 2004; Friederici & Mecklinger 1996; Friederici et al. 2001; Schlesewsky & Bornkessel 2006) have also observed a P600 effect at the position of the disambiguating verb in visually presented German complement clauses such as 4.2:
Chapter 4. The Neurophysiological Status of Grammatical Relations

(4.2) Er wußte, daß...
The
He knew that...

\[
\begin{array}{llllll}
\text{die} & \text{Professorinnen} & \text{die} & \text{Studentin} & \text{gesehen} & \text{haben/habt}
\end{array}
\]
\[
\begin{array}{llllll}
\text{the}_{\text{NOM/ACC}} & \text{Professors}_{\text{PL}} & \text{the}_{\text{NOM/ACC}} & \text{student}_{\text{SG}} & \text{seen} & \text{have}_{\text{PL}}/\text{has}_{\text{SG}}
\end{array}
\]

'He knew that the professors had seen the student / the students had seen the professors'

In Example 4.2, both argument NPs are ambiguous with respect to their grammatical functions, but the sentence-final verb disambiguates the sentence towards an object-initial interpretation on the basis of its number marking. The fact that the P600 appears as a general response to both subject-direct object reanalyses and to syntactic reanalyses seems to indicate that the processing mechanisms underlying these revisions do not qualitatively differ, in line with the theoretical assumptions outlined above.

The functional account of Grammatical Function Reanalysis Other accounts have claimed that grammatical function reanalysis does not involve syntactic reinterpretations, but is rather concerned with a revision of the mapping between thematic roles and argument NPs. More specifically, the Extended Argument Dependency (eADM) Model (Bornkessel & Schlesewsky 2006; Bornkessel-Schlesewsky & Schlesewsky 2008, 2009b, 2009c, 2013), presented in Section 2.4.3, is consistent with this view. The eADM model assumes that the goal of argument interpretation, following an initial stage of structure building, is to determine which of the NP arguments is the Actor, and thereby to identify the thematic dependency between the arguments. That is, one argument is mapped onto the Actor role and the other onto the Undergoer role (see, e.g., Van Valin 2005). This is a highly incremental process that initiates directly when the first NP is encountered, and which draws upon both morphosyntactic and prominence-based cues. Crucially, the eADM assumes that generalized semantic roles are not tied to specific structural positions, but that languages differ with respect to the weightings of the available cues. Whereas argument word order functions as the main cue for determining the argument roles in some languages (e.g., English), other cues and their interactions are of more importance in others (e.g., German). Grammatical function reanalysis occurs in cases where an initial assumption regarding the thematic status of the argument(s) turns out to be erroneous and needs to be revised. This revision process does not involve a revision of an initial syntactic representation, but rather a remapping between argument NPs and generalized semantic roles. It is therefore assumed to involve revision processes at the thematic level of language interpretation, rather than the syntactic.

Evidence for the eADM account of grammatical function reanalysis comes from a number of ERP studies on various languages that indicate that problems with the mapping of thematic roles to argument NPs engender an N400 effect, introduced in Section 2.4.1. On the one hand, the effect is engendered by various types of cue conflicts in unambiguous sentences, such as conflicts between word order and Actor argument animacy (Philipp et al. 2008; Roehm et al. 2004; Weckerly & Kutas 1999), which are presumed to result in thematic interpretation conflicts (see Bornkessel-Schlesewsky and Schlesewsky 2009c for a review). On the other, the N400 effect was observed as a response to grammatical
function reanalysis in a recent ERP study by Haupt et al. (2008), using German verb-final clauses such as Example 4.2 (i.e., using similar sentences as Bornkessel, McElree, et al. 2004 and Schlesewsky and Bornkessel 2006). Sentences were presented auditorily rather than visually, either embedded in short story contexts (experiment 1) or in isolation (experiment 2). In both experiments, the disambiguating sentence-final verbs engendered an N400 effect followed by a P600. The authors interpreted the P600 as a response to the markedness of the target interpretation, rather than reflecting a revision of the phrase structure tree. The N400, on the other hand, was assumed to reflect the reanalysis process proper, and to correlate with a revision of the mapping between the arguments and the participant roles of the main verb.

The authors further suggested that the failure to find an N400 effect in the Bornkessel, McElree, et al. (2004) and Schlesewsky and Bornkessel (2006) studies, in which similar sentence materials were used, resulted from a modulation of the observed ERP patterns due to an overlapping P300 component, which attenuated the N400 effect. The P300 is a positive deflection with a peak amplitude around 300 ms post stimuli, which has been interpreted as a correlate of domain-general processes of ‘context-updating’, i.e., of the need to update one’s mental model of the environment (Donchin and Coles 1988; but see Polich 2007 for a more specific account and Picton 1992 for alternative views). It is elicited by attended stimuli that either differ from a subjectively expected pattern or that are predictable and relevant for the performance of the experimental task at hand. Its amplitude is proportional to the extent that the stimuli provide the information needed to perform the task (Donchin & Coles 1988). In experimental settings where the critical stimuli also function as predictable target items needed to perform the task, they might therefore elicit a P300 effect, which modulates the ERP response under study (see Roehm, Bornkessel-Schlesewsky, Rösler, and Schlesewsky 2007 for evidence that target predictability in the experimental context can significantly modulate the N400 response to the processing of semantic anomalies). In the Bornkessel, McElree, et al. (2004) and Schlesewsky and Bornkessel (2006) experiments, the disambiguating verbs also provided the information that was needed to perform the experimental task (a comprehension task), and therefore functioned as predictable and task-relevant target items. Haupt et al. (2008) suggested that auditory sentence presentation is less susceptible to task-related influences than visual, word-by-word presentation, and that the N400 effect therefore was attenuated by a P300 component in the earlier studies, in which visual presentation was employed. No N400 effect was therefore observed, and the subsequent P600 that occurs as a response to the markedness of the target interpretation, was erroneously interpreted as the correlate of the reanalysis.

4.1.2. The present study

Most of the studies on grammatical function reanalysis thus far presented were conducted on German, a language in which the grammatical functions of arguments are primarily identified by morphological information (i.e., case and agreement). In Swedish, on the other hand, argument functions are primarily determined on the basis of their word order. Whereas the eADM account of argument interpretation translates well to German grammar, a structural account might be more suitable for Swedish. It is possible that the
processing mechanisms underlying argument interpretation qualitatively differ between the languages. This study therefore investigates the ERP response to grammatical function reanalysis in Swedish and whether the reanalysis processes seem to involve a phrase structure revision (as suggested by the P600), in line with a structural account, or a thematic role remapping (as indicated by the N400), in accordance with the functional account and the eADM. The study adopts visual sentence presentation, but tries to control for a possible confound between target predictability of the experimental task and point of disambiguation by using a greater variety of comprehension questions (see below).

The sentences in the experiment As discussed more thoroughly in Section 3.1.2, Swedish lacks noun case marking and verb agreement, but has an unequivocal morphological distinction between subjects and objects for 1st and 2nd person pronouns. The only cues available for determining the grammatical functions of sentence arguments are therefore word order and personal pronoun morphology. Only one constituent may occupy the clause-initial position preceding the main verb, and subjects therefore follow the verb in transitive sentences with topicalized objects. Object-topicalized sentences with a lexical object and a pronominal subject therefore provide a clear-cut mismatch between word order and case marking, as illustrated below:

(4.3) (a) Tjejen gillar vi inte
girl.the like we not
'The girl we don’t like'
(b) Dig gillar vi inte
you like we not
'You we don’t like'

In Example 4.3a, the initial argument NP consists of a noun and is ambiguous with respect to its grammatical function. It should, however, initially be interpreted as the sentence subject on the basis of the subject-first-preference. This interpretation cannot be upheld once the unambiguous subject pronoun is encountered - the pronoun disambiguates the sentence toward an object-initial interpretation. In Example 4.3b, on the other hand, the initial argument NP consists of an unambiguous object pronoun, giving rise to an object-initial interpretation directly.

Both the structural and the eADM account of grammatical function reanalysis are consistent with these predictions. Both Government and Binding (e.g. Holmberg 1986; Holmberg & Platzack 1995) and Minimalism (e.g. Platzack 1998, 2010) accounts of Swedish assume that object NPs move to the sentence-initial position in object-topicalized sentences, but remain in situ in canonical, subject-initial sentences. Object-topicalized sentences therefore contain an additional dependency between the topicalized object and its long-distance base position. A structural account that assumes a general preference for structural interpretations with as few dependencies as possible therefore predicts that sentences such as 4.3a are initially interpreted as subject-initial, but are revised toward the dispreferred and syntactically more complex object-initial interpretation when the disambiguating subject pronoun is encountered. The eADM account, on the other hand, predicts that the first argument is initially mapped onto the Actor role on the basis of
its initial position, but remapped onto the Undergoer role when the subject pronoun is encountered.

**Frequency and acceptability of object-topicalized sentences** Although object topicalized sentences in Swedish are grammatical, they are highly infrequent and marked when occurring outside of an appropriate discourse context. As the corpus study presented in Chapter 5 will show, only about 5% of transitive sentences in written Swedish discourse are object-initial. In order to evaluate the acceptability of object-topicalized sentences occurring outside of a licensing context, I conducted an initial rating study. In all, 32 participants rated four types of transitive sentences: canonical sentences with an SVO word order, object topicalized sentences with an OVS word order, semantically implausible SVO sentences with inanimate subject arguments in violation to the verb semantics, and ungrammatical SVO sentences with two subject pronouns. Sentences were rated for their acceptability on a scale from 1 (not at all acceptable) to 7 (highly acceptable). Canonical SVO sentences received the highest ratings \((M = 6.15, SD = 0.57)\), topicalized OVS-sentences the next highest \((M = 4.9, SD = 1.17)\), followed by semantically implausible sentences \((M = 3.43, SD = 1.81)\). Ungrammatical sentences, finally, received the lowest ratings \((M = 1.49, SD = 0.85)\). The overall difference between mean ratings was significant (One-way repeated measures ANOVA, \(F(3, 103) = 135.03, p < .001\), and the mean ratings of each individual sentence type differed significantly from each other (Bonferroni corrected pairwise comparisons, all \(p\)s < .001). Thus, although object-topicalized sentences are less acceptable than canonical SVO sentences, they are much more acceptable than ungrammatical as well as semantically implausible sentences. It is therefore likely that they will not engender a P600 effect due to a dispreference for them.

**The predictions of the experiment** The six sentence conditions of the experiment are shown in Table 4.1 below. All conditions consist of transitive sentences with a final adverbiaial. Each successive pair is differentiated with respect to word order: the former of the two has a canonical SVO word order whereas the latter has an object-initial OVS order. In the first pair, both arguments are pronominal. In the second pair, only the subject NP is pronominal, and in the last pair, only the object NP is pronominal. Henceforth, each condition will be labeled as specified in the table.

The initial argument (Argument 1) of both the OLex-V-SPro and SLex-V-OPro conditions is locally ambiguous with respect to its grammatical function, but should initially be interpreted as the subject on the basis of the subject-first-preference. In SLex-V-OPro, this interpretation is confirmed when the second argument (Argument 2) is encountered, as this argument consists of an object pronoun. In the critical OLex-V-SPro condition, on the other hand, Argument 2 consists of a subject pronoun, and hence disambiguates the sentence towards an object-initial interpretation. Argument 2 is therefore predicted to engender a reanalysis effect (either a P600 or an N400 effect) in OLex-V-SPro but not in SLex-V-OPro. However, as the second arguments of these conditions also differ with respect to their forms, an observed differential ERP effect between them cannot be unequivocally attributed to a presumed reanalysis. The unambiguous OPro-V-SPro condition will therefore also function as a control condition. If the ERP effect observed in

\[1\] Note that object topicalization might be more frequent in spoken language.
OLex-V-SPro is also present in comparison to OPro-V-SPro, it cannot be due to a form difference between the second arguments, since they consist of subject pronouns in both of these conditions. The effect rather has to reflect a reanalysis towards an object-initial interpretation in OLex-V-SPro.

Another alternative explanation pertains to the fact that both OPro-V-SPro and SLex-V-OPro differ from OLex-V-SPro with respect to the relative prominence of the arguments in terms of their referential properties. Recall that, whereas Actor arguments tend to be pronominal and highly prominent, Undergoer arguments are more frequently lexical and therefore less prominent. A number of studies have shown that an N400 effect is engendered in cases where it becomes apparent that the Undergoer is more prominent than the Actor, for instance, at the position of an inanimate Actor following an animate Undergoer (see Weckerly and Kutas 1999 for evidence from English; Roehm et al. 2004, for German; Philipp et al. 2008 for Mandarin Chinese and Bornkessel-Schlesewsky and Schlesewsky 2009 for examples from further languages). This effect seems to correlate with mismatches between the thematic dependency of arguments and their relative prominence (Bornkessel-Schlesewsky & Schlesewsky 2009). In OLex-V-SPro, the sentence-final Actor is more prominent than the Undergoer. But in OPro-V-SPro, both arguments are equally prominent, and in SLex-V-OPro, the Actor is more prominent than the Undergoer. It is therefore possible that any ERP differences between OLex-V-SPro and the OPro-V-SPro and SLex-V-OPro conditions stem from a difference between the relative prominence of the arguments rather than reflecting reanalysis processes. If a relative prominence difference is responsible for an observed difference, however, it should also be observed at Argument 2 when comparing SLex-V-OPro with SPro-V-OPro, as the Undergoer argument is more prominent than the Actor in the former condition but not in the latter.

One more effect is also predicted. Open-class words elicit an N400 effect in comparison to closed-class words, both for words presented in isolation (Münte et al. 2001) and in a

Table 4.1. The six sentence conditions used in the experiment.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Example sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPro-V-OPro</td>
<td>Ni visade oss till köket 2PL.SBJ show-PST 1PL.OBJ to kitchen-DEF</td>
</tr>
<tr>
<td>OPro-V-SPro</td>
<td>Oss visade ni till köket 1PL.OBJ show-PST 2PL.SBJ to kitchen-DEF</td>
</tr>
<tr>
<td>SPro-V-OLex</td>
<td>Ni visade bagarna till köket 2PL.SBJ show-PST baker-DEF.PL to kitchen-DEF</td>
</tr>
<tr>
<td>OLex-V-SPro</td>
<td>Bagarna visade ni till köket baker-DEF.PL show-PST 2PL.SBJ to kitchen-DEF</td>
</tr>
<tr>
<td>SLex-V-OPro</td>
<td>Bagarna visade oss till köket baker-DEF.PL show-PST 1PL.OBJ to kitchen-DEF</td>
</tr>
<tr>
<td>OPro-V-SLex</td>
<td>Oss visade bagarna till köket 1PL.OBJ show-PST baker-DEF.PL to kitchen-DEF</td>
</tr>
</tbody>
</table>
sentence context (Neville, Mills, & Lawson 1992). This suggests that the N400 amplitude is sensitive to the ‘semantic content’ of lexical items (i.e., to their number of semantic, contextual and associative relations), which is greater for open-class words (Münte et al. 2001). Roll, Horne, and Lindgren (2007) found that lexical direct objects of Swedish sentences elicited an N400 in comparison to pronominal equivalents. Nouns are therefore predicted to engender an N400 effect in comparison to pronouns, irrespective of their grammatical function and position.

4.2 Method

4.2.1. Participants

A total of 32 right-handed participants (11 male) conducted the experiment after giving informed consent in writing. Most of the participants were students at the Department of Linguistics at Stockholm University. The mean age was 25.7 years ($SD = 8.18$). In order to encourage participation, each participant received a cinema voucher. Data from eight participants were excluded from the final analysis due to excessive EEG artifacts.

4.2.2. Materials

Experimental sentences A total of eighty stimulus sets of the six conditions shown in Table 4.1 were constructed on the basis of forty verbs, forty nouns and eight pronouns. All conditions within a set contained the same noun, verb, object pronoun and/or subject pronoun, in the manner shown in Table 4.1. Each condition was therefore matched with a condition with an identical Argument 1 (e.g., OLex-V-SPro and SLex-V-OPro) and a condition with an identical Argument 2 (e.g., OLex-V-SPro vs. OPro-V-SPro). The specific words used in each stimulus set are listed in Appendix A. The sets were divided into two stimulus lists. Half of the participants were presented the first list and the other half the second. All verbs were prototypical, transitive action verbs and were selected on the basis of frequency counts in the Swedish part of the PAROLE corpus. Half of them occurred in the present tense in the first stimulus list and in the past tense in the second list, whereas the other half occurred in the past tense in the first list but in the present tense in the second one. Nouns consisted of kinship terms, nouns denoting professions or occupations (e.g., ‘student’, ‘teacher’ or ‘soldier’) and nouns denoting individuals without any reference to kinship or occupation (e.g., ‘child’, ‘girl’, ‘man’). Half of them occurred in the singular in the first stimulus list and in the plural in the second, whereas the other half occurred in the plural in the first list and in the singular in the second. Nouns were between 5 to 12 letters long. Presented at a one-meter distance, their angular size ranged between $0.57^\circ$ to $1.03^\circ$ in height and $2.46^\circ$ to $5.84^\circ$ in width. Only 1st and 2nd person pronouns were used, as these are the only pronouns in Swedish for which an unequivocal distinction between subjects and objects exists. Pronouns occurred both in the singular and in the plural, and eight different pronouns were therefore used (see Table 4.2). Pronouns were 2 to 3 letters long and a had maximal angular size of $1.03^\circ$ in height and $1.84^\circ$ in width. Sentence final adverbials consisted of an adverbial phrase up to three words long that was semantically compatible with the verb at hand. All grammatical categories and their possible combinations were evenly balanced across stimulus sets.
Table 4.2. Pronouns used in the experiment.

<table>
<thead>
<tr>
<th>Subject form</th>
<th>Object form</th>
</tr>
</thead>
<tbody>
<tr>
<td>1SG</td>
<td>Jag</td>
</tr>
<tr>
<td>1PL</td>
<td>Du</td>
</tr>
<tr>
<td>2SG</td>
<td>Vi</td>
</tr>
<tr>
<td>2PL</td>
<td>Ni</td>
</tr>
</tbody>
</table>

Comprehension questions Each experimental sentence was matched with a corresponding comprehension question. The experimental task was to determine whether the comprehension questions referred back to the event described by the experimental sentence at hand. For instance, the comprehension question to the first example sentence in Table 4.1, correctly answered with a yes, was ‘Visar ni oss till köket?’ (‘Will you show us to the kitchen?’). The purpose of this task was to ensure that participants paid attention to the experimental sentences and read them accurately. Incorrectly answered trials were excluded from the final analysis.

Half of the comprehension questions corresponded to their experimental sentences and were correctly answered with a yes, whereas the other half did not, and were to be answered with a no. In order to eliminate the possibility of adopting heuristic strategies when performing the experimental task and to make sure that no specific word functioned as the critical target item needed to perform it, five different types of ‘no’ questions were used. In four ‘no’ questions, one of the words of the corresponding experimental sentence was replaced by a semantically compatible word of the same word class. In the final ‘no’ question, the subject and object of the sentence was exchanged. All ‘no’ questions occurred equally often. With these comprehension questions, any word of the critical sentences, rather than the disambiguating second argument only, could potentially function as the critical item that provided the information needed to perform the experimental task.

4.2.3. Procedure

Experimental sessions were conducted in a dimly lit and sound attenuated room at the Phonetics Lab at the Department of Linguistics at Stockholm University. Participants were initially informed about the procedure of the experiment and on how to perform the experimental task. They were told that they could terminate the experiment at any time without giving a reason and gave a written consent. Participants were seated in front of a computer monitor, at a distance of one meter, and the EEG net was applied. They were asked to avoid blinking and moving their eyes during the presentation of the sentences, but were told that they could blink or move once the comprehension questions were presented or in between blocks. Before the actual experiment started, written instructions on how to perform the experiment were presented. This was followed by a practice session consisting of 12 practice trials, during which participants received feedback on whether they had answered the comprehension questions correctly.

Each practice and experimental trial consisted of a visual presentation of the sentence at hand. The trials began with the presentation of a fixation cross that appeared in the center of the computer screen for 800 ms, followed by a 100 ms blank screen. The
experimental sentences were then presented one word at a time. Each word was presented for 400 ms with an inter-stimulus interval of 100 ms. After the last word was presented, a blank screen was presented for 800 ms followed by the comprehension question, which remained visible until the participant answered by pressing one of two buttons labeled ‘yes’ and ‘no’ on a response box. There was no time limit for the participants to make their answer. The assignment of the left and right buttons to the answers ‘yes’ and ‘no’ was counterbalanced across stimulus lists. When the question had been answered, a final blank screen appeared for 100 ms before the next trial begun. Before each of the six experimental blocks started, a screen appeared that informed the participants that the block was about to begin. The sequential number of the upcoming block was explicitly stated. Participants started the next block by pressing any of the keys on the response box and were encouraged to take small breaks in between blocks.

4.2.4. Data analysis

**EEG recordings** EEG data were collected with a high-impedance 128 electrode Hydrocell Sensor Net and analyzed using Net Station equipment (Electrical Geodesics, Inc.). The electro-oculogram (EOG) was monitored with two electrodes positioned at the outer canthus of each eye, four positioned above the eyes and two below. The signal was amplified with a Net Amps 300 amplifier with a fixed sampling rate of 20000 Hz and a low-pass filter at 4000 Hz, but down-sampled during recording to a user set sampling rate of 250 Hz. Impedances of all electrodes were adjusted below 50 kΩ before the recording was started. The ground electrode was positioned in between CPz and Pz. Channels were referenced to Cz during recording, but re-referenced to the average of all channels.

**ERP data analysis** The data was initially band-pass filtered off-line using a 0.3- to 20-Hz filter. The EEG was divided into single trial epochs, ranging from -200 ms to 1000 ms relative to the onset of Argument 1 and Argument 2, with 200 ms used for baseline correction. Participant data with more than 10 bad channels or more than 15 bad epochs relative to Argument 2, in any of the 6 conditions, was excluded from further analysis. Channels were defined as bad if the full signal exceeded ±75 µV in more than 50% of the time windows during which the experimental stimuli were presented (from 200 ms before the presentation of Argument 1 to 2000 ms after the presentation of Argument 1). Epochs were defined as bad and excluded if they contained more than 10 bad channels in which the signal exceeded ±55 µV in the full epoch, if the signal exceeded ±100 µV in a 640 ms time window in any of the anterior or posterior EOG channels, or if the signal exceeded ±55 µV in a 500 ms time window in any of the EOG channels outside the canthus of each eye. All single trial epochs in which participants answered incorrectly were also defined as bad and excluded. Data from a total of 26 participants, consisting of 79.6% of the single trial epochs for Argument 1 and 84.9% for Argument 2, was included in the final analysis. Bad channels in the included data were interpolated from the remaining good channels, using spherical splines (Perrin, Pernier, Bertrand, Giard, & Echallier 1987). ERPs were then calculated per participant, electrode, condition and argument onset (Argument 1 and Argument 2).
Figure 4.1. Electrode positions and regions of interest. Electrodes whose positions approximately correspond to the 10-10 standard positions are labeled accordingly. Other electrodes are numbered according to the Electrical Geodesics system. Selected electrodes shown in Figure 4.2 to 4.5 are dark gray, whereas the electrode shown in Figure 4.6 is light gray.

Statistical analysis  Statistical analyses of the ERP-data were conducted on mean amplitudes in time windows that were chosen on the basis of findings in earlier studies and visual inspection of the data. Initial analyses were conducted across and within Regions of Interest (ROIs). Lateral electrodes were grouped in the following eight ROIs: Left Anterior Inferior (AF3, AF7, F5, F7, F9, FP1, FT7, Ft9, T9, 18, 21, 25, 39 and 40), Left Anterior Superior (C1, C3, F1, F3, FC1, FC3, FC5, 7, 12, 20 and 35), Left Posterior Inferior (O1, P5, P7, P9, PO7, T7, Tp7, 50, 59, 66, 69, 71 and 74), Left Posterior Superior (C5, CP1, CP3, Cp5, P1, P3, PO3, 31, 53, 54 and 61), Right Anterior Inferior (AF4, AF8, F6, F8, F10, FP2, FT8, Ft10, T10, 8, 10, 14, 109 and 115), Right Anterior Superior (C2, C4, F2, F4, FC2, FC4, FC6, 5, 106, 110, 118), Right Posterior Inferior (O2, P6, P8, P10, PO8, T8, TP8, 76, 82, 84, 89, 91 and 101) and Right Posterior Superior (C6, Cp2, CP4, CP6, P2, P4, PO4, 78, 79, 80 and 86). Midline electrodes were grouped in two ROIs: Midline Anterior (Fpz, Afz, Fz and Fcz) and Midline Posterior (Cpz, Pz, Poz and Oz). Electrode locations and ROIs are illustrated in Figure 4.1.
Initial analyses consisted of repeated measures ANOVAs on mean amplitudes in the relevant time windows of the Argument 1- and the Argument 2-ERPs, respectively. Both global analyses across multiple ROIs and local analyses within specific ROIs were conducted. The correction method proposed by Huynh and Feldt (1970) was always used when evaluating the effects of factors or interactions for which compound symmetry could not be assumed, as indicated by the test proposed by Mauchly (1940). Follow-up analyses were finally performed in order to assess differences between individual conditions and/or groups of conditions. These involved tests between individual conditions, tests of contrasts with contrast weights defined such that individual conditions were compared against groups of conditions, as well as one-way ANOVAs across groups of conditions. Only significant effects are reported.

4.3. Results

4.3.1. Behavioral data

A 6 (Condition) × 6 (Question Type) repeated measures ANOVA was conducted on mean error rates of the comprehension task. The factor Condition differentiated the six sentence conditions, and Question Type the six comprehension question types. This ANOVA yielded a main effect of Condition, $F(5, 125) = 2.58$, $p < .05$, a main effect of Question Type, $F(5, 125) = 6.13$, $p < .01$, and a significant Condition × Question Type interaction, $F(5, 125) = 3.65$, $p < .01$. The grand mean error rate was 5.2% (SD = 12.7). The error rate per condition was highest for SLex-V-OPro sentences ($M = 7.08\%$, $SD = 15.61$), and lowest for OPro-V-SPro sentences ($M = 3.33\%$, $SD = 9.04$). ‘No 5’ questions, in which the arguments of the sentence have been exchanged, had by far the highest per question error rate ($M = 10.26\%$, $SD = 18.03$), whereas ‘No 4’ questions, in which the final adverbial has been replaced, had the lowest ($M = 2.72\%$, $SD = 10.46$). Error rates for SPro-V-OPro sentences with ‘No 5’ questions was further exceptionally high ($M = 20.19\%$, $SD = 27.4$). This is also the case for error rates for SLex-V-OPro sentences with ‘No 3’ questions ($M = 19.23\%$, $SD = 27.67$).

4.3.2. ERP data

ERP analyses were conducted relative to the onset of Argument 1 and Argument 2, respectively. Analyses investigating ERP differences between word classes and word orders are presented first, followed by analyses investigating the reanalysis effect.

**Word class differences** Figure 4.2 compares conditions with Argument 1 nouns (SLex-V-OPro and OLex-V-SPro) with SPro-V-OPro and Figure 4.3 conditions with Argument 2 nouns (SPro-V-OLex and OPro-V-SLex) with SPro-V-OPro. They illustrate that both Argument 1 and Argument 2 nouns elicit a negative deflection peaking around 400 ms post stimuli, in comparison to the corresponding pronominal arguments. This negativity, further referred to as the ‘lexical N400’, is distributed across the posterior ROIs and peaks in the Midline Anterior ROI. Nouns also engender a dipolar effect in the inferior/anterior ROIs in comparison to pronouns: In the Left Anterior Inferior ROI, they give rise to a positive deflection with a broad latency, peaking around 400 ms post stimuli. This
positivity is mirrored by a negative deflection in the Right Anterior Inferior ROI with a somewhat later onset and a peak around 500 ms post stimuli. As the posterior ‘lexical N400’ effect and the frontal dipolar pattern appears in similar time windows, initial analyses were conducted across lateral and midline ROI:s in the 300-475 ms time window relative to the onset of both arguments. Analyses involved the factor Condition and ROI, differentiating between the eight lateral or the two midline ROIs. Two 6 (Condition) × 8 (ROI) ANOVA:s conducted across lateral ROI:s for Argument 1 and 2 ERP:s revealed significant main effects of Condition, (Argument 1: $F(5, 125) = 5.48$, $p < .001$; Argument 2: $F(5, 125) = 6.8$, $p < .001$), of ROI, (Argument 1: $F(7, 175) = 4.06$, $p < .05$; Argument 2: $F(7, 175) = 12.18$, $p < .001$) and significant Condition × ROI interactions, (Argument 1: $F(35, 875) = 7.73$, $p < .001$; Argument 2: $F(35, 875)$, $p < .001$). Two 6 (Condition) × 2 (ROI) ANOVA:s conducted across midline ROI:s for Argument 1 and 2 ERP:s showed a significant effect of Condition for both arguments (Argument 1: $F(5, 125) = 2.94$, $p < .05$; Argument 2: $F(5, 125) = 2.38$, $p < .05$), but only Argument 2 analyses revealed a main effect of ROI ($F(1, 25) = 4.3$, $p < .05$) and a ROI × Condition interaction ($F(5, 125) = 4.66$, $p < .01$).

Bonferroni corrected follow-up analyses were conducted across each individual ROI. Tests on contrasts were made with contrast weights defined in such a manner that Argument 1 and 2 noun ERP:s were individually compared against the mean of Argument 1.
4.3 Results

Figure 4.3. Grand Average ERP:s relative to the onset of Argument 2 at selected electrodes from each ROI (shown in Figure 4.1) for the pronominal SPro-V-OPro condition and the lexical SPro-V-OLex and OPro-V-SLex conditions.

and 2 pronoun ERP:s. One-way ANOVA:s were also conducted across Argument 1 and 2 pronoun ERP:s in order to determine whether they differed among each other. The results of these analyses, shown in Table 4.3, show that the dipolar frontal pattern has a broader scalp distribution for Argument 1 nouns than for Argument 2 nouns, as it is significant in the Anterior Superior ROIs for the latter but not for the former. The ‘lexical N400’ effect, on the other hand, has a broader and more central distribution for Argument 2 nouns, as it is significant in the Left Posterior Superior ROI for Argument 2 but not for Argument 1. There are no significant differences between pronominal arguments.

Word order differences Analyses were conducted in order to investigate differences between object-topicalized sentences in general and canonical, subject-initial sentences. Argument 2 subject pronouns in object-topicalized sentences were found to engender an enhanced P3 wave in the 275-375 ms time window, in comparison to object pronouns in canonical subject-initial sentences, which is mirrored by an anterior negativity. This early positivity, henceforth referred to as the ‘P300’ (see discussion below), is illustrated in Figure 4.4. Argument 1 object pronouns, on the other hand, appear to engender a negative deflection which is confined to the Midline Anterior ROI, in comparison to subject pronouns. This effect is also illustrated in Figure 4.4. Analyses were conducted in the 275-375 ms time window across conditions with pronominal arguments only, relative to
Table 4.3. Results of Bonferroni corrected follow-up analyses, conducted across individual ROI:s on mean amplitudes in the 300–475 ms time window relative to the onset of Argument 1 and Argument 2. The left-hand column shows follow-up analyses across all conditions. The middle column shows tests on contrasts in which mean amplitudes of both lexical subjects and lexical objects are compared with mean amplitudes of pronouns. The right-hand column shows follow-up analyses on mean amplitudes of pronouns.

<table>
<thead>
<tr>
<th>ROI</th>
<th>All conditions</th>
<th>Contrast comparisons</th>
<th>Pronouns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F(5, 125)</td>
<td>p</td>
<td>F(1, 125)</td>
</tr>
<tr>
<td>LAI</td>
<td>22.61</td>
<td>&lt;.001</td>
<td>43.04</td>
</tr>
<tr>
<td>LAS</td>
<td>2.96</td>
<td>&lt;.1</td>
<td>7.47</td>
</tr>
<tr>
<td>MA</td>
<td>1.38</td>
<td>n.s.</td>
<td>-</td>
</tr>
<tr>
<td>RAS</td>
<td>9.97</td>
<td>&lt;.001</td>
<td>5.5</td>
</tr>
<tr>
<td>RAI</td>
<td>6.8</td>
<td>&lt;.001</td>
<td>10.01</td>
</tr>
<tr>
<td>LPI</td>
<td>1.67</td>
<td>n.s.</td>
<td>-</td>
</tr>
<tr>
<td>LPS</td>
<td>1.17</td>
<td>n.s.</td>
<td>-</td>
</tr>
<tr>
<td>MP</td>
<td>3.29</td>
<td>&lt;.05</td>
<td>9.63</td>
</tr>
<tr>
<td>RPS</td>
<td>7.35</td>
<td>&lt;.001</td>
<td>12.14</td>
</tr>
<tr>
<td>RPI</td>
<td>2.26</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LAI</td>
<td>14.18</td>
<td>&lt;.001</td>
<td>28.62</td>
</tr>
<tr>
<td>LAS</td>
<td>0.6</td>
<td>n.s.</td>
<td>-</td>
</tr>
<tr>
<td>MA</td>
<td>1.5</td>
<td>n.s.</td>
<td>-</td>
</tr>
<tr>
<td>RAS</td>
<td>1.09</td>
<td>n.s.</td>
<td>-</td>
</tr>
<tr>
<td>RAI*</td>
<td>3.64</td>
<td>&lt;.05</td>
<td>14.62</td>
</tr>
<tr>
<td>LPI</td>
<td>2.6</td>
<td>n.s.</td>
<td>-</td>
</tr>
<tr>
<td>LPS</td>
<td>4.54</td>
<td>&lt;.01</td>
<td>7.32</td>
</tr>
<tr>
<td>MP</td>
<td>5.9</td>
<td>&lt;.001</td>
<td>7.2</td>
</tr>
<tr>
<td>RPS</td>
<td>6.79</td>
<td>&lt;.001</td>
<td>8.97</td>
</tr>
<tr>
<td>RPI</td>
<td>2.42</td>
<td>n.s.</td>
<td>-</td>
</tr>
</tbody>
</table>

*conducted in the 425-575 ms time window

The analysis conducted across lateral ROI:s found a significant effect of Function, $F(1, 25) = 4.92, p < .05$, an effect of ROI, $F(1, 25) = 15.03, p < .001$, and a Function × ROI interaction, $F(7, 175) = 6.5, p < .001$. The analysis across midline ROI:s revealed a significant Function × ROI interaction, $F(1, 25) = 10.22, p < .01$, but no other significant effects. Within-ROI analyses only found main effects of Function, shown in Table 4.4. They show that the positive shift is evenly distributed across posterior ROI:s, and the corresponding negative shift appears in the Midline and Inferior Anterior ROI:s. For Argument 2 ERP:s, a 2 (Function) × 2 (Final Argument) × 8 (ROI) ANOVA was conducted across lateral ROI:s and a 2 (Function) × 2 (Initial Argument) × 2 (ROI) ANOVA across midline ROI:s. The factor Function differentiated between the grammatical function of the Argument 2 pronoun (subject vs. object) and the factor Initial Argument between the word class of Argument 1 (noun vs. pronoun).
4.3 Results

Figure 4.4. Grand Average ERP:s relative to the onset of both Argument 1 and Argument 2 in selected electrodes from the Midline Anterior and Midline Posterior ROI:s, comparing subject pronouns with object pronouns.

midline ROIs, respectively. Here, the factor Final Argument differentiated between the word class of Argument 2 (noun vs. pronoun). The analysis conducted across lateral ROI:s only found a main effect of ROI, $F(1, 25) = 7.9, p < .01$, but no other significant effects. The midline ROI analysis, on the other hand, revealed a main effect of Function, $F(1, 25) = 8.62, p < .01$, but no other effects. Within-ROI analyses found a main effect of Function in the Midline Anterior ROI, $F(1, 25) = 4.76, p < .05$, but no other significant effects. Thus object-initial sentences engender an enhanced P3 wave with a centro-parietal scalp distribution at the position of Argument 2, and a negativity with a local, centro-anterior distribution at Argument 1, in comparison to canonical, subject-initial sentences.

The reanalysis effect In Figure 4.5, Argument 2 ERP:s of the critical OLex-V-SPro condition and the SLex-V-OPro and OPro-V-SPro control conditions are shown. On the

Table 4.4. The effect of word order on mean amplitudes in the 275 – 375 ms time window relative to the onset of Argument 2, within ROI:s.

<table>
<thead>
<tr>
<th>ROI</th>
<th>Left Inferior</th>
<th>Left Superior</th>
<th>Midline</th>
<th>Right Superior</th>
<th>Right Inferior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>F 8.84</td>
<td>0.45</td>
<td>4.29</td>
<td>0.66</td>
<td>6.07</td>
</tr>
<tr>
<td></td>
<td>$p &lt; .01$</td>
<td>n.s.</td>
<td>$&lt; .05$</td>
<td>n.s.</td>
<td>$&lt; .05$</td>
</tr>
<tr>
<td>Posterior</td>
<td>F 14.48</td>
<td>6.78</td>
<td>9.93</td>
<td>6.82</td>
<td>8.97</td>
</tr>
<tr>
<td></td>
<td>$p &lt; .01$</td>
<td>$&lt; .05$</td>
<td>$&lt; .01$</td>
<td>$&lt; .05$</td>
<td>$&lt; .01$</td>
</tr>
</tbody>
</table>
one hand, OLex-V-SPro appears to elicit a long latency positivity in the Midline Posterior ROI, starting around 700 ms post-stimuli, and, on the other, a negative deflection in the Right Posterior Superior ROI, peaking around 475 ms post-stimuli, in comparison to the control conditions. Analyses were conducted across the OLex-V-SPro, OPro-V-SPro and SLex-V-OPro conditions. An initial analysis in the 800-1000 ms time window across the Midline Anterior ROI showed that the late positivity in this ROI is not significant. The negativity in the Right Posterior Superior ROI, further referred to as the ‘reanalysis N400’ and illustrated in greater detail in Figure 4.6, was analyzed in the 375-550 ms time window. Although initial global analyses failed to find a significant effect, an analysis across the Right Anterior Superior ROI did reveal a significant difference between the three conditions, $F(2, 50) = 3.69, p < .05$. Follow-up analyses found significant differences between OLex-V-SPro and OPro-V-SPro, $t(25) = 2.04, p < .05$, between OLex-V-SPro and SLex-V-OPro, $t(25) = 1.85, p < .05$, but not between the control conditions OPro-V-SPro and SLex-V-OPro, $t(25) = 0.06, p = .46$. A one-way ANOVA conducted across the non-critical conditions with pronominal second arguments (i.e., SPro-V-OPro, OPro-V-SPro and SLex-V-OPro), finally, showed that these conditions did not significantly differ. Note, that these follow-analyses were not corrected for multiple comparisons.
4.4 Discussion

The purpose of the present ERP experiment was to investigate whether the processing mechanisms underlying grammatical function reanalysis in Swedish involve revisions at the syntactic or the thematic level of representation. This was done on the basis of visually presented transitive sentences, with either a canonical SVO word order or an object-initial OVS word order, and in which either the subject NP, the object NP or both arguments were pronominal (see Table 4.1).

The following effects were found. Noun arguments in general elicited two effects in comparison to pronouns at the corresponding sentence positions. On the one hand, they engendered a frontal dipolar pattern, consisting of a long-latency positivity with a right-frontal distribution, mirrored by a long-latency negativity at the corresponding left hand scalp positions. This effect had a broader scalp distribution for Argument 1 nouns than for Argument 2 nouns. On the other, nouns gave rise to a ‘lexical N400’ effect, a negativity in the 300-475 ms time window with a parietal scalp distribution. This effect had a right parietal scalp distribution for Argument 1 nouns and a somewhat broader, centro-parietal distribution for Argument 2 nouns. Object-initial sentences also differed from canonical, subject-initial sentences. Argument 2 subject pronouns engendered an enhanced P3 wave in the 275-375 ms time window, in comparison to object pronouns. This effect appeared in the posterior scalp regions and was mirrored by a negativity in centro-anterior and inferior-anterior regions. Argument 1 object pronouns, on the other hand, elicited an enhanced negativity with a local, centro-anterior distribution, in comparison to subject pronouns.

Most importantly, a reanalysis effect was engendered by Argument 2 in the critical OLex-V-SPro sentence condition, which disambiguated these sentences towards an object-initial interpretation. A negativity in the 375-550 ms time window was found in comparison to the OPro-V-SPro and SLex-V-OPro control conditions. This ‘reanalysis N400’ effect had a local, right parietal scalp distribution. No other differences between conditions turned out to be significant. In the following, these effects will be discussed in the light of the predictions presented in Section 4.1.2, starting with the differences between nouns and pronouns, then turning to the word-order differences, and finally the reanalysis effect.
4.4.1. The frontal dipolar effect

It is possible that the highly unexpected frontal dipolar ERP pattern stems from electro-ocular activity. The effect is at its largest around the superior EOG channels and gradually decreases in channels farther away from them. Whereas no pronoun was longer than three letters and subtended no more than 1.84° visual angle, nouns were up to twelve letters long and subtended 5.84°, approximately half of them more than 4°. Given that visual acuity decreases as a function of the distance between the retinal stimulus position and the point of fixation (Hershenson 1969), and is impaired when the stimulus subtends more than 4° visual angle (Lefton & Norman Haber 1974), this word length difference might have influenced participants’ eye fixations and given rise to differences in the muscular activity of the eyes during the reading of nouns versus the reading of pronouns. That is, the presentation of long nouns might have engendered electro-ocular activity which fell below the rejection thresholds of the EOG channels. In order to test this account, mean amplitudes in a 200-600 ms time window, relative to the onset of Argument 2, were calculated for each Argument 2 lexical item, on the basis of non-rejected single trial epochs recorded by electrode F9 and F10, respectively, as the dipolar pattern was at its strongest at these electrodes. These mean amplitudes were then correlated with the physical word lengths of Argument 2. There was a small but significant positive correlation between the mean amplitudes of the left-lateral electrode F9 and word lengths, \( r_{86} = 0.22, p < .05 \), and a small yet significant negative correlation between the mean amplitudes of the right-lateral electrode F10 and word lengths, \( r_{86} = -0.35, p < .001 \). That is, in the 200-600 ms time window, longer words elicited a more positive-going response at the left-lateral electrode F9, but a more negative-going response at the right-lateral electrode F10. These results support the suggestion that this dipolar pattern stems from differential electro-ocular activity due to differences in the fixation of short versus long words.

4.4.2. The ‘lexical’ N400

As expected, nouns in general elicited a ‘lexical N400’ effect in comparison to pronouns, independent of their grammatical functions and sentence positions. These results are in line with previous findings that open-class words elicit N400 effects in comparison to closed-class words (Münte et al. 2001; Neville, Nicol, Barss, Forster, & Garret 1991) and the results of Roll et al. (2007) who found that lexical direct objects engendered an N400 effect in comparison to pronominal equivalents in Swedish sentences. This ‘lexical N400’ effect has been interpreted to reflect the greater ‘semantic content’ of open-class words in comparison to closed-class words, in terms of their greater number of semantic and associative relations to other lexical items in the mental lexicon, and the increased semantic integration costs that consequently follows (Münte et al. 2001; Roll et al. 2007; and see Kutas and Federmeier 2000 for a review and interpretation of the N400 effect). That is, nouns differ from pronouns in that they convey more meaning and consequently are more costly to integrate into the semantic context.
4.4.3. The effects of an object-initial word order

Pronominal arguments in sentences with an object-initial word order engendered two unpredictable effects, in comparison to the corresponding pronouns in canonical, subject-initial sentences. Argument 1 object pronouns engendered a local, centro-anterior negative shift in comparison to subject pronouns, and Argument 2 subject pronouns elicited an enhanced P3 wave with a centro-parietal distribution, in comparison to object pronouns. The centro-anterior negativity engendered by Argument 1 object pronouns, which directly are interpreted as object arguments due to their morphological form, might reflect working memory related processes. Some studies have found that unambiguously marked initial objects engender negative deflections with a somewhat left anterior scalp distribution (i.e. LAN effects) in comparison to unambiguous subjects (Felser, Clahsen, & Münte 2003; Hagiwara, Soshi, Ishihara, & Imanaka 2007; Matzke et al. 2002). In some cases, yet another LAN or a late positive effect has been observed when the canonical position of the dislocated object is identified (i.e., when the subcategorizing verb or the second argument is encountered) (Felser et al. 2003; Fiebach et al. 2002; Hagiwara et al. 2007; Kaan, Harris, Gibson, & Holcomb 2000; Phillips, Kazanina, & Abada 2005). The LAN effects are generally assumed to reflect increased working memory demands due to maintenance of the dislocated element. Although the scalp distribution of the negativity found in the present study differs from that of earlier studies, it is possible that it also reflects increased working memory demands. From a structural perspective, the initial object pronouns are directly identified as dislocated elements, and need to be maintained in working memory until their base positions are identified, following the subject arguments. From the eADM perspective, a working memory related account applies because, as discussed in Section 2.4.3, Undergoer arguments are assumed to be semantically dependent on Actor arguments, but not vice versa (Primus 2006). Whereas semantic properties can be assigned to an initial Actor argument once the verb is encountered, the semantics of an initial Undergoer argument is dependent on semantic properties of the Actor. The Undergoer therefore needs to be maintained in working memory until the Actor is encountered for its full interpretation. The idea that the negativity engendered by object-initial pronouns reflects increased working memory demands is therefore consistent with both accounts.

The enhanced P3 wave, engendered by Argument 2 subject pronouns cannot, however, be working memory related as it also is elicited by OLex-V-SPro sentences. These sentences are identified as object-initial at Argument 2 and therefore cannot give rise to increased working memory demands at Argument 1. The effect cannot reflect reanalysis processes either, as it is not affected by whether Argument 1 is a noun, and therefore ambiguous, or a pronoun hand hence unambiguous. I instead suggest that the enhanced P300 wave stem from the relative infrequency of object-topicalized sentences in Swedish. As discussed in the introduction, the P300 has been interpreted as a domain-general component that is elicited by stimuli that differ from an expected pattern or are predictable and significant for the experiment specific task (Donchin & Coles 1988). Further, whereas some studies have assumed that P600 effects engendered by syntactic anomalies correlate with syntactic repair processes (Hagoort et al. 1993; Osterhout et al. 1996), others have claimed that these effects rather are manifestations of the domain-general P300 component, and occur because syntactic anomalies in general are less frequent than their correct counterparts, and hence unexpected (Coulson et al. 1998b; Gunter, Stowe, & Mulder
In line with this, Coulson et al. (1998b) found that the P600 amplitude varies as a function of the probability of occurrence of the syntactic anomalies that engender the effect. A subsequent study found evidence indicating that the P600 in fact is comprised of subcomponents resulting both from domain-general processes sensitive to stimulus probability (i.e., P300), and language-specific repair processes (Friederici et al. 2001). This indicates that the P300 wave is sensitive to the overall frequency of a construction type since infrequent constructions also are unexpected. As reported in the introduction, only about 5% of transitive sentences in written Swedish are object-initial, and it is therefore likely that the enhanced P300 effect stems from their general infrequency. The fact that the constructions engender an enhanced P300 wave rather than a long-latency positivity further indicates that these constructions, although infrequent, are not considered ungrammatical, in line with the results of the rating study.

4.4.4. Grammatical function reanalysis

Argument 2 in the critical OLex-V-SPro condition elicited a ‘reanalysis N400’ effect in comparison to the OPro-V-SPro and SLex-V-OPro control conditions, in line with the predictions: Whereas the unambiguous OPro-V-SPro sentences are identified as object-initial directly, OLex-V-SPro and SLex-V-OPro sentences are initially interpreted as subject-initial on the basis of the subject-first-preference. This interpretation is confirmed for the SLex-V-OPro sentences when the object pronoun is encountered, and processing proceeds according to plan. The subject-pronoun in the OLex-V-SPro sentences, on the other hand, disconfirms the initial interpretation, and these sentences are reanalyzed as object-initial. The N400 correlates with this reanalysis. The fact that the N400 is observed in comparison to both control conditions and that, further, these conditions do not differ among themselves, effectively rules out the alternative explanation left open by each individual control condition. It cannot be due to a difference between the pronoun forms of Argument 2 (as in comparison to SLex-V-OPro) nor to a word class difference between Argument 1 (as in comparison to OPro-V-SPro), as both of these differences are controlled for by the other control condition. The effect cannot stem from the difference in the relative argument prominence between the conditions either. If this was the case, it should also be observed at Argument 2 when comparing SPro-V-OPro with SLex-V-OPro, as these conditions also differ with respect to the relative prominence of their arguments. But no differences between the pronominal second arguments of these conditions were observed. It should be stressed that the ‘Reanalysis N400’ effect needs to be interpreted with caution since it only reached significance in the local analysis of the Right Posterior Superior ROI, and that the follow-up analyses conducted on differences between individual conditions were not corrected for multiple comparisons. The post-hoc nature of the analysis is, however, justified by the fact that the scalp distribution of the effect is consistent with findings of earlier studies. The amplitude of the effect is at its largest at electrode 78, which is adjacent to the scalp position which Dien, Franklin, and May (2006) assume to be the focus site of the conventional N400, and its overall scalp distribution is very similar to that of an right-lateralized N400 observed in the same study (Dien et al. 2006; and also see Dien 2008). The effect further appears to be attenuated by the overlapping word order-related P300. The Argument 2 subject pronouns in OLex-V-SPro and OPro-V-SPro give rise to
4.4 Discussion

an enhanced P3 wave and therefore a more positive-going wave in the 300-475 ms time window, in comparison to the SLex-V-OPro condition, in which the amplitude of the P3 wave is smaller. As evident from Figure 4.6, the ‘reanalysis N400’ effect of OLex-V-SPro is therefore more pronounced in comparison to OPro-V-SPro than SLex-V-SPro.

The fact that the reanalysis engenders an N400 effect rather than a P600 further indicates that it does not involve a revision of the syntactic structure of the sentence (e.g., Osterhout & Holcomb 1992, 1993; Osterhout et al. 1994), but rather a revision of the mapping of thematic roles to the argument NPs, in line with the eADM account of grammatical function reanalysis (Bornkessel & Schlesewsky 2006; Bornkessel-Schlesewsky & Schlesewsky 2008, 2009a, 2009b, 2009c, 2013). These results show that the ‘reanalysis N400’ is not constrained to disambiguation of German complement clauses (Haupt et al. 2008) but also correlates with the disambiguation of Swedish main clauses. Firstly, this suggests that the processes underlying grammatical function reanalysis do not qualitatively differ between structurally different languages, and that a thematic role remapping account also applies to a language in which grammatical functions are primarily determined on the basis of word order rather than case marking. Secondly, it shows that the ‘reanalysis N400’ is engendered by disambiguations of main clauses in which the ambiguous object is positioned in the sentence-initial, prefield position, and not only by disambiguations of complement clauses with a word order permutation in the so-called middlefield (i.e., in this case in between the complementizer and the finite verb of German complement clauses). Whereas unambiguously marked object NPs in the prefield position elicit LAN effects, presumably as a response to increased working memory costs, unambiguous object NPs in the initial middlefield position give rise to a negativity occurring between 300 to 500 ms post-stimuli (see Bornkessel, Schlesewsky, and Friederici 2002a; Rösler, Pechmann, Streb, Röder, and Hennighausen 1998; Schlesewsky, Bornkessel, and Frisch 2003 for German; Wolff, Schlesewsky, Hirotani, and Bornkessel-Schlesewsky 2008 for Japanese, and importantly, Roll et al. 2007 for Swedish), which seems to differ from the LAN (Bornkessel-Schlesewsky & Schlesewsky 2009b). The processing of prefield vs middlefield word order permutations therefore seems to differ, and there is no a priori reason to assume that the ‘reanalysis N400’ should be elicited when the ambiguous object at hand occupies the prefield position rather than the middlefield position as in German complement clauses.

The present study also shows that the ‘reanalysis N400’ can be engendered by visual, word-by-word sentence presentation, at least as long as a confound between target predictability and point of disambiguation is controlled for. Haupt et al. (2008) suggested that ERP experiments adopting visual sentence presentation might be more sensitive to task-related influences, and that the failure to observe an N400 effect in response to grammatical function reanalysis in earlier studies (e.g., Bornkessel, McElree, et al. 2004; Schlesewsky & Bornkessel 2006) might stem from an attenuation of the N400 due to an overlapping, task-related, P300 component. In order to avoid an influence of a task-related P300 effect in the present study, six comprehension question types were used. This was done to make sure that the disambiguating Argument 2 was not the only word that provided the information needed to perform the experimental task, and therefore did not function as the only task-relevant target-item. This setup seems to have been sufficient to avoid a full attenuation of the ‘reanalysis N400’ effect due to an N400/P300 component overlap,
although visual sentence presentation was employed.

Argument 2 subject pronouns, did, however engender an enhanced P3 wave in comparison to corresponding object pronouns, an effect that seems to be related to the relative infrequency of object-initial constructions in comparison to their canonical, subject-initial counterparts. This finding is highly compatible with the N400/P300 component overlap account suggested by Haupt et al. (2008). This account entails that the P300 effect is greater for object-initial sentences than for subject-initial sentences. Since the effects of independent ERP component generators summate in the scalp-recorded ERP (e.g., Coulson et al. 1998b; Osterhout et al. 1996), an enhanced negativity in the N400 time window should be observed for object-initial sentences in comparison to their subject-initial controls if the P300 component has the same influence on subject- and object-initial sentence conditions. The findings of this study suggest that P300 effects in typical experiments investigating grammatical function reanalyses (i.e., word-by-word sentence presentation followed by a comprehension task) not only depend on experiment-specific task demands, but also on the relative infrequency of object-initial sentences in comparison to their subject-initial counterparts. A reanalysis-related N400 effect can therefore be attenuated by a task-related P300 component because the P300 is more pronounced for the critical, object-initial sentences due to their relative infrequency.

4.5. Conclusions

On the basis of an ERP experiment conducted in Swedish, this study provides evidence against structurally based accounts of grammatical function reanalysis. Such accounts assume that all types of subject-direct object reanalyses involve a reinterpretation of the phrase structure representation of the sentence, and do not differ from other syntactic reanalyses, which engender P600 effects. This study found that disambiguation toward an object-initial interpretation in object-topicalized sentences rather engendered an N400 effect. This finding speaks in favor of the view that grammatical function reanalyses are functionally distinct from syntactic reanalyses, and instead involve a revision of the mapping of thematic roles to the argument NPs, as a number of studies have shown that the N400 correlates with problems with the mapping of thematic roles to arguments, during the comprehension of both unambiguous and locally ambiguous sentences. This finding also shows that the ‘reanalysis N400’ effect is not confined to the disambiguation of German verb-final complement clauses, but can also be elicited on the basis of verb-medial main clauses in Swedish. Also, the effect is not only engendered during spoken language comprehension, but can be elicited by visual, word-by-word presentation, at least as long as a confound between target predictability and point of disambiguation is controlled for. This study also found that subject pronouns in object-topicalized sentences engendered an enhanced P300 wave in comparison to corresponding object pronouns in canonical, subject-initial sentences. This effect seems to be related to the overall infrequency of object-topicalized constructions. This finding speaks in favor of the view that the ‘reanalysis N400’ effect in some cases can be attenuated by a task-related P300 component.

All in all, the results of this study provide evidence for the hypothesis that the comprehension of grammatical functions in part involves determining the role-semantic properties of the NP arguments. Word order is an important cue in this process in most languages,
in particular in Swedish. However, the findings of the present study show that word order is not the only cue, but that it also draws upon case marking. The question that remains to be investigated is to what extent also prominence-based information, such as animacy and definiteness, also serve as cues during GF assignment. In the next chapter, I will start addressing this question first by investigating the distribution of both morphosyntactic and prominence-based information across grammatical functions in written language use.
5. Argument Interpretation Cues in Written Swedish Discourse

5.1. Introduction

In Chapter 2, I argued that grammatical functions in transitive sentences are concerned with the role-semantic and discourse-pragmatic properties of the argument referents. In syntactically accusative languages such as English and Swedish, grammatical functions in transitive sentences express both of these dimensions, capitalizing on the fact that Actors in most cases are also highly discourse prominent. In the prototypical case, the English and Swedish subject argument of a transitive clause therefore refers to an Actor participant that is also highly discourse prominent, whereas the object argument refers to an Undergoer participant that is low in prominence in terms of discourse prominence. In less prototypical cases, on the other hand, in which the Undergoer is pragmatically marked in terms of either being topical or expressing contrastive focus (see Section 3.2), a marked construction such as a passive (thereby realizing the Undergoer as pivot), a topicalization, or a left dislocation construction must be used.

In other words, although the subject-initial word order is by far the most frequent in Swedish transitive sentences (see, for instance, Hörberg et al. 2013; Josefsson 2012; Rahkonen 2006), alternative word orders are used in cases where, for instance, the discourse pragmatic properties of either the subject or the object are marked in some way. The word order of a transitive sentence therefore does not always correctly predict the grammatical functions of the arguments. Other means such as case marking and prominence-based information must in a few cases be resorted to for determining the correct GF assignment during language comprehension. As discussed in Chapter 1 and 2, a primary goal of this dissertation is to determine whether GF assignment draws upon prominence-based and morphosyntactic information, that is, whether these information types function as argument interpretation cues during the process of GF assignment, and whether the strength of these cues can be determined on the basis of their co-occurrence with grammatical functions in language use. As a first step, it must be determined how different prominence properties are distributed across subjects and objects in language use, and further, whether and to what extent individual prominence properties predict the sentence word order (i.e., whether a transitive sentence is subject- or object-initial) in language use. The present chapter therefore investigates these issues on the basis of usage data from two balanced corpora of written Swedish.

In Chapter 2, I also presented an overview of some studies that indicate that unambiguous morphosyntactic information is used more frequently when the sentence at hand is potentially ambiguous with respect to the argument functions, such that the functions cannot be readily determined on the basis of prominence information. These studies indi-
cate that writers are inclined to balance their production efforts by avoiding redundancies in order to minimize processing costs, while they at the same time providing enough information to keep the message unambiguous (i.e., the ambiguity avoidance hypothesis, see Section 2.3.1, and, for instance, MacDonald 2013).

As discussed in Section 3.4, Rahkonen (2006) investigated the ambiguity avoidance hypothesis on the basis of the distribution of morphosyntactic information in transitive sentences in written Swedish. Although his results showed that writers somewhat more frequently provide unambiguous information in potentially ambiguous sentences, Rahkonen himself argued against the ambiguity avoidance hypothesis. Several language production studies have also failed to find any evidence for the ambiguity avoidance hypothesis (see, e.g., Arnold, Wasow, Asudeh, and Alrenga 2004; V. S. Ferreira and Dell 2000; Jaeger 2006, 2010; Roland, Elman, and Ferreira 2006, and V. S. Ferreira 2008 for a review). Ambiguities that appear to be problematic in isolated sentences might in most cases be unproblematic at the discourse level (V. S. Ferreira 2008; Rahkonen 2006), and there is some evidence suggesting that sentence-level ambiguities in fact can be beneficial for communication provided these ambiguities can be resolved in context (Piantadosi et al. 2012). With these conflicting findings in mind, a second aim of the present study is to test the ambiguity avoidance hypothesis. More specifically, I will investigate whether morphosyntactic means of disambiguating a transitive sentence with respect to GF assignment is more common in (potentially) ambiguous sentences than in unambiguous ones.

As mentioned above and in Chapters 2 and 3, the object-initial word order is used to indicate that the sentence at hand is pragmatically marked in terms of its information structure. In Section 3.2, I presented some of the functional motivations that have been suggested for object-initial word order in Swedish. A third aim of the present study is to investigate whether differences in the distribution of prominence properties between subject- and object-initial sentences are consistent with these suggestions.

In the following section (Section 5.2), I present the method of the study in further detail. In Sections 5.3 and 5.4, I present the results, and in Section 5.5 I summarize these and discuss them with respect to the theoretical issues raised here and in the previous chapters.

5.2. Method

5.2.1. Database

The sentence materials were collected from the treebank ‘Svensk trädbank’ . The treebank consists of the full Stockholm-Umeå Corpus (SUC) (Gustafson-Capkova & Hartmann 2006) and materials from the Talbanken (TB) corpus (Einarsson 1976a, 1976b). The SUC corpus consists of 500 published texts from various genres, making up a total of 1,172,419 tokens in 74,237 graphs. The distribution of texts across genres and styles is balanced and is similar to that of the Brown (Francis 1971) and the London/Oslo/Bergen (LOB) corpora (Johannesson, Leech, & Goodluck 1978). The TB corpus consists of 85 ‘professional prose’ texts from four different genres, of a total of 96,346 tokens in 6,160 graphs. The TB texts were originally compiled for a stylistic study of written Swedish by Westman (1974). A list of the main genres of the two corpora as well as the number of texts and words of
each genre is shown in Table 5.1.

Table 5.1. SUC and TB corpora main genres and their respective text, sentence and word frequencies. The number of search hits in each genre is also shown.

<table>
<thead>
<tr>
<th>Corpus</th>
<th>Genre</th>
<th>N texts</th>
<th>N sentences</th>
<th>N words</th>
<th>N hits</th>
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<tr>
<td></td>
<td>Press: Reportage</td>
<td>44</td>
<td>7278</td>
<td>106079</td>
<td>1495</td>
</tr>
<tr>
<td></td>
<td>Press: Editorial</td>
<td>17</td>
<td>2385</td>
<td>40887</td>
<td>473</td>
</tr>
<tr>
<td>SUC</td>
<td>Press: Reviews</td>
<td>27</td>
<td>3961</td>
<td>66002</td>
<td>712</td>
</tr>
<tr>
<td></td>
<td>Skills, Trades and Hobbies</td>
<td>58</td>
<td>8933</td>
<td>134947</td>
<td>1840</td>
</tr>
<tr>
<td></td>
<td>Popular Lore</td>
<td>48</td>
<td>6525</td>
<td>109665</td>
<td>1503</td>
</tr>
<tr>
<td></td>
<td>Belles Letters, Biography, Memoirs</td>
<td>26</td>
<td>3598</td>
<td>61297</td>
<td>805</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td>70</td>
<td>10847</td>
<td>163333</td>
<td>1540</td>
</tr>
<tr>
<td></td>
<td>Learned and Scientific Writing</td>
<td>83</td>
<td>9633</td>
<td>192827</td>
<td>1899</td>
</tr>
<tr>
<td></td>
<td>General fiction</td>
<td>82</td>
<td>13028</td>
<td>191507</td>
<td>3110</td>
</tr>
<tr>
<td></td>
<td>Mysteries and Science fiction</td>
<td>19</td>
<td>4070</td>
<td>45321</td>
<td>826</td>
</tr>
<tr>
<td></td>
<td>Light reading</td>
<td>20</td>
<td>2908</td>
<td>46126</td>
<td>749</td>
</tr>
<tr>
<td></td>
<td>Humor</td>
<td>6</td>
<td>1071</td>
<td>14428</td>
<td>248</td>
</tr>
<tr>
<td></td>
<td>Brochure texts</td>
<td>25</td>
<td>1733</td>
<td>23122</td>
<td>390</td>
</tr>
<tr>
<td>TB</td>
<td>Newspaper texts</td>
<td>28</td>
<td>1669</td>
<td>24125</td>
<td>361</td>
</tr>
<tr>
<td></td>
<td>Educational texts</td>
<td>14</td>
<td>1624</td>
<td>25623</td>
<td>374</td>
</tr>
<tr>
<td></td>
<td>Debate articles</td>
<td>18</td>
<td>1134</td>
<td>23476</td>
<td>316</td>
</tr>
</tbody>
</table>

5.2.2. Data selection and exclusion

The overall intent of the data collection procedure was to find as many of the transitive sentences available in the corpus as possible, with the aim of minimizing the constraints on the structural variation of the sentences. Following Jaeger (2011), search patterns were constructed so as to avoid false exclusions rather than false inclusions. False hits were excluded from the initial data at a later stage (see below).

The ‘Svensk trädbank’ treebank is morphologically and syntactically annotated in Tiger-XML format, and searches were conducted with TIGER search 2.1. (König, Lezius, & Voorman 2003), using the TIGER search query language (König & Lezius 2003). The search patterns used are described in more detail in Appendix B. In the following, properties of the target transitive clauses as well as of the excluded false hits are described.

Clause properties  The target clauses of interest are of the following three structural types: canonical transitive sentences (as exemplified in Example 3.2), object-initial transitive sentences (as seen in Example 3.3), and transitive sentences with an initial adverbial phrase (as exemplified in Example 3.4 and henceforth referred to as ‘adverbial initial’). These sentence types are again exemplified in Example 5.1, 5.2 and 5.3 for convenience.

(5.1) canonical subject-initial transitive clause

(a) **Barnen** _får inte_ _äta upp_ _all glass_ _innan_ _middan_
children, the can not eat up all ice-cream before dinner

‘The children can’t eat all the ice-cream before dinner’
(b) *barnen inte får äta upp all glass innan middan*
children.the not can eat up all ice-cream before dinner
‘the children can’t eat all the ice cream before dinner’

(5.2) object-initial transitive clause

(a) *All glass får barnen inte äta upp innan middan*
all ice-cream can children.the not eat up before dinner
‘All the ice cream the children can’t eat before dinner’

(b) *All glass får inte barnen äta upp innan middan*
all ice-cream can not children eat up before dinner
‘All the ice cream the children can’t eat before dinner’

(5.3) adverbial-initial transitive clause

(a) *Innan middan får barnen inte äta upp all glass*
before dinner can children.the not eat up all ice-cream
‘Before dinner the children can’t eat all the ice cream’

(b) *Innan middan får inte barnen äta upp all glass*
before dinner can not children eat up all ice-cream
‘Before dinner the children can’t eat all the ice cream’

The argument NPs of all three sentence types can be of any length. The sentences can optionally contain up to three auxiliary verbs in addition to the main verb (see Teleman et al. 1999:3:278ff), one verb particle, and one sentential adverbial phrase. This is illustrated in all example sentences, which contain one auxiliary verb (‘får’), a verb particle (‘upp’) and a single word sentential adverbial (‘inte’). Each of the three clause types can also have two alternative word orders. In subject-initial clauses, the sentential adverbial either follows the finite verb (Example 5.1a) or precedes it (Example 5.1b). As mentioned in 3.1.1, the former word order is used in main clauses and the latter in subordinate clauses (Teleman et al. 1999:4:7). In object-initial and adverbial-initial clauses, the sentential adverbial either follows the subject (Example 5.2a) or precedes it (Example 5.2b).

The data selection process was also guided by finding clauses with the following properties. The target clauses of interest should be declarative transitive clauses only. The clauses should contain argument NPs that refer to the participants involved in the event denoted by the clause predicate. The NPs should further serve as arguments of that predicate only (as opposed to in, for instance, object predicative constructions, see below). The clauses should not contain any idiomatic or lexicalized constructions. The clause types exemplified in Table 5.2, and elaborated upon in the following, were therefore excluded.

**Exclusions** The initial data set containing false inclusions consisted of a total of 33,691 clauses. Some of these were clause duplicates that had to be removed. For example, in some cases the final NP of the clause dominates one or multiple NP nodes due to errors in the corpus annotation (such as in, e.g., ‘[[en tredje klasse]Ns] medborgare[NP]’ – ‘a third
### Table 5.2. Excluded clause types and example sentences of each type.

<table>
<thead>
<tr>
<th>Clause type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct question</td>
<td>Var har [maginNP] tagit [vägenNP], Morrissey? Where has the magic gone, Morrissey?</td>
</tr>
<tr>
<td>Intransitive clause</td>
<td>[SommartidNP] går [en bussNP] härifrån till Bourg St Maurice In the summer a bus departs from here to Bourg St Maurice</td>
</tr>
<tr>
<td>Incorrect annotation</td>
<td>Eller [rättare sagtNP] återupplivar [en gammalNP] Or rather revive an old one</td>
</tr>
<tr>
<td>Non-NP object</td>
<td>Clause [En sådan människaNP] trodde [jagNP] att jag var [jagNP] Such a person I thought I was</td>
</tr>
<tr>
<td></td>
<td>Infinitival phrase När [AktuelltNP] väljer [att följa den linjen] When Aktuellt choose to take that approach</td>
</tr>
<tr>
<td>Dummy argument</td>
<td>Subject [detNP] står [20 studenterNP] i korridorerna Together we will make it more habitable at home</td>
</tr>
<tr>
<td></td>
<td>Object Tillsammans ska [vigNP] bona om [detNP] där hemma When he in the autumn of 1977 drove her</td>
</tr>
<tr>
<td>Embedded adv. phrase</td>
<td>när [hanNP] den där höstdagen 1977NP skjutsade [hennesNP] when he in the autumn of 1977 drove her</td>
</tr>
<tr>
<td>Ditransitive clause</td>
<td>NP Clause [jagNP] kan [jagNP] inte ge [mig självNP] And I can’t give my self a better score</td>
</tr>
<tr>
<td></td>
<td>Subject predicative [Var tredje människaNP] är [analfabetNP] Every third person is illiterate</td>
</tr>
<tr>
<td>Predicative expression</td>
<td>Object predicative [HummerNP] kallar [Per MoksnesNP] för Rocky The lobster Per Moksnes calls Rocky</td>
</tr>
<tr>
<td></td>
<td>Object w. infinitive [JagNP] såg [världenNP] gå under I saw the world perish</td>
</tr>
<tr>
<td></td>
<td>Causative clause [En hastig ingivelseNP] får [migNP] att härma tjuren A sudden impulse makes me imitate the bull</td>
</tr>
<tr>
<td>Idiomatic expression</td>
<td>Idiom Även [fack och forskareNP] får [sin släng av elevenNP] Also the unions and scientists get theirs (lit: Also the unions and scientists get their throw of the trowel)</td>
</tr>
<tr>
<td></td>
<td>Lexicalisation [alla invånarenNP] skulle ha [rådNP] med [bilNP] the citizens would afford a car</td>
</tr>
<tr>
<td>Light constituent</td>
<td>Light verb [DemodokosNP] gör [ett besökNP] i underjorden Demodokos makes a visit to the underworld</td>
</tr>
<tr>
<td></td>
<td>Light object Det kostar pengar It costs [moneyNP]</td>
</tr>
<tr>
<td></td>
<td>Idiom [hanNP] målar [massorNP] He paints a lot</td>
</tr>
</tbody>
</table>

grade citizen’). The search patterns therefore find the ‘correct’ version of the clause with the dominating NP, together with the ‘incorrect’ versions with the dominated NPs.

A number of direct questions and non-transitive clauses were incorrectly included.
in the initial data set due to annotation errors, or due to containing an indirect object or a non-argument NP, and were excluded. Clauses with non-argument NPs contained embedded adverbial phrases that in many cases were mistaken for the direct object NP in both intransitive and transitive clauses (i.e., when consisting of an NP adjunct, see Teleman et al. 1999:3:64). All clauses with embedded adverbial phrases were therefore excluded. Sentences in which the direct object either consists of a clause (Teleman et al. 1999:3:293) or an infinitival complement phrase (Teleman et al. 1999:3:292), rather than an NP, were also excluded. However, clauses containing the future construction ‘kommer att’ (e.g., ‘Era barn kommer att tacka er’ – ‘Your children will thank you’) were kept, although from a purely syntactic perspective, they do contain an infinitival complement phrase. The reason for keeping them is that the ‘kommer att’ future construction is highly grammaticalized in Swedish, and therefore should be considered a complex future tense construction that, together with the lexical verb (e.g., ‘tacka’ in the example), functions as the clause predicate. Ditransitive clauses with an infinitival phrase argument (e.g., ‘Någon rekommenderade mig att pröva kommage’ – ‘Someone advised me to try cow stomach’) and clauses with an adverbial complement that is required by the verb (Teleman et al. 1999:3:435ff) (e.g., ‘vi lämnade bilen under lindarna i Berlin’ – ‘we left the car under the lindens in Berlin’) were also kept, although the infinitival and adverbial phrases of such clauses can be considered to be additional arguments of the verb.

Clauses with either a dummy subject or direct object with a purely grammatical function were also excluded. This was also the case for all types of predicative clauses and related clause types (see Table 5.2 for examples), elaborated upon in the following. In predicative clauses, a predicative expression is used to assign a property to either the subject (subject predicative) or the object (object predicative) (Teleman et al. 1999:3:325ff). Subject predicatives contain a copula verb and a nominal predicative that does not function as an argument, but rather is (part of) the clause predicate. Object predicatives, on the other hand, contain a complement or an adjunct predicative expression that assigns a property to the object NP, and thereby functions as a secondary predicate of the object. Object with infinitive constructions, often referred to as raising constructions, are functionally similar to object predicatives, in that they contain an infinitival complement phrase that functions as a predicate of the object (Brolin 2006; Teleman et al. 1999:3:575). In causative clauses, the subject argument denotes the cause of the event expressed by an additional complement phrase, but the actual Actor of that event is denoted by the object. The complement phrase of the causative clause therefore functions as a secondary predicate of the object, as in object predicative and object with infinitive constructions.

Clauses with idiomatic expressions and lexical predicate constructions were also excluded. The former clause type consists of idioms per se, that is, clauses with a non-compositional meaning such as the example in Table 5.2. In the latter clause type, the verb(s), the initial NP and either a verb particle and/or an additional adverbial phrase as a whole functions as the predicate of the clause at hand (Teleman et al. 1999:3:311), for example, the construction ‘ha råd med’ in the example in Table 5.2. The NPs in such constructions in most cases consist of an uninflfected single word noun (i.e., such as ‘råd’ in the example).

Clauses with ‘light constituents’, finally, were also excluded. These consist of clauses with traditional light or function verb constructions, in which it is the NP rather than the
verb(s) that provides the primary semantics of the predicate (Teleman et al. 1999:3:262ff). They also include clauses with ‘light object’ constructions, containing a semantically ‘rich’ main verb, but in which the syntactic direct object is semantically impoverished and has to be considered either part of the predicate (Teleman et al. 1999:3:179) or to function as an adverbial rather than a direct object proper (see examples in 5.2) (see Teleman et al. 1999:3:222ff, see also Teleman et al. 1999:2:682). It was in many cases hard to draw a clear line between lexicalized predicate constructions with a semantically weak NP, on the one hand, and light object constructions, on the other.

All exclusions were done with reference to Teleman et al. (1999) as well as on the basis of my intuitions as a native speaker. The identification of excluded clauses was done automatically to the extent that it was possible. For example, subject predicatives were identified on the basis of the head verbs of the clauses. It was however in many cases impossible to automatically identify all clauses of a specific exclusion type. Light constituent constructions, for instance, were in most cases identified by searching for verbs and nouns that commonly are used in such constructions (e.g., the verb ‘ta’ and the noun ‘beslut’) but this obviously does not entail that all light constituent constructions in the data are identified. Since a complete manual search of the full data set never was conducted, the final data still contains a small number of false inclusions. A random sample of 166 cases, constituting approximately 1% of the total data, was shown to contain 15 false cases. This indicates that only about 8.5% of the total data consist of false inclusions. A total of 16,652 clauses remained after data exclusion, out of which 15,679 sentences were subject-initial and 873 were object-initial. In other words, sentences with an object-initial word order are highly infrequent: only about 5.2% of all remaining sentences in the corpus are object-initial. I will henceforth refer to this data set as the ‘Argument Interpretation Cues (AIC) corpus’.

5.2.3. Prominence properties

In the following sections, the properties under investigation are described. The study focuses on prominence-based properties and properties related to verb semantics. The former concern both grammatical (e.g., pronominality and case marking) and referential / semantic (e.g., givenness and animacy) properties of the argument NPs. The latter concern semantic properties of the kind of involvement that the main verbs entail for their argument NPs. The study also includes a few more grammatical properties that are of less interest by themselves, but that need to be accounted for.

**Givenness** As described in Section 2.2, grammatical functions are in many languages conditioned by the discourse topicality of the argument. In natural discourse, subjects tend to be more prominent than objects in terms of discourse status. The grammatical encoding of argument structure is also in many languages conditioned by the discourse prominence of the argument referents. Discourse topicality should therefore function as an important cue to argument interpretation. However, since determining whether an argument NP is (part of) the topic or the focus of the sentence requires a qualitative analysis of the sentence in its immediate discourse, it was not possible to determine the ‘topichood’ of the NP arguments in the database. Instead, NP arguments were annotated for their
Table 5.3. Givenness categories and their correspondence to the givenness distinctions proposed by Gundel et al. (1993), Prince (1981), and the Accessibility Hierarchy of Ariel (1990).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New / type identifiable</td>
<td>Brand new</td>
<td>Type identifiable</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(indefinite) Inferrables</td>
<td>Referential</td>
<td>full name + modifier;</td>
</tr>
<tr>
<td></td>
<td>(definite) Inferrables</td>
<td>Uniquely identifiable</td>
<td>long definite description</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(introduces unique referent)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>long definite description</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(identifies unique referent)</td>
</tr>
<tr>
<td>Familiar</td>
<td>Unused</td>
<td>Familiar</td>
<td>full name; short definite description; last and first names; distal demonstrative + modifier; proximal demonstrative + modifier; distal demonstrative + NP</td>
</tr>
<tr>
<td></td>
<td>Evoked</td>
<td></td>
<td>proximal demonstrative + NP; naked distal demonstrative; naked proximal demonstrative; personal pronounas</td>
</tr>
<tr>
<td>Given</td>
<td>Evoked</td>
<td>Activated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(pronominal NPs)</td>
<td>In focus</td>
<td></td>
</tr>
</tbody>
</table>

Givenness status. As explained in Section 2.1.2, givenness pertains to the cognitive status of an argument NP referent in the discourse model, that is, the degree to which a referent is either given or new in the discourse, and thereby more or less accessible by the reader or listener (Ariel 1990; Gundel & Fretheim 2004; Gundel et al. 1993). Although givenness is independent of the topic/focus distinction, it is commonly assumed to be highly correlated with topic and focus (Gundel & Fretheim 2004; Lambrecht 1994:162ff). Some suggest that topical arguments are always given (e.g., Erteschik-Shir 2007:20), others that they at least have to be familiar to the addressee (Gundel & Fretheim 2004; Lambrecht 1994:166). Focused arguments, on the other hand, tend to be new since they often introduce a new referent into the discourse (e.g., Erteschik-Shir 2007:27ff; Lambrecht 1994:262). Also, both anaphoric and deictic arguments tend to be highly given since they refer to entities that are highly accessible in the discourse or the situation.

Since the form of a referring expression is commonly assumed to correspond to a specific level of givenness or accessibility, and a number of givenness/accessibility hierarchies have been proposed (e.g., Ariel 1990:69ff; Gundel et al. 1993; Lambrecht 1994:105ff), NP arguments were annotated for their givenness status on the basis of form. A four-level givenness scale that aimed to capture the givenness / accessibility distinctions suggested by Prince (1981), Gundel et al. (1993) and Ariel (1990) was used. The scale is illustrated in Table 5.3 above and described in the following. The scale differentiates between new / type identifiable NPs, token identifiable NPs, familiar NPs and given NPs. Each category

1Lambrecht (1994) claims that topical referents have to at least have the cognitive status of ‘unused’, which corresponds to the ‘familiar’ category in the present work - see Table 5.3 below.
5.2 Method

is defined on the basis of the category definitions proposed by Gundel et al. (1993) and also aim to capture the categories of Prince (1981). The categories correspond at large to the NP forms of the Accessibility Hierarchy of Ariel (1990), as shown in Table 5.3. A full list of NP forms of each category with examples is shown in Appendix C.

Conceptually, ‘new / type identifiable’ argument NPs designate referents of a new type that are introduced into the discourse by the speaker under the assumption that the particular referent in question is unknown to the addressee. The addressee needs to ‘create’ and determine the type of referent without being able to determine which specific referent it pertains to (see Appendix C for examples). This category corresponds to the ‘Type identifiable’ category of Gundel et al. (1993) and the ‘Brand new’ category of Prince (1981). It does not have any correspondence in the Accessibility Hierarchy, which only concerns degree of accessibility/givenness and therefore only covers argument NPs with definite reference. The category consists of, for example, indefinite NPs and a few grammatically definite NPs with generic reference.

Conceptually, ‘token identifiable’ NPs designate a specific referent that the speaker assumes is unknown to the addressee. The addressee needs to be able to either ‘construct’ a unique referent with no previous knowledge of it, or to identify the referent on the basis of the expression, either through inference or on the basis of the information provided in the expression. The category corresponds to the categories ‘referential’ and ‘uniquely identifiable’ of Gundel et al. (1993) and to the ‘inferrables’ category of Prince (1981).

‘Familiar’ NPs designate a specific referent that the speaker assumes is known by the addressee. The addressee can identify the referent on the basis of a memory representation or through inference in cases where the ‘link’ between the referent and its associated discourse entity is ‘strong enough’ ². As such, the category corresponds to the ‘familiar’ category of Gundel et al. (1993) as well as to ‘inferrables’ with demonstrative determiners, the ‘unused’ and ‘evoked’ NP categories of Prince (1981).

‘Given’ NPs, finally, designate a specific referent that is active in the discourse. The speaker therefore assumes that it is represented in the short term memory of the addressee, possibly at the current center of attention. The referent has been activated from the long term memory or the immediate experience of the addressee, from the immediate discourse, or it is the topic of the discourse. Given NPs therefore correspond to the ‘activated’ and ‘in focus’ categories of Gundel et al. (1993) and the ‘evoked’ category of Prince (1981).

Animacy As illustrated in Section 2.2.1, animacy is a pervasive determinant of the morphosyntactic encoding and syntactic behavior of argument structure. Subjects are also more frequently animate than objects in natural discourse (see Section 2.2.2). Dahl (2008) argues that animacy is an ontological type in its own right in the sense that ‘membership in this type is important for determining what can be said about an entity’ (p. 145).

²Whereas Prince (1981) classifies referring expressions assumed to be familiar to the addressee through inference as a category of its own, i.e. ‘inferrables’, Gundel et al. (1993) instead claim that the cognitive status of inferrables depend on the ‘nature and the strength of the link between the inferrable and its discourse entity’ (p. 281) and therefore that the cognitive status of inferrables corresponds to other cognitive statuses. This is reflected by the fact that a specific form of an inferrable may or may not be pragmatically permissible in a specific context. Thus, an inferrable may for instance be expressed with an NP with a demonstrative determiner in some contexts but not in others, signaling that the inferrable at hand is familiar (rather than token identifiable).
That is, semantic properties associated with prototypical actorhood such as volitionality and sentience can only be attributed to animate beings, and predicates that assign such properties to the Actor argument therefore require that the Actor argument is animate. This is why the grammatical encoding of argument structure in many cases is sensitive to the animacy distinction. Animacy can in some cases function as a cue to argument interpretation in its own right, and therefore alleviates the need for overt argument marking. In other cases, animacy engenders potential ambiguity, and therefore necessitates overt marking.

The distinction between animate and inanimate NPs was done in the following way. NPs referring to humans, non-human animate beings, formal and informal organizations (e.g., rock bands and political parties), as well as politically organized geographic regions that depend on human organization in some sense (e.g., municipals and countries) were annotated as animate. All other NPs were annotated as inanimate. Short pronominal NPs were annotated on the basis of morphological annotation and form. Nominal NPs and long pronominal NPs were manually annotated, but the annotation was conducted on the basis of tokens of head nouns for NPs that were up to three words long.

**Definiteness** Definiteness is also an important determinant of the grammatical encoding of argument structure in the languages of the world, and subjects are more frequently definite than objects in natural discourse (see Section 2.2). Pragmatically, definiteness is an important cue for determining the givenness of NP referents, and, by extension, whether an NP argument is topical or (part of) the focus information (see above). As such, definiteness is highly correlated with givenness, although a few new NPs in the material are grammatically definite (see Appendix C). Semantically, definiteness is important for signaling the affectedness of the object (Hopper & Thompson 1980).

A three-way distinction for definiteness was used: definite, indefinite and indefinite with weak reference. Definite and indefinite argument NPs were classified as definite or indefinite on the basis of the grammatical definiteness of either the head or the prephrasal element (e.g., the article, determiner or initial pronoun), in accordance with Teleman et al. (1999:3:15). Indefinite NPs also included plural NPs without indefinite marking. Indefinite NPs with weak reference included all NPs without a grammatically definite or indefinite head or prephrasal element, also in accordance with Teleman et al. (1999:4:175-176).

**Number** Although the grammatical category of number may or may not function as a prominence cue in and of itself, morphological number marking is in many languages conditioned by the prominence hierarchies. The distribution of number marking in languages with restricted overt number marking obeys the prominence hierarchies such that overt number marking only applies to NP arguments at the higher ends of the prominence scales. For instance, whereas a distinction between singular and plural is made for all NPs in English, in Tiwi, the same morphological distinction is only made for human referents. In Guaraní, that distinction is instead limited to speech act participants (i.e., 1st and 2nd person pronouns) (see Croft 2003:133-134). Cross-linguistically, then, overt morphological number marking is more frequently found on NP arguments with prototypical Actor properties. It is therefore likely that also overt number marking functions as a cue to argument

[^3]: The distribution of subjects and objects across these subcategories are reported in Table 5.5 below.
interpretation. Non-singular argument NPs are also considered to be less prominent than singular arguments in terms of individuation (Hopper & Thompson 1980:253), which is reflected in the grammatical encoding of objects in a few cases. In Sicilian, for instance, direct object case marking of kinship terms is obligatory for singulars only, but not for plurals (Iemmolo 2010b:259).

Argument NPs were primarily defined as singular or plural on the basis of NP morphology. For NPs with ambiguous or non-existent number morphology, number was either determined on the basis of number agreement or on meaning, in accordance with Teleman et al. (1999:3:149) to the extent that it was possible.

Egophoricity  Egophoric NPs refer to speech act participants (1st and 2nd person) and generic referents, in contrast to allophoric NPs that refer to non-generic 3rd person referents (Dahl 2000, 2008). Egophoricity therefore corresponds to the person distinction (see above), with the inclusion of generic reference. As such, egophoricity is perhaps the most important determinant of the morphosyntactic encoding of argument structure across languages (e.g., see examples from Lummi and Picuris above). In spoken Swedish discourse, subjects are most frequently realized as egophoric NPs, whereas objects are almost exclusively expressed by allophoric NPs. In Dahl’s (2000) study, subjects outranked objects in terms of egophoricity in more than 80% of all transitive sentences. The proportion of egophoric subjects was particularly high for sentences with experiential and cognition verbs, but also in sentences with action verbs. Dahl (2000) concluded that egophoric Actor arguments most frequently occur together with predicates of propositions whose truth value can only be determined on the basis of private knowledge of one individual only, such as thoughts, feelings or individual plans. The high preponderance of egophoric actor arguments therefore appears to relate to the fact that the information of natural discourse tends to be conveyed from the perspective of the speaker (Dahl 2000; DeLancey 1981; Dixon 1994:84).

Egophoric argument NPs included NPs with a head consisting of a 1st or 2nd person pronoun or the generic pronoun ‘man’ (i.e., with 1st, 2nd and 3rd person reference). All other NPs were categorized as allophoric.

Pronominality  There is an obvious difference between pronominal and lexical NP arguments in terms of discourse function. Definite pronouns tend to be anaphoric and therefore refer to highly discourse prominent referents that have been introduced into discourse at an earlier stage (see Section 2.1.2). As discussed in the introduction, this is reflected in the discourse distribution of subjects and objects in many languages. Subjects are most commonly pronominal or zero anaphoric, and objects are in comparison more frequently lexical. The distinction is also manifested in the morphosyntactic encoding of argument structure in some languages. In Dyirbal, personal pronouns are differentiated from all other arguments by displaying the accusative alignment pattern (see Section 2.2.1). As such, pronominality is highly likely to function as an important cue to argument interpretation. A three-way distinction between pronominal NPs, proper noun NPs and lexical NPs was done on the basis of the word class of the NP head.
Chapter 5. Argument Interpretation Cues in Written Swedish Discourse

Case  Core case marking functions as an important morphological cue for the assignment of functions to argument NPs that interacts with other prominence-based cues in systematic ways (e.g., differential object marking, see Section 2.2.1). A number of authors have argued that case marking has an indexing and/or discriminating function with respect to the functions of argument NPs (e.g., Comrie 1989; de Hoop & Malchukov 2008; Dixon 1994; Hopper & Thompson 1980; Malchukov 2006, 2008; Malchukov & de Swart 2009; Naess 2007). The case marking system of Swedish is highly limited in the sense that an unequivocal case marking distinction only exists for 1st and 2nd person pronouns (see Section 3.1.2). This system distinguishes subjects from direct objects and obliques. Third person pronouns are also case marked, but since the case marking system is on decline, 3rd person objects occurring in nominative case are not considered ungrammatical in many dia- or sociolects. As such, Swedish case marking overlaps with animate personal pronouns, and unequivocal case marking only applies to 1st and 2nd person.

Argument NPs were classified as marked or unmarked on the basis of the morphology of the phrasal head. In practice, this meant that all NPs with a head consisting of an animate personal pronoun, including the 3rd person generic ‘man’ and the 3rd person reflexive ‘sig’, were classified as marked. All other NPs were classified as unmarked.

5.2.4. Verb semantic properties

Ultimately, the participant roles of the arguments in a transitive event depend on the semantics of the sentence main verb. It is the main verb that determines the involvement of the participants of the event, that is, the degree to which the participants are associated with Actor or Undergoer properties. For instance, Dowty (1991) conceives of participant roles as the set of semantic properties or entailments that are shared by one of the arguments of a group of predicates. For example, the subject of the predicates ‘x murders y’, ‘x nominates y’, and ‘x interrogates y’ all share the entailment that x does a volitional act. The extent to which an argument functions as a Proto-Agent (i.e., Actor) or Proto-Patient (i.e., Undergoer) depends on the number of Actor or Undergoer entailments that the predicate at hand assigns to that argument. Proto-Role membership is therefore a matter of degree. In a transitive event, however, one argument will always outrank the other in terms of being associated with the most Actor entailments. The entailments associated with the Actor and Undergoer roles, respectively, as suggested by Dowty (1991), are listed in the second column of Table 5.4.

Actor entailments consist of volitional involvement in the event or state, sentence and/or perception, causing an event or change of state in another participant and movement relative to the position of another participant. Undergoer entailments involve changes of state, being incrementally affected in a telic event, being causally affected by another participant and being stationary relative to the movement of another participant. Primus (2006) makes similar assumptions as those of Dowty (1991). The extent to which an argument functions as the Actor or the Undergoer depends on the set of entailments of the predicate at hand, or the degree and kind of involvement of the participant in the event, and Proto-role membership is therefore a matter of degree. Primus departs from Dowty (1991) by further assuming that Undergoers have no defining involvement properties of their own, but that these rather are determined on the basis of their causal dependence of
Table 5.4. Categories of entailed involvement of the main verbs in the sentence materials. Column 1 lists the categories used in the present work, whereas columns 2 and 3 show how these categories correspond to those of Dowty (1991) and Primus (2006).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actor</td>
<td>Undergoer</td>
</tr>
<tr>
<td><strong>Volitionality</strong></td>
<td>Volitional involvement</td>
<td>Undergoes change of state</td>
</tr>
<tr>
<td><strong>Experiencer</strong></td>
<td>Sentience</td>
<td>-</td>
</tr>
<tr>
<td><strong>Object Experiencer</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Causation</strong></td>
<td>Cause event or change of state</td>
<td>Incremental theme</td>
</tr>
<tr>
<td><strong>Possession</strong></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

the involvement of the Actor argument (shown in the third column of Table 5.4). Whereas the Actor of a sentence is in volitional control, sentient, physically involved or in possession, the Undergoer is reciprocally under control, the object of sentience, physically affected or possessed.

Irrespective of whether Undergoer properties are causally dependent on the Actor properties, it is clear that the distribution of prominence features will depend on the set of entailments or the degree and kind of involvement that the predicates assign to the sentence arguments. For instance, predicates that entail volitionality and/or sentience (e.g., predicates with action or experiencer main verbs) require an animate Actor argument, which very commonly is egophoric (see Dahl 2000, 2008, and the discussion of animacy and egophoricity above). The semantics of the verb of a transitive sentence is therefore likely to function as a cue to argument interpretation, at least in conjunction with some or several argument prominence properties. For example, if the initial NP argument is inanimate and the upcoming main verb entails volitionality and/or sentience, the initial NP cannot function as the Actor. Argument interpretation can therefore be done confidently on the basis of the information provided by the initial and the sentence main verb.

All sentences were therefore categorized on the basis of the kind of involvement the sentence main verbs entail for their sentence arguments. I used the five different categories found in the first column of Table 5.4. As illustrated in the table, these categories roughly correspond to the categories of Dowty (1991) and Primus (2006). Each of the five categories constitutes a variable of its own, corresponding to whether the main verb of the sentence entails the involvement feature or not (e.g., whether the verb is volitional or not). Each verb could therefore potentially be classified as entailing all, some or none of the five features. Volitional involvement was defined as a conscious and intentional action by the subject participant with a purpose that affects the object participant, or a conscious choice by the subject participant, concerning the object participant. Experiencer involvement was defined as a subjective experience of the subject participant caused by the object participant, or a conscious mental state of the subject participant concerning the object participant. Object experiencer involvement was defined as a subjective experience or a subjective mental state of the object participant, caused by the subject participant.
Causal involvement was defined as an involvement of the subject participant physically changing, touching, affecting or constructing the object participant, or physically moving in relation to the object participant. Possessive involvement, finally, was defined as the subject participant owning, including, being a part of or possessing the object participant. The categorization was done on the basis of the semantics of the main verb types. This involved the time consuming effort of manual categorization on five dimensions of a total of 1,869 verb types. My classification was strict in the sense that all dominant verb senses of the verb must entail the involvement feature at hand in order for the verb to be categorized as such. For example, a verb such as ‘falla’ (fall) expresses physical movement in its canonical sense, but is also very often used metaphorically (e.g., as in ‘stock prizes keep falling’) and was therefore not categorized as a causation verb. To the extent that it was possible, the categorization was done with reference to Swedish Framenet++ (Borin, Dannélls, Forsberg, Kokkinakis, & Toporowska Gronostaj 2010; Toporowska Gronostaj & Dannélls 2009). In Swedish Framenet, a limited amount of verbs is associated with one or several semantic frames that contain information about the semantic class and the argument participant roles of those verbs (cf., e.g., Ruppenhofer, Ellsworth, Petruck, Johnson, & Scheffczyk 2006). For a minority of the verb types in the data set, it was therefore possible to consult the semantic frames represented in Swedish Framenet++. In all, 2,948 verb tokens were categorized as volitional, 2,007 as experiencer, 142 as object experiencer, 1,579 as causative, and 2,547 as possessive.

5.2.5. Additional properties under investigation

Argument length Although the length of the NP arguments is highly correlated with givenness, because new and token identifiable NPs will more often contain one or several modifiers that describe the referent at hand (see examples in Appendix C), NP length can influence the ordering of the argument NPs on its own (e.g., Arnold, Wasow, Losongco, & Ginstrom 2000). In many languages, there is a general preference for ordering short and less complex constituents before long and more complex constituents, referred to as grammatical weight (Wasow 1997, 2002). A special instance of this phenomenon is the heavy NP shift, according to which complex NPs are moved to the right of their canonical position, towards the end of the clause. It has been suggested that the ordering of short-before-long constituents either facilitates syntactic parsing during comprehension (e.g., Frazier & Fodor 1978; Gibson 1998; Hawkins 1994, 2003; Temperley 2007), or utterance planning during production (e.g., Arnold et al. 2004, 2000; Wasow 1997). Independent of whether either or both of these accounts is correct, it is clear that NP length can affect the ordering of NP arguments over and above the influence of, for instance, givenness. The lengths of NP1 and NP2 were therefore included as control variables.

Text deixis As discussed earlier, object-initial word order is especially common in Swedish when the object is discourse deictic (Rahkonen 2006) and refers to an earlier or an upcoming proposition of the discourse (Levinson 2004). This is true both in spoken and written discourse. Both Rahkonen (2006) and Bouma (2008) found pronominal and discourse deictic objects to be highly frequent in OVS sentences. In order to control for the high frequency of text deictic reference among object-initial sentences, argument NPs were
classified on the basis of whether or not they were text deictic, and these variables were included in the analyses as control predictors. Because of the vast amount of pronominal NPs in the data set, the classification was done on the basis of NP form only, without considering the actual reference of the NPs. NPs in which the head of the NP either consisted of a 3rd person singular neuter pronoun (i.e., ‘det’), a singular neuter demonstrative pronoun (i.e., ‘detta’, ‘det här’ or ‘det där’) or the neuter relational pronoun ‘detsamma’ were categorized as text deictic (see Teleman et al. 1999:2:5). Although these forms do not necessarily refer to a proposition, it is very common for them to do so. In a random sample of 10% of the sentences with initial object NPs classified as text deictic, 88% of the objects had propositional reference. In the remaining 12%, consisting of four items, the pronouns instead referred to a noun phrase introduced in the left context (rather than a proposition). That is, ‘det’ and ‘detta’ are most commonly used with propositional reference.

Sentence type The sentence type variable differentiates adverbial-initial sentences (Example 5.3), from sentences with an initial NP (i.e., subject- and object-initial sentences, Example 5.1 and 5.2). Because topicalization of the object in Swedish involves positioning the object in sentence-initial, preverbal position, an object-before-subject word order is highly unlikely in sentences in which an adverbial phrase occupies the sentence-initial position. However, although highly rare, such long object shift (Heinat 2010) is permissible when the object consists of a weak and unstressed personal pronoun (Heinat 2010; Holmberg 1986; Josefsson 1992). This is exemplified in Example 5.4 below.

(5.4) I det ögonblicket grep henne ett oerhört lugn
   ‘In that moment caught her an immense calm’

Because object-before-subject word ordering is only permissible under quite specific circumstances in adverbial-initial sentences, it is expected to be a lot less frequent than in NP-initial sentences. Sentences were therefore categorized on the basis of whether the initial, preverbal constituent was one of the NP arguments or an adverbial phrase, and this variable was used as a control predictor.

Main vs. embedded clauses Object topicalization is also expected to be a lot less frequent in embedded clauses. Non-canonical word orders such as the object-initial word order are highly restricted in embedded clauses in Swedish, presumably due to a general difference in the function of main versus embedded clauses (Andersson 1975)\textsuperscript{4}. Embedded clauses themselves often function as modifiers within a matrix clause. Sentences were therefore categorized as main or embedded clauses, and this variable was included as a control predictor. The categorization was determined on the basis of the syntactic annotation of the SUC treebank. Sentences that were either directly or indirectly dominated by a root node and not preceded by a subjunction were categorized as a main clause.

\textsuperscript{4}Object topicalization is probably only permissible in nominative clauses, but not in any other embedded clause types in Swedish.
Auxiliary verbs The final control variable concerns whether the sentence predicate at hand consists of the main verb only or a verb complex of one or several auxiliary verbs and a main verb. Although it is unclear whether complex predicate sentences should differ from sentences with single verb predicates in terms of the frequency of the object-initial word order, they differ with respect to which information types are available at different time points during incremental interpretation: In object-initial sentences, information about the verb semantics will not be available before the subject is encountered if the sentence at hand contains one or several auxiliary verbs, because it is only the finite verb that precedes the subject in such sentences (see Example 5.2a and 5.2b above). As discussed in Section 3.2, this also entails that the difference in the ordering of the final NP and the infinite verbs between subject- and object-initial sentences provides an unambiguous cue to GF assignment: When the final NP follows all verbs, the sentence must be subject-initial, but when it precedes the main verb, it must be object-initial. Complex predicate sentences therefore differ from simple predicate sentences in as much as with regard to the amount of information being available over the course of the comprehension process. Sentences were therefore categorized on the basis of whether they contained one or several auxiliary verbs, and this variable was included as a control variable.

5.2.6. Analysis

In order to evaluate the effect of individual properties as well as the interactions between prominence-based and verb semantic properties, while at the same time controlling for the effect of all other properties and the control predictors, the data was analyzed with logistic mixed effects modeling. The modeling is used to quantify the relative strengths of the NP prominence properties and verb semantic properties and their interactions in predicting the sentence word order (object- vs. subject-initial), while controlling for the influence of the control predictors as well as differences between text genres (see Section 5.3.3). In Section 5.3.3, I also use it to predict the probability (in terms of log odds) for a sentence to contain formal markers of grammatical functions on the basis of the sentence word order, and whether the sentence is semantically reversible or not.

The logistic mixed effects model is a type of generalized linear model used for binomially distributed data. The model predicts probability in terms of log odds, i.e., logits, of a given outcome Y of a dichotomous variable (i.e., the dependent variable) as a linear combination of a vector of fixed effects or predictors X (i.e., the independent variables) and one or several conditional random effects Z that are assumed to be normally distributed around zero (Gelman & Hill 2006; Jaeger 2008):

\[
\text{logit}(Y) = \log\frac{P(Y)}{1-P(Y)} = \beta_0 + \beta_1X_1 + ... + \beta_nX_n + Z_{1...m}, Z_{1...m} \sim N(0, \sigma^2\Sigma)
\]

For categorical predictors, the coefficients \( \beta_n \) in the model specify the change in log odds of outcome Y given predictor \( X_n \). The predictors therefore provide an estimate of the change of the probability of outcome Y given \( X_n \). Exponentiating \( \beta_n \) gives an estimate of how many times higher the odds for outcome Y is given \( X_n \) in comparison to \( \neg X_n \). For continuous predictors \( X_n \), \( \beta_n \) specify the change in log odds of outcome Y given a one point change in \( X_n \), and \( \exp^{\beta_n} \) provides the model estimate of how many times higher
the odds for $Y$ is given a one point change in $X_n$. The outcome in the present model is whether the second NP of a given clause is the subject, and indirectly, therefore, whether the initial NP is the object. The model thus estimates the cue strengths of each individual predictor in terms of their associated change in the probability or log-odds of an object-initial word order, while controlling for the effect of the other predictors at hand and that of the control predictors. But it also estimates the overall probability of an object-initial word order, given the prominence and control predictors taken together.

The mixed model also accounts for variation in the probability of an object-initial word order across different text genres through the use of random effects (e.g., Baayen, Davidson, & Bates 2008). Because of stylistic differences between genres, object-initial sentences are expected to be more frequent and therefore more probable in some genres than in others, and individual prominence predictors might have a stronger effect in some genres than in others. Random effects can account for overall variation in the probability of an object-initial word order by the inclusion of random intercepts, as well as variation in the strength of individual predictors, by the inclusion of random slopes.

All statistical analyses concerning the modeling were conducted with the statistical software R (R Core Team 2014). The model parameters were fit with laplace approximation using the lmer() function (D. Bates 2009) of the statistical package lme4 (D. Bates, Maechler, Bolker, & Walker 2014).

5.3 Results

In this section, I start out with a presentation of the descriptive results of the data set together with examples, in order to give an overview of the distributions and interactions of the features under investigation. I first present differences in the distributions of prominence features between subjects and objects in general (Section 5.3.1). I then discuss these distributions with respect to the functional motivations of the object-initial word order that was discussed in Section 3.2 on the basis of the distributional differences between subject- versus object-initial sentences (Section 5.3.2). I then go on to investigate the results with respect to the ambiguity avoidance hypothesis, according to which writers are inclined to avoid ambiguities in order to accommodate the understanding of their readers. More specifically, I investigate whether formal disambiguators such as case marking and the use of auxiliary verbs are more frequently used in (potentially) ambiguous sentences than in unambiguous sentences (Section 5.3.3). Finally, I discuss the prevalence of the object-initial word order as a function of prominence features and verb semantic classes and, in particular, as a function of their interactions (Section 5.3.4).

In the subsequent Section 5.4, I go on to quantify prominence, verb semantic and morphosyntactic features and their interactions in terms of their strengths as argument interpretation cues. This is done on the basis of logistic mixed effects modeling, which is used to estimate the strength of these features in predicting the object-initial word order. I also briefly discuss differences between text genres in this section.
Table 5.5. The distribution of prominence features of subjects and objects, in sentences with either an initial subject or object, as well as across both sentence types.

<table>
<thead>
<tr>
<th>Prominence feature</th>
<th>Subject</th>
<th></th>
<th></th>
<th></th>
<th>Object</th>
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<th></th>
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<tbody>
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<td>Initial</td>
<td>Final</td>
<td>Total</td>
<td>Final</td>
<td>Initial</td>
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<td>46%</td>
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<td>26%</td>
<td>16%</td>
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<td>74%</td>
<td>71%</td>
<td>30%</td>
<td>63%</td>
<td>32%</td>
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<tr>
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<td>18%</td>
<td>12%</td>
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<td>49%</td>
<td>10%</td>
<td>2%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Unmarked</td>
<td>52%</td>
<td>33%</td>
<td>51%</td>
<td>90%</td>
<td>98%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>Text deixis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deictic</td>
<td>2%</td>
<td>0%</td>
<td>2%</td>
<td>2%</td>
<td>39%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>98%</td>
<td>100%</td>
<td>98%</td>
<td>98%</td>
<td>61%</td>
<td>96%</td>
<td></td>
</tr>
</tbody>
</table>

5.3.1. The distribution of prominence properties

Table 5.5 shows the distribution of prominence features, and Table 5.6 below shows the distribution of sentences with regard to the relative prominence of the arguments.

Overall, subjects occur more frequently with prominence features at the higher ends of the prominence hierarchies, whereas objects occur more commonly with features at the lower ends. That is, subjects are overall more frequently given (71% vs. 32%), animate (78% vs. 18%), definite (80% vs. 50%), egophoric (28% vs. 3%), pronominal (55% vs. 18%) and case marked (i.e., are realized as personal pronouns; 49% vs. 10%) than objects. The proportion between singular and plural NPs, on the other hand, is virtually the same for subjects and objects (74% vs. 69%). This is also the case for the proportion of text deictic NPs, which are about equally infrequent for subjects and objects (2% vs. 4%).

This pattern is also confirmed when considering the relative prominence of the arguments, shown in Table 5.6. Overall, the subject almost always outranks or is equally
Table 5.6. The distribution of sentences with respect to the relative prominence of the arguments, for sentences with an initial subject, an initial object and across both sentence types.

<table>
<thead>
<tr>
<th>Prominence feature</th>
<th>Subject initial</th>
<th>Object initial</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Givenness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given</td>
<td>New</td>
<td>48%</td>
<td>17%</td>
</tr>
<tr>
<td>New</td>
<td>New</td>
<td>22%</td>
<td>10%</td>
</tr>
<tr>
<td>Given</td>
<td>Given</td>
<td>23%</td>
<td>46%</td>
</tr>
<tr>
<td>New</td>
<td>Given</td>
<td>7%</td>
<td>27%</td>
</tr>
<tr>
<td>Animacy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animate</td>
<td>Inanimate</td>
<td>61%</td>
<td>1%</td>
</tr>
<tr>
<td>Inanimate</td>
<td>Inanimate</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>Animate</td>
<td>Animate</td>
<td>16%</td>
<td>7%</td>
</tr>
<tr>
<td>Inanimate</td>
<td>Animate</td>
<td>3%</td>
<td>83%</td>
</tr>
<tr>
<td>Definiteness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definite</td>
<td>Indefinite</td>
<td>40%</td>
<td>13%</td>
</tr>
<tr>
<td>Indefinite</td>
<td>Indefinite</td>
<td>12%</td>
<td>5%</td>
</tr>
<tr>
<td>Definite</td>
<td>Definite</td>
<td>40%</td>
<td>63%</td>
</tr>
<tr>
<td>Indefinite</td>
<td>Definite</td>
<td>8%</td>
<td>19%</td>
</tr>
<tr>
<td>Egophoricity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egophoric</td>
<td>Allophoric</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Allophoric</td>
<td>Allophoric</td>
<td>72%</td>
<td>55%</td>
</tr>
<tr>
<td>Egophoric</td>
<td>Egophoric</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Allophoric</td>
<td>Egophoric</td>
<td>1%</td>
<td>44%</td>
</tr>
<tr>
<td>Pronominality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pronominal</td>
<td>Lexical</td>
<td>43%</td>
<td>12%</td>
</tr>
<tr>
<td>Lexical</td>
<td>Pronominal</td>
<td>41%</td>
<td>16%</td>
</tr>
<tr>
<td>Pronominal</td>
<td>Pronominal</td>
<td>12%</td>
<td>34%</td>
</tr>
<tr>
<td>Lexical</td>
<td>Pronominal</td>
<td>5%</td>
<td>37%</td>
</tr>
<tr>
<td>Case/Person</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marked</td>
<td>Unmarked</td>
<td>41%</td>
<td>0%</td>
</tr>
<tr>
<td>Unmarked</td>
<td>Unmarked</td>
<td>48%</td>
<td>32%</td>
</tr>
<tr>
<td>Marked</td>
<td>Marked</td>
<td>6%</td>
<td>1%</td>
</tr>
<tr>
<td>Unmarked</td>
<td>Marked</td>
<td>4%</td>
<td>66%</td>
</tr>
</tbody>
</table>

ranked with the object in terms of prominence. The percentage of sentences in which the object outranks the subject in terms of givenness, animacy, definiteness, egophoricity, pronominality or case marking is less than 10% in all cases.

These results are in line with the results of the multitude of previous studies, presented in Section 2.2.2, which have shown that subjects are more frequently higher in prominence than objects.

5.3.2. Differences between subject- and object-initial sentences

The distribution of prominence features is also conditioned by the relative positioning of the arguments. When positioned in the initial position, objects are more frequently given (63% vs. 30%), definite (76% vs. 49%) and pronominal (46% vs. 16%). This indicates that objects in general tend to be more discourse prominent when positioned initially. The results show almost the same inverse relationship between the givenness and the position of the object found by Rahkonen (2006). Sentence-initial objects are also very frequently text deictic (39% versus 2% in final position), also in line with the findings of Rahkonen
These findings are consistent with the idea that the fronting of the object is used to signal that it refers to a discourse topic (see Section 3.2), that is, a discourse prominent entity that either has been introduced into the discourse by the previous sentence (i.e., focus-topic chaining) or at an even earlier stage (i.e., topic-topic chaining) (Engdahl & Lindahl 2014). Object fronting is in particular very frequent in cases where the object is text deictic and therefore refers back to a proposition of the previous sentence, as exemplified in Example 3.6 in Section 3.2.

However, the fronting of objects is not only motivated by discourse topicalization. About half (54%) of all initial objects are lexical and more than a third are new (37%). In these cases, fronting is presumably done either in order for the object to function as the sentence topic (i.e., as the base of predication, see 5.5, from the corpus), or to express contrastive focus (see Example 5.6) (Teleman et al. 1999:4:431-432).

(5.5) **Hård hud lär Bill Clinton behöva**
   tough skin will Bill Clinton need
   ‘Bill Clinton will probably need tough skin’

(5.6) **Oregano kan man också tänka sig**
   Oregano one can also consider
   ‘Oregano one can also consider’

Subjects that follow the object, finally, are more frequently animate (90% vs. 77%), egophoric (45% vs. 27%), pronominal (46% vs. 29%), and case marked (67% vs. 48%) in comparison to initial subjects. This is because they more commonly occur as personal pronouns (such as in, e.g., Example 5.6). Subjects therefore appear to refer more often to highly discourse prominent 1st, 2nd or 3rd person participants when occurring in the post verbal position. This finding is consistent with the view that in object-initial sentences, the remainder of the sentence, and therefore also the subject, tends to be predictable in context. As a result, subjects of such sentences can be expected to be encoded with personal pronouns, which commonly refer to discourse participants that are highly given and therefore predictable in the discourse.

In general, these results confirm the account of object fronting in Teleman et al. (1999:4:341-343), by Rahkonen (2006) and Engdahl and Lindahl (2014). This construction is used when the object is the topic of the sentence, and in particular when it refers to a discourse topic. This is especially the case when the object is text deictic and refers back to a proposition in the previous sentence. In these cases, the object tends to be highly discourse prominent. In cases where an initial object is lower in discourse prominence, it tends to either express the sentence topic, as in Example 5.5, or it has a contrastive function, as in Example 5.6. The post-verbal subject in object-initial sentences also tends to be predictable in the discourse and is therefore more frequently realized as a personal pronoun than subjects of subject-initial sentences are.

### 5.3.3. The distribution of formal disambiguators

As discussed in Section 2.3.1, it is possible that language producers adopt their productions by avoiding redundancies in order to minimize processing and costs, while at the
same time providing unambiguous information in order to accommodate the understanding of their recipients (i.e., ambiguity avoidance). In the context of the present study, this would involve a more frequent use of formal disambiguators such as case marking and auxiliary verbs in (potentially) ambiguous sentences than in unambiguous sentences. This was investigated by Rahkonen (2006). He found case marking to be more frequent in potentially ambiguous OVS sentences than in SVO sentences (where argument functions are assigned on the basis of the word order dominance), on the one hand, and in semantically ambiguous or ‘reversible’ OVS sentences than in semantically unambiguous or ‘irreversible’ OVS sentences, on the other. These results indicate that formal disambiguators indeed are more frequently used by writers in sentences that are potentially ambiguous although Rahkonen (2006) himself argued against this interpretation.

In this section, I test this hypothesis on the basis of the present data. To that end, both subject- and object-initial sentences were cross categorized as morphosyntactically unambiguous versus morphosyntactically ambiguous, on the one hand, and semantically ambiguous / reversible versus semantically unambiguous / irreversible, on the other. All sentences containing either a case marked argument or auxiliary verb(s) were categorized as morphosyntactically unambiguous. The remaining sentences were categorized as morphosyntactically ambiguous. Sentences in which either of the arguments is inanimate were classified as semantically unambiguous / irreversible and all other sentences as semantically ambiguous / reversible. In order to investigate the very same categories that Rahkonen (2006) looked at, semantically unambiguous / irreversible sentences in which (one of) the inanimate arguments consist of a text deictic pronoun were differentiated from all semantically irreversible sentences. Morphosyntactically unambiguous sentences were differentiated between those with case marking and those with auxiliary verbs. The descriptive results are shown in Table 5.7 below. The table shows the percentage of sentences that are morphosyntactically ambiguous and unambiguous, respectively, as a function of semantic reversibility and word order.

The table shows that the percentage of formal marking is higher in object- than in subject-initial sentences (79% vs. 65%), in line with the findings of Rahkonen (2006). A

<table>
<thead>
<tr>
<th>Word order</th>
<th>Formal ambiguity</th>
<th>Irreversible</th>
<th>Reversible</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Text Deictic</td>
<td>Inanimate</td>
<td></td>
</tr>
<tr>
<td>Subject-initial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambiguous</td>
<td>23%</td>
<td>40%</td>
<td>13%</td>
<td>35%</td>
</tr>
<tr>
<td>Unambiguous</td>
<td>Auxiliary</td>
<td>33%</td>
<td>31%</td>
<td>36%</td>
</tr>
<tr>
<td></td>
<td>Marked</td>
<td>29%</td>
<td>29%</td>
<td>36%</td>
</tr>
<tr>
<td>Total</td>
<td>77%</td>
<td>60%</td>
<td>87%</td>
<td>65%</td>
</tr>
<tr>
<td>Object-initial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambiguous</td>
<td>16%</td>
<td>26%</td>
<td>8%</td>
<td>21%</td>
</tr>
<tr>
<td>Unambiguous</td>
<td>Auxiliary</td>
<td>37%</td>
<td>36%</td>
<td>41%</td>
</tr>
<tr>
<td></td>
<td>Marked</td>
<td>47%</td>
<td>38%</td>
<td>51%</td>
</tr>
<tr>
<td>Total</td>
<td>84%</td>
<td>74%</td>
<td>92%</td>
<td>79%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
\( \chi^2 \) test found this difference to be significant, \( \chi^2(1) = 73.84, p < .0001 \). Formal marking is further more frequent in semantically reversible versus semantically irreversible sentences. Overall, the percentage of formal marking is higher in semantically reversible subject-initial sentences (87\%) than in semantically irreversible subject-initial sentences (60\%), \( \chi^2(1) = 684.76, p < .0001 \). This is also the case in semantically reversible object-initial sentences (92\%) in comparison to semantically irreversible object-initial sentences (74\%), \( \chi^2(1) = 9.39, p < .01 \). The percentage of formal marking is also higher in semantically reversible subject-initial sentences when only comparing the percentage of case marking in semantically reversible sentences (51\%) to sentences with a text deictic argument (44\%), \( \chi^2(1) = 25.43, p < .0001 \), in the same manner as Rahkonen (2006). This is not the case in the corresponding object-initial sentences, however, in which the percentage of formal marking between semantically reversible sentences and sentences with a text deictic argument is quite similar (51\% versus 47\%), \( \chi^2(1) = 2.06, p = .15 \). Nevertheless, the data shows that formal disambiguators occur more frequently in object-initial sentences in comparison to subject-initial sentences, on the one hand, as well as in semantically ambiguous / reversible sentences in comparison to semantically unambiguous / irreversible sentences, on the other.

As a final step, the propensity for using formal markers given the sentence word order and whether it is semantically ambiguous or not was investigated on the basis of logistic mixed effects modeling. As discussed in more detail in Section 5.2.6, the mixed effects model allows for an estimation of the probability that a given sentence will contain formal markers, conditioned by the sentence word order and its semantic reversibility, while at the same time taking into account differences in the distribution of formal markers across text genres. In the model, the occurrence of formal ambiguity (formally ambiguous vs. formally unambiguous) served as the outcome variable, whereas sentence word order (subject-initial vs. object-initial) and semantic reversibility (reversible vs. irreversible) and their interaction served as predictor variables. The model also contained a by-genre random intercept and by-genre slopes for word order, semantic reversibility and their interaction, thereby controlling for differences in the occurrence of formal ambiguity across genres as well as differences in the influence of word order and semantic reversibility across genres (see Section 5.4 for further details). The model found a significant influence of word order on the probability of formal marking, \( \beta = 0.77, z = 6.89, p < .0001 \), object-initial sentences being about 2.15 times more likely to be formally marked than subject-initial sentences. The model also found a significant influence of semantic reversibility on the probability of formal marking, \( \beta = 1.26, z = 9.83, p < .0001 \). A semantically reversible sentence is about 3.5 times more likely to be formally marked than a semantically irreversible sentence. The model fit is also very good. In other words, the model makes good predictions of the probability for a given sentence to be formally marked. This is illustrated in Figure 5.1, which plots the observed percentage of formally marked sentences per genre against the percentage of formally marked sentences as predicted by the model. The correlation between the observed and the predicted percentages is high, \( r^2 = 0.9, t(57) = 22.64, p < .0001 \).
5.3 Results

5.3.4. The prevalence of the object-initial word order

Table 5.8 shows the differences between the observed percentages of object-initial sentences, categorized on the basis of argument prominence and verb class, and the percentages that would be expected by chance. A positive value indicates that an object-initial word order is more frequent than expected by chance, and a negative value that it is less frequent than expected. For the crossed categories defined on the basis of argument prominence together with verb class (e.g., sentences with volitional verbs and a given initial NP argument), the expected percentages were calculated on the basis of the margin totals. For the total percentages across either argument prominence categories or verb classes, the grand percentage of object-initial sentences of 5.27% was used as expected value. Shades of gray correspond to uncorrected significance levels of binomial tests testing whether the observed percentages significantly differ from expected percentages.

Object-initial sentences are significantly more frequent among sentences in which the initial NP argument is low in terms of some prominence feature (e.g., inanimate, indefinite or lexical), but less frequent when the initial argument is high in terms of prominence (e.g., animate, definite or lexical), in comparison to what would be expected. This is true for all prominence features except for number. Further, the object-initial word order is far more frequent than expected when the initial argument of the sentence is text deictic. The opposite pattern is found when considering prominence properties of the final argument. Here, the object-initial word order is significantly less frequent in sentences where the final
Table 5.8. Differences between observed percentages of object-initial sentences and the percentages that would be expected by chance, as a function of argument prominence and verb class. Shades of gray correspond to uncorrected significance levels of binomial tests of whether the proportion at hand differs from the expected proportion, as calculated on the basis of the margins.

<table>
<thead>
<tr>
<th></th>
<th>Volitional</th>
<th>Experiencer</th>
<th>O. experiencer</th>
<th>Causative</th>
<th>Possessive</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Given</td>
<td>-0.6</td>
<td>0.1</td>
<td>0.8</td>
<td>-0.2</td>
<td>1.2</td>
<td>0.0</td>
</tr>
<tr>
<td>New</td>
<td>1.7</td>
<td>-0.3</td>
<td>-1.7</td>
<td>0.3</td>
<td>-2.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Animate</td>
<td>-0.1</td>
<td>0.0</td>
<td>0.3</td>
<td>-0.1</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Inanimate</td>
<td>25.1</td>
<td>-2.0</td>
<td>12.6</td>
<td>-1.1</td>
<td>-5.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Definite</td>
<td>0.0</td>
<td>0.0</td>
<td>0.4</td>
<td>-0.1</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Indefinite</td>
<td>0.1</td>
<td>0.0</td>
<td>-1.7</td>
<td>0.2</td>
<td>-2.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Singular</td>
<td>-0.3</td>
<td>0.1</td>
<td>0.4</td>
<td>-0.1</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Plural</td>
<td>0.8</td>
<td>-0.2</td>
<td>-2.1</td>
<td>0.3</td>
<td>-1.4</td>
<td>0.0</td>
</tr>
<tr>
<td>Egophoric</td>
<td>0.1</td>
<td>0.0</td>
<td>-0.2</td>
<td>0.0</td>
<td>2.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Allocphoric</td>
<td>0.5</td>
<td>-0.1</td>
<td>4.5</td>
<td>-0.2</td>
<td>-0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Pronominal</td>
<td>-1.2</td>
<td>0.3</td>
<td>-0.5</td>
<td>-0.2</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Lexical</td>
<td>1.6</td>
<td>-0.3</td>
<td>4.8</td>
<td>0.1</td>
<td>-0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Marked</td>
<td>0.1</td>
<td>0.0</td>
<td>-0.2</td>
<td>0.0</td>
<td>1.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Unmarked</td>
<td>0.8</td>
<td>-0.2</td>
<td>12.8</td>
<td>-0.5</td>
<td>-1.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Deictic</td>
<td>28.6</td>
<td>-2.6</td>
<td>25.9</td>
<td>-6.0</td>
<td>-19.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Not</td>
<td>0.5</td>
<td>-0.1</td>
<td>-1.8</td>
<td>0.2</td>
<td>0.2</td>
<td>0.0</td>
</tr>
</tbody>
</table>

|                  | Volitional | Experiencer | O. experiencer | Causative | Possessive | All |
|                  | Y  | N  | Y  | N  | Y  | N  | Y  | N  | Y  | N  | All |
| Given            | -1.3 | 0.3 | -3.7 | 0.3 | -4.2 | 0.2 | -2.1 | 0.1 | -21.7 | -1.6 | 0.7 |
| New              | 0.4 | -0.1 | 0.1 | 0.0 | 8.7 | 0.0 | -0.6 | 0.1 | -0.8 | 0.3 | -3.2 |
| Animate          | -0.5 | 0.1 | -3.0 | 0.0 | -7.7 | 0.6 | 2.4 | -0.2 | 0.8 | -1.2 | 15.5 |
| Inanimate        | -0.4 | 0.1 | -1.1 | 0.1 | 8.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | -4.6 |
| Definite         | -0.8 | 0.2 | -2.9 | 0.3 | -1.9 | 0.1 | -0.1 | 0.0 | 0.8 | -0.9 | 3.3 |
| Indefinite       | 0.3 | -0.1 | 1.5 | -0.1 | 6.9 | 0.0 | -0.7 | 0.1 | -0.7 | 0.3 | -3.3 |
| Singular         | 0.2 | -0.1 | -0.4 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | -0.3 | 0.0 | 0.7 |
| Plural           | -0.5 | 0.1 | 0.6 | 0.0 | -1.5 | 0.0 | 0.0 | 0.0 | 0.8 | -0.1 | -1.4 |
| Egophoric        | -5.6 | 1.3 | 0.2 | -2.2 | -20.0 | 1.9 | -4.1 | 0.6 | 51.7 | -3.3 | 37.2 |
| Allocphoric      | 0.2 | -0.1 | -2.1 | 0.3 | 0.8 | 0.0 | 0.8 | -0.1 | 0.3 | 0.0 | -2.2 |
| Pronominal       | -1.4 | 0.3 | -7.5 | 0.4 | -6.7 | 0.5 | -4.3 | 0.4 | 22.4 | -1.9 | 14.2 |
| Lexical          | 0.4 | -0.1 | -1.6 | 0.2 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -3.4 |
| Marked           | -2.5 | 0.5 | -3.4 | -0.4 | -10.5 | 1.2 | -3.2 | 0.3 | 52.0 | -2.9 | 21.3 |
| Unmarked         | 0.4 | -0.1 | -1.5 | 0.2 | 2.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | -3.3 |
| Deictic          | -0.8 | 0.2 | -1.7 | 0.4 | 0.0 | 0.0 | 0.0 | -0.1 | -0.5 | 0.0 | -4.5 |
| Not              | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 |

\[ p < .001, \quad \ddot{p} < .01, \quad \dddot{p} < .05, \quad \dddot{p} < .1 \]

The argument is low on some prominence feature, but significantly higher when that argument is high in prominence. Object-initial sentences in which the final argument is text deictic are also somewhat less frequent than expected. The object-initial word order is finally more common in sentences with an experiencer or causative verb, but less common in sentences with a possessive verb.

The prevalence of the object-initial word order is also affected by the interaction...
5.4 Quantifying cue strengths with mixed effects modeling

between argument prominence and verb class. In sentences in which the initial argument is low in prominence, the relative preference for the object-initial word order is in some cases even greater when the verb at hand either is volitional, experiencer, causative or possessive. In sentences with volitional verbs, the object-initial word order is more frequent than expected when the initial argument is inanimate or lexical. For sentences with experiencer verbs, this is true when the initial argument is either inanimate, allophoric, lexical or unmarked / non-person. In sentences with causative verbs, this is true when the initial argument is inanimate, and in sentences with possessive verbs, finally, it applies when that argument is either new or indefinite. In sentences with object experiencer verbs, a tendency toward the opposite pattern is found. Here, object-initial word order is somewhat less frequent when the initial argument is low in prominence, but somewhat more frequent when that argument is high in some prominence feature. These percentages do not tend to significantly differ from what would be expected, however.

When considering the prominence features of the final argument, the interactions between argument prominence and verb class tend to show the opposite patterns of those found for the initial argument. In sentences with a low-prominent final argument, the dispreference for the object-initial word order is more pronounced when the sentence verb is an experiencer verb. That is, the object-initial word order of such sentences is somewhat less frequent than expected when the final argument is inanimate, allophoric or unmarked/non-person. On the other hand, the relative preference for the object-initial word order when the final argument is high in prominence is much stronger in sentences with possessive verbs. Here, the word order is a lot more frequent than expected when the final argument is either given, animate, definite, egophoric, pronominal or case marked/person. Again, sentences with object experiencer verbs show the opposite pattern of that of sentences with possessive or experiencer verbs. When the final argument is low in some prominence feature, object-initial word order is more frequent than expected, whereas when the second argument is high in some prominence feature, it is less frequent than what would be expected.

5.4. Quantifying cue strengths with mixed effects modeling

Although the frequency distributions of prominence features, verb classes, and their interactions provide some clues about the strength with which these information types predict the argument functions, that is, whether the sentence at hand has an object-initial word order, they do not take into account the interplay between predictors. The frequency distributions cannot by themselves show whether and to what extent a given predictor is still informative when the influence of all other predictors is accounted for. Nor can they be used to quantify the expectation for a given word order when the joint influence of all or a subset of predictors is considered. In order to do so, a logistic mixed effects model was used. As explained more thoroughly in Section 5.2.6, logistic mixed effects modeling estimates the probability for a dichotomous outcome (e.g., word order) in terms of log odds, as a function of a set of predictor variables (e.g., NP animacy), while at the same time controlling for differences between different strata (e.g., text genres) (Gelman & Hill 2006; Jaeger 2008). The purpose of the modeling was to quantify the relative strengths of the various predictors, while controlling for the influence of all other predictors, other
confounding factors (e.g., NP argument length), as well as differences in the frequency of object-initial sentences across text genres. In Chapter 6, logistic mixed effects models also form the basis for the incremental modeling, which models the on-line change in the expectation for a given word order, as a function of the serial presentation of the sentence constituents over time.

5.4.1. Model evaluation and selection

Overfitting There is a trade-off between the predictive ability of a regression model, and the reliability of those predictions. With more parameters, the ability of the model to predict the sample outcome improves. But with too many parameters, the model predictions are likely to be overoptimistic and will not generalize beyond the sample data (c.f., e.g. Babyak 2004). Because the main goal of the model is to make predictions, extra care was taken to ensure that the model does not suffer from such overfitting.

The number of parameters in a binomial model is constrained by the limiting sample size, that is, the number of observations of the less frequent outcome (i.e., the number of object-initial sentences in the sample). Harrell (2010:61) suggests that the less frequent outcome should be 10-20 times more frequent than the number of parameters, setting an upper limit of 58 parameters for the present data set. However, for highly unbalanced data sets such as corpus data, more data is often required. For some data sets, the less frequent outcome has to be 50-100 times more frequent than the number of parameters (Jaeger 2011:170-171), suggesting that the number of parameters for the present data set should be constrained to 17. Ultimately, the degree to which the models are overfitted must be evaluated using model validation. Following Harrell (2010:94-95), model overoptimism was evaluated using bootstrap validation. In order to evaluate the overall amount of overoptimism in the models, the shrinkage coefficients $\gamma_0$ and $\gamma_1$ was estimated on the basis of 2,000 bootstrap samples. These coefficients did not differ significantly from the intercept and slope of the observed values regressed against the predicted values of any of the models, as evident by Wald tests (all $p$s > .05, see Table 5.9 below) (see Baayen et al. 2008:194-195; Gude, Mitchell, Ausband, Sime, and Bangs 2009; Harrell 2010:249-250).

Bootstrapping was also used to account for overoptimism in the individual parameter estimates. Parameter estimates were calculated on the basis of 1,000 bootstrap samples, shown in Table 5.10 below. The bootstrap validation showed that the object experiencer verb parameter and its interaction parameter estimates suffer from overoptimism due to the few object experiencer verbs in the corpus (141 tokens). These parameters were therefore excluded from the final model. All other significant parameters in the original model remained significant in the bootstrapped model (see Table 5.10).

Collinearity If two or several predictors in a model are highly correlated, some of the individual predictors might not be able to account for the variance in the outcome variable over and above that of the other predictors. Severe collinearity will increase the instability of the model in the sense that the model design matrix approaches singularity, and the effects of the individual predictors cannot be reliably estimated. Mild to moderate collinearity will increase the standard errors of the individual coefficient estimates, which reduces the confidence of those estimates.
Because many of the predictors in the present model are highly related (e.g., given-
ness and definiteness), collinearity was expected to be a concern, and several measures
collinearity were adopted. Collinearity effects on individual parameters was estimated
by fixed effects correlations and Variance Inflation Factor (VIF). The effects of individual
predictors were also confirmed using leave-one-out model comparison, and hence indepen-
dently of their possibly inflated standard errors. Here, the predictor effects are determined
using model comparison on the basis of the deviance\(^5\) between the full model and a model
without the parameter at hand. As shown in Table 5.10 below, these results converged
with the Wald statistics. The degree of singularity of the model design matrix was assessed
on the basis of the condition number (\(\kappa\)), following Belsley, Kuh, and Welsch (1980)\(^6\). A
\(\kappa\) value between 15-30 or above points to potentially harmful collinearity, but \(\kappa\) did not
exceed 8 (see Table 5.9).

Model selection and fitting  The full model was selected by first fitting an optimal fixed
effects model without any random effects. The optimal random effects structure was then
chosen on the basis of that model.

Estimations of collinearity and overfitting (see Table 5.9 below) showed that all promi-
nence and control predictors could reliably be included in the model. However, all cate-
gorical predictors had to be dichotomized in order to limit collinearity. The categorical
predictors were also centered (i.e., the predictor values were re-coded as 0 and 1 and their
mean was subtracted) in order to reduce collinearity (see Gelman & Hill 2006:55). Visual
inspection of residuals plotted against NP1 and NP2 raw lengths suggested non-linear
relationships between argument length and the outcome variable. The argument length
predictors were therefore transformed in the following way. Outlier predictor values were
trimmed such that all extreme values were set to the value of the 99th percentile of the
original distributions. These trimmed values were then log transformed and standardized.

Because of interdependencies (e.g., all case marked pronouns are animate) and cor-
relations (e.g., given arguments are usually definite) among argument prominence fea-
tures, interactions between prominence features were not entertained. Interactions be-
 tween prominence features and verb classes were selected by fitting a full model containing
all potentially significant interaction predictors (selected interactions are shown in Table
5.9), and then performing stepwise selection using backward parameter elimination on the
interaction parameters only. This procedure involves the subsequent removal of model
predictors that account for the least amount of variance in the data, until some stopping
criterion is reached. In this case, backward elimination stopped when the removal of the
upcoming interaction predictor would result in a marginally significant \((p < 0.1)\) difference
in the amount of variance explained. The resulting model did not differ significantly from
the full model \((\chi^2(16) = 16.57, p = 0.1)\). Although stepwise variable selection is consid-
ered to be problematic for many reasons (see Harrell 2010:56-57), the procedure was in
this case limited to a small subset of predictors that had been chosen a priori on the basis
of the descriptive statistics and theoretical considerations.

The optimal random effects structure was selected on the basis of the method sug-

\(^5\) \(2(LL_{M1} - LL_{M2})\) where model M2 is nested in model M1.

\(^6\) \(\kappa\) was computed with the colldiag() function in the R package ‘Perturb’ (Hendrickx 2012).
effects across genres only, on the one hand, and subgenres only, on the other, were fitted. These included random intercepts, random slopes for all model predictors, as well as terms for the covariances between random effects. These models were then compared against models with less complex random effects structures, that is, models without terms for the random effect covariances, with random intercepts only, with a dummy random variable consisting of two categories that all sentences were randomly assigned to, as well as models without random effects. In order to account for the problem of testing on the boundary, which makes comparisons between models with and without random effects problematic, all model comparisons were conducted on the basis of the method suggested by Zuur et al. (2009:123-124). This method tests the significance of the model deviance, but accounts for the problem of testing on the boundary by adjusting the degrees of freedom. These comparisons showed that only the inclusion of random intercepts for subgenres is justified.

Table 5.9. Model fit and collinearity statistics for the full model. Model statistics for the full interaction model and a null model with intercept and random effect for subgenre only is also included for comparison.

<table>
<thead>
<tr>
<th>Model</th>
<th>Full</th>
<th>Interaction</th>
<th>Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.F.</td>
<td>35</td>
<td>51</td>
<td>2</td>
</tr>
<tr>
<td>LL</td>
<td>-968.37</td>
<td>-956.90</td>
<td>-3389.56</td>
</tr>
<tr>
<td>AIC</td>
<td>2006.73</td>
<td>2015.81</td>
<td>6783.11</td>
</tr>
<tr>
<td>$D_{xy}$</td>
<td>.970</td>
<td>.970</td>
<td>.227</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>.977</td>
<td>.954</td>
<td>1</td>
</tr>
<tr>
<td>p shrinkage</td>
<td>.420</td>
<td>.112</td>
<td>-</td>
</tr>
<tr>
<td>corr.$D_{xy}$</td>
<td>.966</td>
<td>.965</td>
<td>-</td>
</tr>
<tr>
<td>Collinearity</td>
<td>max corr.</td>
<td>.875</td>
<td>.784</td>
</tr>
<tr>
<td></td>
<td>max VIF</td>
<td>6.08</td>
<td>28.91</td>
</tr>
<tr>
<td></td>
<td>Kappa</td>
<td>7.39</td>
<td>8.01</td>
</tr>
</tbody>
</table>

5.4.2. The full model

Model evaluation The statistics of the model evaluations are shown in Table 5.9. The full model shows a good fit ($D_{xy} = .970$), which is significantly better than that of the null model ($\chi^2(35) = 4849.55, p < .0001$). The model fit is also illustrated in Figure 5.2.

The figure shows mean predicted probabilities of an object-initial word order plotted against observed percentages of object-initial sentences, as calculated within bins divided on the basis of 100 quantiles of the predicted probabilities. The figure illustrates a good

---

7Because the tested hypothesis is $\sigma > 0$, the model deviance cannot be assumed to follow $\chi^2$ with the degrees of freedom corresponding to the difference in degrees of freedom between the models.

8This does not necessarily entail that the predictor effects do not differ between genres. It is on the contrary quite likely that some prominence features such as case / person will have a stronger influence in less formal genres (e.g., ‘light reading’ and ‘humor’) than in more formal ones (e.g., ‘debate articles’). But it is quite likely that there is not enough data to capture such differences (cf., e.g., Jaeger, Graff, Croft, and Pontillo 2011 for a discussion of the problem of data sparsity when fitting mixed models with random slopes)
fit between predicted and observed values, for bins with both low and high percentages of object-initial sentences. Overfitting does not seem to be a concern, as indicated by the fact that the slope shrinkage coefficient does not significantly differ from 1. The collinearity statistics indicate that collinearity is a concern for some of the highly correlated predictors. However, the parameter statistics of both the bootstrapped model and the leave-one-out model comparisons confirm the effects of the parameters in the original model, in terms of both effect direction and significance (see Table 5.10).

Figure 5.2. Mean predicted percentages of an object-initial word order plotted against observed percentages of object-initial sentences within bins divided on the basis of 100 quantiles of the predicted probabilities. Each bin on average contains 82 data points.

**Fixed effects** The parameter statistics of the full model are shown in Table 5.10. The table includes statistics of both the original and the bootstrapped model, as well as the results of the leave-one-out-model comparisons, which estimate the effect of the individual parameters on the basis of deviance between the full model and a model without the parameter at hand. The strength and (in)significance of the parameters in the full model is confirmed in the bootstrapped model and by the leave-one-out model comparisons, and attest to the stability of the model parameters.

Figure 5.3 illustrates the effects of the model predictors, in terms of their strength and direction. The figure shows the log odds ratio of each predictor, that is, the change in the log odds of the object-initial word order in sentences with the predictor value at hand versus sentences without that predictor value, as estimated by the model. For example,
Table 5.10. β coefficients, Wald Z-scores and p-values of both the original (org.) and bootstrap (B.S.) full model. The table also includes 95% pointwise confidence intervals for the coefficients, based upon the 0.025 and 0.975 quantiles of the coefficient estimates in 1,000 bootstrap samples. The right-hand columns also show the statistics of the leave-one-out model comparisons, which estimate the effects of the model predictors on the basis of deviance between the full model and a model without the parameter at hand. Significant predictors are highlighted in gray.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>Wald Z</th>
<th>p</th>
<th>95% B.S. CIs</th>
<th>LOOMC</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org.</td>
<td>B.S.</td>
<td>Org.</td>
<td>B.S.</td>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>Intercept</td>
<td>-7.01</td>
<td>-7.18</td>
<td>-29.90</td>
<td>-27.47</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>NP1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Givenness</td>
<td>-0.27</td>
<td>-0.27</td>
<td>-1.19</td>
<td>-1.15</td>
<td>.233</td>
<td>.251</td>
</tr>
<tr>
<td>Animacy</td>
<td>3.36</td>
<td>3.44</td>
<td>16.13</td>
<td>14.78</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>× Volitionality</td>
<td>1.52</td>
<td>1.56</td>
<td>3.49</td>
<td>3.38</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>× Causation</td>
<td>1.02</td>
<td>1.14</td>
<td>1.72</td>
<td>1.59</td>
<td>.086</td>
<td>.113</td>
</tr>
<tr>
<td>Definiteness</td>
<td>0.72</td>
<td>0.72</td>
<td>3.44</td>
<td>3.39</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>× Possession</td>
<td>1.25</td>
<td>1.28</td>
<td>2.40</td>
<td>2.45</td>
<td>.016</td>
<td>.014</td>
</tr>
<tr>
<td>Number</td>
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<td>0.05</td>
<td>0.33</td>
<td>0.33</td>
<td>.745</td>
<td>.739</td>
</tr>
<tr>
<td>Egophoricity</td>
<td>0.39</td>
<td>0.38</td>
<td>0.69</td>
<td>0.66</td>
<td>.491</td>
<td>.508</td>
</tr>
<tr>
<td>Pronominality</td>
<td>0.14</td>
<td>0.17</td>
<td>0.55</td>
<td>0.55</td>
<td>.583</td>
<td>.582</td>
</tr>
<tr>
<td>Case / Person</td>
<td>1.47</td>
<td>1.55</td>
<td>3.06</td>
<td>3.00</td>
<td>.002</td>
<td>.003</td>
</tr>
<tr>
<td>× Experiencer</td>
<td>2.55</td>
<td>2.77</td>
<td>3.04</td>
<td>2.59</td>
<td>.002</td>
<td>.010</td>
</tr>
<tr>
<td>Length</td>
<td>0.45</td>
<td>0.46</td>
<td>3.13</td>
<td>3.08</td>
<td>.002</td>
<td>.002</td>
</tr>
<tr>
<td>Text deixis</td>
<td>1.99</td>
<td>2.04</td>
<td>6.78</td>
<td>6.59</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Verb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volitionality</td>
<td>-0.59</td>
<td>-0.63</td>
<td>-1.32</td>
<td>-1.36</td>
<td>.185</td>
<td>.175</td>
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<tr>
<td>Experiencer</td>
<td>0.43</td>
<td>0.35</td>
<td>0.94</td>
<td>0.86</td>
<td>.346</td>
<td>.392</td>
</tr>
<tr>
<td>Causation</td>
<td>0.53</td>
<td>0.46</td>
<td>1.28</td>
<td>1.20</td>
<td>.199</td>
<td>.230</td>
</tr>
<tr>
<td>Possession</td>
<td>0.16</td>
<td>0.14</td>
<td>0.53</td>
<td>0.52</td>
<td>.598</td>
<td>.605</td>
</tr>
<tr>
<td>Syntax</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentence type</td>
<td>-3.00</td>
<td>-3.14</td>
<td>-4.80</td>
<td>-4.38</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Embedding</td>
<td>-1.78</td>
<td>-1.81</td>
<td>-9.64</td>
<td>-9.52</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Helping verb</td>
<td>0.40</td>
<td>0.41</td>
<td>2.96</td>
<td>3.09</td>
<td>.003</td>
<td>.002</td>
</tr>
</tbody>
</table>

the log odds for the object-initial word order is 0.72 higher for sentences in which the initial NP is indefinite, in comparison to sentences in which the initial NP is definite. The figure also shows the log odds ratio associated with each interaction. For interactions, this is the change in the log odds of the object-initial word order with the set of predictor values in the interaction at hand versus sentences without those predictor values, as estimated by the model. For example, the log odds for object-initial word order is 2.12 higher for sentences in which the initial NP is indefinite and the verb is also possessive, in comparison to sentences that lack these features. The figure also includes 95% confidence intervals of the log odds ratios. These were calculated on the basis of simulation (c.f. Gelman & Hill 2006:140-151),
Figure 5.3. Log odds ratios associated with each predictor, in terms of the change in the log odds for object-initial word order in sentences with the predictor value at hand (e.g., NP1 Inanimate) versus sentences without that predictor value (e.g., NP1 Animate), as estimated by the full model. For interaction terms, log odds ratios represent the change in the log odds for object-initial word order in sentences with both predictor values (e.g., NP1 Inanimate & Volitional) versus sentences without those predictor values (e.g., NP1 Animate & Non-volitional). Error bars display 95% confidence intervals, calculated on the basis of simulation.

using the sim() function in the arm package (Gelman & Yu-Sung 2014)^9. For individual predictors, the lower and upper confidence limits are the 5% and 95% percentiles of 1,000 simulations of the beta coefficients of each predictor. For interactions, the 5% and 95%

---

^9This involves drawing a large number of beta coefficients at random, conditioned on the actual beta coefficients and their standard errors.
percentiles of 1,000 predicted values calculated on the basis of the simulations were used instead. These predictor values are, for each simulation run, the sum of beta coefficients of the interacting predictors and the coefficient of the interaction term. Finally, Table 5.11 shows the odds ratio of each predictor and interaction, together with their confidence limits. In order to make the predictor effects easier to interpret, the table shows the ratios of the odds for both the object- and the subject-initial word order.

Overall, the model results are in line with the descriptive statistics presented above. The model predicts an increase in the odds of an object-initial word order when the

Table 5.11. Ratios of the odds for an object- and a subject-initial word order, between sentences that either have or do not have the predictor value(s) at hand. The table also includes confidence intervals, calculated on the basis of simulation. Significant predictors are highlighted in gray.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Object initial</th>
<th>Subject initial</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O.R.</td>
<td>lower</td>
<td>upper</td>
</tr>
<tr>
<td>New</td>
<td>0.77</td>
<td>0.51</td>
<td>1.21</td>
</tr>
<tr>
<td>Inanimate</td>
<td>28.84</td>
<td>19.24</td>
<td>41.84</td>
</tr>
<tr>
<td>× Volitional</td>
<td>72.94</td>
<td>32.75</td>
<td>159.89</td>
</tr>
<tr>
<td>× Causative</td>
<td>135.53</td>
<td>64.72</td>
<td>277.92</td>
</tr>
<tr>
<td>Indefinite</td>
<td>2.05</td>
<td>1.37</td>
<td>3.1</td>
</tr>
<tr>
<td>× Possessive</td>
<td>8.35</td>
<td>2.76</td>
<td>25.27</td>
</tr>
<tr>
<td>Plural</td>
<td>1.05</td>
<td>0.77</td>
<td>1.46</td>
</tr>
<tr>
<td>Allophoric</td>
<td>1.48</td>
<td>0.52</td>
<td>4.49</td>
</tr>
<tr>
<td>Lexical</td>
<td>1.15</td>
<td>0.72</td>
<td>1.95</td>
</tr>
<tr>
<td>Unmarked</td>
<td>4.36</td>
<td>1.81</td>
<td>11.4</td>
</tr>
<tr>
<td>× Experiencer</td>
<td>86.63</td>
<td>21.32</td>
<td>357.32</td>
</tr>
<tr>
<td>Long</td>
<td>1.57</td>
<td>1.16</td>
<td>2.06</td>
</tr>
<tr>
<td>Text deictic</td>
<td>7.28</td>
<td>4.03</td>
<td>13.04</td>
</tr>
</tbody>
</table>

NP1

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Object initial</th>
<th>Subject initial</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O.R.</td>
<td>lower</td>
<td>upper</td>
</tr>
<tr>
<td>New</td>
<td>0.91</td>
<td>0.56</td>
<td>1.49</td>
</tr>
<tr>
<td>× Possessive</td>
<td>0.07</td>
<td>0.02</td>
<td>0.33</td>
</tr>
<tr>
<td>Inanimate</td>
<td>0.05</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td>× Volitional</td>
<td>0.01</td>
<td>0.00</td>
<td>0.04</td>
</tr>
<tr>
<td>Indefinite</td>
<td>0.42</td>
<td>0.27</td>
<td>0.67</td>
</tr>
<tr>
<td>Plural</td>
<td>0.47</td>
<td>0.35</td>
<td>0.63</td>
</tr>
<tr>
<td>Allophoric</td>
<td>0.14</td>
<td>0.09</td>
<td>0.21</td>
</tr>
<tr>
<td>Lexical</td>
<td>0.38</td>
<td>0.21</td>
<td>0.67</td>
</tr>
<tr>
<td>Unmarked</td>
<td>2.07</td>
<td>1.08</td>
<td>3.98</td>
</tr>
<tr>
<td>× Experiencer</td>
<td>0.83</td>
<td>0.17</td>
<td>4.36</td>
</tr>
<tr>
<td>× Possessive</td>
<td>0.41</td>
<td>0.07</td>
<td>2.12</td>
</tr>
<tr>
<td>Long</td>
<td>0.47</td>
<td>0.3</td>
<td>0.69</td>
</tr>
<tr>
<td>Text deictic</td>
<td>0.51</td>
<td>0.12</td>
<td>2.29</td>
</tr>
</tbody>
</table>

NP2

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Object initial</th>
<th>Subject initial</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O.R.</td>
<td>lower</td>
<td>upper</td>
</tr>
<tr>
<td>Volitional</td>
<td>0.55</td>
<td>0.25</td>
<td>1.34</td>
</tr>
<tr>
<td>Experiencer</td>
<td>1.54</td>
<td>0.66</td>
<td>3.86</td>
</tr>
<tr>
<td>Causative</td>
<td>1.7</td>
<td>0.77</td>
<td>3.76</td>
</tr>
<tr>
<td>Possessive</td>
<td>1.17</td>
<td>0.65</td>
<td>2.06</td>
</tr>
<tr>
<td>Syntax</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial adverbal</td>
<td>0.05</td>
<td>0.01</td>
<td>0.17</td>
</tr>
<tr>
<td>Embedded clause</td>
<td>0.17</td>
<td>0.12</td>
<td>0.24</td>
</tr>
<tr>
<td>Auxiliary verb(s)</td>
<td>1.49</td>
<td>1.14</td>
<td>1.97</td>
</tr>
</tbody>
</table>
initial NP argument is low in prominence in terms of animacy, definiteness or case marking/person. The magnitude of the increase is further mediated by the semantic class of the verb. The predicted odds for an object-initial word order are almost 29 times higher for sentences with an initial inanimate NP, 73 times higher when occurring with a volitional verb, and as much as 136 times higher when occurring with a causative verb. In sentences with initial indefinite NPs, the odds for an object-initial word order are predicted to be about two times higher than in sentences with definite NPs, and when the verb also is possessive, the odds are predicted to be about eight times higher. An initial unmarked / non-person NP argument predicts about a 4-fold increase, and almost an 87-fold increase together with an experiencer verb. A final NP argument that is low in prominence in terms of givenness, animacy, definiteness, number, egophoricity or referentiality, on the other hand, predicts a decrease in the odds for an object-initial word order. The magnitude of that decrease again depends on the verb class in some cases. A final inanimate argument predicts a 20-fold decrease in the odds for the object-initial word order, and almost a 164-fold decrease when occurring with a volitional verb. A final argument that is indefinite or plural predicts more than a two-fold decrease, a final allophoric argument is associated with a seven-fold decrease, and a final lexical argument predicts close to a three-fold decrease. The givenness of the final argument is not a significant predictor on its own, but has an effect together with a possessive verb: A final argument that is new and occurs with a possessive verb predicts almost a 13-fold decrease in the odds for an object-initial word order. When the final argument is low in prominence in terms of case/person, finally, the model somewhat unexpectedly predicts a two-fold increase in the odds for an object-initial word order. No other NP argument predictors or the verb class predictors considered in isolation predict any significant odds changes.

Finally, most of the control predictors are also predictive of the sentence word order. A length difference of both arguments is associated with a significant change in the odds for the object-initial word order. The odds are 1.5 times higher in sentences with an initial two-word NP in comparison to a one-word NP, and two times lower when the final NP consists of two words rather than one. As expected, whether or not the initial argument is text deictic is also highly predicative for the word order. When the initial NP is text deictic, the odds for the object-initial word order are about seven times as high as when it is not. Whether or not the second argument is text deictic, on the other hand, is not of importance. Also the syntactic properties of the sentences are, as expected, highly important for predicting word order. The odds for the object-initial word order are 20 times lower in sentences with an initial adverbial phrase, and close to 6 times lower in embedded sentences. If the sentence contains auxiliary verb(s), on the other hand, the predicted odds for the object-initial word order are 1.5 times higher.

The random effects The only random parameter of the model, a by-subgenre random intercept, adjusts for differences in the overall probability of an object-initial word order across subgenres. The random parameter (i.e., the estimated standard deviation of the logit across subgenres) is 0.47, meaning that the model predicts a ±12% difference in the probability of an object-initial word order across subgenres (see Gelman & Hill 2006).

In order to make the random parameter more interpretable, predicted probability differences on the genre level were estimated on the basis of the model’s estimated random
Table 5.12. Observed and predicted differences in the probability of an object-initial word order between genres in comparison to the overall probability of 5.27% across all genres. The table also shows 95% confidence intervals and p-values of tests of whether the probability of the genre differs from the overall probability of 5.27%. Standard errors of the predicted differences are calculated on the basis of the pooled error variance of the random effects. Confidence intervals are calculated using normal approximation. P values of the observed differences are calculated with the binomial test whereas p-values of predicted differences are calculated with Wald tests.

<table>
<thead>
<tr>
<th>Genre</th>
<th>Observed</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% diff</td>
<td>lower</td>
</tr>
<tr>
<td>Press: Reportage</td>
<td>-0.7%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Press: Editorial</td>
<td>-0.8%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Press: Reviews</td>
<td>2.0%</td>
<td>4.0%</td>
</tr>
<tr>
<td>Skills, Trades and Hobbies</td>
<td>1.1%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Popular Lore</td>
<td>-1.6%</td>
<td>-0.7%</td>
</tr>
<tr>
<td>Belles Letters, Biography, Memoirs</td>
<td>1.1%</td>
<td>-0.8%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>-2.3%</td>
<td>-1.1%</td>
</tr>
<tr>
<td>Learned and Scientific Writing</td>
<td>-1.7%</td>
<td>-0.9%</td>
</tr>
<tr>
<td>General fiction</td>
<td>0.7%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Mysteries and Science fiction</td>
<td>1.8%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Light reading</td>
<td>1.8%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Humor</td>
<td>5.6%</td>
<td>9.5%</td>
</tr>
</tbody>
</table>

The estimated random effects on the subgenre level. Genre-level probabilities were estimated on the basis of the mean random effects of the subgenres in each genre, weighted with respect to the subgenre sample sizes. Their standard errors were calculated on the basis of the pooled error variance of the random effects. Table 5.12 shows observed and predicted differences in the probability of an object-initial word order between genres in comparison to the overall probability across all genres (i.e., 5.27%). The table also provides confidence intervals and p-values of tests of whether the genre probabilities differ from the overall probability of 5.27%. The models’ ability to predict differences in the probability of an object-initial word order at the genre level is not very good. The correlation between observed and predicted probabilities is low and non-significant ($r^2(14) = .072$, $p = .31$), and the predicted genre probabilities are non-significant for all but one genre.

The estimated random effects on the subgenre level fair somewhat better. The correlation between observed and predicted probabilities is moderate and significant ($r^2(50) = .429$, $p < .001$), but the predicted genre probabilities are only significant for 6 out of 52 subgenres. The relationship between predicted and observed probability differences across subgenres is illustrated in the left-hand panel of Figure 5.4 below.

The assumption that the random effect is normally distributed is met. This is illustrated in the right-hand panel of Figure 5.4, which plots the standardized random effects against the expected quantiles of the standard normal distribution. The high degree of fit illustrates that the distribution of the random effects do not depart from normality. Figure 5.4 also includes error bars that represent 95% confidence intervals. The fact that most of these span zero shows that only a handful of the estimated random effects are significant.
5.5 Summary

In this chapter, I set out to investigate whether and to what extent NP prominence properties such as animacy, definiteness and givenness, verb semantic properties such as volitionality and sentience and their interactions co-occur with the grammatical functions of transitive sentences in written Swedish, and by extension, whether these properties can predict the word order of transitive sentences in language use. I also address the more specific question of whether writers tend to adapt their language production by avoiding ambiguities in order to accommodate the understanding of their readers (i.e., ambiguity avoidance, see Section 2.3.1, and, for instance, MacDonald 2013) by using more formal means of disambiguation in potentially ambiguous transitive sentences, a question that was raised by Rahkonen (2006). I also investigated whether the discourse pragmatic functions that have been suggested for the object-initial word order in the literature (e.g., Engdahl & Lindahl 2014; Rahkonen 2006; Teleman et al. 1999) are confirmed by the distributional differences of prominence features between object- and subject-initial sentences found in the present study.

In the following, I discuss these issues in turn by starting with a discussion of the discourse pragmatic functions of the object-initial word order (Section 5.5.1), then turning to the issue of whether writers tend to adopt their productions in order to avoid potential ambiguities (Section 5.5.2). Finally, I discuss the findings regarding the strength by which prominence features, verb semantic features and their interactions predict the sentence word order (Section 5.5.3).

Figure 5.4. Left-hand panel: Predicted differences in the probability of an object-initial word order between subgenres in comparison to the overall probability across all subgenres, plotted against the observed probability differences between subgenres. Right-hand panel: Standardized random effects of each subgenre plotted against the expected quantiles of the standard normal distribution. Error bars show 95% confidence intervals based upon the error variance of the random effects, re-scaled by dividing by the standard deviation of the random effects. The plot shows that the random effect is roughly normally distributed because most of the standard random effects agree with the expected quantiles of the standard normal distribution.

5.5. Summary
5.5.1. The function of the object-initial word order

As discussed in Section 3.2, the primary motivation for positioning the object sentence-initially is to signal that it is the sentence topic, and therefore serves as the base of prediction in the sentence. It is especially common for topics to also be highly prominent in the discourse context, thereby being anaphoric and referring back to discourse participants or propositions introduced in the previous sentence or earlier in the discourse (Engdahl & Lindahl 2014; Rahkonen 2006). This account is confirmed by the present data, which shows that objects more frequently are given, definite and pronominal when positioned in sentence-initial position. In fact, there is almost an inverse relationship between the givenness of the object and its positioning, such that the object is given in almost two-thirds of all cases when initial, but only one-third when occurring in final position. The object-initial construction is especially common when the object is text deictic, thereby referring back to a proposition in the previous sentence (see Example 3.6). These results are in line with the findings of Rahkonen (2006).

Not all sentence-initial objects are highly given, however. About half of all initial objects were found to be lexical, and more than a third are new. Although Rahkonen (2006) argues that such sentences ‘cannot be considered to represent the typical information structure of OVS sentences’ (p. 45), the rather high frequency of such occurrences needs to be accounted for. Here, I assume that such sentences reflect instances in which the object either functions as a sentence topic that is not particularly high in discourse prominence (as in Example 5.5) or expresses contrastive focus (as in Example 5.6), in line with the functional motivations of the object-initial word order proposed in SAG (Teleman et al. 1999:4:431-432). It should be emphasized here that many researchers (but not all, see Erteschik-Shir 2007:11-12) assume that the topic/comment distinction is logically independent from the focus/ground distinction (although these dichotomies are highly correlated). An initial NP argument that functions as the sentence topic can therefore also express contrastive focus, that is, being contrasted against a limited set of alternatives. More generally, it can express (a part of) the focus, that is, the new information of the sentences which is not presupposed\(^\text{10}\). On this view, in sentences such as Example 3.8 in Chapter 3, repeated in Example 5.7 for convenience, the initial object ‘Åsa’ can be said to function as the sentence topic, because the sentence is about Åsa, but also to be in contrastive focus, because Åsa is contrasted against another individual (‘Sandra’).

\[
\begin{align*}
\text{(5.7) } Åsa & \text{ är jag mycket förjust i (men inte Sandra)} \\
\text{Åsa am I very fond of (but not Sandra)}
\end{align*}
\]

‘Åsa I am very fond of (but not Sandra)’

It was also found that the subject also tends to behave somewhat differentially in object-initial sentences, in that subjects in post-verbal position are more frequently high in prominence in terms of animacy, egophoricity, pronominality and case marking. This reflects the fact that subjects more frequently consist of personal pronouns in post-verbal position in comparison to when they occur sentence-initially. This in turn suggests that the object-initial construction is preferred in cases where the subject is highly discourse prominent.

\(^{10}\) Although some accounts of focus blurs the distinction between contrastive and information focus.
and therefore more predictable, in line with the suggestion of Teleman et al. (1999) that the remainder of the sentence in an object-initial construction tends to be highly predictable, and that its final meaning in many cases can be inferred upon encountering the initial object only (Teleman et al. 1999:4:432, and see Example 3.7).

5.5.2. The use of formal markers in order to avoid ambiguity

As discussed in Section 2.3.1, writers might balance their production efforts by avoiding the use of redundant information in order to reduce processing costs, while also providing unambiguous information in order to accommodate comprehension. As discussed in Chapter 3, this question was addressed by Rahkonen (2006), who found that OVS sentences are somewhat more frequently case marked than SVO sentences and that case marking is somewhat more common in semantically ambiguous / reversible OVS sentences than in semantically unambiguous / irreversible OVS sentences. In other words, writers use case marking to a greater extent in sentences that are potentially ambiguous, which is to be expected if their productions are influenced by ambiguity avoidance. Similar results were found in the present study (see Section 5.3.3). It was found that both case marking and auxiliary verbs are used more often in OVS sentences than in SVO sentences, and that these formal markers occur more frequently in semantically reversible sentences than in semantically irreversible sentences. When accounting for differences between text genres, the probability for whether a given sentence is formally marked can be predicted with very high accuracy by a model that only considers word order and semantic irreversibility. These results therefore provide rather compelling evidence for the idea that writers indeed tailor their productions in order to avoid redundancies and ambiguities.

5.5.3. Predicting word order from NP prominence and verb class

The primary aim of this chapter is to quantify the strength by which prominence information, verb semantic information and their interactions correlate with the grammatical functions of the arguments in transitive sentences, and therefore function as argument interpretation cues in terms of predicting the sentence word order of Swedish transitives. As discussed in Section 2.1, the grammatical encoding of grammatical functions is conditioned by NP prominence properties in many languages. A marked construction (in terms of e.g. case marking or passivization, see Section 2.2.1) is used in cases where the relative or the absolute prominence of the arguments is marked, given their roles. Further, the frequency distributions of prominence features in natural discourse also show a clear pattern according to which subjects are most frequently realized with prominence properties at the higher ends of the prominence hierarchies, and objects most commonly are low in prominence. Given the rather high correlations between prominence properties and grammatical functions observed both across grammars and within natural discourses, it is likely that prominence properties and their interactions with more fine-grained semantic and discourse pragmatic distinctions serve as important cues for GF assignment during language comprehension, perhaps on par with formal means such as case marking, agreement and word order (e.g., Bornkessel-Schlesewsky, Grewe, & Schlesewsky 2012; Bornkessel-Schlesewsky & Schlesewsky 2009a, 2009c, 2013; MacWhinney 2005; MacWhinney & Bates 1989b), the strength of these cues being dependent on their availability.
in natural discourse. Indeed, Section 2.4 provided an overview of psycholinguistic and
neurolinguistic studies of language comprehension providing evidence for the view that
prominence information is utilized during language comprehension. If there exists a ca-
sual relationship between the distribution of prominence information in the discourse of
individual languages and the strength by which the comprehenders of these languages
make use of these information types, these strengths should be able to be quantified on
the basis of discourse distributions found in corpora. To this end, the present corpus
study quantifies the strength by which NP prominence properties and their interactions
with verb semantic features predict the argument functions, and by extension the word
order of transitive sentences in written Swedish.

In general, the results of the study show that subjects tend to be more prominent
than objects in terms of givenness, animacy, definiteness, egophoricity and pronominality.
These results confirm the results of a multitude of previous studies, presented in Section
2.2.2.

As a first step toward determining the strength by which prominence features, verb
semantic features and their interactions predict the sentence word order, the prevalence
of the object-initial word order as a function of prominence features of each NP argument,
verb semantic features and their crossed categories (e.g., animate & volitional, see Table
5.8) was investigated. **Prevalence** was calculated as the difference between the observed
and the by-chance-expected percentage of object-initial sentences within each category.
Generally, object-initial sentences were found to occur more frequently in sentences in
which the initial NP is low in prominence, but less frequent when the initial argument
is high in prominence. Conversely, object-initial sentences were less frequent when the
post verbal NP is low in prominence but more frequent when it is high in prominence.

When investigating the influence of prominence on the prevalence of the object-initial
word order within sentences of different verb classes, the patterns turned out to be even
more striking. In sentences with volitional, experiencer and causative verbs, object-initial
word order is much more frequent when the initial NP is inanimate. In experiencer verb
sentences, object-initial word order was also found to be more frequent when the initial
NP is lexical, allophoric and unmarked (i.e., when not consisting of a personal pronoun),
but less frequent when the post-verbal NP is inanimate, allophoric or unmarked / non-
person. In possessive verb sentences, object-initial word order is somewhat more frequent
when the initial NP is new or indefinite, but substantially more frequent when the post-
verbal NP is highly prominent in general (i.e., in terms of givenness, animacy, definiteness,
egophoricity, pronominality and case marking).\footnote{The prevalence in sentences with object-experiencer verbs was also investigated. Because so few of these
sentences are object-initial, these results are highly unreliable, however.}

These results provide some initial tentative evidence for the idea that the strength by
which prominence features function as cues for the sentence word order can be quantified
on the basis of corpus distributions. They further indicate that the influence of prominence
features largely depend on the verb class at hand. For example, in sentences with volitional
or experiencer verbs, which in most cases require an animate Actor argument, the animacy
cue serves as a much stronger predictor of the word order than in sentences with verbs
(such as possessive verbs) that do not require an animate Actor argument. However,
the prevalence measure, as directly based upon frequency distributions in the different
categories, cannot by itself show whether and to what extent a given information type is still informative when the influence of all information types as well as other confounding factors is accounted for. Given that many of the prominence features are highly correlated (e.g., all egophoric NPs are also pronominal), this is extra important. Nor does the prevalence measure take into account genre differences, that is, that the object-initial word order might be more frequent in some genres than in others. In order to overcome these problems, the data was analyzed with logistic mixed effects modeling, which quantifies the strength of the prominence features, the verb semantic feature and their interactions (as well as some additional confounding factors) in terms of (log) odds ratios, while controlling for the influence of all other factors as well as differences between genres.

Overall, the results of the logistic regression model is in line with the prevalence measurements, showing that the odds for the object-initial word order increase when the initial NP is low in prominence in terms of animacy, definiteness and case marking / person. Conversely, when the final NP argument is low in prominence with respect to givenness, animacy, definiteness, number, egophoricity and referentiality, the odds for an object-initial word order instead decrease. But it is in conjunction with differences in verb class that the influence of prominence features is of the greatest importance. The odds for an object-initial word order are about 73 times higher in sentences with a volitional verb and an inanimate initial NP, and as much as 136 times higher in causative verb sentences in which the initial NP is inanimate. When instead the final NP of a volitional verb sentence is inanimate, there is a 164-fold decrease in the odds for the object-initial word order. Thus, the animacy cue functions as a very strong predictor of word order in sentences with volitional or causative verbs. Given that the verbs in these verb classes in most cases require an Actor participant that is either in volitional or physical control of the event denoted by the verb and therefore in most cases is human or animate, it comes as no surprise that they very seldom co-occur with an inanimate subject. Their co-occurrence with an initial inanimate NP is therefore highly predictive of the object-initial word order. Conversely, the co-occurrence of a volitional verb and a final inanimate argument is predictive of the subject-initial word order.

Case marking / person is also of extra importance for predicting the word order in sentences with experiencer verbs. When the initial NP of a sentence with an experiencer verb is unmarked, and therefore not a personal pronoun, there is almost a 87-fold increase in the odds for the object-initial word order. Experiencer verbs require an Actor participant that is sentient and therefore unequivocally required to be human (or at a minimum animate). Given that 1st, 2nd and 3rd person pronouns occupy the top of the (extended) animacy hierarchy on many accounts (e.g., Croft 2003:130, Dixon 1994:85, Silverstein 1976), the Actor argument can be expected to very frequently be realized as a personal pronoun in experiencer verb sentences. In fact, as mentioned in Section 2.2.2, experiencer verbs very frequently occur with subjects that are realized as 1st or 2nd person pronouns. Dahl (2000) found that as many as 82% of all subjects in experiencer verb sentences in his corpus were 1st or 2nd person pronouns. He suggested that since experiencer verbs frequently express private knowledge and subjective experiences (e.g. verbs such as ‘know’, ‘think’, ‘see’ or ‘feel’), they are more likely to express propositions from the perspective of the speaker. They therefore more frequently occur with subjects that are 1st and 2nd person pronouns, that is, that are egophoric and speech act participants. In the present
data, however, subjects in experiencer verb sentences more frequently occur with personal pronouns in general, and therefore also 3rd person pronouns. This difference is probably due to the fact that whereas Dahl (2000) investigated spoken language, the present study is concerned with written language. Whereas spoken conversations most frequently take the perspective of the speaker or the interlocutor, in written language it is probably more common to take on a third-person narrative. Indeed, it has been suggested that the third-person narrative is optimal for describing the actions, thoughts and feelings of the protagonists in novels and written texts (Ricoeur & McLaughlin 1985:89), suggesting that the third-person perspective is preferable and therefore also more frequent in written language. Thus the underlying reason for why experiencer verb sentences more frequently occur with personal pronouns in both spoken and written texts appears to be the same: experiencer verb sentences tend to express private knowledge and subjective experiences, and therefore frequently take on the perspective of the speaker, the interlocutor or the (third-person) protagonist, that is, the most prominent discourse participants, both in terms of referentiality and animacy.

Definiteness and givenness also turned out to be of extra influence in predicting the word order in sentences with possessive verbs. The odds for the object-initial word order are eight times higher in sentences with an indefinite initial NP and a possessive verb. The odds for the subject-initial word order, on the other hand, are 13 times higher in sentences with a new final NP and a possessive verb. In other words, a possessive verb that co-occurs with either an initial NP that is low in discourse prominence or a post-verbal NP that is high in discourse prominence provides additional support for the object-initial word order, over and above that provided by discourse prominence itself. Discourse prominence is therefore of extra importance in possessive verb sentences. It is not exactly clear why this is the case. It might be that a possessive construction in some cases is used to introduce a new discourse topic, and thereby serves to mark a topic shift (James 1995). In such constructions, the topical object NP would be low in referential status but occupy initial position in order to emphasize its topic function. The final subject, on the other hand, is generally given and therefore highly discourse prominent, and serves as a reference point or a ‘ground’ for the introduction of the new topic. This is exemplified in Example 5.8 below, taken from the corpus.

(5.8) Några kvinnliga konstnärsidoler har Cecilia inte, tyvärr
any female favorite-artists have Cecilia not, unfortunately

‘Any female favorite artists Cecilia unfortunately do not have’

Example 5.8 appears to introduce a new sentence topic into the discourse, related to the already known discourse referent ‘Cecilia’. Importantly, in the subsequent sentences following Example 5.8, the discourse takes a turn, departing from a short description of the studio that Cecilia works in, to a discussion of inspirational artists. Example 5.8 therefore appears to introduce favorite and inspirational artists as a new discourse topic, using the possessive verb ‘ha’.

Rather unsurprisingly, most of the control predictors were also found to be predictive of the sentence word order. When the initial NP is longer, the odds for the object-initial word order go up, and, conversely, when the post-verbal NP is longer, the odds go down.
This is most likely because objects tend to be longer than subjects because they are discourse new more often than subjects, and new NPs more often contain modifiers that describe the referent. Thus the increase in the odds for the object-initial word order conditioned by the length of the initial NP is most likely due to the existence of topicalization constructions with topicalized objects that are discourse new and therefore long (as in Example 5.5). Conversely, the decrease in the odds conditioned by the length of the final NP is due to the fact that post-verbal objects are most frequently discourse new, and therefore long. It should be noted, however, that in the bulk of most object-initial topicalization constructions, the initial object is highly given and therefore also short. Thus the preference for putting short constituents before long (e.g., Arnold et al. 2000; Wasow 1997) might also play its part in the motivation for the object-initial word order. That is, the use of object-initial word order might be motivated in sentences with a highly given and short object and a long subject, on the basis of the length difference by itself.

Whether or not the initial argument is text deictic was also found to be highly predictive of the sentence word order. This finding simply reflects the fact that object topicalization is especially common when the object is text deictic, thereby referring back to a proposition introduced in the previous clause (see Section 5.3.2 and Example 3.6).

Object-before-subject word order is also much less frequent in adverbial-initial sentences. Here, the odds for the object-initial word order are 20 times lower than in sentences with an initial NP argument. These results are highly expected and reflect the fact that an object-before-subject word order in adverbial-initial sentences, a phenomenon called long object shift (Heinat 2010), is only permissible under quite specific circumstances and is therefore very infrequent. As mentioned in Section 5.2.3, the object may only shift to the position in front of the subject when it consists of a weak and unstressed personal pronoun, which prototypically is the 3rd person reflexive ‘sig’ (Heinat 2010; Holmberg 1986; Josefs- son 1992). Only three out of a total of 2,733 adverbial-initial sentences in the AIC corpus have an object-before-subject-initial word order. In all three cases, the object consists of a highly discourse prominent person pronoun and the subject of a lexical NP that is long and discourse new. Thus, long object shift appears to occur in cases where both arguments are highly marked in terms of both discourse prominence (i.e., the object is highly given, and the subject is new) and length (the object is short, and the subject is long). As such, the ordering might very well be motivated by the need to place the discourse prominent argument in the initial position together with the preference of placing short constituents before long (but see Heinat 2010 for an argument against a short-before-long account).

The object-initial word order is finally less frequent in embedded clauses than in main clauses. The odds for the object-initial word order are six times lower in the former sentence types than in the latter. This is because non-canonical word orders such as object-initial word order are highly restricted in embedded clauses in Swedish (Andersson 1975). This is in turn presumably due to a general difference in the function between main versus embedded clauses. In many cases, the embedded clause functions as a modifier of a constituent of a matrix clause (e.g., a relative clause in an NP). The embedded clause as a whole makes up a part of a constituent that serves a function in the matrix clause. For instance, Andersson (1975) claims that whereas matrix clauses express assertions or other speech acts (see Searle 1975), embedded clauses prototypically express propositions that are part of the speech act as a whole, and therefore have canonical word order.
For instance, the assertion of the sentence ‘Jack believes that the king of France is bald’ is about Jack’s belief, which in turn is expressed by the proposition referred to by the embedded clause ‘that the king of France is bald’. Embedded clauses also tend to make up a part of an informational structural unit in the matrix clause (e.g., an adverbial clause that is part of the sentence focus of the matrix clause). In other words, the embedded clause is not directly related to the information structure of the overall discourse, but only to the information structural units of the matrix clause through its complementizer (cf. Platzack 2010:102). There is therefore no need to signal that the information structure of the embedded clause is marked in some way, and the prototypical subject-initial word order is resorted to.

Differences in the prevalence of the object-initial word order between genres were finally also briefly investigated (see Table 5.12). Table 5.12 gives some indication that the object-initial word order is somewhat more frequent in informal genres than in formal ones. For example, the percentage of object-initial sentences is somewhat higher than the overall percentage of object-initial word order in the fiction, ‘Light reading’ and ‘Humor’ genres, but somewhat lower in the ‘Learned and Scientific Writing’, ‘Educational texts’ and the ‘Debate articles’ genres. There are, however, counterexamples, and deviations from the overall percentage are only statistically significant for the larger genres. It is therefore hard to draw any general conclusions regarding genre differences.
6. Three Models of Incremental Argument Interpretation

6.1. Introduction

In Chapter 2, I argued for a constraint-based and probabilistic view of the comprehension of grammatical functions. On this view, the comprehension of grammatical functions involves assigning role-semantic and discourse-pragmatic functions to the argument NPs (e.g., to determine which argument is the Actor and which is the Topic) on the basis of both morphosyntactic and prominence-based information. These information types function as argument interpretation cues in the interpretation process that are activated in parallel in a probabilistic fashion. I assume that this is a highly incremental and dynamic process that draws upon the information that is currently available in the input. An initial tentative interpretation is probabilistically assigned immediately upon encountering the first NP argument. The strength of this interpretation then varies as a function of the upcoming cues provided by subsequent constituents. Cue weights are further assumed to depend on their co-occurrence with grammatical functions in language use.

In this chapter, I present three computational models of the process of GF assignment. These models make predictions regarding the overall change in processing difficulty during incremental GF assignment. The models also make predictions regarding the influence of individual cues on this processing difficulty. These predictions are tested in Chapter 7. As discussed in more detail below, the change in processing difficulty is assumed to depend on the change in the current expectedness of a particular GF assignment.

In Chapter 5, the strengths with which argument interpretation cues predict the grammatical functions of NP arguments in transitive sentences was quantified using mixed effects logistic modeling. This method provides a way of estimating the weights assigned to these cues. Since the logistic model predicts the log odds of a dichotomous outcome as a linear combination of the log-odds ratios of a set of predictors, it is able to predict the probability of a particular GF assignment (i.e., whether an NP argument of a transitive sentence is either the Actor or the Undergoer), conditional on a set of prominence cues available at a specific time point. This makes it possible to model incremental GF assignment in terms of change in the expectedness of a particular GF assignment (i.e., Actor- or Undergoer-initial) as a function of the additional cues provided by the subsequent sentence constituents. The three models presented in this chapter, ‘the random noise model’ (RN model), ‘the penalization regression model’ (PR model) and ‘the categorical disambiguation model’ (CD model), aim to do this.

As will be discussed in more detail in Section 6.2.4, it is not entirely clear whether morphosyntactic cues (such as case marking) should be treated as categorically disambiguating information or in the same manner as other probabilistic or prominence-based
cues (such as animacy). Although the underlying architecture of the three models is the same, they therefore differ in the way that morphosyntactic versus prominence-based cues are handled. Whereas the CD model treats morphosyntactic cues as categorically disambiguating information, the RN and PR models do not, but instead treat both cue types as probabilistic. The RN and PR models differ in how estimation of cue strengths is implemented, as described in further detail in Section 6.2.6. An important distinction that the CD model tries to capture, as will become apparent in more detail in Section 6.2.4, is that of incremental GF assignment before and after unambiguous morphosyntactic information has been provided. An additional aim of the CD model is therefore to account for processing costs after the point of disambiguation toward a specific GF assignment. In the CD model, the processing difficulty at and after the point of disambiguation is assumed to depend on the expectedness or consistency of the prominence information given the current GF assignment. This will be discussed in more detail in Section 6.2.6.

In the following, I briefly present the background that motivates these models (Section 6.1.1). I then go on to present the model specifications, starting with the aspects that all three models have in common (Section 6.2), and then moving on to their more specific differences (Section 6.2.6). In Section 6.3, I then give an overview of the predictions that the models make, focusing on the effect of individual cues, as well as differences between the models.

6.1.1. Surprisal theory

The three models proposed in this chapter quantify incremental argument interpretation in terms of the change in the expectation of a particular GF assignment upon encountering the constituents in a transitive sentence, given their features (or, in terms of prediction error, see Kuperberg and Jaeger 2016:36). The models share this with the surprisal theory of word-by-word incremental parsing (see, e.g., Hale 2001; Levy 2008 and Levy 2013 for an introduction and a review), which I briefly summarize next. According to surprisal theory, the surprisal of a word depends on the extent to which that word is unpredictable in the syntactic context, in the sense that it is inconsistent with previous assumptions regarding the syntactic structure of the sentence. At a given time point during incremental language comprehension, there are often multiple syntactic interpretations of a sentence that are possible. Surprisal theory assumes that language comprehenders hold multiple hypotheses about the syntactic structure of the sentence at hand. These parsing hypotheses are each held with different strengths, and can therefore be described as a probability distribution that is determined by the statistics of the previous language input. At successive time points during on-line comprehension, new words become available that provide further evidence for or against these possible hypotheses. Incremental language comprehension therefore involves the updating of the probability distribution over possible parses after encountering each incoming word. The processing difficulty of a word is then determined by the degree to which that word either disconfirms parsing hypotheses that previously comprised a great amount of probability (Hale 2001) or, more generally, the degree to which the probability distribution over possible parses is updated (Levy 2008).

Formally, the shift in the distribution over possible parses following word presentation can be quantified in terms of the relative entropy between the posterior and the prior
6.2 Model specifications

This is the Kullback-Leibler (KL) divergence of the posterior probability distribution with respect to the prior distribution. The KL divergence of probability distribution $Q$ from probability distribution $P$ is defined as (see, e.g., Shlens, 2007):

$$D_{KL}(P \parallel Q) = \sum_i \log_2 \left( \frac{P(i)}{Q(i)} \right) P(i)$$

The relative entropy between an updated probability distribution of possible parses $I$ at the presentation of word $W_i$ and the prior distribution of $I$ at the presentation of the previous word $W_{i-1}$ is therefore equal to KL divergence from $P(I \mid W_1...W_i)$ to $P(I \mid W_1...W_{i-1})$, i.e.,

$$D_{KL}(P(I \mid W_1...W_i) \parallel (P(I \mid W_1...W_{i-1}))$$

Levy (2008) has further shown that, under very general assumptions, the relative entropy between $P(I \mid W_1...W_i)$ and $P(I \mid W_1...W_{i-1})$ is equivalent to the original formalization of surprisal proposed by Shannon (1948) and adopted by Hale (2001). Here, the surprisal of word $W_i$ is equal to the negative log probability of word $W_i$ in its context of words $W_1...W_i$, on the one hand, and its discourse context $C$, on the other:

$$-\log_2 P(W_i \mid W_1...W_i, C)$$

Thus, surprisal theory holds that the processing difficulty of a word can be predicted by its surprisal. Surprisal can either be quantified in terms of the relative entropy between the posterior and the prior probability distribution over possible parses at the word at hand and at the previous word (Levy 2008) or in terms of the negative log of the words probability in the syntactic context (Hale 2001). Previous research has shown that the processing load of a word during incremental language interpretation is predicted by its surprisal (Boston, Hale, Kliegl, Patil, & Vasishth 2008; Frank, Otten, Galli, & Vigliocco 2015; Jäger, Chen, Li, Lin, & Vasishth 2015; Linzen & Jaeger 2014; Smith & Levy 2013).

### 6.2. Model specifications

Rather than predicting the processing difficulty of a word given its syntactic left context in terms of surprisal, the models proposed in this chapter concern the processing difficulty of GF assignment during incremental language comprehension. This can also be conceived of as the difficulty of determining the sentence word order (i.e., whether the initial argument is either the subject or the object), given the preference for the subject-initial word order and the previously encountered sentence features (e.g., NP1 animacy, NP1 case marking and verb class).

The models estimate on-line change in the expectation of an object-initial word order in terms of the relative entropy between the probability of the object-initial word order (i.e., $p($object-initial$)$) at time $t_i$ and the probability at time $t_{i-1}$. As such, the models estimate the updating in Bayesian belief in the object-initial word order from $t_{i-1}$ to $t_i$, a measure known as Bayesian surprise (Kuperberg & Jaeger 2016). It should be stressed that, although Bayesian surprise is equivalent to word-by-word surprisal under...
some circumstances, it is formally different from surprisal. For simplicity, I will still use
the term ‘surprisal’ throughout the dissertation, however.

In the models, the surprisal of encountering a constituent \( C_i \) (i.e., NP1, the predicate
or NP2) in a transitive sentence is quantified as the KL divergence of \( p(\text{object-initial}) \)
given the information available at the presentation of constituent \( C_i \), with respect to
\( p(\text{object-initial}) \) given the information immediately after the presentation of constituent
\( C_{i-1} \), that is,

\[
D_{KL}(P(\text{object-initial} \mid C_1...C_i) \mid\mid P(\text{object-initial} \mid C_1...C_{i-1}))
\]

Surprisal can be seen as a measure of the information gain in bits about \( p(\text{object-initial}) \)
given the information available at time point \( t_i \), in comparison to \( p(\text{object-initial}) \) given
the information at time point \( t_{i-1} \). A value of 0 means that \( p(\text{object-initial}) \) at \( t_i \) does
not differ from the probability at \( t_{i-1} \). In other words, there is no additional information
regarding \( p(\text{object-initial}) \) at \( t_i \) in comparison to \( t_{i-1} \), and therefore no surprisal to speak
of. A high value, on the other hand, means that the information available at \( t_i \) drastically
changes \( p(\text{object-initial}) \) in comparison to \( t_{i-1} \), and therefore is highly unexpected.

The sentence information that the incremental models operate upon is the prominence
features of each NP, the verb semantic properties, and the other morphosyntactic features
of importance (e.g., the NP lengths, the sentence type and whether the sentence is a main
or an embedded clause). As such, the models concern the surprisal of encountering whole
constituents, rather than individual words (see, e.g., Example 6.4 below). This information
is provided to the models as a specification of the predictors used in the full model (see,
e.g., Table 5.10). On the basis of this information, the models provide the surprisal in
bits associated with constituent \( C_i \), given the information provided by the constituent
\( C_{i-1} \) and the overall expectation of an object-initial word order. This is illustrated in the
following examples.

### 6.2.1. Model illustrations

First, consider Example 6.1 below, taken from the corpus.

(6.1) [De levande\( D_{KL}=0.02 \)] [fångade\( D_{KL}=0.00 \)] [jag\( D_{KL}=5.64 \)]

The living caught I

‘I caught the living’

The surprisal and \( p(\text{object-initial}) \) in Example 6.1 is shown in Figure 6.1. The figure
illustrates the surprisal as well as the probability at each time point \( t_i \) and for each
corresponding constituent \( C_i \). The relevant prominence features of the constituents are
listed below each constituent. Since the first NP ‘De levande’ in Example 6.1 is high in
prominence in terms of animacy and definiteness, it speaks in favor of a subject-initial
interpretation.

It is therefore associated with a low probability for the object-initial word order
(\( p(\text{object-initial}) = .02 \)). Because of the subject-first-preference (see Chapter 2), a highly

\(^1\text{If constituent } C_i \text{ is the initial NP of the sentence, the baseline probability of an object-initial word order is used as prior probability.}\)
6.2 Model specifications

prominent initial NP is expected. In other words, the prominence features of the initial NP are in line with the baseline assumption of the subject-initial word order, which, in the incremental models, is a result of the low baseline probability for the object-initial word order ($p(\text{object-initial}) = .047$). The initial NP therefore does not engender any surprisal effect. Since there is no verb semantic information at the verb that speaks against the initial assumption of a subject-initial word order, $p(\text{object-initial})$ remains low ($= .01$) after the presentation of the verb. There is therefore no surprisal engendered by the verb either. However, since the second NP ‘ni’ consists of a personal pronoun that is case marked in the nominative, it provides solid evidence for the object-initial word order ($p(\text{object-initial}) = .88$), and the initial assumption needs to be revised. As illustrated in Figure 6.1, this is reflected by the large surprisal effect engendered by the final NP ($D_{KL} = 5.20$).
In Example 6.2 above, the first NP (‘säckiga byxor’) is instead low in prominence in terms of animacy and definiteness / givenness, thereby providing some evidence for the object-initial word order ($p(\text{object-initial}) = 0.22$). Because this information speaks against the baseline assumption of the subject-initial word order, this NP engenders a small but noticeable surprisal effect ($D_{KL} = 0.26$). This and subsequent effects are illustrated in Figure 6.2. The upcoming verb (‘har’) is possessive and therefore speaks in favor of the object-initial word order by virtue of its co-occurrence with an initial indefinite NP. This effect is very small, however, and hardly has any impact on $p(\text{object-initial}) = 0.23$. No surprisal effect is therefore observed at the verb. Since the second NP again consists of a personal pronoun that is case marked in the nominative, it too provides overwhelming evidence for the object-initial word order ($p(\text{object-initial}) = 0.99$). In this case, however, the resulting surprisal effect ($D_{KL} = 2.10$) is much smaller than the one observed in Example 6.1 because evidence for the object-initial word order has already been provided by the first NP and the verb.
In Example 6.3 below, finally, the first NP (‘En liknande strävan’) is again low in prominence in terms of animacy, definiteness / givenness and length, and therefore provides some initial evidence for the object-initial interpretation \( p(\text{object-initial}) = .24 \). As illustrated in Figure 6.3, it therefore also engenders a small but noticeable surprisal effect \( D_{KL}=0.31 \).

\[
(6.3) \quad [\text{En liknande strävan}D_{KL}=0.31] \quad [\text{urskiljer}D_{KL}=1.35] \quad [\text{han}D_{KL}=0.17] \quad \text{också}
\]

‘He also discerns a similar endeavor’

In Example 6.3, the upcoming verb (‘strävan’) is however both volitional as well as experiencer. Since it co-occurs with an initial inanimate NP, it strongly speaks against the baseline assumption of the subject-initial word order and instead provides much support for the object-initial interpretation \( p(\text{object-initial}) = .88 \). The verb therefore engenders a rather strong surprisal effect \( D_{KL}=1.35 \). The final NP, which again consists of a personal pronoun case marked in the nominative, therefore does not provide much additional evidence for the object-initial interpretation \( p(\text{object-initial}) = .99 \) and does not engender any surprisal effect to speak of (see Figure 6.3).

---

**Figure 6.3.** Surprisal (upper panel) and probabilities (lower panel) at each constituent of Example sentence 6.3. The relevant constituent features are listed below each constituent.
These examples illustrate how the models predict processing difficulties in GF assignment in terms of surprisal as a function of a dynamic interplay between morphosyntactic and prominence-based cues and their estimated weightings. In particular, the processing difficulty associated with grammatical function reanalysis in (morphosyntactically) locally ambiguous sentences (such as the critical sentences used in the experiment in Chapter 4) is in the models assumed to depend on a dynamic interplay between prominence based and verb-semantic properties provided prior to the presentation of the disambiguating pronoun.

6.2.2. Presentation order

As illustrated in the examples in the previous section, the serial presentation of sentence constituents over time in the incremental models is represented by the three time points $t_1$, $t_2$ and $t_3$. The presentation order of constituents across $t_1$, $t_2$ and $t_3$ differs depending on whether the sentence at hand is canonical subject-initial (as in Examples 3.2 and 5.1), object-initial (as in 3.3 and 5.2), or adverbial initial (as in Examples 3.4 and 5.3), on the one hand, and whether the sentence contains one or several auxiliary verbs, on the other. The constituent orderings across time points in the different sentence types are illustrated and exemplified in Table 6.1 (see the columns named ‘Constituent ordering’).

In subject-initial sentences, the initial NP precedes the predicate, that is, the finite verb and any additional auxiliary verbs, which in turn precede the final NP. In object-initial sentences, the initial NP precedes the predicate, but the final NP is only preceded by the finite verb. Any infinite verbs, which provide information about the verb semantic properties, always follow the final NP. The order of presentation of sentence constituents in subject- and object-initial sentences is therefore different if the sentence at hand contains auxiliary verbs. The incremental models therefore always assume an NP1-verb-NP2 order for subject-initial sentences, but an NP1-NP2-verb order for object-initial sentences, when the sentence at hand contains auxiliary verbs. In adverbial-initial sentences, the finite verb precedes both the initial and the final NP. If the sentence contains auxiliary verbs, however, the infinite verbs follow the initial NP but precede the final NP. The order of presentation in adverbial-initial sentences therefore also depends on whether the sentence contains auxiliary verbs. For adverbial-initial sentences, the incremental models therefore assume a verb-NP1-NP2 order when the sentence contains one finite verb only, and an NP1-verb-NP2 order when the sentence contains auxiliary verbs.

6.2.3. Probability estimation

As mentioned in Section 5.4, the probabilities for the object-initial word order associated with subsequent sentence constituents presented at time points $t_1$, $t_2$ and $t_3$ are estimated on the basis of three sets of mixed effects or ordinary logistic regression models (henceforth referred to as regmodels in order to avoid confusion with the incremental models) that underlie each of the three incremental models. Each of these sets contain regmodels that correspond to a subset or all of the sentence constituents that, depending on the sentence word order, are available at $t_1$, $t_2$ or $t_3$. In canonical subject-initial sentences, for example, NP1 becomes available at $t_1$, the verb at $t_2$ and NP2 at $t_3$. The regmodels that estimate $p$(object-initial) at $t_1$, $t_2$ and $t_3$ in subject-initial sentences, therefore correspond to NP1,
Table 6.1. Illustration of constituent ordering (as described in Section 6.2.2) and the selection of logistic regression models (as described in Section 6.2.3), at time points $t_0$, $t_1$, $t_2$ and $t_3$ in the different sentence types, together with example sentences. Sentences are differentiated with respect to sentence type (subject-initial, object-initial or adverbial-initial) as well as with respect to whether they contain auxiliaries. Constituent orderings are shown under the columns ‘Constituent order’ and logistic regression models under the columns ‘Regmodel’. Time point $t_0$ corresponds to the time before any information regarding the sentence word order is available, and therefore represents the baseline probability for the object-initial word order.

<table>
<thead>
<tr>
<th></th>
<th>No auxiliary</th>
<th>Auxiliaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constituent order</td>
<td>Regmodel</td>
<td>Constituent order</td>
</tr>
<tr>
<td><strong>subject-initial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_0$:</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$t_1$:</td>
<td>NP1</td>
<td>NP1</td>
</tr>
<tr>
<td>$t_2$:</td>
<td>NP1 + Verb</td>
<td>NP1 + Verb*</td>
</tr>
<tr>
<td>$t_3$:</td>
<td>NP1 + Verb + NP2</td>
<td>NP1 + Verb* + NP2</td>
</tr>
<tr>
<td></td>
<td>[Barnen$\text{NP}_1$] $\text{Int NP}$</td>
<td>[Barnen$\text{NP}_1$] $\text{Int NP}$</td>
</tr>
<tr>
<td></td>
<td>The kids eat ice cream before dinner</td>
<td>The kids may eat ice cream before dinner</td>
</tr>
<tr>
<td><strong>object-initial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_0$:</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$t_1$:</td>
<td>NP1</td>
<td>NP1</td>
</tr>
<tr>
<td>$t_2$:</td>
<td>NP1 + Verb</td>
<td>NP1 + NP2*</td>
</tr>
<tr>
<td>$t_3$:</td>
<td>NP1 + Verb + NP2</td>
<td>NP1 + NP2* + Verb</td>
</tr>
<tr>
<td></td>
<td>[Glass$\text{NP}_1$] $\text{Int NP}$</td>
<td>[Glass$\text{NP}_1$] $\text{Int NP}$</td>
</tr>
<tr>
<td></td>
<td>Ice cream the kids eat before dinner</td>
<td>Ice cream the kids may eat before dinner</td>
</tr>
<tr>
<td><strong>Adv initial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_0$:</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$t_1$:</td>
<td>Verb</td>
<td>NP1*</td>
</tr>
<tr>
<td>$t_2$:</td>
<td>Verb + NP1</td>
<td>NP1* + Verb</td>
</tr>
<tr>
<td>$t_3$:</td>
<td>Verb + NP1 + NP2</td>
<td>NP1* + Verb + NP2</td>
</tr>
<tr>
<td></td>
<td>Innan middan $\text{Int NP}$</td>
<td>Innan middan $\text{Int NP}$</td>
</tr>
<tr>
<td></td>
<td>Before dinner the kids eat ice cream</td>
<td>Before dinner the kids may eat ice cream</td>
</tr>
</tbody>
</table>

A star (*) indicates the point in the sentence at which disambiguation occurs due to the occurrence of a auxiliary verb. See Section 6.2.4 for more information.

NP1 + verb, and NP1 + verb + NP2, respectively. A regmodel that corresponds to the constituent(s) available at $t_i$ (e.g., NP1) is therefore always nested in the regmodel that corresponds to the constituents available at $t_{i+1}$ (e.g., NP1 + verb) in that it contains a subset of the predictors in the other model (e.g., the NP1 predictors only). Each regmodel set contains the following regmodels.

The Null regmodels estimate the baseline probability and essentially correspond to the proportion of object-initial sentences across all genres in the corpus. As such, they only contain an intercept and no other predictors. The Int NP regmodels estimate $p$ (object-initial) given the information provided by the initial NP, and therefore contain all NP1 predictors (see Table 5.10). The Verb regmodels estimate the probability given the information in the verb (e.g., the verb semantic properties) and contain the verb predic-
tors. The Both NPs regmodels provide the probability with respect to the information in both NPs, and hence contain the NP1 and NP2 predictors. The Int NP & verb regmodels obtain the probability given the information in the initial NP, the information in the verb, and their interactions, and therefore contain the NP1 and the verb semantic predictors together with their interactions. The Full regmodels, finally, estimate the probability given the information in the verb and both NPs, together with their interactions. All models (apart from the null regmodels) also contain the ‘Sentence type’ and ‘Main vs. embedded clauses’ predictors, the former distinguishing between NP-initial and adverbial-initial sentences, and the latter between main and embedded clauses (see Section 5.2.5).

The selection of the regmodels over time points in the different sentence types is also illustrated in Table 6.1 (see see the columns named ‘Regmodel’). It is important to note that there is not a one-to-one correspondence between constituent orderings across time points in the different sentence types and regmodels. This is because the regmodels estimate $p$(object-initial) given the information provided by the constituents available at the different time points, but do not take into account the relative ordering of the constituents. Thus, for example, although the ordering between the NPs and the verb is different in subject-initial sentences in comparison to adverbial-initial sentences, the same regmodels are used at $t_2$ and $t_3$ in both sentence types. Differences between the sentence types are in this case instead represented by the Sentence type predictor, which differentiates between NP- and adverbial-initial sentences.

6.2.4. Disambiguating information

During the on-line presentation of sentence constituents, disambiguating information becomes available at different time points depending on the morphosyntactic structure of the sentence at hand. For example, in subject- and object-initial sentences with an initial lexical NP, a single finite verb, and a case marked final NP, the disambiguating information about the argument functions becomes available upon encountering the second NP at $t_3$. If the initial NP is case marked, on the other hand, this information is provided already at $t_1$, when the initial NP is encountered. Disambiguation can be assumed to be done on the basis of case marking and on the basis of whether the sentence contains auxiliary verbs (see Section 3.3), and perhaps also on the basis of the semantic relationship between the NP arguments and the predicate.

Case marking provides unambiguous information about the argument functions, as case marked pronominal NPs always bear nominative case when functioning as the subject, and accusative case when functioning as the object. A sentence with a case marked initial NP is therefore assumed to be disambiguated at $t_1$ in subject- and object-initial sentences, and at $t_2$ in adverbial-initial sentences.

As discussed in Section 3.3, the occurrence of auxiliary verbs provides an indirect cue about the argument functions. In subject-initial sentences, the final NP follows all verbs, whereas in object-initial sentences, the infinite verb(s) instead follow the final NP. The relative ordering of the final NP and the infinite verb(s) therefore provides an unambiguous cue to argument function assignment. In subject- and object-initial sentences, auxiliary verb disambiguation is assumed to occur at $t_2$ at which point either all verbs or the finite verb and final NP are encountered. In adverbial-initial sentences, the finite verb always
precedes both NPs, but any infinite verbs always follow the initial NP, which in this case
must function as the subject. An adverbial-initial sentence with an initial finite auxiliary
verb as in Example 5.3\(^2\) must therefore be subject-initial. Adverbial-initial sentences are
therefore assumed to be disambiguated already at \(t_1\) where the verb is encountered. In
Table 6.1, a * indicates the point at which sentences with auxiliaries are assumed to be
unambiguous due to their additional verbs.

When both sentence arguments are unmarked, and the sentence contains only one
verb, the argument functions instead need be determined on the basis of semantic infer-
encing. For example, in Example 6.4 below, taken from the AIC corpus, it is the initial NP
that functions as the object of the sentence. But this can only be determined on the basis
of the semantic relationship between the verb and the second NP. Because the first NP is
inanimate and the second NP is animate, the only plausible interpretation of the sentence
is that it was the thick-headed Olof who survived the event denoted by the NP ‘that
thing’, and not the other way around. The fact that object-initial sentences without any
other morphosyntactic disambiguating information are attested indicates that argument
interpretation at least in some cases must be done on the basis of semantic inferencing.
Sentences with unmarked NPs and no auxiliaries might therefore also be disambiguated
at \(t_3\), at which point all semantic information is available.

(6.4) *den slagen överlevde den tjockskallige Olof*
  ‘that thing survived the thick-headed Olof’

6.2.5. Beyond the point of disambiguation

Beyond the point of disambiguation, the disambiguating information can be expected
to generate predictions about the upcoming information, resulting in processing costs in
cases where those predictions are not fulfilled. For example, encountering the final NP
in unambiguous object-initial sentences as in Example 6.5 might be somewhat less costly
when that NP is more prominent (as in Example 6.5a) than when it is not (as in Example
6.5b), because it fits better with the prediction of a highly prominent subject.

(6.5) (a) *Dig försenade jag på väg till jobbet*
  ‘You delayed I on way to work’

(b) *Dig försenade en trafikolycka på väg till jobbet*
  ‘You a traffic accident delayed on the way to work’

Indeed, as discussed in Chapter 2, there is plenty of evidence for predictive processing in
the domain of argument interpretation. Studies in several languages have, for example,
found that an unambiguous inanimate subject that follows an object argument engen-
ders an N400 effect, which is assumed to reflect violations of the expectation of a highly

\(^2\)But note that the verb ‘få’ (‘get’) also can function as the main verb of the sentence and therefore not
by necessity entails (such as, e.g., ‘kan’ (‘may’)) that the sentence contains additional verbs.
Chapter 6. Three Models of Incremental Argument Interpretation

prominent and therefore animate subject (Bornkessel-Schlesewsky & Schlesewsky 2009c; Philipp et al. 2008; Roehm et al. 2004; Weckerly & Kutas 1999). There are therefore good reasons to assume that probabilistic cues such as prominence features will have an impact at and beyond the point of disambiguation. As described in Section 6.1, the processing difficulty (as reflected in surprisal) at and after the point of disambiguation is in the CD model therefore assumed to depend on the expectedness or consistency of the prominence information given the current GF assignment. After the point of disambiguation, the surprisal effect will therefore be somewhat lower when the prominence features are consistent with the GF assignment (as in Example 6.5a) than when it is not (as in Example 6.5b). Exactly how this is implemented is described in the next section.

6.2.6. Differences between the three models

As briefly described in Section 6.1, the CD, RN and PR models differ with respect to whether they treat morphosyntactic cues as categorically disambiguating information that is processed prior to and is distinct from all other probabilistic cues (as in the CD model), or whether they handle morphosyntactic cues in the same manner as the probabilistic cues (as in the RN and PR models). In the following, I discuss the motivations for these two different approaches and then move on to presenting the specific details of the models.

As discussed in Section 3.3, Rahkonen (2006) makes a distinction between formal means of disambiguating sentences, such as word order and morphology as discussed above, and semantic / prominence-based means, such as when an NP argument is semantically unfit to fill the Actor or the Undergoer role of the verb. In this view, there is an (at least implicit) distinction between categorically disambiguating cues, on the one hand, corresponding to formal disambiguators (e.g., case marking), and probabilistic cues, on the other, corresponding to prominence-based disambiguators (e.g., animacy). Whereas the former are assumed to be categorical in nature and provide definite evidence for a given word order, the latter are not, and instead provide probabilistic evidence in favor or against a given interpretation. However, there is evidence that comprehenders do not make a categorical distinction between disambiguating and probabilistic cues in this way. This would assume that the language comprehension process is noise free, but much research has shown that this not the case: Comprehenders do not always resolve structural ambiguities toward the correct interpretation after the disambiguating information has been encountered (Christianson, Hollingworth, Halliwell, & Ferreira 2001; F. Ferreira, Bailey, & Ferraro 2002; F. Ferreira, Christianson, & Hollingworth 2001; F. Ferreira, Engelhardt, & Jones 2009; F. Ferreira & Patson 2007). Comprehenders have also been found to use the subsequent context during auditory word and segment recognition, suggesting that they maintain uncertainty about the speech input even after the point of recognition (e.g., Bicknell, Tanenhaus, and Jaeger 2016; Connie, Blasko, and Hall 1991; McMurray, Tanenhaus, and Aslin 2002, and see Dahan 2010 for a review). In other words, comprehenders do not always make the correct or final interpretation on the basis of disambiguating information, suggesting that such information types should be treated on par with other probabilistic cues.

Whether or not disambiguating cues are considered to be distinct from other probabilistic cues (and presumably processed prior to the probabilistic information) has conse-
sequences for how these information types interact at the time point where the disambiguating information is provided. These views therefore make different predictions regarding the processing at disambiguation. The probabilistic cues provided by the disambiguating constituent might either influence argument interpretation independent of the disambiguating information, in conjunction with the disambiguating information, or they might be rendered obsolete by the disambiguating information and therefore are ignored. Consider Example 6.6.

\begin{itemize}
\item[(6.6)] (a) *Byggherren kände jag litet grann*
  Constructor.the knew I little bit
  ‘The constructor I knew a little bit’
\item[(b) *Byggherren kände de litet grann*
  Constructor.the knew they little bit
  ‘The constructor they knew a little bit’
\end{itemize}

In both Example 6.6a and Example 6.6b, the second NP is pronominal and therefore case marked, and disambiguates the sentence toward the object-initial interpretation. However, the pronominal NPs in 6.6a and 6.6b differ from each other with respect to egophoricity (1st person vs 3rd person) and number (singular vs plural). The NP2 pronoun is therefore somewhat higher in prominence in 6.6a than in 6.6b. If the disambiguating information *per se* (i.e., the case marking) is processed prior to and independent of the prominence information, the participant roles should be assigned to the NP arguments prior to the processing of the prominence-based information. In this scenario, the processing cost of the second NP can be expected to depend on the extent to which its prominence features are consistent with the Actor role. Disambiguation should therefore be somewhat less costly in 6.6a than in 6.6b. If, on the other hand, the disambiguating information and the prominence information is processed simultaneously and in the same manner, both of the information types functioning as probabilistic cues that are weighted together, the processing cost should instead be higher in 6.6a than in 6.6b, because the weighed evidence against the baseline assumption of the subject-initial word order is stronger in 6.6a than in 6.6b. If, finally, the prominence information is rendered obsolete when the disambiguating information is encountered, the processing cost of the final NP should not differ between 6.6a and 6.6b.

Beyond the point of disambiguation, higher processing costs can be expected in cases where the upcoming information is inconsistent with the disambiguating information, in line with the assumption that the disambiguating information generates predictions regarding the upcoming materials (e.g., a highly prominent second NP in an object-initial sentence with a case marked first NP, see Section 6.2.5 and Example 6.5), independent of whether the disambiguating information is conceived of as categorical or not. In both cases, the disambiguating information will provide compelling evidence for either the subject- or the object-initial word order, and any upcoming information that goes against that evidence will be surprising.

The RN, PR and CD models primarily differ in the way that disambiguating information is handled, and this is described in more detail in the following.
The random noise and penalization regression models. Both the RN and the PR models assume that disambiguating information is processed and integrated in the same manner as all other probabilistic cues, such as prominence-based information: The probability for a given word order when a disambiguating constituent is encountered is determined by the sum of the weights attached to both the probabilistic and the disambiguating cues. As such, the RN and the PR models can be seen to be purely ‘data-driven’ in that they do not make any additional assumptions regarding the influence of disambiguating information on $p(\text{object-initial})$ beyond that which is estimated by the regmodels. These models therefore do not make the assumption that all sentences are eventually disambiguated (such as, e.g. in Example 6.4) on the basis of semantics.

In the RN and the PR models, the disambiguating predictors NP1 case, NP2 case and Auxiliary verbs (see Table 5.10) in the underlying regmodels directly encode disambiguating information. The NP1 and NP2 case predictors are assigned three levels (‘unmarked’ vs. ‘nominative’ vs. ‘accusative’) rather than two (‘marked’ vs. ‘unmarked’), for which the type of case marking perfectly predicts the sentence word order\(^3\). The auxiliary verb predictor, on the other hand, is assigned the three levels ‘none’, ‘main verb final’ and ‘main verb non-final’. ‘None’ indicates that the sentence does not contain auxiliaries. ‘Main verb final’ and ‘main verb non-final’, on the other hand, distinguish between auxiliary verb sentences in which the main verb either follows or precedes the final NP. As such, these two categories perfectly predict the sentence word order, as all the sentences of the former category are object-initial and all of those of the latter subject-initial.

However, in line with the discussion in Section 5.4.1 it is problematic to incorporate information that perfectly disambiguates towards the subject- or object-initial word order in the regmodels. This would entail including predictors that perfectly predict the argument functions, such as, for instance, whether an NP is marked in the nominative or the accusative. But such predictors would be highly collinear with the outcome variable, the function of the second NP argument. The resulting regression models would therefore not fit, or, at a minimum, suffer from inaccurate parameter estimations. The RN and the PN models differ with respect to how this problem is handled.

In the RN model, collinearity and overfitting in the underlying regmodels is avoided by introducing noise into the data for the disambiguating predictors. Importantly, this also deals with the somewhat problematic assumption that language comprehension is noise free (see above). In the model, noise is introduced by randomly confusing all the cases of the dichotomous disambiguating categories (i.e., ‘NP1 nominative’ vs. ‘NP1 accusative’, ‘NP2 nominative’ vs. ‘NP2 accusative’ and ‘main verb final’ vs. ‘main verb non-final’) with each other with a probability of 1%. This is done by re-sampling each case of the disambiguating categories from a Bernoulli distribution with $p = 0.01$, and re-assigning the categories of the successful cases. This ensures that the relationship between the disambiguating categories and word order is probabilistic rather than categorical, thereby mitigating the collinearity problem, while at the same time introducing some noise by assuming that the disambiguating information is misinterpreted in 1% of all cases. Due to problems of collinearity, it was not possible to include interaction terms either between NP1 and NP2 case and the experiencer verb class, nor between NP1 and NP2 egophoricity and the experiencer verb class. The influence of the experiencer verb class therefore

\(^3\)See Section 5.2.3 for more information on the classification of the NP1 and NP2 case predictors.
6.2 Model specifications

Table 6.2. Model fit and collinearity statistics for the logistic mixed effects models used to estimate $p$\((\text{object-initial})\) associated with sentence constituents in the RN model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Full</th>
<th>Both NPs &amp; verb</th>
<th>Int NP</th>
<th>Verb only</th>
<th>Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.F.</td>
<td>35</td>
<td>23</td>
<td>22</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>LL</td>
<td>-451.73</td>
<td>-473.85</td>
<td>-1233.74</td>
<td>-1900.56</td>
<td>-3021.11</td>
</tr>
<tr>
<td>AIC</td>
<td>979.47</td>
<td>999.69</td>
<td>2515.47</td>
<td>3829.11</td>
<td>6058.22</td>
</tr>
<tr>
<td>Dxy</td>
<td>.992</td>
<td>.992</td>
<td>.957</td>
<td>.899</td>
<td>.554</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>p shrinkage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>corr.Dxy</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>max corr.</td>
<td>.766</td>
<td>.767</td>
<td>.763</td>
<td>.733</td>
<td>.259</td>
</tr>
<tr>
<td>max VIF</td>
<td>8.28</td>
<td>4.15</td>
<td>10.20</td>
<td>3.43</td>
<td>1.11</td>
</tr>
<tr>
<td>Kappa</td>
<td>35.01</td>
<td>31.40</td>
<td>17.71</td>
<td>15.68</td>
<td>3.11</td>
</tr>
</tbody>
</table>

manifests itself as a ‘main effect’ in the RN model predictions. The categorical predictors in regmodels underlying the RN model were not centered and therefore were categorical and dichotomous. Model evaluations and degree of fit of the regmodels in the RN model are shown in Table 6.2. Evaluations were done on the basis of the same methods presented in Section 5.4.1. These found high kappa values in many of the regmodels. Considering the high correlations between the disambiguating predictors and the outcome variable, however, this can be expected. Evaluations also found problems with variance inflation in the full and NP1 + verb models. However, since the standard errors of the regmodel predictors are rather low, and since the model evaluations presented below showed that the predicted surprisal effects of the RN model in most cases match those of the CD model, both in terms of predicted effects and prediction errors, variance inflation does not seem to distort the results in any significant ways.

In the PR model, the problem of collinarity and overfitting in the underlying regmodels is dealt with in another way. Instead of using logistic mixed effects models in which the disambiguating categories are confused with each other, the PR model uses penalization. Penalized logistic regression involves shrinking of the model parameters with respect to the extent that they may suffer from overfitting. The estimation of regression coefficients for predictor variables that are highly correlated with the outcome variable and/or suffer from data sparsity is therefore ‘penalized’, resulting in less optimistic estimates and lower standard errors. Penalization therefore allows for the inclusion of disambiguating predictors that are highly correlated with the outcome variable (in this case the function of the final NP).

Penalization was achieved in terms of Penalized Maximum Likelihood Estimation, following Harrell (2010:207-210), as implemented in the lrm() function in the rms package (Harrell 2013). Here, parameters are estimated on the basis of maximum likelihood estimation in which the log likelihood is weighed with respect to an individual penalty factor and a set of scaling factors for each model parameter, which determines the amount of shrinkage of each parameter. The scaling factors were determined on the basis of the standard method suggested by Harrell (2010:207-208), as implemented in the lrm() function.
Following Harrell (2010:208-209), the penalty factor was determined by maximizing the modified AIC\(^4\). This was done by refitting each model 40 times, increasing the penalty factor by 0.05 (starting at 0) at each run, and calculating the corresponding modified AICs. In order to use the same amount of penalization in all five models, the highest penalty factor (1.9) that maximized modified AIC in any of the models was used in all of the models.

The categorical predictors in the regmodels underlying the PR model were also uncentered and therefore are categorical and dichotomous. Because the PR model utilizes penalization, it was possible to include interaction terms between NP1 and NP2 egophoricity, on the one hand, and experiencer verb class, on the other, in the regmodels. The PR model therefore differs from the RN model also in that the influence of the experiencer verb class manifests itself as an interaction between NP1 and NP2 egophoricity, rather than a main effect. Further, the underlying regmodels do not include random subgenre intercepts (being fixed-effect models only), and therefore do not account for differences in \(p(\text{object-initial})\) across genres. As shown in Table 6.3, model evaluations found high kappa and variance inflation values in the full, the both NPs, and the NP1 & verb models, indicating that these models suffer from very severe collinearity problems. This is mainly due to the fact that they include interactions between NP1 and NP2 egophoricity, on the one hand, and experiencer verb, on the other. However, model evaluations (see Section 6.3) again found that the predictions of the PR model in most cases match those of both the RN model and the CD model, both in terms of predicted effects and prediction errors.

\[ \chi^2 - 2 \times \text{the effective degrees of freedom}, \text{the degrees of freedom adjusted for the penalization.} \]

### Table 6.3

<table>
<thead>
<tr>
<th>Model</th>
<th>Full</th>
<th>Both NPs</th>
<th>Int NP &amp; verb</th>
<th>Int NP</th>
<th>Verb only</th>
<th>Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.F.</td>
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<td>11.83</td>
<td>6.82</td>
<td>1</td>
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<tr>
<td>LL</td>
<td>-487.51</td>
<td>-521.31</td>
<td>-1255.90</td>
<td>-2022.98</td>
<td>-3048.15</td>
<td>-3415.27</td>
</tr>
<tr>
<td>AIC</td>
<td>1033.87</td>
<td>1082.70</td>
<td>2550.10</td>
<td>4067.62</td>
<td>6107.94</td>
<td>6832.54</td>
</tr>
<tr>
<td>Dxy</td>
<td>.993</td>
<td>.993</td>
<td>.952</td>
<td>.874</td>
<td>.505</td>
<td>-</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>p shrinkage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>corr. Dxy</td>
<td>.992</td>
<td>.992</td>
<td>.951</td>
<td>.872</td>
<td>.503</td>
<td>-</td>
</tr>
<tr>
<td>Max corr.</td>
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<td>.734</td>
<td>.737</td>
<td>.729</td>
<td>.244</td>
<td>-</td>
</tr>
<tr>
<td>Max VIF</td>
<td>15.86</td>
<td>3.58</td>
<td>25.77</td>
<td>3.56</td>
<td>1.11</td>
<td>-</td>
</tr>
<tr>
<td>Kappa</td>
<td>39.82</td>
<td>35.23</td>
<td>18.86</td>
<td>16.58</td>
<td>3.11</td>
<td>-</td>
</tr>
</tbody>
</table>

The categorical disambiguation model

In the CD model, finally, the processing of the disambiguating information is assumed to be categorical in nature and to temporarily precede the processing of other probabilistic cues. The CD model therefore differs from the RN and the PR models in that it assumes that disambiguating information is treated differentially from probabilistic information. In the CD model, disambiguation is
not accounted for by incorporating disambiguating information in the underlying regmodels. The probabilities obtained by them is therefore seen only as an estimate of the joint probabilities of the probabilistic cues (i.e., prominence and verb semantic cues), henceforth referred to as $P_{prob}$. That is, disambiguating information is not encoded in the disambiguating predictors NP1 case, NP2 case and Auxiliary verbs, as in the regmodels underlying the RN and the PR models. The NP1 and NP2 case predictors, on the one hand, and the Auxiliary verbs predictor, on the other, are instead dichotomously coded in the same manner as in the full mixed effects model presented in Chapter 5 (i.e., with ‘marked’ / ‘unmarked’ for the case predictors and with ‘yes’ / ‘no’ for the auxiliary verbs predictor). Disambiguation is instead accounted for by assuming a probability close to 0 at those constituents where the sentence at hand is disambiguated towards the subject-initial word order, and a probability of 1 when it is disambiguated towards the object-initial word order. Disambiguating information can be seen as setting a new baseline probability close to either 1 or 0. Any surprisal effects beyond the point of disambiguation are then determined by the extent to which the new probabilistic information is inconsistent with that of the new baseline probability of the disambiguating constituent.

The probabilities associated with the disambiguating information types, henceforth referred to as $P_{disamb}$, are estimated on the basis of the empirical probabilities of the corpus data. This is done by dividing the number of object-initial sentences with the disambiguating cues $C_{1...n}$ available at time point $t_i$ by the sum of the number of both the subject- and the object-initial sentences with cues $C_{1...n}$ at $t_i$, assuming +1 for each of these three counts in order to smooth the disambiguating probabilities (i.e., Laplace or add-one smoothing, cf. Jurafsky & Martin 2009). Thus, $p$(object-initial) associated with the disambiguating cues $C_{1...n}$ is calculated as:

$$P_{disamb} = p(O-int | C_{1...n}) = \frac{n(O-int \cap (C_{1} \cup ... \cup C_{n})) + 1}{n(O-int \cap (C_{1} \cup ... \cup C_{n})) + n(S-int \cap (C_{1} \cup ... \cup C_{n})) + 1}$$

Thus, for example, $p$(object-initial) at $t_2$ in object-initial sentences with an accusative NP1 and auxiliary verb(s) equals

$$P_{disamb} = p(O-int | NP1 acc, Aux) = \frac{n(O-int \cap (NP1 acc \cup Aux)) + 1}{n(O-int \cap (NP1 acc \cup Aux)) + n(S-int \cap (NP1 acc \cup Aux)) + 1} = 0.997$$

where ‘NP1 acc’ represents the set of sentences with an initial NP that is marked with accusative case marking and ‘Aux’ represents the set of sentences with auxiliary verbs. In order to ensure that the disambiguating probabilities always provide the strongest support for the given word order (and therefore do not bias against such an interpretation), however, they are also adjusted with respect to the probabilistic probabilities $P_{prob}$ available at the same time point. In subject-initial sentences, $P_{disamb}$ is adjusted in a manner that ensures that it is not higher than $P_{prob}$, and therefore does not incorrectly bias against the subject-initial word order. In object-initial sentences, $P_{disamb}$ is adjusted to ensure that

---

5‘S-’ and ‘O-int’ stand for ‘subject-’ and ‘object-initial’, respectively
Figure 6.4. Disambiguating probabilities $P_{\text{disamb}}$ of 0.05 for subject-initial sentences and 0.95 for object-initial sentences, adjusted with respect to different levels of probabilistic probabilities $P_{\text{prob}}$. It is not lower than $P_{\text{prob}}$, and does not bias against the object-initial word order. The adjustments are weighed by the extent to which $P_{\text{prob}}$ speaks in favor of the given word order in the following manner:

$$P_{\text{disamb}} = \begin{cases} P_{\text{disamb}} - (P_{\text{prob}} \cdot (1 - P_{\text{disamb}})), & \text{if WO = subject-initial} \\ P_{\text{disamb}} + (P_{\text{prob}} \cdot (1 - P_{\text{disamb}})), & \text{if WO = object-initial} \end{cases}$$

Figure 6.4 illustrates the adjustment of $P_{\text{disamb}}$ set to 0.05 for subject-initial sentences and 0.95 for object-initial sentences with respect to different levels of $P_{\text{prob}}$. The more $P_{\text{prob}}$ speaks in favor of the given word order, $P_{\text{disamb}}$ is adjusted towards 0 or 1, ensuring that $P_{\text{disamb}}$ is always stronger than $P_{\text{prob}}$.

Since the CD model accounts for disambiguating information by assuming set probabilities at the point of disambiguation and beyond, rather than including it in the reg-models, the interaction between probabilistic and disambiguating cues is accounted for by additional assumptions and solutions. The CD model assumes that argument interpretation is somewhat less costly when the probabilistic cues of the disambiguating constituent are consistent with the disambiguating information, as illustrated in Example 6.6 above. It also assumes an increase in the processing cost after the point of disambiguation, to the extent to which the upcoming probabilistic cues speak against the disambiguating information (and consequently against the predictions it generates, as exemplified in Example 6.5 above). In both cases, this is done by adjusting $P_{\text{disamb}}$ at time point $t_i$ on the basis of the difference between $P_{\text{prob}}$ at $t_i$ and $t_{i-1}$. In order to ensure that the adjusted probabilities do not exceed 1 or go below 0, and, more importantly, that they are only affected by the extent to which $P_{\text{prob}}$ at $t_i$ relative to $P_{\text{prob}}$ at $t_{i-1}$ bias in the right direction, they are converted to log odds. These two adjustments are described in the following. For clarity, a schematic illustration of these are adjustments further found in Figure 6.6.

In order to account for the influence of the probabilistic cues of the disambiguating constituent, $P_{\text{disamb}}$ is adjusted to yield $P_{\text{disambadj}}$. $P_{\text{disambadj}}$ can be seen as an estimate of the probability of the disambiguating constituent at $t_i$ that also takes into account the
Figure 6.5. The effect of adjusting $P_{\text{disamb}}$ as a function of the change in $P_{\text{prob}}$ at the disambiguating constituent at $t_i$ with respect to $P_{\text{prob}}$ at $t_i-1$ set to 0.5. The upper panels show the resulting adjusted $P_{\text{disamb}}$, and the lower panels show the surprisal effect calculated as $D_{KL}(P_{\text{prob}_{i-1}} || P_{\text{disamb}_{adj}})$.

Probabilistic information with respect to that available at $t_i-1$. $P_{\text{disamb}_{adj}}$ is calculated by subtracting the difference between the log odds of $P_{\text{prob}_{i-1}}$ and $P_{\text{prob}_i}$ from the log odds of $P_{\text{disamb}}$, and then converting back to probabilities in the following way:

$$P_{\text{disamb}_{adj}} = \frac{1}{1 + \exp(-\log(P_{\text{disamb}}) - \log(P_{\text{prob}_{i-1}}) - \log(P_{\text{prob}_i}))}$$

The effect of adjusting $P_{\text{disamb}}$ in the disambiguating region is illustrated in Figure 6.5 above. The figure illustrates the effect of a change in $P_{\text{prob}_i}$ with respect to $P_{\text{prob}_{i-1}}$ set to 0.5, in subject- and object-initial sentences, respectively. The upper panels show the $P_{\text{disamb}_{adj}}$ per se, and the lower show the resulting surprisal values\(^6\). The figure illustrates that to the extent that $P_{\text{prob}}$ at $t_i$ converges with $P_{\text{disamb}}$ at $t_i$, $P_{\text{disamb}}$ is adjusted towards $P_{\text{prob}}$ at $t_i-1$, thereby reducing the surprisal effect. In the event that $P_{\text{prob}}$ at $t_i$ is instead

\(^6\)i.e., calculated as $D_{KL}(P_{\text{prob}_{i-1}} || P_{\text{disamb}_{adj}})$. 
consistent with \( P_{\text{disamb}} \), no significant adjustment is made, and the surprisal effect is only marginally effected. In other words, to the extent that the probabilistic cues of the disambiguating constituent are consistent with the disambiguating information and thus bias towards the correct interpretation, the surprisal effect of encountering the disambiguating constituent is mitigated. If the probabilistic cues instead speak against the disambiguating information, the surprisal effect is more or less unaffected. The model therefore predicts the somewhat weaker surprisal effect of \( D_{KL} = 4.39 \) at the disambiguating pronoun in sentences such as 6.6a in comparison to the surprisal effect of \( D_{KL} = 4.51 \) in sentences such as 6.6b. An illustration of the adjustments of \( P_{\text{disamb}} \) in sentences in which the probabilistic cues of the disambiguating constituent are consistent with the disambiguating information (such as in Example 6.6a) is shown in Figure 6.6a. Figure 6.6b illustrates the \( P_{\text{disamb}} \) adjustment in sentences in which the probabilistic cues of the disambiguating constituent are instead inconsistent with the disambiguating information (such as in Example 6.6b).

In order to account for the influence of the probabilistic cues beyond the point of disambiguation, and the extent to which they are consistent with the disambiguating information, \( P_{\text{disamb}} \) is adjusted to yield \( P_{\text{unamb}} \) at time point \( t_i \) following disambiguation. \( P_{\text{unamb}} \) can be seen as an estimate of the probability for the word order given the disambiguating information that has been adjusted for the evidence provided by the probabilistic cues provided at \( t_i \) with respect to those available at \( t_{i-1} \). \( P_{\text{unamb}} \) is calculated by adding the difference between the log odds of \( P_{\text{prob}}_{t_{i-1}} \) and \( P_{\text{prob}}_{t_i} \) to the log odds of \( P_{\text{disamb}} \), the resulting quantity being converted back to probabilities:

\[
P_{\text{unamb}} = \frac{1}{1 + \exp(-\log\left(\frac{P_{\text{disamb}}}{1-P_{\text{disamb}}}\right) + \log\left(\frac{P_{\text{prob}}_{t_{i-1}}}{1-P_{\text{prob}}_{t_{i-1}}}\right) - \log\left(\frac{P_{\text{prob}}_{t_i}}{1-P_{\text{prob}}_{t_i}}\right))}
\]

Under the assumption that the surprisal effects beyond the point of disambiguation reflect the extent to which the probabilistic cues speak against the predictions set up by the disambiguating information, the surprisal effect at time point \( t_i \) in the unambiguous region is then calculated as the KL divergence between \( P_{\text{disamb}} \) at \( t_i \) and \( P_{\text{unamb}} \) at \( t_i \). \( P_{\text{unamb}} \) as well as the surprisal effect in an unambiguous region is illustrated in Figure 6.7 below. The figure illustrates again the effect of a change in \( P_{\text{prob}} \) with respect to \( P_{\text{prob}}_{t_{i-1}} = 0.5 \), in subject- and object-initial sentences, respectively. The upper panels illustrate \( P_{\text{unamb}} \) and the lower panels illustrate the resulting surprisal values. The figure shows that to the extent that \( P_{\text{prob}} \) at \( t_i \) diverges from \( P_{\text{disamb}} \), \( P_{\text{unamb}} \) moves away from \( P_{\text{disamb}} \) towards \( P_{\text{prob}} \) at \( t_{i-1} \). In the event that \( P_{\text{prob}} \) at \( t_i \) instead is consistent with \( P_{\text{disamb}} \), \( P_{\text{unamb}} \) remains close to \( P_{\text{disamb}} \). Since the surprisal effect is calculated on the basis of the divergence between \( P_{\text{disamb}} \) and \( P_{\text{unamb}} \), the surprisal effect increases as \( P_{\text{prob}} \) diverges from \( P_{\text{disamb}} \). In other words, to the extent that the probabilistic cues of an unambiguous constituent are inconsistent with the disambiguating information and hence speak against it, the surprisal effect of encountering the unambiguous constituent is increased. If the probabilistic cues are instead consistent with the disambiguating information, the surprisal effect is unaffected. The model therefore predicts a larger surprisal effect of \( D_{KL} = 0.27 \) at the second NP in sentences such as Example 6.5b in comparison to a surprisal effect

\[i.e.,\; D_{KL}(P_{\text{disamb}}_{t_i} \parallel P_{\text{unamb}}_{t_i})\]
6.2 Model specifications

Figure 6.6. Illustration of the probability adjustment to yield $P_{\text{disamb}, \text{adj}}$ and $P_{\text{unamb}}$. Panels A and B show the adjustment of $P_{\text{disamb}}$ at disambiguation and Panels C and D the calculation of $P_{\text{unamb}}$ after disambiguation. Panel A illustrates the adjustment of $P_{\text{disamb}}$ in sentences such as Example 6.6a: $P_{\text{disamb}}$ is lowered because $P_{\text{prob}}$ at $t_i$ moves towards $P_{\text{disamb}}$ with respect to $P_{\text{prob}}$ at $t_{i-1}$, thereby reducing the surprisal effect. Panel B illustrates the adjustment of $P_{\text{disamb}}$ in sentences such as Example 6.6b: $P_{\text{disamb}}$ is virtually unaffected because $P_{\text{prob}}$ at $t_i$ instead moves away from $P_{\text{disamb}}$ with respect to $P_{\text{prob}}$ at $t_{i-1}$. Panel C illustrates the calculation of $P_{\text{unamb}}$ in sentences such as Example 6.5a: $P_{\text{unamb}}$ equals $P_{\text{disamb}}$ adjusted for the extent to which $P_{\text{prob}}$ at $t_i$ moves away from $P_{\text{disamb}}$ relative to $P_{\text{prob}}$ at $t_{i-1}$. A small surprisal effect is therefore engendered at $t_i$ when the information bias against the GR assignment relative to the information at $t_{i-1}$. Panel D illustrates the calculation of $P_{\text{unamb}}$ in sentences such as Example 6.5b: $P_{\text{unamb}}$ virtually equals $P_{\text{disamb}}$ because $P_{\text{prob}}$ at $t_i$ is equally close or closer to $P_{\text{disamb}}$ relative to $P_{\text{prob}}$ at $t_{i-1}$. No surprisal effect is therefore engendered at $t_i$ when the information is consistent with the GR assignment in comparison to the information at $t_{i-1}$.

In contrast to the RN and PR models, the categorical predictors in the regmodels of the CD model were centered. Model evaluations did not indicate any severe collinearity
Chapter 6. Three Models of Incremental Argument Interpretation

Figure 6.7. The effect of adjusting $P_{\text{disamb}}$ as a function of the change in $P_{\text{prob}}$ at the unambiguous constituent at $t_i$ with respect to $P_{\text{prob}}$ at $t_{i-1}$ set to 0.5. The upper panels show the resulting $P_{\text{unamb}}$, and the lower panels show the surprisal effect calculated as $D_{KL}(P_{\text{disamb}} \parallel P_{\text{unamb}})$.

problems in any of the models, as shown in Table 6.4 below.

6.2.7. Interval estimation

The incremental models predict point estimates of surprisal values associated with transitive sentences, but do not provide any information regarding the confidence in those estimates. Interval estimates, which provide confidence intervals of surprisal values, were therefore calculated on the basis of simulations of predicted values of the regmodels (c.f. Gelman & Hill 2006:140-151). Simulation involves drawing a large number of coefficient vectors at random, conditioned on the estimated beta coefficients and their standard errors. From these, a vector of simulated model predictions can be calculated. Simulation was implemented using the sim() function in the arm package (Gelman & Yu-Sung 2014). Probability distributions for $p(\text{object-initial})$ at $t_1$, $t_2$ and $t_3$, respectively, were calculated on the basis of simulations. Distributions of surprisal values for $t_1$, $t_2$ and $t_3$, respectively, were then calculated from these probability distributions. The lower and upper confidence limits for the surprisal effect at $t_i$ are the 5% and 95% percentiles of the respective distributions.
Table 6.4. Model fit and collinearity statistics for the mixed effects logit models used to estimate $p(\text{object-initial})$ associated with sentence constituents in the CD model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Full</th>
<th>Both NPs &amp; verb</th>
<th>Int NP</th>
<th>Verb only</th>
<th>Null</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D.F.</td>
<td>-968.37</td>
<td>-1091.37</td>
<td>-1712.78</td>
<td>-1947.33</td>
</tr>
<tr>
<td>LL</td>
<td>35</td>
<td>23</td>
<td>22</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>AIC</td>
<td>2006.73</td>
<td>2228.73</td>
<td>3469.57</td>
<td>3920.66</td>
<td>6044.09</td>
</tr>
<tr>
<td>Dxy</td>
<td>.970</td>
<td>.965</td>
<td>.908</td>
<td>.886</td>
<td>.563</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>.977</td>
<td>.982</td>
<td>.987</td>
<td>.989</td>
<td>.968</td>
</tr>
<tr>
<td>$p$ shrinkage</td>
<td>.420</td>
<td>.503</td>
<td>.621</td>
<td>.704</td>
<td>.495</td>
</tr>
<tr>
<td>corr.Dxy</td>
<td>.966</td>
<td>.961</td>
<td>.886</td>
<td>.853</td>
<td>.511</td>
</tr>
<tr>
<td>Collinearity</td>
<td>max corr.</td>
<td>.875</td>
<td>.741</td>
<td>.920</td>
<td>.744</td>
</tr>
<tr>
<td></td>
<td>max VIF</td>
<td>6.08</td>
<td>5.78</td>
<td>6.99</td>
<td>3.54</td>
</tr>
<tr>
<td></td>
<td>Kappa</td>
<td>7.39</td>
<td>7.18</td>
<td>6.51</td>
<td>6.39</td>
</tr>
</tbody>
</table>

6.3. Model evaluation

Next, I evaluate the predictions of the three incremental models, looking only at model predictions in subject- and object-initial main clause sentences without auxiliary verbs (see Table 6.1 for examples). I begin by looking at locally ambiguous sentences that are disambiguated at the final NP. This sentence type is of the greatest theoretical interest, because it allows for investigating the extent to which probabilistic prominence cues guide on-line argument interpretation. This is why this sentence type was used in the ERP experiment presented in Chapter 4. First, I investigate locally ambiguous sentences with respect to how the surprisal effect is distributed across the sentence constituents, and then look at the surprisal effect associated with individual predictors at each constituent.

I then move on to investigating the models’ abilities to make predictions at and beyond the point of disambiguation in, for instance, sentences with an initial case marked NP, focusing on the differences between the three models.

6.3.1. Fake data construction

Although the model can be applied to the original corpus data, as in Example 6.1, 6.2 and 6.3 above, this data set does not include sentences with all possible combinations of the predictors that the models operate upon. An evaluation of the models on the basis of the corpus data will therefore be incomplete insofar as it is not based upon the full range of legit sentence types. I therefore constructed a fake data set to conduct the model evaluation on. This data set consists of 833,504 ‘fake’ sentences, which can be conceived as the population of all permissible transitive sentence types. Subsets of this data set were used to evaluate different aspects of the incremental models.

The data set was constructed on the basis of all permissible combinations of predictor levels in the full regmodel (see Table 5.10). The data set was constrained on the basis of possible co-occurrences of predictor levels in the original data set: It only includes combinations of predictor levels such that for any given pair of predictors, the predictor levels co-occur with each other in the original data set. That is, the fake data only include
sentences with combinations of pairs of features that are also found in the original data. For example, since egophoric NP arguments only consist of 1st and 2nd person pronouns, which in turn are always case marked, egophoricity always co-occurs with case marking. All egophoric NP arguments are therefore also case marked in the fake data set. NP1 and NP2 argument lengths, which are the only two non-dichotomous predictors in the full model, were constrained to only one or two words, and were therefore also treated as dichotomous in the fake data set. It should be stressed that since the fake data was constrained only on the basis of combinations of pairs of features, it does contain sentences with combinations of more than two features that do NOT occur in the actual data. Some of the sentences in the fake data are therefore illegit. However, since the evaluations in this section were done on selected subsets of fake sentences that represent legit sentences, this was not a problem.

6.3.2. Surprisal in locally ambiguous sentences

In this section, I evaluate the predicted surprisal effects of the three models in subject- and object-initial sentences with an initial NP that is unmarked and therefore ambiguous, and a case-marked final pronoun (e.g., ‘Lisa träffade jag på stranden igår’ - ‘Lisa I met on the beach yesterday’). Note, however, that this excludes sentences in which the first NP is a personal pronoun - but not necessarily sentences in which it is pronominal (e.g., ‘Någon träffade jag på stranden igår’ - ‘Someone I met on the beach yesterday’). These sentences are therefore locally ambiguous up until the presentation of the final NP. This section therefore investigates model predictions before the point of disambiguation. It should be stressed that since the RN, PR and CD models differ first and foremost with respect to how disambiguating information is treated, the evaluations in this section are NOT primarily concerned with model differences (although the results of the individual models are presented). As will be shown below, all three models make very similar predictions in these types of sentences. Model differences will instead be investigated in more detail in Sections 6.3.3 and 6.3.4, in which the predicted effects at the point of disambiguation and beyond are investigated.

I start out by looking at the predicted change in surprisal over time, across constituents. The purpose of this is to investigate how uncertainty in GF assignment is generally distributed across sentence constituents in locally ambiguous sentences. I then go on to investigate the influence of individual predictors on the surprisal effect of each constituent in turn. Those predictors or interactions between predictors that have the strongest influence on the surprisal effect in terms of, for instance, mitigating the effect at the second NP, are those that can be expected to have the strongest influence on GF assignment. As such, this investigation gives an idea of which information types that have the highest influence on GF assignment during the on-line comprehension of Swedish transitive sentences, according to the different models.

Surprisal over time The change in surprisal across sentence constituents in ambiguous sentences is illustrated in Figure 6.8 below. The figure shows the predicted surprisal effect of each model, engendered by each constituent in clauses in which disambiguation occurs at the final NP. The final NP always consists of a 3rd person plural pronoun (i.e., ‘de’ or
‘dem’). All sentences have been ordered on the basis of the surprisal effect at the final NP, and the color scale represents the order of the sentences. Whereas sentences with a low surprisal at the final NP are represented by a red diamond, sentences with a high surprisal at the final NP are marked with a yellow diamond.

Figure 6.8 illustrates that in subject-initial sentences, large surprisal effects at the final constituent are generally accompanied by large surprisal effects at the previous constituents. In object-initial sentences, on the other hand, a large surprisal effect at the final constituent is most often preceded by rather low surprisal effects at the previous constituents. The figure indicates that the change in surprisal across sentence constituents depends on whether the sentence at hand is subject- or object-initial. In general, however, the surprisal effect depends on the extent to which the current information is inconsistent

Figure 6.8. Surprisal of each constituent in sentences with an unmarked initial NP and a final NP consisting of a 3rd person plural pronoun, as predicted by the RN, PR and CD models. The sentences are therefore disambiguated towards a subject- or an object-initial word order at the final NP. Sentences are ordered on the basis of the surprisal effect at the final NP, represented by the color scale. Sentences represented with a red diamond engender a low surprisal effect at the final NP, and sentences represented with a yellow diamond engender a high surprisal effect at the final NP.
with the previous information. For object-initial sentences, this means that the surprisal of the disambiguating constituent is large when the surprisal of previous constituents is small. The disambiguation towards the object-initial word order at the final NP will engender a large surprisal effect when the prominence properties of the previous constituents speak in favor of a subject-initial interpretation. Since this is the preferred word order overall, the information of the previous constituents is expected and does not engender any surprisal effects to speak of. In Example 6.7a, for instance, the first NP is both animate and definite, and therefore very likely to function as the subject. There is therefore virtually no surprisal effect to speak of engendered by either the first NP or the verb. The second NP, which disambiguates the sentence towards the object-initial word order, is therefore highly unexpected and engenders a huge surprisal effect. In Example 6.7b, on the other hand, the first NP (‘det här’) is text deictic and therefore highly predictive of the object-initial word order. In the context of the incremental models, the first NP is inconsistent with the baseline assumption of a subject-initial word order and is therefore highly unexpected, and engenders a fairly large surprisal effect. The upcoming verb (‘uppfattar’) is an experiencer verb that, in conjunction with a first NP that is allophoric, further speaks in favor of the object-initial interpretation. It therefore also engenders a small surprisal effect. When the final NP (‘vi’) is encountered, the evidence for the object-initial word order is rather compelling, and there is therefore hardly no surprisal effect due to the disambiguation to speak of.

\[(6.7)\] (a) \[\text{De levande}_{D_{KL}=0.02} \text{fångade}_{D_{KL}=0.00} \text{jag}_{D_{KL}=5.64}\] \\
\text{‘The living I caught’}

(b) \[\text{Det här}_{D_{KL}=1.87} \text{uppfattar}_{D_{KL}=0.26} \text{vi}_{D_{KL}=0.15}\] \text{ofta inte alls}

\text{‘This we often do not percieve at all’}

In subject-initial sentences, the opposite pattern of that of object-initial sentences is found. The surprisal of the disambiguating constituent is large when the surprisal of the previous constituents is also large. When the final NP disambiguates the sentence towards the subject-initial word order, there will only be a large surprisal effect when the information of the previous constituents points in the direction of an object-initial interpretation. But this is in itself unexpected, because of the general preference for the subject-initial word order, and the presentation of the previous constituents will therefore engender relatively high surprisal effects. In Example 6.8a, for example, the initial NP consists of a 3rd person neuter pronoun (which lacks case marking). As such, it is inanimate and therefore unfit to fill the Actor role. It is therefore inconsistent with the baseline assumption of a subject-initial word order and engenders a small surprisal effect. Since the subsequent verb is causative, its co-occurrence with the initial inanimate NP provides evidence for the object-initial word order. It therefore speaks against the baseline assumption of a subject-initial word order and engenders a somewhat larger surprisal effect. The second NP ‘henne’ finally disconfirms the prediction of the object-initial word order and therefore also engenders a surprisal effect. All sentence constituents therefore engender small surprisal effects because they are unexpected with respect to the baseline assumption of a subject-
6.3 Model evaluation

initial sentence and their left context⁸. In Example 6.8b, on the other hand, the first NP ‘Quist’ is a proper noun and therefore definite and animate, and therefore consistent with the subject-initial interpretation. The subsequent verb is again causative, but since in this case it co-occurs with an animate first NP, it is in line with the previous information and provides further evidence for the subject-initial interpretation. There is therefore no surprisal effect to speak of, neither at the verb nor at the second NP, which confirms the prediction of the subject-initial word order. In this case, all three constituents speak in favor of the subject-initial interpretation.

(6.8) (a) [Den
KL =0.15] [åt
KL =0.49] [henne
KL =0.37]
   it ate her
   ‘It ate her’

(b) [Quist
KL =0.02] [ryckte
KL =0.00] [mig
KL =0.00] i armen
   Quist yanked me in the arm
   ‘Quist yanked me in the arm’

Surprisal associated with individual predictors ⁹ The evaluation of the extent to which individual prominence features influence the surprisal effect is again limited to sentences that are disambiguated at the final NP. These evaluations are done in three ways. Firstly, the mean surprisal of the set of sentences that have the prominence feature at hand (e.g., ‘NP1 animate’) is compared with the mean surprisal of the set that does not have that prominence feature (e.g., ‘NP1 inanimate’). P-values of the null hypothesis that the mean difference in surprisal between these groups is equal to 0 are calculated on the basis of bootstrapping, based upon the method suggested by Howell (2010:663-670).

Secondly, sentences are ranked with respect to the extent that constituent C available at tᵢ, Cᵢ, speaks in favor of the object-initial interpretation in comparison to the information provided by constituent Cᵢ₋₁ in the following manner. Sentences in which p(object-initial) is lower at Cᵢ than at Cᵢ₋₁ (i.e., p(object-initial | Cᵢ) < p(object-initial | Cᵢ₋₁)) are ranked with respect to a decrease in surprisal. Sentences in which p(object-initial) is higher at Cᵢ than at Cᵢ₋₁ (i.e., p(object-initial | Cᵢ) > p(object-initial | Cᵢ₋₁)), on the other hand, are ranked with respect to an increase in surprisal. The latter sentence group in which p(object-initial | Cᵢ) > p(object-initial | Cᵢ₋₁) is finally ranked more highly than the former sentence group in which p(object-initial | Cᵢ) < p(object-initial | Cᵢ₋₁). These rankings represent the degree to which the information provided by the present constituent bias towards the object-initial interpretation. These rankings are then correlated with the individual prominence features using the Kendall rank correlation (τ). These correlations provide a measure of the extent to which the individual features at Cᵢ bias towards the object-initial interpretation, rather than measuring the correlation between prominence features and surprisal per se. This is important, because the direct correlation between prominence features and surprisal does not necessarily indicate whether those features have a systematic influence on the surprisal effect in terms of biasing towards or against the object-initial interpretation. This is because individual

⁸To be more specific, in the case of the first NP, it is rather the lack of context that is responsible for the surprisal effect. In the discourse context, the 3rd person neuter pronoun ‘den’ is most likely not particularly unexpected.
prominence features of a constituent $C_i$ that bias either towards or against the object-initial interpretation can in some cases enhance the surprisal effect but in others mitigate it, depending on whether all other features of $C_i$ speak either in favor of the object-initial word order, so that $p(\text{object-initial} \mid C_i) > p(\text{object-initial} \mid C_{i-1})$, or against it, so that $p(\text{object-initial} \mid C_i) < p(\text{object-initial} \mid C_{i-1})$. For example, the NP1 mean surprisal effect is virtually identical when that NP is either definite (0.13) or indefinite (0.12). Indefiniteness therefore appears to have no influence on the NP1 surprisal effect. However, using this kind of measure obscures the fact that indefiniteness always biases towards the object-initial interpretation. This bias results in an increase in the surprisal effect when other NP1 features also speak in favor of the object-initial word order (so that $p(\text{object-initial} \mid C_i) > p(\text{object-initial} \mid C_{i-1})$), but a reduction when the other features instead bias towards the subject-initial word order (so that $p(\text{object-initial} \mid C_i) < p(\text{object-initial} \mid C_{i-1})$). NP1 indefiniteness therefore has a reversed influence on the surprisal effect depending on the state of the other NP1 prominence features, even though it has a consistent influence on the bias towards the object-initial interpretation that is potentially significant.

Thirdly, in cases where the information available at constituent $C_i$ always speaks in favor of either the object- or the subject-initial word order, such as, for instance, at the point of disambiguation, evaluations are done by directly correlating the surprisal effect with individual prominence features using the Pearson correlation. In these cases, the direct correlation between prominence features and the surprisal effect per se (rather than rankings) is justified because prominence features here can only influence surprisal in one direction. It is therefore also possible to look at the direct relationship between a feature and the actual magnitude of the surprisal effect. As such, this method provides a better and more accurate estimate of the influence of individual prominence features on the surprisal effect than the Kendall rank correlation test.

In the following, I present the results of each surprisal effect of each subsequent constituent in turn (i.e., NP1, verb, and NP2 surprisal). Since all sentences are locally ambiguous up until the presentation of the final NP, the models make identical predictions for subject- and object-initial sentences at NP1 and the verb. Differences between subject- and object-initial sentences are therefore only discussed when the predicted surprisal effect of the final NP is presented.

**Initial NP** Table 6.5 shows the statistics of the influence of the individual prominence features on NP1 surprisal, presented above. The surprisal effect at NP1 as a function of possible combinations of NP1 prominence features is also illustrated in Figure 6.9 below. The figure shows the predicted surprisal effects of the RN model, the PR model, and the CD model, respectively. The upper parts of the figure panels plot NP1 surprisal in possible sentence types that vary with respect to NP1 prominence features. The lower parts illustrate those sentence types as sets of NP1 prominence features. The Y-axis of the upper part shows the surprisal in bits, and the X-axes correspond to sentence types defined as sets of NP1 prominence features in the lower parts. The Y-axis of the lower part displays the individual NP1 prominence features of the sentences. A gray square indicates that a given sentence has the prominence feature value (e.g., inanimate) and a white square indicates that it does not (e.g., animate). The distribution of NP1 prominence features of
Table 6.5. Statistics of the influence of the individual prominence features on NP1 surprisal as predicted by the RN, PR and CD models. These include Kendall rank coefficients of the correlations between prominence features and sentence rankings, p-values of tests of the correlation coefficients, mean difference surprisal between the sentence sets that either have or do not have the prominence feature at hand as well as bootstrapped p-values of the null hypothesis that the surprisal mean differences equal 0.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>RN model</th>
<th>PR model</th>
<th>CD model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation</td>
<td>Difference</td>
<td>Correlation</td>
</tr>
<tr>
<td></td>
<td>(\tau)</td>
<td>(p)</td>
<td>mean</td>
</tr>
<tr>
<td>Animacy</td>
<td>.71</td>
<td>.001</td>
<td>.18</td>
</tr>
<tr>
<td>Text Deixis</td>
<td>.28</td>
<td>.017</td>
<td>1.42</td>
</tr>
<tr>
<td>Definiteness</td>
<td>.27</td>
<td>.020</td>
<td>-0.01</td>
</tr>
<tr>
<td>Length</td>
<td>.11</td>
<td>.347</td>
<td>0.02</td>
</tr>
<tr>
<td>Pronominality</td>
<td>-.08</td>
<td>.485</td>
<td>-0.11</td>
</tr>
<tr>
<td>Givenness</td>
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<td>.518</td>
<td>-0.13</td>
</tr>
<tr>
<td>Number</td>
<td>.00</td>
<td>1.000</td>
<td>-0.11</td>
</tr>
</tbody>
</table>

a given sentence is therefore illustrated as a column of squares in the lower parts whose surprisal value is plotted on the same X coordinate in the upper parts. For example, the first column in the lower panel corresponds to sentences with a one-word initial NP that is animate, definite, lexical, new, lexical and singular. The surprisal of encountering such an NP is displayed on the corresponding X axis in the upper part. The figure is finally faceted on the basis of model type, so that the first panel shows predicted surprisal of the RN model, the second predicted surprisal of the PR model, and the third predicted surprisal of the CD model.

Sentences are further ordered on the X-axis with respect to the extent that the NP1 prominence features bias towards the object-initial interpretation in comparison to the baseline probability \(p(\text{object-initial})\) provided by the null models: sentences in which \(p(\text{object-initial})\) at NP1 is lower than the baseline probability are ordered with respect to a surprisal decrease and sentences in which \(p(\text{object-initial})\) at NP1 is higher than the baseline probability are ordered with respect to a surprisal increase, the former sentence group being ordered before the latter. The distribution of prominence features across sentence types, and, more specifically, the extent to which each prominence feature biases towards or against the object-initial word order, is therefore illustrated by the distribution of features of each row in the lower panel. Prominence features that cluster on the left-hand side of a row bias towards the subject-initial interpretation, prominence features that cluster on the right-hand side bias towards the object-initial interpretation and features that are evenly distributed across the row have little to no influence. As such, the rows are illustrations of the Kendall rank correlations between the sentence ranking of the object-initial bias and prominence features (see Table 6.5). The rows of prominence features are ordered with respect to the magnitude of the correlation coefficients so that the top row shows the prominence feature that has the strongest influence on the surprisal effect and the bottom row the feature that has the smallest effect. The shaded diamonds that span the surprisal values on their X axes, finally, show simulated surprisal values. One hundred simulated values are shown for each sentence type, and the light gray areas show the 5% and 95% percentiles of these distributions.

The prominence features of importance for the surprisal effect of NP1 are, in turn,
Figure 6.9. (See caption at next page.)
Figure 6.9. NP1 surprisal in ambiguous object-initial sentences as a function of possible combinations of NP1 prominence features as predicted by the RN, PR and CD models. The upper panels plot NP1 surprisal of sentences that vary with respect to NP1 prominence features. The lower panels illustrate those sentences as sets of NP1 prominence features. The Y-axis of the upper panels show the surprisal in bits and the X-axis corresponds to sentences defined as sets of NP1 prominence features in the lower panel. The Y-axis of the lower panel displays the individual prominence features of the sentences. A gray square indicates that a given sentence has the prominence feature value, and a white square indicates that it does not. Sentences are ordered on the X-axis with respect to the degree to which NP1 bias towards the object-initial interpretation: sentences for which $p(\text{object-initial} \mid \text{NP1}) < p(\text{object-initial})$ are ordered with respect to a surprisal decrease and sentences for which $p(\text{object-initial} \mid \text{NP1}) > p(\text{object-initial})$ with respect to a surprisal increase, the latter being ordered before the former. Prominence features are ordered on the y-axis on the basis of the magnitude of the Kendall rank correlation coefficients between prominence features and the sentences ranked with respect to their object-initial bias. Gray diamonds show 100 simulated surprisal values corresponding to each sentence, and the light gray areas show 95% confidence intervals, which are the 5% and 95% percentiles of these distributions.

Animacy (all $\tau$s = .71, all $p$s < .001), text deixis (all $\tau$s = .28, all $p$s < .05) and definiteness (all $\tau$s = .27, all $p$s < .05). Animacy is of great importance, as animacy on its own demarcates sentences with respect to whether NP1 biases towards a subject- or an object-initial interpretation, independent of all other NP1 prominence features. Text deixis is also of great importance as the two text deictic NPs of the sentence sample give rise to large surprisal effects in comparison to all other NPs. Definiteness also has a small but significant influence. For sentences with an initial animate NP, which bias towards the subject-initial interpretation, the surprisal effect approaches zero if that NP is also indefinite. In sentences with an initial inanimate NP that biases towards the object-initial word order, on the other hand, the surprisal effect is at the higher end of the spectrum if the initial NP is also indefinite. Thus definiteness mitigates the surprisal effect when NP1 animacy speaks in favor of the subject-initial word order, but enhances it when NP1 animacy instead biases towards the object-initial word order.

As evident from Table 6.5, all three models make very similar predictions. The PR model differs from the RN and the CD models, however, in that it predicts a significant influence of pronominality on the surprisal effect ($\tau = -.24, p < .05$). The CD model predicts that pronominal NPs significantly bias towards the object-initial interpretation in comparison to lexical NPs. This is probably because topicalized objects often are anaphoric and text deictic (even to a greater extent than subjects), and are therefore pronominal. In sentences with an initial animate NP, the surprisal effect is mitigated if that NP is also pronominal. When the initial NP is instead inanimate, the surprisal effect is somewhat enhanced when the NP is pronominal (see Figure 6.9). Thus, as with indefiniteness, pronominality mitigates the surprisal effect when NP1 animacy speaks in favor of the subject-initial word order, but enhance it when NP1 animacy instead biases towards the object-initial word order.

**Verb** Table 6.6 shows statistics on the influence of NP1 prominence features, verb semantic features and their interactions on verb surprisal. Sentences are in this case ranked with respect to the extent that these information types bias towards the object-initial interpretation in comparison to the object-initial bias at NP1, as determined by $p(\text{object-initial})$ |
Table 6.6. Statistics on the influence of NP1 prominence features, verb classes, and their interactions on verb surprisal as predicted by the RN, PR and CD models. See the text and Table 6.5 for a description.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>RN model</th>
<th>PR model</th>
<th>CD model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation</td>
<td>Difference</td>
<td>Correlation</td>
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<tr>
<td></td>
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<td>$p$</td>
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<td>.001</td>
<td>.43</td>
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<tr>
<td>Volitional</td>
<td>.39</td>
<td>.001</td>
<td>.27</td>
</tr>
<tr>
<td>* Animacy</td>
<td>.48</td>
<td>.001</td>
<td>.58</td>
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<tr>
<td>Causative</td>
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<td>-.09</td>
</tr>
<tr>
<td>* Animacy</td>
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<td>.001</td>
<td>.07</td>
</tr>
<tr>
<td>Possessive</td>
<td>-.34</td>
<td>.001</td>
<td>-.19</td>
</tr>
<tr>
<td>* Definiteness</td>
<td>-.07</td>
<td>.095</td>
<td>-.20</td>
</tr>
<tr>
<td>Animacy</td>
<td>.23</td>
<td>.001</td>
<td>.33</td>
</tr>
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<td>-.02</td>
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</tr>
<tr>
<td>Givenness</td>
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<td>.820</td>
<td>-.03</td>
</tr>
</tbody>
</table>

$N P 1, verb \rightarrow p(\text{object-initial} \mid N P 1)$. Figure 6.10 below illustrates the influence of these features on the verb surprisal effect. Only the NP1 prominence features that interact with verb semantic features (i.e., animacy and definiteness) are included in the figure\(^9\). The figure is structured in the same way as Figure 6.9. It plots verb surprisal as predicted by the models in possible sentence types that vary with respect to verb semantic features and their interactions with NP1 prominence features.

The verb classes and their interactions with NP1 prominence features of importance for the surprisal effect at the verb are, in turn, experiencer ($.55 > \tau > .46$, all $p:s < .001$), the animacy × volitionality interaction ($-.39 > \tau > .31$, all $p:s < .001$), possession ($-.34 < \tau < -.29$, all $p:s < .001$), animacy ($-.30 > \tau > .28$, all $p:s < .001$), and, finally, the animacy × causation interaction ($-.28 > \tau > .24$, all $p:s < .001$). The only difference of importance between the three models is that it is, again, only the PR model that shows a significant effect of pronominality ($\tau = 0.12, p < .05$).

What mainly drives the surprisal effect at the verb are verb classes and their interactions with the animacy of the initial NP. The surprisal effect is higher in sentences with experiencer and volitional verbs. The occurrence of these verbs speaks in favor of the object-initial interpretation when the initial NP is lexical. Possessive verbs, on the other hand, to some extent bias against the object-initial interpretation. The interactions between animacy, on the one hand, and volitionality and causation, on the other, are highly important. A volitional or a causation verb that follows an inanimate initial NP provides compelling evidence for the object-initial interpretation, because such verbs so frequently occur with animate subjects. This renders the subject-initial interpretation very unlikely, and therefore gives rise to the observed surprisal effect. As illustrated in Figure 6.10, the surprisal effect at the verb is at its highest for experiencer verb sentences, or sentences

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\(^9\)This is because no other NP1 prominence features are correlated with the sentence rankings. See Table 6.6.
with an inanimate initial NP and a volitional or causation verb. All other predictors have a very limited impact.

Table 6.7. Statistics on the influence of the individual NP1 prominence features for each verb class on NP2 surprisal as predicted by the RN, PR and CD models. See the text and Table 6.5 for a description.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>RN model</th>
<th>PR model</th>
<th>CD model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation</td>
<td>Difference</td>
<td>Correlation</td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>p</td>
<td>mean</td>
</tr>
<tr>
<td>Volitional</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Animacy</td>
<td>-.98</td>
<td>.001</td>
<td>-4.42</td>
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<td>Causative</td>
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<td></td>
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<td>-</td>
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<td>.622</td>
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<tr>
<td>-</td>
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</tr>
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<td>.220</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Final NP in object-initial sentences  Table 6.7 above shows statistics on the influence of individual NP1 prominence features for each verb class on NP2 surprisal, as predicted by the RN, the PR and the CD models. Since NP2 in these sentences disambiguates towards the object-initial interpretation and therefore never speaks against the object-initial interpretation, the direct correlation between the surprisal effect and individual
Figure 6.10. Model predictions of verb surprisal in ambiguous object-initial sentences as a function of verb semantic features and their interactions with NP1 prominence features, plotted in the same manner as NP1 surprisal in Figure 6.9.
prominence features can meaningfully be interpreted as an indicator of the influence of prominence features on the surprisal effect. Table 6.7 therefore includes coefficients and p-values of the Pearson correlations between prominence features and NP2 surprisal (rather than rank correlations).

The surprisal effect of the final NP with respect to NP1 prominence features, faceted on the basis of each verb, is also illustrated in Figure 6.11. The figure includes sentences that are differentiated with respect to all features available at the verb: initial NP features, verb semantic features, and their interactions. The features of the final NP are held constant across sentences such that all final NPs are case marked, egophoric, singular and short. As such, the final NP is high in prominence and disambiguates the sentences toward the object-initial word order. The figure is similar to Figure 6.9 and 6.10 in that it plots surprisal, in this case at NP2, in sentence types that vary with respect to NP1 prominence features and verb semantic features, the upper parts showing surprisal and the lower parts illustrating sentence features. The figure differs from previous figures in that it is faceted on the basis of verb types, rather than model types. The panels differentiate between verb classes rather than models. Model differences are instead illustrated by using separate lines for each model in each panel (the RN model: red squares; the PR model: green diamonds; the CD model: blue triangles). In order to make model comparisons possible, sentences are ordered on the X-axis with respect to the rankings of NP1 beta coefficients of the full regmodel used in the PR model, taking into account their interactions with verb semantic features. For example, volitional verb sentences are primarily ordered with respect to animacy, secondarily with respect to text deixis, tertiary to definiteness and so forth. Possessive verb sentences, on the other hand, are primarily ordered with respect to animacy, secondarily with respect to definiteness, tertiary to text deixis and so forth. The distribution of prominence features of each row in the lower panels should therefore not be seen as an illustration of the extent to which each prominence feature bias towards or against the object-initial word order in a particular model. Rather, they correspond to the relative strengths of prominence features as determined by the full regmodel underlying the PR model. Consequently, sentences with high prominence NP1 arguments are found on the left-hand side of the plots and sentences with low prominence NP1 arguments on the right-hand side of the plots. The ordering of prominence features on the y-axis is also done on the basis of the rankings of the NP1 beta coefficients of the full regmodel of the PR model. The strongest prominence features are found at the top of the lower panels and the weakest at the bottom. The shaded areas, finally, show 95% confidence intervals, as estimated on the basis of the 5% and 95% percentiles of 1,000 simulated surprisal values.

The initial NP prominence features that mainly influence the NP2 surprisal are animacy (-.99 > r > -.81, all ps < .001 for all verb classes) and text deixis (-.53 > r > -.29, all ps < .05 for all verb classes). The surprisal effect is a lot lower when the initial NP is inanimate in comparison to when it is animate, and it is further mitigated when the initial NP is also text deictic. The influence of animacy is weaker in sentences with possessive verbs in comparison to other sentences, and the influence of text deixis is somewhat stronger in sentences with uncategorized verbs. Animacy and text deixis are by far the best NP1 prominence features for predicting the object-initial word order, in line with the results presented in Chapter 5. Inanimate and/or text deictic initial NPs therefore greatly mitigate the surprisal effect when the sentence is disambiguated toward the object-initial
Figure 6.11. (See caption at next page.)
6.3 Model evaluation

Figure 6.11. NP2 surprisal in ambiguous object-initial sentences as a function of verb semantic features and their interactions with NP1 prominence features, as predicted by the RN model (red squares), the PR model (green diamonds) and the CD model (blue triangles). The upper panel plots NP2 surprisal in possible sentence types that vary with respect to NP1 prominence features. The lower panel illustrates those sentences as sets of NP1 prominence features. The Y-axis of the upper panel shows surprisal in bits, and the X-axis corresponds to the sentence types defined as sets of NP1 prominence features in the lower panel. The Y-axis of the lower panel displays the individual prominence features of the sentences. A gray square indicates that a given sentence has the prominence feature value and a white square indicates that it does not. Sentences are ordered on the X-axis with respect to the rankings of the NP1 beta coefficients, adjusted for verb interactions, of the full regmodel underlying the RN model in such a manner that they are primarily ordered with respect to animacy, secondarily with respect to text deixis and definiteness and so forth. Sentences with high prominence NP1 arguments are consequently found on the left-hand side of the plots and sentences with low prominence NP1 arguments on the right-hand side. Prominence features are ordered on the y-axis on the basis of the rankings of the NP1 beta coefficients of the full mixed effects model presented in Chapter 5. The shaded areas show 95% confidence intervals, estimated on the basis of the 5% and 95% percentiles of 1,000 simulated surprisal values.

Word order at NP2. Verb class also has a strong influence on NP2 surprisal. As illustrated in Figure 6.11, the surprisal effect is considerably lower in sentences with experiencer verbs in comparison to sentences with other verb classes. The occurrence of an experiencer verb provides evidence for the object-initial interpretation, at least when following a non-person NP.

Furthermore, there are rather strong interactions between animacy and some of the verb semantic features. As Figure 6.11 illustrates, the influence of animacy on the surprisal effect is more pronounced for sentences with volitional or causative verbs. Again, this is because such verbs occur most frequently with animate subjects. Such verbs therefore provide evidence for the object-initial interpretation when they follow an inanimate NP. There is also an interaction between definiteness and verb class. Definiteness only has an impact on surprisal in sentences with possessive verbs (-.49 > r > -.31, all ps < .001). In such sentences, the surprisal effect is mitigated when NP1 is indefinite in comparison to when it is definite.

Final NP in subject-initial sentences NP2 surprisal in ambiguous subject-initial sentences with respect to NP1 prominence features, faceted on the basis of each verb, is shown in Figure 6.12. The figure includes sentences that are differentiated with respect to all features available at the verb: NP1 features, verb semantic features, and their interactions. The final NP of all sentences is a one-word object that is case marked, allophoric and plural. It is therefore low in prominence and disambiguates the sentences towards the object-initial word order.

The figure is identical to Figure 6.11. The upper part plots NP2 surprisal, and the lower parts illustrate the corresponding sentences as sets of prominence features (in this case, NP2 features).

Figure 6.12 shows that all three models predict fairly similar NP2 surprisal effects in ambiguous subject-initial sentences. In all sentences, there are small but significant
Figure 6.12. Model predictions of NP2 surprisal in ambiguous subject-initial sentences as a function of verb semantic features and their interactions with NP1 prominence features, as predicted by the RN model (red squares), the PR model (green diamonds), and the CD model (blue triangles), and plotted in the same manner as in Figure 6.11.
surprisal effects when NP1 is inanimate. This is evident from the Pearson correlations between NP2 surprisal and NP1 animacy (.84 > r > .47, all p:s < .001 for all verb classes and models), on the one hand, and the mean surprisal differences between animate versus inanimate NP1 sentences (0.94 > MD > 0.03, all p:s < .001 for all verb classes and models), on the other. This surprisal effect is particularly strong when NP1 is also text deictic (.93 > r > .61, all p:s < .001; 2.4 > MD > 0.1, all p:s < .001 for all verb classes and models).

In possessive verb sentences, all models also predict a strong influence of NP1 definiteness (.36 > r > .34, all p:s < .05 for all models). The surprisal effect is significantly stronger when the initial NP is indefinite in comparison to when it is indefinite (0.1 > MD > 0.02, all p:s < .001 for all models). Surprisal is finally stronger in sentences with volitional (.33 > r > .21, all p:s < .001; 0.5 > MD > 0.15, all p:s < .001 for all models) and experiencer verbs (.56 > r > .38, all p:s < .001; 0.64 > MD > 0.45, all p:s < .001 for all models) but somewhat weaker in sentences with possessive verbs (−.26 > r > −.19, all p:s < .001; −0.42 > MD > −0.27, all p:s < .001 for all models).

6.3.3. Surprisal at the point of disambiguation

As discussed in Section 6.2.4, the probabilistic information of a disambiguating constituent might influence the surprisal effect over and above the effect of encountering the disambiguating information per se, either by mitigating or enhancing it. Since the RN, PR and CD models differ with respect to such assumptions, this section focuses on differences in the model predictions. This is done by evaluating the influence of the NP2 prominence features in locally ambiguous sentences without initial adverbials that are disambiguated at NP2 (such as those in Example 6.6). Since disambiguating NPs consist only of personal pronouns, the number of prominence features is limited by those that differentiate personal pronouns and therefore consist of egophoricity (e.g., ’jag’/’du’ vs. ’han’/’hon’), number (e.g., ’jag’ vs. ’vi’), and definiteness / givenness (e.g., ’jag’ vs. ’man’). I first look at object-initial sentences and then at subject-initial sentences.

Object-initial sentences

Table 6.8 shows statistics on the influence of individual NP2 prominence features for each verb class on NP2 surprisal, as predicted by the three models. Figure 6.13 plots NP2 surprisal with respect to NP2 prominence features, faceted on the basis of each verb class. Table 6.8 and Figure 6.13 include sentences with a highly prominent but lexical and therefore ambiguous NP1 whose prominence features are held constant (i.e., NP1 is animate, definite and given, singular and short). Sentences are instead differentiated with respect to verb semantic features and the prominence features of a short and case marked (and therefore disambiguating) final NP. The final NP therefore varies in prominence with respect to egophoricity, definiteness, givenness and number.

As evident from both Table 6.8 and Figure 6.13, the RN and PR models, on the one hand, and the CD model, on the other, make opposite predictions. Whereas the former models predict a rather substantial decrease in NP2 surprisal with a reduction in NP2 prominence, the CD model instead predicts a small increase. The RN and PR models predict high surprisal effects when NP2 consists of a highly prominent personal pronoun
Table 6.8. Statistics on the influence of the individual NP2 prominence features for each verb class on NP2 surprisal as predicted by the RN, PR and CD models. See the text and Table 6.5 for a description.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>RN model</th>
<th>PR model</th>
<th>CD model</th>
</tr>
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<td>Difference</td>
<td>Correlation</td>
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<tr>
<td></td>
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<td>$p$</td>
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<td>- .32</td>
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<td>- .15</td>
<td>.631</td>
<td>- 0.65</td>
</tr>
<tr>
<td>Egophoricity</td>
<td>- .76</td>
<td>.005</td>
<td>- 1.68</td>
</tr>
<tr>
<td>Definiteness</td>
<td>- .59</td>
<td>.045</td>
<td>- 1.38</td>
</tr>
<tr>
<td>Givenness</td>
<td>- .33</td>
<td>.292</td>
<td>- 0.78</td>
</tr>
<tr>
<td>Number</td>
<td>- .15</td>
<td>.636</td>
<td>- 0.34</td>
</tr>
<tr>
<td>Egophoricity</td>
<td>- .33</td>
<td>.289</td>
<td>- 1.95</td>
</tr>
<tr>
<td>Definiteness</td>
<td>- .61</td>
<td>.037</td>
<td>- 3.76</td>
</tr>
<tr>
<td>Givenness</td>
<td>- .91</td>
<td>.001</td>
<td>- 5.64</td>
</tr>
<tr>
<td>Number</td>
<td>- .08</td>
<td>.817</td>
<td>- 0.44</td>
</tr>
<tr>
<td>Egophoricity</td>
<td>- .82</td>
<td>.001</td>
<td>- 3.48</td>
</tr>
<tr>
<td>Definiteness</td>
<td>- .52</td>
<td>.083</td>
<td>- 2.33</td>
</tr>
<tr>
<td>Givenness</td>
<td>- .31</td>
<td>.329</td>
<td>- 1.38</td>
</tr>
<tr>
<td>Number</td>
<td>- 1.5</td>
<td>.637</td>
<td>- 0.64</td>
</tr>
</tbody>
</table>

(e.g., ‘jag’ (me) and ‘du’ (you), which are egophoric, definite/given and singular), but low NP2 surprisals for personal pronouns that are low in prominence (e.g., ‘en’ (one), which is allophoric, indefinite and new). The CD model instead predicts somewhat higher NP2 surprisal for a low-prominence pronoun (e.g., ‘en’) in comparison to high-prominence pronouns (e.g., ‘jag’ and ‘du’).

These fundamentally different predictions reflect the two different conceptions of disambiguating information embodied in the RN and the PR models, on the one hand, and the CD model, on the other. In the RN and the PR models, disambiguating information is treated in the same way as all other prominence and verb semantic cues. It is therefore conceived of as probabilistic cues on par with all other probabilistic information in the model. On this view, disambiguating information is processed and integrated in the same manner as other probabilistic cues such as animacy or definiteness during GF assignment. The probability for a given word order when a disambiguating constituent $C_i$ has been processed is determined by the sum of the weights attached to both the probabilistic and the disambiguating cues available at $C_i$. In the present sentences, $p$(object-initial) is therefore simply reduced when NP2 is low in prominence in comparison to when it is high.
Figure 6.13. NP2 surprisal in ambiguous object-initial sentences as a function of NP2 prominence features in ambiguous object-initial sentences, as predicted by the RN model (red squares), the PR model (green diamonds) and the CD model (blue triangles), and plotted in the same manner as in Figure 6.11.
This results in a reduction in surprisal, because the resulting probability is closer to that determined by the information available at the verb. This might result in lower processing costs when NP2 is low in prominence in comparison to when it is highly prominent. But it also entails greater uncertainty regarding the argument functions at NP2, which has been shown to also incur processing, over and above surprisal (Linzen & Jaeger 2014, 2015). It is therefore unclear whether NP2 would be less costly to process when low in prominence in these instances.

In the CD model, on the other hand, disambiguating information is treated differentially from other prominence and verb semantic cues. It is conceived of as categorical information that takes precedence over all other probabilistic cues. On this view, the processing of the disambiguating information of constituent C_i is implicitly assumed to be categorical and temporarily precede the processing of the probabilistic cues of C_i. The disambiguating information resets the stage, so to speak, by disambiguating the sentence towards either the object- or the subject-initial word order in terms of adopting a new baseline probability close to either 1 or 0. Surprisal is then determined by the extent to which the probabilistic cues of C_i speak against the disambiguating information with respect to the probabilistic cues available at C_{i-1}, as determined by the difference in p(object-initial) between C_i and C_{i-1}. In the present sentences, there is therefore a small increase in NP2 surprisal as NP2 prominence is reduced, thereby speaking against the disambiguating information at C_i. The CD model therefore predicts somewhat higher processing costs when NP2 is low in prominence in comparison to when it is high. Whether the account offered by the RN and PR models, on the one hand, or the account provided by the CD model, on the other, is correct is therefore an empirical question. Given that uncertainty regarding the argument functions at NP2 can be expected to incur processing beyond the processing costs incurred by surprisal (cf. Linzen & Jaeger 2014, 2015), however, it might be hard to tease these accounts apart. They both are consistent with overall higher processing costs for a low (versus high) prominence NP2.

The models also differ with respect to the relative importance of NP2 prominence features. In the RN and CD models, it is mainly egophoricity that affects NP2 surprisal. In all sentence types apart from sentences with possessive verbs, the RN model predicts a significantly smaller NP2 surprisal effect when NP2 is allophoric in comparison to when it is egophoric (-1.68 < MD < -3.48, all p:s < .05). The CD model predicts significantly larger NP2 surprisal when NP2 is allophoric versus egophoric (0.12 < MD < 0.42, all p:s < .05). In the PR model, egophoricity only has a significant influence in sentences with experiencer verbs, due to the interaction between experiencer and NP2 egophoricity. NP2 surprisal in sentences with experiencer verbs is significantly smaller in the PR model when NP2 is allophoric versus egophoric (MD = 1.12, p < .05). The RN and CD models also predict a significant but numerically smaller influence of NP2 definiteness. In the RN model, NP2 surprisal is smaller when the NP2 pronoun is indefinite in comparison to when it is definite (-1.38 < MD < -3.76, all p:s < .01). In the CD model, NP2 surprisal is larger when NP2 is indefinite versus definite (0.04 < MD < 1.0, all p:s < .01). The RN model also predicts a givenness effect. NP2 surprisal is significantly smaller when NP2 is new in comparison to when it is given (-0.78 < MD < -5.64, all p:s < .01). The PR model,
6.3 Model evaluation

on the other hand, only predicts a significant influence of definiteness and givenness on NP2 surprisal. In the PR model, NP2 surprisal is smaller when the NP2 pronoun is either indefinite in comparison to definite (-0.97 < MD < -3.46, all p:s < .01), or new rather than given (-0.55 < MD < -5.07, all p:s < .01). All three models also predict a strong interaction between verb class and definiteness / givenness. In sentences with possessive verbs, the influence of definiteness and givenness is significant and the numerically strongest in all models. The RN and the PR models predict significantly smaller NP2 surprisal when the NP2 pronoun is indefinite rather than definite (both p:s < .001), as well as when it is new in comparison to given (both p:s < .001). The CD model predicts higher NP2 surprisal when NP2 is indefinite versus definite (MD = 1, p < .001) and when it is new versus given (MD = 1.53, p < .001).

Overall, all three model predictions confirm the findings in Chapter 5. Both NP2 egophoricity and definiteness function as significant predictors of the sentence word order, and in sentences with possessive verbs, givenness functions as a very strong predictor.

Subject-initial sentences  Figure 6.14 plots NP2 surprisal as a function of NP2 prominence features in ambiguous subject-initial sentences that are disambiguated at NP2. The figure is identical to Figure 6.11, 6.12 and 6.13 and again differentiates between sentences that differ with respect to the prominence features of the case marked final NP. In order to maximize the engendered surprisal effects, the initial NP is assumed to be high in prominence in all sentences (i.e., it is animate, definite, given, singular and short).

Figure 6.14 illustrates that the RN and PR models, on the one hand, and the CD model, on the other, again make different predictions. Whereas the former models predict low NP2 surprisal when NP2 is high in prominence, the CD model does not predict any significant differences as a function of NP2 features. This can again be seen as reflecting the different conceptualizations of disambiguating information, outlined above. Whereas the RN and the PR models treat disambiguating information in the same way as all other probabilistic cues, which therefore are weighted in the same way, the CD model treats it as categorical information that takes precedence over probabilistic cues. The influence of the probabilistic cues on p(object-initial) of a disambiguating constituent is therefore much stronger in the RN and PR models than in the PR model.

The RN and the PR models again differ with respect to the relative importance of NP2 prominence features. Whereas the RN model only predicts a significant influence of NP2 egophoricity on surprisal (all r:s > .82, all p:s < .001), the PR model predicts an effect of NP2 definiteness (.85 > r > .68, all p:s < .05) and NP2 egophoricity (.85 > r > .68, all p:s < .05) in sentences without experiencer verbs. The PR model also predicts a very strong influence of NP2 givenness in possessive verb sentences (r = .95, p < .001). All three models finally predict a significant influence of verb class. Surprisal is significantly higher in all sentences with a categorized verb in comparison to sentences with an uncategorized verb. This is because all verb classes bias towards the object-initial interpretation when co-occurring with an initial NP that is low in prominence, thereby speaking against the disambiguating information of NP2.
Figure 6.14. NP surprisal in ambiguous subject-initial sentences as a function of NP prominence features in ambiguous subject-initial sentences, as predicted by the RN model (red squares), the PR model (green diamonds), and the CD model (blue triangles), and plotted in the same manner as in Figure 6.11.
6.3.4. Surprisal in unambiguous sentences

In this section, I evaluate the influence of prominence and verb class features in sentences without initial adverbials and in which the initial NP is a case marked pronoun (e.g., ‘Jag träffade henne på stranden igår’ - ‘I met her on the beach yesterday’ or ‘Henne träffade jag på stranden igår’ - ‘Her I met on the beach yesterday’). As such, these sentences are disambiguated directly at the initial NP. This section therefore investigates model predictions at and beyond the point of disambiguation. Since the models differ with respect to their treatment of disambiguating information, this section is also concerned with model differences. I again start by evaluating the change in surprisal across constituents, and then investigate the influence of individual predictors on the surprisal effect of each constituent in turn.

Surprisal over time

The change in surprisal across sentence constituents in unambiguous sentences is illustrated in Figure 6.15 below. The figure differs from Figure 6.8 in that the color scale does not represent the ordering of sentences with respect to the NP2 surprisal, but instead shows \( p(\text{object-initial}) \) associated with the information available at the specific constituent. The figure illustrates that all three models make similar predictions for subject-initial sentences. The models predict low probabilities for the object-initial word order for all sentences at the initial NP and at the subsequent constituents. All models therefore predict little to no surprisal effects in subject-initial sentences. This pattern is expected. Since the disambiguating information of NP1 confirms the baseline assumption of the subject-initial word order, no surprisal effect is expected. At the subsequent constituents, surprisal effects can be expected to the extent that the current information speaks against the subject-initial interpretation. Given that the disambiguating information of NP1 together with the baseline assumption of the subject-initial word order provide rather compelling evidence for the subject-initial interpretation, however, these effects are expected to be very low.

Predictions for object-initial sentences, on the other hand, differ substantially between the three models. The figure illustrates that the RN model severely underestimates \( p(\text{object-initial}) \) at NP1, resulting in low NP1 surprisal effects. At the verb, the RN model predicts high surprisal effects when the verb class at hand biases towards the object-initial word order (i.e., is an experiencer verb) rather than against it. At NP2, sentences with both low and high probabilities for the object-initial word order seem to engender surprisal effects. In other words, the RN model predicts that both low-prominent and high-prominent final NPs engender surprisal effects in unambiguous object-initial sentences. The RN model therefore makes the wrong predictions in these sentences. Since the disambiguating information of NP1 speaks against the baseline assumption of the subject-initial word order, a large NP1 surprisal effect is expected. Surprisal of the subsequent constituents should then depend on the extent to which the current information speaks against the object-initial interpretation so that a surprisal effect is engendered only when NP2 is low in prominence. The PR model provides a better estimate of \( p(\text{object-initial}) \) at NP1, resulting in fairly high surprisal effects. At subsequent constituents, the largest surprisal effects are generally found for constituents that bias against the object-initial
word order, in line with the expectations. This is exemplified in Example 6.9 below, consisting of the same sentences as in Example 6.5, repeated here for convenience. In both Example 6.9a and 6.9b, NP1 consists of a case marked 2nd person object pronoun that disambiguates the sentences toward the object-initial word order. It therefore engenders an equally high surprisal effect. The surprisal at the verb is also the same. At NP2, however, surprisal is a little bit lower in 6.9a than in 6.9b. This is because NP2 consists of a 1st person pronoun in 6.9a but an indefinite NP in 6.9b. It is therefore higher in prominence in 6.9a than in 6.9b, and hence more consistent with the expectation of a highly prominent subject.
6.3 Model evaluation

The CD model, finally, provides high estimates of $p$(object-initial) for all sentences and at all constituents, resulting in high surprisal effects at NP1 and low effects at the subsequent constituents in all cases. As such, it is likely that the CD model overestimates the influence of disambiguating information in object-initial sentences, and therefore underestimates the effect of expectancy violations in unambiguous sentences. From this perspective, the PR model outperforms both the RN and the CD model in that it appears to make the best predictions in unambiguous sentences.

**Surprisal associated with individual predictors**  The evaluation of prominence feature influences on surprisal in unambiguous sentences is done on sentences without initial adverbials that are disambiguated directly at NP1, in the same ways as in the previous sections. Again, I present the results of each subsequent constituent in turn (i.e., NP1, the verb and NP2). Because all three models predict little to no surprisal effects in unambiguous subject-initial sentences, I only present results for object-initial sentences.

**Initial NP**  Figure 6.16 below illustrates surprisal at the case marked NP1 in object-initial sentences as predicted by the RN, PR and CD models, in the same manner as in Figure 6.9 and 6.10. The figure shows that neither of the three models predict any significant differences in surprisal as a function of NP1 prominence differences: all of the predicted surprisal values lie within the confidence intervals of all other surprisal values. The differences between the three models is striking, however. The RN model predicts very small surprisal effects that in almost all cases do not depart from 0, the PR model predicts surprisal effects between 1.65 - 2.66 that significantly depart from 0 in all cases, and the CD model, finally, predicts the strongest surprisal effects above 4.

This again illustrates that the RN model severely underestimates $p$(object-initial) at NP1. A case marked pronoun that disambiguates the sentence toward the object-initial interpretation directly at the initial position should greatly increase $p$(object-initial) with respect to the baseline probability, and therefore engender a large surprisal effect. The RN model therefore makes the wrong predictions in these sentences. This is due to the inability of the regmodels of the RN model to accurately estimate the influence of predictors that disambiguate towards the object-initial word order. This is especially true for the NP1 regmodel. In this regard, the (penalized) regmodels that underlie the PR model do a far better job, but they still do not attain the probability levels assumed by the CD model, in which the empirical probabilities of the corpus data are used directly (see Section 6.2.4).
Verb  Figure 6.17 below illustrates verb surprisal in unambiguous object-initial sentences as predicted by the RN, PR and CD models, in the same manner as in Figure 6.16. The figure differentiates between sentences with different verb classes, and, in order to account for the Possession × Definiteness interaction, between sentences with definite or an indefinite NP1. All other prominence features of NP1 are set to the high end of the scales. NP1 is consequently assumed to be case marked, egophoric, singular and short.

The figure shows that the PR and the CD models do not predict verb surprisal that significantly differs from 0 in any of the sentences. The RN model, on the other hand, predicts surprisal effects between 1.15 to 1.69 in sentences with experiencer verbs. An experiencer verb provides additional evidence for the object-initial word order and therefore biases towards the object-initial interpretation. Since the RN model underestimates the influence of the disambiguating information of NP1 on $p(\text{object-initial})$, this additional evidence is unexpected and has a significant effect on surprisal. In the PR and the CD models, the evidence for the object-initial word order provided by NP1 is much stronger. The object-initial word order is therefore highly expected directly at NP1, and the additional evidence for the object-initial word order provided by an upcoming experiencer verb is less surprising.

Final NP  Figure 6.18 illustrates surprisal at NP2 in unambiguous object-initial sentences as predicted by the RN, PR and CD models, in the same manner as in Figure 6.11, 6.12 and 6.13. The figure differentiates between sentences that differ with respect to the prominence features of a lexical final NP. All prominence features of the case marked NP1 are set to the high end of the scales. NP1 is consequently assumed to be case marked, egophoric, definite, singular and short.

Figure 6.18 shows that the models make quite different predictions. NP2 surprisal predicted by the CD model does not differ significantly from 0 in any of the sentences. The RN and the PR models, on the other hand, do predict significant surprisal effects in many sentences, but the wide confidence intervals show that these predictions are rather uncertain. In experiencer verb sentences, the PR model tends to predict stronger surprisal effects than the RN model. In all other sentence types, however, the RN model tends to make the wrong predictions. In some cases, it predicts high surprisal effects when the final NP is high in prominence and is therefore consistent with the disambiguating information of NP1. This is again a result of the RN model’s inability to accurately estimate the influence of the disambiguating information of NP1. In experiencer verb sentences, the verb provides additional support for the object-initial interpretation, resulting in a rather high $p(\text{object-initial})$. In the other sentences, $p(\text{object-initial})$ is fairly low at the verb. A final NP that is highly prominent therefore engenders a surprisal effect because it provides additional support for the object-initial word order. This is almost never the case in the PR model, which more accurately estimates the influence of the disambiguating information of NP1, and therefore almost always provides a sufficiently high estimate of $p(\text{object-initial})$ at the verb. Therefore, in most cases, it predicts high surprisal effects when NP2 is low in prominence, and therefore speaks against the disambiguating information of NP1, as expected.

Looking at the relative influence of individual predictors on NP2 surprisal in unambiguous object-initial sentences, all three models provide very similar results. Since
Figure 6.16. Model predictions of NP1 surprisal in unambiguous object-initial sentences as a function of possible combinations of NP1 prominence features, plotted in the same manner as NP1 surprisal in Figure 6.9.
Figure 6.17. Model predictions of verb surprisal in unambiguous object-initial sentences as a function of possible combinations of NP1 prominence features, plotted in the same manner as NPI surprisal in Figure 6.9.
Figure 6.18. NP2 surprisal in unambiguous subject-initial sentences as a function of NP2 prominence features and their interactions with verb classes, as predicted by the RN model (red squares), the PR model (green diamonds) and the CD model (blue triangles), and plotted in the same manner as in Figure 6.11.
individual predictors in some cases either mitigate or enhance the surprisal effect (such as, e.g., NP2 pronominality), depending on the influence of all other predictors, the influence of individual predictors is therefore again evaluated using the Kendall rank correlations between sentence rankings and predictors. All three models again predict NP2 animacy to have the strongest influence on NP2 surprisal, in all sentence types apart from those with possessive verbs (all $\tau$:s = .71, all $p$:s < .001), followed by NP2 definiteness (all $\tau$:s = .31, all $p$:s < .001). In sentences with possessive verbs, all three models instead predict NP2 givenness to have the strongest influence (all $\tau$:s = .69, all $p$:s < .001), followed by NP2 definiteness (all $\tau$:s = .51, all $p$:s < .001) and NP2 animacy (all $\tau$:s = .35, all $p$:s < .01). When any of these NP2 features are low in prominence, the evidence for the object-initial word order is significantly increased. All three models also predict significant influences of verb class. Both possessive (all $\tau$:s = -.25, all $p$:s < .001) and causative (all $\tau$:s = -.19, all $p$:s < .01) verbs significantly bias against the object-initial word order. No other predictors were found to have a significant influence as evaluated on the basis of Kendall rank correlations.

6.4. Summary

In this chapter, I have presented three models of the process of assigning grammatical functions to the NP arguments that make predictions regarding processing difficulty during incremental language comprehension. These models are based upon the assumption that both morphosyntactic and prominence-based information function as probabilistic cues to GF assignment, and that the strength of a particular GF assignment is dynamically updated as additional cues are provided by the presentation of subsequent constituents. The models predict overall change in the processing difficulty during incremental GF assignment, as well as make predictions on the influence of individual cues on this processing difficulty. This is done in terms of estimating the on-line change in the expectation of an object-initial word order over sentence constituents, that is, the surprisal of encountering a constituent, quantified as the relative entropy between $p_{C_i}$ with respect to the probability at constituent $C_{i-1}$.

6.4.1. Model differences

The three models primarily differ with respect to their treatment of disambiguating information. In the RN and the PR models, disambiguating information is assumed to be processed and integrated in exactly the same manner as other probabilistic cues such as animacy or definiteness during GF assignment. This is done by incorporating disambiguating information in the underlying regmodels that serve to estimate $p$(object-initial) given the information available at the different sentence constituents. As such, the treatment of disambiguating information in these models is on par with the treatment of prominence and verb semantic cues. These two models in turn differ in the way that the regression modeling is implemented. The RN model uses mixed effects logistic regression models in which the disambiguating categories (e.g., ‘NP1 nominative’ vs. ‘NP1 accusative’) in the
data are randomly confused with each other with a probability of 1%. This introduces some noise in the data that overcomes problems with collinearity and overfitting. The PR model, on the other hand, uses penalized logistic regression, which deals with collinearity and overfitting problems by shrinking model parameters to the extent that they are correlated with the outcome variable.

The CD model differs from the RN and PR models in the way that disambiguating information is treated and conceptualized. Here, disambiguating information is treated as categorical information that is distinct from and take precedence over the probabilistic cues (e.g., prominence-based and verb-semantic cues). This is done by assuming a new baseline probability close to 0 or 1 upon encountering disambiguating information in subject- or object-initial sentences, respectively. The surprisal effect of subsequent constituents is then determined by the extent to which the probabilistic cues of the current constituent speak against the disambiguating information with respect to the probabilistic cues available at the previous constituent, as determined by the difference in $p(\text{object-initial})$ between the present and previous constituents. As such, the CD model engenders strong surprisal effects at the point of disambiguation, but little to no surprisal effects in unambiguous regions.

As discussed in more detail below, the PR model appears to be the model that makes the most accurate predictions in unambiguous object-initial sentences, which provide a good testing ground for making comparisons between models.

6.4.2. Predictions in locally ambiguous sentences

In locally ambiguous sentences that are disambiguated at the final NP (such as the sentences in Example 6.1), all three models make similar predictions. In object-initial sentences, high surprisal effects at NP1 and the verb are accompanied by low surprisal effects at the disambiguating NP2, thereby showing a pattern of complementary distribution of surprisal between the ambiguous and disambiguating constituents (see Figure 6.8). Initial information that speaks in favor of the object-initial interpretation at NP1 and the verb is costly, as it speaks against the baseline assumption of the subject-initial word order. But this information provides additional evidence for the object-initial word order and therefore helps mitigate the surprisal effect at NP2 that disambiguates the sentence toward the object-initial word order. In subject-initial sentences, on the other hand, high surprisal effects at the ambiguous constituents are accompanied by high surprisal effects at the disambiguating NP2. In this case, the evidence for the object-initial word order provided by the ambiguous constituents is disconfirmed, resulting in somewhat increased surprisal effects.

Looking at the influence of individual predictors on the surprisal of each constituent in turn, all three models predict higher surprisal effects at the initial NP when it is either inanimate or text deictic, and a small but significant effect for an indefinite versus a definite initial NP. These prominence cues speak in favor of the object-initial word order and therefore provide information that goes against the baseline assumption of a subject-initial word order. At the verb, the models predict surprisal effects when the verb is either experiencer or volitional. These verbs bias towards the object-initial interpretation when following a non-person NP. Surprisal effects are also engendered when NP1 is inanimate
and the verb is either volitional or causative. Because such verbs very seldom occur with inanimate subjects, the subject-initial interpretation is rendered highly unlikely. At the disambiguating NP2, the large surprisal effect engendered by the disambiguation towards the unexpected object-initial word order is highly mitigated when NP1 is either inanimate or text deictic. The animacy influence is particularly strong in volitional or causative verb sentences. Surprisal is also substantially lower in experiencer verb sentences in comparison to other sentences. In possessive verb sentences, surprisal is also mitigated when NP1 is indefinite in comparison to definite.

These results show that the prominence cue that primarily provides evidence for the object-initial word order is animacy. The impact of animacy further depends on the verb class, and particularly on the extent to which the verb requires an animate subject. This is in line with the assumptions presented in Chapter 2: Grammatical functions are associated with the semantic role of Actor and Undergoer, respectively. Prototypical Actors are in turn volitional and sentient, and are therefore necessarily animate. Animacy therefore functions as an important cue to GF assignment. A few predicates further require a volitional and/or sentient Actor argument. That is, some verb classes require an animate subject. The animacy cue is therefore of extra importance when it co-occurs with such verbs.

Another important cue for the object-initial interpretation is whether the verb at hand is an experiencer verb. In Chapter 5, NP1 case marking was found to interact with sentence\(^{10}\) in predicting the sentence word order: A transitive sentence with an experiencer verb is 86 times more likely to be object-initial when the initial NP is unmarked in comparison to when it is case marked (see Table 5.11). Experiencer verbs frequently express private knowledge and subjective experiences (e.g., verbs such as ‘know’, ‘think’, ‘see’, ‘feel’) from the perspective of the speaker, the interlocutor or a third-person protagonist that is highly given in the discourse (Dahl 2000; Ricoeur & McLaughlin 1985). Subjects of experiencer verb sentences are therefore more likely to consist of a 1st, 2nd or a 3rd person pronoun. In line with this, Dahl (2000) found that 82% of the subjects in experiencer verb sentences consisted of speech act participants. The co-occurrence of a non-person (i.e., an unmarked) initial NP and an experiencer verb should therefore provide substantial evidence for the object-initial word order. Although the regmodels underlying the RN and the PR models were unable to converge with the experiencer \(\times\) NP1 case and experiencer \(\times\) NP2 case interactions included, it is likely that the strong influence of sentience on the surprisal effect at both the verb and the disambiguating initial NP is driven by the preference for experiencer verb sentences to occur with personal pronoun / case marked subjects.

In sentences with possessive verbs, NP1 definiteness and, to a small extent, also NP1 givenness, that is, NP1 discourse prominence, is of extra importance for predicting the object-initial word order. The surprisal effect at the disambiguating NP2 in possessive verb sentences is highly mitigated when NP1 is either indefinite or new in comparison to definite or given. A possessive verb that follows an NP that is low in discourse prominence therefore provides compelling evidence for the object-initial word order. As discussed in Section 5.5.3, it might be that possessive constructions in some cases are used to introduce a new discourse topic. The topical object NP would then be low in discourse prominence

\(^{10}\)Experiencer verbs require the Actor to be a sentient being.
but occupy the sentence-initial position in order to emphasize its topic function. The final subject would, on the other hand, generally be given and therefore be highly discourse prominent, in order to serve as a reference point for the introduction of the new topic. Such a construction was exemplified in Example 5.8 in Section 5.5.3, repeated in 6.10 below for convenience.

(6.10) Några kvinnliga konstnärsidoler har Cecilia inte, tyvärr
Any female favorite-artists have Cecilia not, unfortunately
‘Any female favorite artists Cecilia unfortunately do not have’

Example 6.10 introduces a new sentence topic into the discourse, which is related to the already known discourse referent ‘Cecilia’. The discourse takes a turn in the sentences following sentence 6.10, departing from a short description of the studio that Cecilia works in to a discussion of inspirational artists. Example 6.10 therefore seems to introduce favorite and inspirational artists as a new discourse topic, using the possessive verb ‘ha’ (‘have’).

6.4.3. Predictions at the point of disambiguation

At the point of disambiguation and beyond, the models make quite different predictions. The prominence features of a final NP that disambiguates towards the object-initial interpretation were found to have quite different influences on surprisal when comparing the predictions of the RN and the PR models with those of the CD model. Whereas the RN and the PR models predict a substantial reduction in surprisal when the NP2 is low in prominence in comparison to when it is high, the CD model conversely predicts a small reduction when NP2 is high in prominence. This difference reflects the two different conceptions of disambiguating information assumed by the RN model and the PR models in comparison to the CD model. Whereas the RN model and the PR models treat disambiguating information as they do other probabilistic cues, the CD model treats disambiguating information as categorical information that is distinct from and takes precedence over the probabilistic cues. Which of these views is correct is an empirical question that might be hard to settle, given that both surprisal of an upcoming word (Linzen & Jaeger 2014; Smith & Levy 2013) as well as uncertainty about the sentence interpretation (Linzen & Jaeger 2014, 2015) have been shown to impede sentence processing. In the RN and PR models, the surprisal effect might be lower when NP2 is low in prominence than in the CD model, but the uncertainty about the GF assignment will also be greater, resulting in additional processing costs. It might therefore not be possible to contrast the models against each other when uncertainty is also considered.

The RN and the CD models predict a significant influence of NP2 egophoricity in all but possessive verb sentences, as well as a marginally significant effect of definiteness. Whereas the RN model predicts a decrease in surprisal for an allophoric versus an egophoric NP2, the CD model predicts an increase. The PR model, on the other hand, predicts a decrease in surprisal for an indefinite versus a definite NP2, and a marginally significant decrease associated with egophoricity. All three models finally predict a significant influence of NP2 givenness and a marginally significant effect of NP2 definiteness in possessive verb sentences. These findings largely confirm the findings of the corpus study.
in Chapter 5. There, it was found that the object-initial word order is approximately
7 times more likely when NP2 is egophoric and about 2.5 times more likely when it is
definite.

These results confirm the generalization in Teleman et al. (1999:4:341-343) that the
subject of object-initial sentences tends to be highly discourse prominent and therefore
definite, and, in particular, a 1st or 2nd person pronoun. The extra influence of given-
ness/definiteness on surprisal in possessive verb sentences is unexpected, but could also
be a reflex of the topic-introducing possessive construction, exemplified in Example 6.10.
The subject NP of this construction is predictable and highly discourse-prominent as it
serves as a reference point or a ‘ground’ for the introduction of the new discourse topic
(i.e., the sentence-initial object).

6.4.4. Predictions in unambiguous sentences

Unambiguous sentences that are disambiguated directly at the initial NP provide a way
of testing differences between model predictions beyond the point of disambiguation. In
particular, a disambiguating NP1 is likely to generate predictions about the upcoming
material, and, in the context of argument interpretation, about whether or not the final
NP is low or high in prominence. As illustrated in Example 6.5, an initial NP that
disambiguates the sentence toward the object-initial word order generates a prediction of
a highly prominent subject. NP2 surprisal should therefore be somewhat lower in Example
6.5a than in 6.5b. In line with this, several studies have found that unambiguous subjects
in object-initial sentences are more costly to process when inanimate (and therefore low in
prominence) than when animate (and therefore high in prominence). Most studies have
failed to find additional costs in the processing of an animate versus an inanimate object in
subject-initial sentences, however (Bornkessel-Schlesewsky & Schlesewsky 2009c; Philipp
et al. 2008; Roehm et al. 2004; Weckerly & Kutas 1999). The final NP in unambiguous
object-initial sentences can therefore be expected to engender surprisal effects when it is
low in prominence in comparison to when it is high. In ambiguous subject-initial sentences,
on the other hand, the final NP might either engender surprisal effects when high in
prominence or it might not engender any surprisal effects whatsoever.

In unambiguous subject-initial sentences, all three models predict little to no surprisal
effects whatsoever both at and beyond the point of disambiguation, in line with the findings
of previous experimental results.

In unambiguous object-initial sentences, on the other hand, the models make funda-
mentally different predictions. These differences primarily stem from model differences in
the estimation of the influence of the disambiguating information of NP1. The RN model
severely underestimates the influence of disambiguating information. This results in little
to no surprisal effects at NP1. At the verb, a small surprisal effect is engendered if the
verb is an experiencer verb, and thereby provides additional support for the object-initial
word order. At NP2, a moderate to high surprisal effect is in some cases engendered when
the NP is high in prominence, rather than low, and therefore further biases towards the
object-initial word order. These predictions are clearly wrong. NP1 should provide strong
enough evidence for the object-initial word order for subsequent constituents to engender a
surprisal effect only in cases where they bias against the object-initial word order, thereby
being inconsistent with the prediction of a highly prominent subject.

In the PR model, on the other hand, the evidence for the object-initial word order does appear to be strong enough already at NP1. The PR model predicts fairly high NP1 surprisal effects. At the verb, little to no surprisal effects are predicted. At NP2, moderate to high surprisal effects are predicted only when the NP is low in prominence, and therefore biases against the object-initial interpretation. The PR model therefore predicts a surprisal effect when the NP2 prominence features are inconsistent with the prediction of a highly prominent subject.

The CD model instead seems to overestimate the influence of the disambiguating information of NP1. In particular, it fails to account for the effect of prominence information that goes against the object-initial interpretation. The CD model predicts a high surprisal effect at NP1 but little to no surprisal effects at subsequent constituents. The CD model therefore fails to predict a surprisal effect when NP2 is inconsistent with the prediction of a highly prominent subject. The PR model therefore appears to provide the best predictions of the surprisal effects engendered by constituents beyond the point of disambiguation, which are in line with previous experimental results.

The relative influence of individual NP2 prominence and verb semantic features in unambiguous object-initial sentences was finally found to be similar for all three models. NP2 animacy has the strongest influence, followed by NP2 definiteness. In sentences with possessive verbs, all three models again predict NP2 givenness to have the strongest influence, followed by NP2 definiteness and NP2 animacy. All three models also predict that both possessive and causative verbs significantly bias against the object-initial word order, thereby significantly influencing the surprisal effect in comparison to uncategorized verbs.
7. Testing the Predictions of the Incremental Models

7.1. Introduction

In the previous chapter, I presented three models of incremental argument interpretation. These model the on-line change in processing difficulty during incremental GF assignment. In the models, processing difficulty is assumed to depend on change in the expectedness of a particular GF assignment, or, in other words, change in the expectedness of a particular word order (subject- or object-initial). The models estimate the on-line change in the expectation of an object-initial word order on the basis of surprisal (Hale 2001; Levy 2008, 2013). Surprisal is quantified as the relative entropy between the probability of the object-initial word order given the information available at the time of presentation of constituent $C_i$ and the probability given the information available at the time of presentation of constituent $C_{i-1}$. As such, surprisal is estimated with respect to the subsequent presentation of the three constituents NP1, the verb, and NP2. The probabilities for the object-initial word order associated with each constituent are estimated on the basis of mixed effects logistic regression models. For example, the probability for the object-initial word order given the information available at the presentation of the verb in SVO sentences is estimated on the basis of a regression model that includes all features of NP1, the verb and their interactions as predictors.

Model evaluations showed that all three models make similar predictions in locally ambiguous sentence regions, but differ in their predictions at the point of disambiguation and beyond. In particular, the PR model appears to outperform the RN and the CD models in making predictions beyond the point of disambiguation. In this chapter, I will therefore experimentally test some of the most salient predictions of the PR model regarding the interactions between word order, animacy and verb class, using the self-paced reading paradigm (Aaronson, Ferres, Kieras, & Just 1984; Haberlandt 1994; Jegerski 2014). In this experimental setup, participants read sentences presented one word at the time, at a pace of their own convenience. The participants expose successive words of the sentences themselves, by pressing a button. A crucial assumption of this experimental paradigm is that differences in time latency between button presses reflect differences in processing load during language comprehension (see, e.g., Aaronson et al. 1984; Just & Carpenter 1980). The surprisal effects that the incremental model predicts are therefore expected to correlate with differences in reading times.

In the following, I first outline the properties of the sentences used to test the model predictions. I then describe the actual predictions that the model makes about these sentences and how these predictions translate into predicted reading time differences. I then present the actual method and the results of the experiment.
### Table 7.1. Examples of the sentence types used in the experiment. All of the critical sentences contain a pronominal and case marked subject and a lexical and unmarked object. They are differentiated on the basis of Word order (subject- vs. object-initial), Verb type (volitional vs. experiencer), and Animacy of the lexical object (inanimate vs. animate). The filler sentences consist of subject-initial sentences in which the nouns of the lexical object in the critical sentences function as subjects. Filler sentences are included to ensure that sentence-initial nouns are presented both in the subject and the object function.

<table>
<thead>
<tr>
<th>W.O.</th>
<th>Verb</th>
<th>Animacy</th>
<th>Example sentence</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Volitional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inam.</td>
<td>Bollen sparkar jag mitt upp i krysset</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anim.</td>
<td>Killen sparkar jag mitt på småbenet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘The ball I kick right up into the top corner’</td>
<td>‘The guy I kick in the middle of the shin’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bollen glömmer jag mitt på fotbollsplanen</td>
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<tr>
<td></td>
<td></td>
<td>‘The ball I forget in the middle of the soccer field’</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Killen glömmer jag sent på kvällen</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>‘The guy I forget late at night’</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Jag sparkar bollen mitt upp i krysset</td>
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<td></td>
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<td>‘I kick the ball right up into the top corner’</td>
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<td>Jag sparkar killen mitt på småbenet</td>
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<td>‘I kick the guy in the middle of the shin’</td>
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<td>Jag glömmer bollen mitt på fotbollsplanen</td>
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<td>‘I forget the ball in the middle of the soccer field’</td>
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<td>Jag glömmer killen sent på kvällen</td>
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<td>‘I forget the guy late at night’</td>
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<tr>
<td></td>
<td></td>
<td>Killen sparkar mig mitt på småbenet</td>
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<td>‘The guy kicks me in the middle of the shin’</td>
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<tr>
<td></td>
<td></td>
<td>Killen glömmer mig sent på kvällen</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>‘The guy forgets me late at night’</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bollen träffar mig mitt i pannan</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>‘The ball hits me in the middle of the forehead’</td>
<td></td>
</tr>
</tbody>
</table>

### 7.1.1. Sentence properties

The sentence types used to test model predictions are illustrated in Table 7.1. The critical sentences of the experiment differ with respect to word order (subject- vs. object-initial), verb class (volitional verb vs. experiencer) and the animacy of the object argument (inanimate vs. animate). In the object-initial sentences, the object is lexical and therefore lacks case marking. The subject that follows the verb, on the other hand, is a personal pronoun and is therefore case marked. The object-initial sentences are therefore morphosyntactically ambiguous with respect to grammatical function until the presentation of the post-verbal subject, which disambiguates the sentences toward the object-initial word order. In the subject-initial sentences, on the other hand, the pronominal subject occupies the sentence-initial position. Unambiguous information regarding sentence word order is therefore provided directly. The filler sentences, finally, consist of subject-initial sentences
in which the nouns of the lexical objects of the critical sentences function as sentence-initial subjects. These conditions were included to ensure that the same sentence-initial nouns were presented both in the subject-argument as well as in the object function, in order to avoid predictability effects, and will therefore not be further discussed.

### 7.1.2. Predicted surprisal effects

Figure 7.1 illustrates the surprisal effects at the positions of each constituent in the critical sentences as predicted by the PR model. In the following, I discuss the predicted influences on the surprisal effect and thereby the reading times of the critical sentence constituents, starting with predicted differences between subject- and object-initial sentences, and then moving on to Animacy and Verb class influences in object-initial sentences.

![Surprisal Effects Graph](image)

**Figure 7.1.** Predicted surprisal in subject- and object-initial sentences, differentiated on the basis of animacy and verb class. Error bars show 95% confidence intervals. These are the 5% and 95% percentiles of distributions of 1,000 surprisal values, calculated on the basis of simulations of the beta coefficients in the logistic regression models that underlie the PR model (see Chapter 6).
Chapter 7. Testing the Predictions of the Incremental Model

Subject- versus object-initial sentences  Although the object-initial sentences are morphosyntactically ambiguous with respect to grammatical function at an initial stage, the baseline assumption of the incremental model is that they are subject-initial. This is due to the low baseline probability of the object-initial word order. This prediction is in line with the subject-first preference (see, e.g., Bickel, Witzlack-Makarevich, Choudhary, Schlesewsky, and Bornkessel-Schlesewsky 2015, Demiral et al. 2008 and Chapter 4 for further discussion), according to which comprehenders assume that an initial ambiguous NP functions as the subject of the sentence\textsuperscript{1}. As illustrated in Figure 7.1, surprisal in the object-initial sentences therefore vary as a function of the extent to which the verb class, animacy and case marking cues speak against the baseline assumption of a subject-initial word order, thereby providing support for the object-initial word order. In the context of the present experiment, participants are therefore expected to assume that the initial NP in object-initial sentences functions as the subject. Reading times will then depend on the extent to which subsequent cues provided by the verb and the final NP speak against this assumption and in favor of the object-initial interpretation, as described below.

In the subject-initial sentences, on the other hand, the baseline assumption of a subject-initial word order is confirmed already at the presentation of the initial, subject-argument pronoun. The model therefore predicts little to no surprisal effects throughout the presentation of these sentences (see Figure 7.1), independently of any differences in animacy or verb class, as the probability of an object-initial word order is set close to zero already at the outset of the sentence. Reading times in subject-initial sentences should therefore not be significantly affected by animacy or verb class differences.

Influences of Verb class and Animacy in object-initial sentences  At the initial NP in object-initial sentences, the model predicts little to no surprisal effects, independent of whether the NP is animate or inanimate (see Figure 7.1). Although animacy is the strongest prominence cue (see Chapter 5), an initial inanimate NP is not convincing evidence for the object-initial word order on its own. This is in line with a few studies that have failed to find an influence of the animacy of an initial NP on the comprehension process (see, e.g., Philipp et al. 2008 and Chapter 2).

At the verb, on the other hand, the model predicts a small surprisal effect when the initial NP is inanimate and the verb is experiencer (but not volitional). This is because the initial inanimate NP together with an experiencer verb provide additional evidence for the object-initial word order, and therefore speak against the baseline subject-initial word order assumption. This is largely due to the fact that experiencer verbs are less likely to co-occur with allophoric subjects. As discussed in Chapter 2, Dahl (2000) found that subjects in sentences with experiencer verbs are very frequently egophoric. He argued that this is because experiencer verb sentences are used to express the perspective of the speaker or interlocutor (e.g., thoughts, feelings and other experiences). An allophoric NP is therefore less likely to function as the subject in experiencer verb sentences, which indeed was the case in the corpus data (see Chapter 5). An initial allophoric NP that co-occurs with an experiencer verb therefore provides additional evidence for the object-initial word order over and above that of other prominence cues such as animacy. Since all initial NPs in the

\textsuperscript{1}Which, in the incremental models, is implemented as a low baseline probability for the object-initial word order.
object-initial sentences are allophoric, an experiencer verb always provides extra support for the object-initial word order, in addition to the evidence provided by the inanimacy of the initial NP. This results in a small verb surprisal effect. Reading times at the verb are therefore expected to be somewhat slower in sentences with an initial inanimate object and an experiencer verb in comparison to all other sentence types.

At the final NP, the model predicts large surprisal effects in all sentence conditions. This is because the final NP is case marked and therefore disambiguates toward the object-initial interpretation. The large final NP surprisal effect can be assumed to reflect processes of grammatical function reanalysis towards the object-initial interpretation (see, e.g., Haupt et al. 2008, and Chapter 4). Reanalysis is expected to be reflected in slower final NP reading times in object-initial sentences of all conditions in comparison to their corresponding (and unambiguous) subject-initial sentences. However, the surprisal effect associated with disambiguation also varies as a function of Animacy and Verb class in the following ways.

Firstly, the surprisal associated with disambiguation is substantially reduced when the initial NP is inanimate in comparison to when it is animate. This is because the inanimate initial NP provides evidence for the object-initial interpretation directly, rendering the probability for the object-initial word order higher at the verb. The object-initial word order is therefore less unexpected with an initial inanimate NP, resulting in a decrease in surprisal at the point of disambiguation. In other words, comprehenders should benefit from the animacy cue of the initial NP so that grammatical function reanalysis is less costly when the initial NP is inanimate and therefore speaks in favor of the object-initial interpretation. Indeed, as discussed in Chapter 2, several ERP studies have found evidence that the cost of assigning the Actor role to a final NP is reduced (as reflected by a decrease in N400 amplitude) when the initial NP is inanimate in comparison to when it is animate (e.g., Frenzel et al. 2011; Frisch & Schlesewsky 2001, 2005). In the experiment, final NP reading times are therefore expected to be faster when the object-initial argument is inanimate in comparison to when it is animate.

Secondly, the surprisal effect per se as well as the influence of animacy on the surprisal effect is substantially smaller when the verb is experiencer rather than volitional. That is, the overall surprisal effect of the disambiguating final NP is lower in experiencer verb sentences than in volitional verb sentences, and the difference in surprisal between sentences with an initial inanimate versus an animate NP is smaller when the verb is experiencer in comparison to when it is volitional. This is again because an experiencer verb that co-occurs with an allophoric initial NP provides additional evidence for the object-initial word order. This in turn makes the disambiguating information of the final NP less unexpected, resulting in lower surprisal in experiencer verb sentences than in volitional verb sentences. Further, because the co-occurrence of an experiencer verb and an allophoric initial NP provides support for the object-initial interpretation independently of the animacy of the initial NP, the initial NP animacy cue is rendered less important in experiencer verb sentences in comparison to volitional verb sentences. The influence of animacy is therefore smaller in the former in comparison to the latter. Final NP reading times are therefore expected to be somewhat faster and less influenced by NP1 animacy in experiencer verb sentences than in volitional verb sentences.

To sum up, the following effects on reading times are predicted. At the initial NP,
Chapter 7. Testing the Predictions of the Incremental Model

no reading time differences are expected between any of the conditions. At the verb, somewhat slower reading times should be observed in object-initial sentences with an experiencer verb when the initial NP is inanimate in comparison to when it is animate. Verb RTs of object-initial sentences with experiencer verbs and an initial inanimate NP should also be read slower than the corresponding subject-initial sentences. Object-initial sentences with volitional verbs, on the other hand, should not differ with respect to animacy. At the final NP, object-initial sentences of all conditions are predicted to be read slower than the corresponding subject-initial sentences. Final NP reading times of object-initial sentences are also expected to be faster when the initial NP is inanimate in comparison to when it is animate. This reading time difference should further be bigger for volitional verb sentences than for experiencer verb sentences. Final NP reading times of object-initial sentences are also expected to be faster in experiencer verb sentences than in volitional verb sentences. Final reading times in subject-initial sentences, on the other hand, are expected not to differ between conditions.

7.1.3. Thematic fit between nouns and verbs

There is one possible confound that may influence reading times in unwanted ways. Because a different set of verbs are used in each verb class, verb classes might differ in systematic ways due to lexical or relational-semantic differences such as the thematic fit between individual nouns and verbs, which in turn may affect reading times. The thematic fit between a noun and a verb involves the extent to which a particular noun is semantically suitable to fill the Actor or the Undergoer role of a specific verb (see, e.g. McRae, Ferretti, & Liane Amyote 1997; McRae et al. 1998). For example, the thematic fit between the Undergoer role of the verb ‘arrest’ is better for the noun ‘crook’ than ‘cop’, because crooks are more likely to be arrested than cops. Studies have shown that the thematic fit between a noun and a verb can be used as cue during on-line interpretation of structurally ambiguous sentences (McRae et al. 1998).

In the present experiment, systematic differences in the thematic fit between individual nouns and verbs across verb classes might therefore cause spurious verb class effects that need to be controlled for. If, for example, nouns in general are semantically more plausible to function as the Actor of experiencer verbs than of volitional verbs, the thematic fit between nouns and individual verbs might initially be more consistent with a subject-initial interpretation in experiencer verb sentences than in volitional verb sentences, independent of the verb class difference per se. This in turn might result in faster reading times at the verb and slower reading times at the post-verbal NP for experiencer verb sentences than for volitional verb sentences. For example, in the object-initial sentences from the experiment shown in Example 7.1 below, the initial NP ‘kontoret’ (‘the office’) is more easily interpreted as the Actor in Example 7.1a, containing an experiencer verb, than in 7.1b, with a volitional verb. In Example 7.1a, a metonymical interpretation of the office as the institution that is responsible for the bugging renders a subject-initial interpretation possible. Such a metonymical interpretation would be less plausible together with the verb ‘uppsöka’ (‘seek’) in 7.1a since it entails the act of physically searching for a specific location. Faster reading times at the verb and slower reading times at the post-verbal NP can therefore be expected in Example 7.1a in comparison to Example 7.1b on the basis of
7.2 Method

7.2.1. Participants

The self-paced reading experiment was performed by a total of 45 participants (15 male) who gave informed consent in writing. Most of these were students at Stockholm University. The mean age was 28.4 years (SD = 9.93). In order to encourage participation, each participant received a cinema voucher.

7.2.2. Materials

Thematic fit ratings  The thematic fit between nouns and the participant roles of the verbs was estimated on the basis of a separate rating study. Participants in this study were mainly employees and students at the Department of Linguistics at Stockholm University. Data from 18 participants, who completed more than 50% of the rating items, were used in the analyses. The study was completely anonymous and did not probe for any information regarding, for instance, age or sex. None of the participants took part in the self-paced reading experiment.

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2A total of 49 participants initiated the rating study, which was conducted on-line, but many of them only completed a minority of the rating items.
Chapter 7. Testing the Predictions of the Incremental Model

The materials of the rating study investigated how reasonable it was for all the nouns used in the experiment to function as either the Actor or the Undergoer of the critical sentence verbs. This was done on the basis of a 7-grade scale. Actorhood questions were formulated as in Example 7.2a and undergoerhood questions as in Example 7.2b. In the actual rating study, the scale was labeled as 1) ‘totally unreasonable’, 2) ‘very unreasonable’, 3) ‘somewhat unreasonable’, 4) ‘nor unreasonable nor reasonable’, 5) ‘somewhat reasonable’, 6) ‘very reasonable’ and 7) ‘totally reasonable’.

(7.2) (a)

How reasonable is it...

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>an office</td>
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</tr>
<tr>
<td>a minister</td>
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</table>

... to seek for someone or something...?

(b)

How reasonable is it for someone or something to seek...

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<th>3</th>
<th>4</th>
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<tr>
<td>an office</td>
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<td></td>
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<tr>
<td>a minister</td>
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</table>

...?

Each question asked about the reasonableness of both the animate and the inanimate nouns, in the manner illustrated in the examples. Each question was shown on the screen one at a time in an order that was uniquely randomized for each participant.

Participants conducted the study on-line at their own convenience, using the survey tool ‘Lime Survey’ (LimeSurvey Project Team & Schmitz 2015). The survey was open to anyone. Participants were instructed on how to perform the rating study on an initial screen. They were encouraged to make their ratings on the basis of ‘any interpretation that makes the object/individuals’ involvement in the action/event reasonable’ in order to allow for higher ratings of individual metaphorical or metonymical interpretations. Participants could save their results and return to the survey at a later time point, using temporary login information.

Experimental sentences All sentences in the self-paced reading experiment were transitive sentences with either object- or subject-initial word order, consisting of a one-word NP, a single verb, another one-word NP, and a sentence-final prepositional complement phrase. Thirty-two items consisting of the eight critical sentence conditions as well as the three filler sentences exemplified in Table 7.1 were created out of an animate and an inanimate noun, a personal pronoun, a volitional and an experiencer verb, as well as a verb that allows for an inanimate subject (henceforth referred to as an ‘uncategorized’ verb). Nouns were definite and singular or plural. Pronouns were either 1st or 2nd person in the singular or plural. Nouns and pronouns were identical with respect to number and person within items. All verbs were taken from the Argument Interpretation Cues corpus (see Chapter 5) and were categorized in accordance with the corpus annotation: Volitional and experiencer verbs were annotated as such in the corpus, and uncategorized verbs were either
annotated as uncategorized or as object experiencer verbs. All noun-verb co-occurrences used in the sentences were attested in one of the Swedish corpora found in the Korp corpus collection (Borin, Forsberg, & Roxendal 2012). A complete list of the nouns, verbs and the pronouns used in the sentences is found in Appendix D. The sentence-final prepositional phrases within each item were either identical, or made as similar as possible. In most cases somewhat different prepositional phrases had to be used in order for the sentences to make sense. Crucially, however, the two initial words of the phrases, directly following the second NP, always consisted of short (2-4 letters) function words or adverbs that in most cases were identical across all conditions within a given item.

The eight sentence conditions of each item were distributed across four lists. Twenty-two participants read list one, and eight participants each read the other three lists. None of the critical sentences within a list contained the same nouns or verbs. This ensured that each noun and verb was presented only once for each participant in these conditions. Pronouns were equally distributed across lists so that each participant read the same number of pronouns.

The three filler sentences of each item were distributed across the four lists in such a manner that each filler sentence always occurred in a list with a critical object-initial sentence from the same item. This was to ensure that, for each participant, the same sentence-initial nouns were presented in both the subject and object functions, in order to avoid predictability effects. Filler sentences with an inanimate initial noun of each item were used in two separate lists rather than one, so that each list contained 32 object-initial critical sentences, 32 subject-initial critical sentences and 32 filler sentences. The filler sentences with volitional and experiencer verbs always contained verbs that occurred in one of the other critical sentence types in the same list. The verbs of the filler sentences with uncategorized verbs only occurred once in each list, on the other hand. Each list also contained an additional 32 filler sentences that consisted of subject-initial transitive sentences with pronominal NPs that were 1st/2nd person in the singular or plural. These were identical across the four lists. Each list therefore contained a total of 128 sentences (i.e., 64 critical sentences, 32 filler sentences that varied across lists, and 32 filler sentences that were identical in all lists).

Comprehension questions Each experimental sentence was matched with a corresponding comprehension question. The experimental task was to determine whether the comprehension questions referred back to the event described by the experimental sentence at hand. For instance, the comprehension question to the first example sentence in Table 7.1, correctly answered with a yes, was ‘Sparkar han bollen mitt upp i krysset?’ (‘Does he

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3This was due to a mishap in the experimental setup that went undetected until about half of the participants had been tested. Statistical analyses failed to find any significant differences between lists, however, indicating that the results of the experiment were not driven by a bias of list one items.

4As noticed by a reviewer of an earlier draft of this chapter, the distribution of subject- and object-initial sentences is unbalanced in the sense that only 25% of all sentences are object-initial. This in turn might make the subject-initial word order more predictable, resulting in faster reading times for subject-initial sentences. This distribution needs to be compared to the distribution of subject- and object-initial transitive sentences in natural discourse, however. Here, only about 5% of all transitive sentences are object-initial (see Section 5.2.2). The frequency of object-initial sentences in the experiment is therefore much higher than expected, and should if anything instead bias towards the object-initial interpretation.
Chapter 7. Testing the Predictions of the Incremental Model

kick the ball right up into the top corner?). The purpose of this task was to ensure that participants read the experimental sentences. Incorrectly answered trials were excluded from the analysis.

Half of the comprehension questions corresponded to their experimental sentences and were correctly answered with a yes, whereas the other half did not, and were to be answered with a no. In order to eliminate the possibility of adopting heuristic strategies when performing the experiment, four different types of ‘no’-questions were used. In three ‘no’-questions, the noun, verb or the sentence-final prepositional phrase of the corresponding experimental sentence was replaced by another noun, verb or prepositional phrase. In the fourth ‘no’-question, the subject and the object of the sentence were exchanged with each other. All ‘no’-questions occurred equally often.

Stimulus presentation The four sentence lists were divided into eight blocks of twelve sentences such that item sets, conditions, question types as well as nouns, verbs and pronouns were evenly distributed across blocks. Each noun and verb only occurred once within each block.

Sentences within a block were presented in pseudo-randomized fashion such that two of the same sentence type never followed each other. The ordering of the blocks was counterbalanced across the participants exposed to each respective list using a Latin square design. This ensured that each block occurred equally often in each of the eight possible sequential positions.

7.2.3. Procedure

The self-paced reading experiment was conducted in a dimly lit room at the Phonetics Laboratory at the Department of Linguistics at Stockholm University. Participants were initially informed about the procedure of the experiment and on how to perform the experimental task. They were told that they could terminate the experiment at any time without giving a reason and signed a written consent form. Participants performed the experiment on a standard personal computer. Before the actual experiment started, written instructions on how to perform the experiment were presented. This was followed by a practice session consisting of 12 practice trials, during which participants received feedback on whether they had answered the comprehension questions correctly.

Each practice and experimental trial consisted of a visual presentation of the sentence at hand, using a self-paced moving window paradigm (Aaronson et al. 1984; Haberlandt 1994; Jegerski 2014). Each trial began with the presentation of a fixation cross that appeared on the left hand side of the computer screen for 800 ms, followed by a 400 ms blank screen. The sentence then appeared on the screen with all non-space characters replaced by a hash symbol (#). Participants pressed the space bar with their preferred hand to view each consecutive word in the sentence. At each button press, the currently viewed word reverted to hash symbols as the next word was converted to letters. Durations between space bar presses were recorded.

After the last word was presented, a blank screen was presented for 800 ms followed by the comprehension question, which remained visible until the participant answered by pressing the y button for ‘yes’ and the n button for ‘no’. There was no time limit for
the participants to make their answer. When the question had been answered, a final blank screen appeared for 1000 ms before the next trial begun. Before each of the eight experimental blocks started, a screen appeared that informed the participants that the block was about to begin. The sequential number of the upcoming block was explicitly stated. Participants started the next block by pressing the space bar.

7.3 Results

7.3.1. Exclusions and data transformation

Rating data Both animate and inanimate nouns were rated as being highly reasonable for filling the Undergoer role (all Ms > 6.6). Animate nouns were also highly rated to fill the Actor role (all Ms > 6.9), whereas inanimate nouns received much lower ratings for the Actor role, as can be expected. The rating data was therefore normalized. This was done in order to ensure that ratings capture differences in thematic fit independent of the fit that is predicted by animacy per se, and therefore allow for comparisons across the four groups of animate Undergoers, inanimate Undergoers, animate Actors and inanimate Undergoers. To this end, ratings were standardized with respect to the rating distributions of each group. Standardized ratings were finally collapsed across participants, resulting in an average standardized rating score of the fit between each noun and the Actor and Undergoer roles of each verb.

Reading time data All participants answered the comprehension questions with an accuracy of 80% or higher. No participant data was therefore excluded from the analysis. Extremely low (< 100 ms) and high (> 4000 ms) raw reading times (RTs) were excluded from further analysis, resulting in 0.3% exclusions. Reading times from trials in which the participants answered incorrectly were also excluded, resulting in 5% exclusions. The remaining RTs were corrected for length using linear mixed effects modeling. In this model, raw RTs were regressed against word length, while controlling for individual variation in reading time and sensitivity to word length across participants, using a by-participants random intercept and slope for word length (such as, e.g., Fine, Jaeger, Farmer, & Qian 2013). The residuals of this model are RTs for which the model’s estimation of the variation attributable to word length, on the one hand, and the individual variation and sensitivity of word length, on the other, has been partitioned out. In order to adjust the mean towards the mean of the raw RTs, the fixed-effects intercept of the model was added to the residuals. The resulting data was used as length-corrected RTs. Distributional outliers of length-corrected RTs were finally excluded by removing data points falling three standard deviations away from the mean of each participant. All in all, 7.1% of all data points were excluded.

7.3.2. Analysis

All statistical analyses reported below were again done in the statistical software R (R Core Team 2014). Analyses consisted of linear mixed effect models, which were conducted with the lmer() function (D. Bates 2009) in the lme4 package (D. Bates et al. 2014). Degrees of freedom for the calculation of p-values were estimated using Welch-Satterthwaite
approximation, as implemented in the lmerTest package (Kuznetsova, Brockhoff, & Bojesen Christensen 2014). All results were also confirmed using traditional repeated measurement ANOVAs on participant average RTs.

The optimal random effects structures of all mixed effects models were determined on the basis of backward elimination in the following manner. For each mixed effects model, optimal random effects models were fitted with by-participant and by-item intercepts as well as by-participant and by-item slopes for all factors and interactions in the fixed effects components of the models. Random effects that accounted for the least amount of variance of the data, as estimated on the basis of deviance between the current and the previous model, were subsequently removed until the removal of the upcoming random effect would result in a significant difference. P values were calculated on the basis of the method suggested by Zuur et al. (2009) in order to account for the problem of testing on the boundary.

In the following, I first present analyses of the thematic fit rating data and then move on to the reading time data.

**Figure 7.2.** Boxplots of normalized ratings of the thematic fit between nouns and the Actor or the Undergoer role as a function of animacy and verb class.

**Rating data** The distribution of normalized thematic fit ratings, differentiated on the basis of Animacy and Verb class, is shown in Figure 7.2 above. Actor and Undergoer ratings were analyzed with two linear mixed effects models with the factors Animacy, Verb class and their interaction as well as random by-participant and by-noun intercepts. As illustrated in the figure, both Actor and Undergoer ratings of inanimate nouns differ somewhat between verb classes. The mixed effects models found significant Animacy × Verb class interactions both for Actor ($\beta = 0.18, t(2051.8) = 2.44, p < .05$) and Undergoer ratings ($\beta = -0.32, t(2051.8) = 4.06, p < .001$). Simple effects analyses showed that inanimate nouns are rated significantly higher for the Actor role of volitional verbs than of experiencer verbs ($\beta = 0.24, t(2037.5) = 4.52, p < .001$), but, conversely, significantly
lower for the Undergoer role of volitional verbs than of experiencer verbs ($\beta = -0.23$, $t(2037.7) = -4.19$, $p < .001$). Animate nouns, on the other hand, are not differentially rated, as shown by simple effects analyses of Actor ($\beta = 0.06$, $t(2064.2) = 1.04$, $p = .15$) and Undergoer ratings ($\beta = 0.08$, $t(2064.5) = 1.56$, $p = .12$), respectively.

**Reading time data** Statistical analyses of reading time data were conducted on RT averages of two-word regions, henceforth referred to as the ‘verb region’, ‘NP2 region’ and ‘adverbial region’, respectively. Region RTs, rather than RTs of individual words, were used in order to account for spill-over effects. Spill-over effects occur when the processing associated with a word is postponed to the presentation of subsequent words, and the processing load in terms of longer RTs associated with the word therefore spills over to the presentation of subsequent words (cf., e.g. Mitchell 1984). The verb region consists of the initial NP and the verb, the NP2 region of the final NP and the subsequent word, and the adverbial region of the two words of the sentence-final adverbial subsequent to the NP2 region. These regions are illustrated in Example 7.3 below.

(7.3) [Killen sparkar [verb region] guy.the kick [jag mitt [NP2 region] I middle [på smalbenet [adverbial region] on shin] ]

‘The guy I kick on the middle of the shin’

Verb region RTs are assumed to correspond to the surprisal effects observed at the verb, and NP2 region RTs to the surprisal effects of the final NP. Adverbial region RTs should reflect initial processing of the sentence-final complement phrases and are not expected to differ between conditions.

In the following, I first present analyses of the relationships between thematic fit ratings and RTs, and then move on to analyses of RT differences between the conditions of the critical sentences.

**Thematic fit ratings and reading times** Analyses testing whether thematic fit ratings predict RTs found only small but significant relationships between ratings and RTs when performed across both verb region and NP2 region RTs together. These are illustrated in Figure 7.3 below. The figure shows the relationship between item average RTs in the Verb and NP2 region, on the one hand, and normalized Actor and Undergoer ratings, on the other, in object- and subject-initial sentences, respectively.

Verb and NP2 region RTs in object- and subject-initial sentences were regressed against normalized Actor or Undergoer ratings using four separate mixed effects models with by-participant and by-verb random intercepts. These analyses showed that whereas higher Undergoer ratings predict faster reading times in subject-initial sentences ($\beta = -11.11$, $t(223.80) = -1.95$, $p = .05$), higher Actor ratings predict slower reading times in object-initial sentences ($\beta = 13.45$, $t(162.45) = 2.01$, $p < .05$). No significant relationships were found between Undergoer ratings and RTs in subject-initial sentences, on the one hand, and Actor ratings and RTs in object-initial sentences, on the other.

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5Two models were performed for Actor ratings in subject- and object-initial sentences, respectively, and two for Undergoer ratings in subject- and object-initial sentences.
Figure 7.3. Item average RTs plotted against normalized Actor and Undergoer ratings in object- and subject-initial sentences, respectively. The shaded areas show 95% confidence intervals for the regression lines, and stars indicate significant correlations.

**Word order, verb class and animacy differences in reading times** Means and standard deviations of length-corrected RTs in all regions for object- and subject-initial sentences and all sentence conditions are shown in Table 7.2. RT means are also illustrated in Figure 7.4 and 7.5 below. Whereas Figure 7.4 illustrates RT differences primarily as a function of Word Order, Figure 7.5 shows RT differences across regions with respect to Animacy.

Analyses testing the effects of the sentence conditions on RTs were conducted separately in each region. These consisted of three linear mixed effects models with full factorial designs of Animacy, Verb and Word Order (i.e., object- vs. subject-initial), as well as random intercepts by participants and by items, respectively. The three factors in the factorial analyses were centered (see, e.g., Gelman & Hill 2006:55-56) in order to reduce collinearity. Follow-up analyses of simple effects were subsequently conducted. These also included a by-participants and a by-items random intercept. In order to control for the potential influences of differences in the thematic fit between verb classes, all analyses also included normalized Actor and Undergoer ratings. Actor ratings were used with object-initial sentences, and Undergoer ratings with subject-initial sentences, in line with the finding that RTs of object-initial sentences are correlated with Actor ratings, and RTs of subject-initial sentences are correlated with Undergoer ratings. Alternative analyses were also conducted with normalized ratings excluded. Unless specifically stated, the results of
Table 7.2. Mean and standard deviations of length-corrected RTs in all regions and sentence conditions.

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>Verb</th>
<th>Condition</th>
<th>Animacy</th>
<th>NP2 region</th>
<th>Adverbial region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inanimate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiencer</td>
<td>Inanimate</td>
<td>415.26 (184.8)</td>
<td>455.43 (157.38)</td>
<td>393.35 (149.29)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animate</td>
<td>376.58 (179.25)</td>
<td>447.27 (144.7)</td>
<td>400.04 (150.64)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>396.22 (182.97)</td>
<td>451.4 (151.19)</td>
<td>396.65 (149.88)</td>
<td></td>
</tr>
<tr>
<td>Volitional</td>
<td>Inanimate</td>
<td>403.84 (181.67)</td>
<td>446.76 (144.52)</td>
<td>402.41 (160.56)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animate</td>
<td>394.62 (190.34)</td>
<td>477.3 (169.05)</td>
<td>402.26 (165.12)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>399.34 (185.88)</td>
<td>461.65 (157.59)</td>
<td>402.34 (162.69)</td>
<td></td>
</tr>
<tr>
<td>subject-initial</td>
<td>Inanimate</td>
<td>388.2 (146.3)</td>
<td>411.49 (142.73)</td>
<td>395.69 (156.55)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animate</td>
<td>385.96 (154.9)</td>
<td>428.32 (175.03)</td>
<td>392.38 (166.86)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>387.08 (150.56)</td>
<td>419.91 (159.81)</td>
<td>394.03 (161.69)</td>
<td></td>
</tr>
<tr>
<td>Volitional</td>
<td>Inanimate</td>
<td>383.55 (162.6)</td>
<td>420.54 (173.63)</td>
<td>409.64 (149.94)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animate</td>
<td>390.24 (154.57)</td>
<td>430.12 (167.01)</td>
<td>409.08 (172.34)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>386.93 (158.51)</td>
<td>425.38 (170.26)</td>
<td>409.36 (161.54)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Inanimate</td>
<td>385.93 (154.39)</td>
<td>415.92 (158.55)</td>
<td>402.52 (153.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animate</td>
<td>388.08 (154.64)</td>
<td>429.21 (170.99)</td>
<td>400.65 (169.68)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>387.01 (154.46)</td>
<td>422.6 (164.99)</td>
<td>401.58 (161.74)</td>
<td></td>
</tr>
</tbody>
</table>

these did not qualitatively differ from the analyses that included ratings.

In the verb region, the factorial analysis found a significant Word Order × Animacy interaction \((\beta = 27.53, t(2114) = 2.22, p < .05)\). Simple effects analyses revealed that verb region RTs are slower in object-initial sentences with an experiencer verb and an initial inanimate NP than the corresponding subject-initial sentences \((\beta = -30.93, t(2466.8) = -2.4, p < .05)\). Verb region RTs are also significantly slower in object-initial sentences with an experiencer verb when the initial NP is inanimate in comparison to when it is animate \((\beta = -42.5, t(2467.8) = -3.89, p < .001)\). In object-initial sentences with a volitional verb, on the other hand, verb RTs do not differ between inanimates and animates \((\beta = -9.98, t(2523) = 0.83, p = .41)\), nor do verb RTs of object-initial sentences with a Volitional verb and an initial inanimate NP differ from the corresponding subject-initial sentences \((\beta = -19.32, t(2455.2) = 1.58, p = .11)\).

The factorial analysis of NP2 region RTs found a significant effect of Word Order \((\beta = 34.61, t(2674.8) = 5.41, p < .0001)\), a marginally significant effect of Animacy \((\beta = -13.51, t(2663.3) = -1.91, p = .05)\) and a marginally significant Word Order × Animacy × Verb interaction \((\beta = -21.76, t(2683.5) = -1.74, p = .08)\). Simple effects analyses failed to find a significant effect of Animacy in object-initial sentences generally \((\beta = -11.35, t(2663.4) = -1.31, p = .19)\). NP2 RTs are, however, significantly faster in object-initial sentences with volitional verbs when the initial NP is inanimate in comparison to when it is animate \((\beta = -30.16, t(2639.5) = -2.46, p < .05)\), but do not significantly differ with respect to animacy in the corresponding experiencer verb sentences \((\beta = 7.79, t(2610.3) = .05)\).
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Experiencer

Volitional

350
400
450
500
550

Animate

Inanimate

Word order

Object initial

Subject initial

Region

Length-corrected reading times (msecs)

Verb region

NP2 region

Adverbial region

Final word

Verb region

NP2 region

Adverbial region

Final word

Figure 7.4. Length-corrected RTs in object- and subject-initial sentences, differentiated on the basis of Word Order and Animacy. Error bars show 95% confidence intervals, and stars indicate significant differences.

In subject-initial sentences, there is no significant effect of Animacy on NP2 RTs either in volitional verb (β = −11.18, t(2636) = −0.89, p = .37) or experiencer verb sentences (β = −16.76, t(2548.9) = −1.3, p = .19). Simple effects analyses did not find any significant effects of Verb class on NP2 RTs either in object- (β = −5.9, t(2637.9) = −0.67, p = .5) or subject-initial sentences (β = −2.57, t(2666.6) = −0.29, p = .77).

The factorial analysis of RTs in the adverbial region, finally, found a significant effect of Verb class (β = 7.22, t(2680.5) = 2.1, p < .05), showing that reading times in the adverbial region are somewhat faster in sentences with experiencer verbs than in sentences with volitional verbs. No other significant effects were found in the adverbial region.

In sum, object-initial sentences with experiencer verbs are read more slowly up until the presentation of the verb when the initial NP is inanimate in comparison to animate. This is not the case for the corresponding subject-initial sentences, in which verb RTs do not differ. These results confirm the predictions of verb RT differences that the incremental model predicts. At the position of the final NP and the subsequent word, reading

6This effect was not, however, significant in analyses in which thematic fit ratings were excluded.
7.3 Results

Figure 7.5. Length-corrected RTs in object-initial sentences with initial lexical NPs and subject-initial sentences with initial pronominal NPs, differentiated on the basis of animacy and verb class. Error bars show 95% confidence intervals, and stars indicate significant differences.

Reading times are slower in object-initial sentences than in subject-initial sentences. They are also only affected by Animacy and Verb class differences in object-initial sentences, but not in subject-initial sentences. These results are also in line with the model predictions. Object-initial sentences are further read faster when the initial noun is inanimate, but only in volitional verb sentences. These findings are consistent with the prediction that the influence of NP1 animacy on final NP reading times should be stronger in volitional verb sentences than in experiencer verb sentences, but not with the prediction of a general animacy influence in all sentences. Verb class also only has an influence on final NP reading times in object-initial sentences by virtue of interacting with Animacy. This is not consistent with the prediction of faster final NP reading times in experiencer verb sentences than in volitional verb sentences in general. Analyses instead show that experiencer verb sentences are generally read faster than volitional verb sentences in the adverbial region, at least when thematic fit is controlled for. The results of the experiment are therefore consistent with some, but not all of the predictions of the incremental model.
7.4. Discussion

In this chapter, I set out to test some of the most prominent predictions of the incremental model (see Chapter 6). To this end, participants read transitive sentences with a pronominal subject and a lexical object in a self-paced reading paradigm. These sentences varied with respect to word order (object- vs. subject-initial), verb class (volitional verb vs. experiencer) and object argument animacy (inanimate vs. animate), and were both structurally and semantically similar to the written sentence materials found in corpora that the incremental model is based upon. Since the initial NP argument of the object-initial sentences is lexical and therefore lacks case marking, the object-initial sentences are morphosyntactically ambiguous with respect to grammatical function up until the presentation of the post-verbal subject, which disambiguates the sentences. In subject-initial sentences, on the other hand, disambiguating information regarding the argument functions is provided directly on the basis of its case marking. Reading times were therefore predicted to be significantly faster in the unambiguous subject-initial sentences than in the object-initial sentences, in line with the predictions of the incremental model. Reading times in object-initial sentences were further predicted to vary as a function of the interaction between animacy and verb class as predicted by the model.

The thematic fit between nouns and the Actor and Undergoer roles of all verbs was also estimated on the basis of a rating study. This was primarily done in order to ensure that the results of the experiment were not influenced by systematic differences in the thematic fit between the nouns and verbs across verb classes, thereby causing spurious influences of Verb class on reading times. The thematic fit ratings were also used to investigate whether thematic fit between nouns and verbs affects reading times, as has been found in previous studies.

In the following, I first discuss the results of the rating study, the general relationship between thematic fit ratings and reading times, as well as the influence of the interaction between thematic fit ratings and Verb class on reading times. I then move on to discussing the central results of the experiment, that is, the extent to which they confirm the predictions of the incremental model. First, I address reading time differences between locally ambiguous (i.e., object-initial) and unambiguous sentences, and then discuss the influence of Animacy and Verb class on reading times.

7.4.1. Thematic fit ratings and reading times

McRae et al. (1997) and McRae et al. (1998) have shown that the on-line interpretation of structurally ambiguous sentences is guided by the thematic fit between nouns and verbs. If, for example, an initial noun in a sentence with a grammatical function ambiguity is a suitable Undergoer of the subsequent verb (e.g., ‘The crook arrested by the detective...’), disambiguation toward the object-initial word order is significantly faster when the noun is a suitable Actor for the same verb (e.g., ‘The cop arrested by the detective...’) In the present study, differences in thematic fit between verb classes may therefore cause spurious effects on reading times and was controlled for. But there is also a theoretical interest in evaluating whether thematic fit influences reading times. The thematic fit between nouns and the Actor and Undergoer roles of the verbs was therefore estimated in a rating study.

The rating study showed that inanimate nouns are somewhat better suited to fill the
Actor role of the volitional verbs than of the experiencer verbs. Conversely, the inanimate nouns are somewhat less appropriate for filling the Undergoer role of volitional verbs than of experiencer verbs. These systematic differences in thematic fit across verb classes could potentially influence the results in unwanted ways. In particular, since the thematic fit between inanimate nouns and the Actor role is somewhat better for volitional verbs than for experiencer verbs, thematic fit might bias towards the subject-initial interpretation for volitional verbs to a greater extent than for experiencer verbs. This in turn might result in faster reading times at the verb but slower reading times at the post-verbal NP in sentences with volitional verbs versus sentences with experiencer verbs. This is because the thematic fit between the noun and the verb is more consistent with the baseline assumption of a subject-initial word order, making the verb less unexpected, but less consistent with the post-verbal pronominal NP that disambiguates towards the object-initial word order, rendering the post-verbal NP less expected.

Differences in thematic fit between verb classes were found to have a limited impact on the results, however. Analyses conducted on reading times in both the verb and the NP2 region did not differ in any significant ways depending on whether thematic fit was included as control predictor. In the adverbial region, however, reading times of volitional verb sentences were found to be significantly slower than reading times of experiencer verb sentences only when thematic fit was controlled for. This is further discussed in the next section.

Thematic fit did have a more general impact on reading times across all three regions, however. In subject-initial sentences, a high fit between the noun and the Undergoer role was found to predict somewhat faster reading times across all regions. Example 7.4 exemplifies a subject-initial sentence with either a high (Example 7.4a) or a low (Example 7.4b) fit between the noun and the Undergoer role.

(7.4) (a) Ni överlämnade paketet direkt till adressaten
    you delivered package directly to recipient.the
    ‘You delivered the package directly to the recipient’

(b) Jag tackar träningen för det bra resultatet
    i thank exercise.the for the good result
    ‘I thank the exercise for the good result’

In Example 7.4a, the noun ‘package’ is highly suitable for filling the Undergoer role of the verb ‘to deliver’, because packages are very commonly delivered. In Example 7.4b, on the other hand, the noun ‘exercise’ serves as a bad candidate for the Undergoer role of the verb ‘to thank’, because the act of thanking is prototypically directed towards other humans. That is, the thematic fit between the noun and the Undergoer role (or more specifically, the recipient role in this case) is high in sentences such as 7.4a but low in sentences such as 7.4b. This results in somewhat faster reading times in the former sentence types in comparison to the latter.

In object-initial sentences, on the other hand, a high fit between the noun and the Actor role was found to predict somewhat slower reading times. In Example 7.5, an object-initial sentence with either a high (Example 7.5a) or a low (Example 7.5b) fit between noun and Actor is exemplified.
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(7.5) (a) Filmen hyllar du för det fantastiska manuset

movie.the praise you for the fantastic manuscript.the

‘The movie you praise for the fantastic manuscript’

(b) Skadorna underskattade vi innan den första inspektionen

damages.the underestimated we before the first inspection.the

‘The damages we underestimated before the first inspection’

In Example 7.5a, the noun ‘movie’ can potentially fill the Actor role of the verb ‘to praise’, in the sense that a movie can be a tribute to someone or something. In Example 7.5b, on the other hand, the noun ‘damage’ cannot function as the Actor of the verb ‘underestimate’, which is an experiencer verb that requires an animate Actor argument. The thematic fit between the noun and the Actor role is therefore fairly high in sentences such as Example 7.5a, but low in sentences such as Example 7.5b. This is reflected in longer reading times in the former sentence types than in the latter. This is presumably because the semantic relationship between the initial NP and the verb is consistent with a subject-initial interpretation in the former sentences but not in the latter. The disambiguation towards the object-initial word order at the post-verbal NP is therefore more costly in the former than in the latter, as reflected by their difference in reading times.

These results are consistent with constraint-based theories of language processing, the previous results of, for instance, McRae et al. (1997, 1998) and, importantly, the general framework advocated in this dissertation. They indicate that the language comprehension system can rapidly utilize information regarding the fit between nouns and thematic roles during on-line comprehension. Subject-initial sentences are read somewhat faster when the fit between the post-verbal noun and the Undergoer role is high. This suggests that the on-line assignment of the post-verbal noun to the Undergoer role is somewhat faster when the noun is suitable for that role. Object-initial sentences, on the other hand, are read somewhat slower when the fit between the sentence-initial noun and the Actor role of the verb is high, and therefore speaks in favor of a subject-initial interpretation. The disambiguation towards the object-initial word order engendered by the post-verbal pronoun is therefore more costly, as indicated by the slower sentence reading times. In other words, the lexical-semantic relationship between the noun and the verb in sentences such as Example 7.5, and more specifically the appropriateness of the noun to fill the Actor role of the verb, can function as a cue to GF assignment that is utilized before the disambiguating post-verbal pronoun is encountered. This cue can either bias towards or against the object-initial interpretation, thereby making the disambiguating information more or less expected.

7.4.2. Influences of ambiguity on reading times

Since the objects in the critical sentences are lexical, object-initial sentences are morphosyntactically ambiguous with respect to grammatical function up until the presentation of the post-verbal NP. Since this NP is case marked, it provides unequivocal evidence for the object-initial word order and disambiguates the sentence towards that word order. In line with this, the incremental model predicts both small surprisal effects at the verb and large surprisal effects at the disambiguating post-verbal NP. These effects vary as a
function of the extent to which the verb class and the animacy of the initial NP provide evidence for the object-initial word order (see below). In the subject-initial sentences, on the other hand, unambiguous evidence for the subject-initial word order is provided directly at the initial NP. The incremental model therefore predicts little to no surprisal effects throughout the presentation of sentence constituents in the subject-initial sentences.

If differences in the predicted surprisal effects are reflected in differences in reading times, then reading times in object-initial sentences should be longer than in subject-initial sentences, at least at the post-verbal NP. Any differences in reading times due to differences in verb class or animacy should further be observed in object-initial sentences only. (All predicted reading time differences together with the actual results are summarized in Table 7.3 below for convenience.). The results of the experiment confirm these predictions by showing longer reading times in object-initial sentences than in subject-initial sentences, both at the Verb and the NP2 region. In the verb region, object-initial sentences are read more slowly than subject-initial sentences when the initial NP is inanimate and the verb is experiencer, and in the NP2 region, all object-initial sentences are read more slowly than subject-initial sentences. These results agrees with the predictions of the incremental model.

The finding that locally ambiguous object-initial sentences are read slower than unambiguous subject-initial sentences at and beyond the point of disambiguation is not surprising. As discussed in both Chapter 2 and 4, numerous studies have found processing costs at the point of disambiguation in structurally ambiguous sentences in comparison to unambiguous controls (such as in, e.g., relative clause ambiguities, see Clifton et al. 2003; F. Ferreira and Clifton 1986; Rayner, Carlson, and Frazier 1983, complement clause ambiguities, see, Osterhout et al. 1994; Pickering, Traxler, and Crocker 2000 and, as in the present study, grammatical function ambiguities, see Bader and Meng 1999; Bornkessel, McElree, et al. 2004; Casado et al. 2005; Demiral et al. 2008; Erdocia et al. 2009). This was also the case in the ERP experiment on grammatical function reanalysis presented in Chapter 4. Here, object-initial sentences with lexical objects and pronominal subjects such as in the present study were used to induce reanalysis toward the object-initial word order at the post-verbal subject. The reanalysis was found to engender an N400 effect, which is assumed to correlate with the remapping of the Actor and Undergoer roles to the argument NPs (Bornkessel & Schlesewsky 2006; Bornkessel-Schlesewsky & Schlesewsky 2008, 2009c; Haupt et al. 2008; Hörberg et al. 2013). The longer NP2 region reading times in object-initial sentences in comparison to subject-initial sentences presumably reflects processes of reanalysis, which, in the context of the incremental model, involve a revision of the probability for the object-initial word order.

The finding that reading times also are somewhat slower in the ambiguous region (i.e., at the verb region in experiencer verb sentences with an initial inanimate NP) is, however, somewhat more surprising in that it is inconsistent with previous results. Some studies have found that sentences with prepositional phrase ambiguities in fact are read faster in ambiguous regions in comparison to unambiguous controls (Traxler, Pickering, & Clifton 1998; van Gompel, Pickering, Pearson, & Liversedge 2005; van Gompel, Pickering, & Traxler 2001). Results such as these are consistent with surprisal theory, which predicts low processing costs of an ambiguous word when that word is consistent with several possible interpretations that ‘conspire to facilitate processing of [that word]’ (Levy 2008:1153). In
the incremental model, however, surprisal at the verb results from the fact that information provided at the verb speak against the baseline assumption of the subject-initial word order. Thus it is not the ambiguity *per se* that is assumed to cause processing difficulties, but rather the extent to which the probabilistic cues provided by the verb speak in favor of the object-initial word order (and therefore against the subject-initial interpretation). This is why the model predicts a significant surprisal effect at the verb only in experiencer verb sentences with an initial inanimate NP, in which the probabilistic cues provide sufficient support for the object-initial word order.

**Table 7.3.** Predicted and found reading time differences.

<table>
<thead>
<tr>
<th>Verb region</th>
<th>NP2 region</th>
<th>Adverbial region</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predicted differences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slower RTs in object-initial/Experiencer/Inanimate</td>
<td>Slower RTs in object-initial vs. subject-initial</td>
<td>Faster RTs in object-initial/Inanimate vs. object-initial/Animate</td>
</tr>
<tr>
<td></td>
<td>(Experiencer/Inanimate)</td>
<td>(subject-initial)</td>
</tr>
<tr>
<td></td>
<td>Stronger Animacy effect in object-initial/Volitional vs. object-initial/Experiencer</td>
<td>No differences</td>
</tr>
<tr>
<td>FASTER RTs in object-initial/Experiencer vs. object-initial/Volitional</td>
<td>Faster RTs in object-initial/Volitional/Inanimate vs. object-initial/Volitional/Animate</td>
<td></td>
</tr>
</tbody>
</table>

| Found differences | | |
|-------------------| | |
| Slower RTs in object-initial/Experiencer/Inanimate | Slower RTs in object-initial vs. subject-initial | Faster RTs in Experiencer vs. Volitional |
| | (Experiencer/Inanimate) | (subject-initial) | (Volitional) |
| | Stronger Animacy effect in object-initial/Volitional vs. object-initial/Experiencer |

### 7.4.3. Influences of Animacy and Verb class on reading times

Since animacy is one of the strongest prominence cues for predicting the word order of a transitive sentence, on par with case marking (see Chapter 5), animacy is expected to have a substantial impact on reading times, in line with the findings presented in Section 2.4. More specifically, the animacy of the initial NP in object-initial sentences is expected to function as a cue to GF assignment, in the sense of providing evidence for or against the object-initial interpretation. When the initial NP is inanimate, additional evidence for object-initial word order is provided already at the outset of the sentence, rendering the disambiguation towards the object-initial word order at the post-verbal NP less costly. In line with this, the incremental model predicts a substantial reduction in the surprisal effect associated with the disambiguation at the post-verbal NP when the initial NP is inanimate in comparison to animate.

However, animacy is also expected to interact with the semantic properties of the verb. In sentences with experiencer or volitional verbs, it is not semantically plausible for
7.4 Discussion

an initial inanimate NP to function as the subject. The co-occurrence of an inanimate initial NP and either an experiencer or a volitional verb therefore provides additional evidence for object-initial word order. Importantly though, experiencer verbs also differ from volitional verbs with regard to how they interact with the egophoricity of the NP arguments. As shown by Dahl (2000), subjects in experiencer verb sentences very frequently consist of speech act participants, and are therefore commonly egophoric. Allophoric NPs are therefore less likely to function as subjects in experiencer verb sentences. An initial allophoric NP that co-occurs with an experiencer verb should therefore serve as additional evidence for the object-initial word order, independent of whether that is provided by animacy. Since all initial NPs in the object-initial sentences are allophoric, the incremental model therefore predicts that experiencer verbs engender a small surprisal effect when the initial NP is also inanimate. This is because an experiencer verb provides additional evidence against the baseline assumption of a subject-initial word order, resulting in a small surprisal effect. At the post-verbal NP, on the other hand, the model instead predicts a reduction in the surprisal effect associated with disambiguation in experiencer verb sentences in comparison to volitional verb sentences. Here, the additional evidence for object-initial word order provided by the experiencer verb renders the disambiguating information of the post-verbal NP less unexpected.

In line with these model predictions, verb region reading times in object-initial sentences were expected to be slower in experiencer verb sentences when the initial NP is inanimate in comparison to when it is animate, but not in the corresponding volitional verb sentences. NP2 region reading times were conversely expected to be faster when the initial NP is inanimate in comparison to when it is animate. This animacy influence was also expected to be stronger in volitional verb sentences than in experiencer verb sentences. NP2 region reading times of object-initial sentences were finally expected to be faster with experiencer verbs than with volitional verbs (predicted results are summarized in Table 7.3 above.).

The experimental results confirmed most, but not all, of these predictions. Verb region reading times of object-initial sentences with experiencer verbs were slower when the initial NP was inanimate in comparison to when it is animate. This was not the case for the corresponding volitional verb sentences, as predicted. NP2 region reading times of object-initial sentences were faster when the initial NP was inanimate than when it was animate, but only in volitional verb sentences. In the corresponding Experiencer verb sentences, reading times did not significantly differ as a function of the animacy of the initial NP. These results are consistent with the prediction of stronger influence of NP1 animacy on NP2 reading times in volitional verb sentences than in experiencer verb sentences. They are not consistent with the prediction of a general reduction in NP2 reading times as a function of animacy, however. Also, NP2 reading times of object-initial sentences did not differ between experiencer verb and volitional verb sentences, contrary to the predictions. Reading times of experiencer verb sentences were instead found to be somewhat faster than reading times of volitional verb sentences in the adverbial region, following the final NP.

A possible explanation for this pattern of results is that the incremental model underestimates the effect of the verb class difference, in part because it is based upon written language data rather than spoken. In the present data set, about 42% of all subjects in
experiencer verb sentences are egophoric. In Dahl’s (2000) corpus of spoken data, however, as many as 82% of the subjects of experiencer verb sentences were egophoric. It is therefore likely that the weight attached to the co-occurrence of an allophoric initial NP and an experiencer verb as a cue for the object-initial interpretation is underestimated by the model in that it fails to reflect the ‘weight’ assigned to this cue by the language comprehenders in the experiment.

On this view, the animacy effect observed at the verb region in experiencer verb sentences is due to the surprisal of encountering a sentence-initial inanimate noun as well as an experiencer verb. Together, these information types provide rather compelling evidence for the object-initial word order, and therefore speak against the baseline assumption of a subject-initial word order. This is in line with the original predictions of the model. However, once the verb is encountered, the animacy of the initial NP is no longer taken into account. It is rather the low probability of an experiencer verb to co-occur with an allophoric Actor argument that is of importance. Because both the animate and inanimate initial NPs are lexical and therefore allophoric, the occurrence of the experiencer verb together with an initial allophoric NP provides additional support for the object-initial interpretation independently of the animacy of the initial NP. The probability for the object-initial word order is therefore about the same for experiencer verb sentences with animate and inanimate initial nouns, and is somewhat equal to the probability found in volitional verb sentences with initial inanimate nouns. The cost of disambiguation at the post-verbal pronoun in experiencer verb sentences with either animate or inanimate nouns is therefore equal to that in volitional verb sentences with inanimate nouns, but significantly lower than that of volitional verb sentences with animate nouns. This pattern is supported by NP2 region RT data. A simple effects analysis of NP2 region RTs found that NP2 RTs of experiencer verb sentences do not significantly differ from NP2 RTs of volitional verb sentences with an inanimate initial NP, neither when the initial NP is animate ($\beta = 4.74, t(2607.7) = 0.38, p = .7$) nor inanimate ($\beta = 12.53, t(2628.4) = 1.01, p = .31$). That is, experiencer verb sentences are read equally fast in the NP2 region as volitional verb sentences with an inanimate initial noun. This indicates that the cost of disambiguation at the post-verbal pronoun in experiencer verb sentences with either an animate or an inanimate noun is equal to that in volitional verb sentences with an inanimate noun.

At the sentence-final adverbial, finally, the somewhat faster reading times in experiencer verb sentences in comparison to volitional verb sentences could stem from the fact that the prominence information of the post-verbal NP provides additional support for the sentence word order, over and above all other information types (such as disambiguating information and animacy), in experiencer verb sentences in comparison to volitional verb sentences. This is because the egophoricity of the post-verbal NP is always consistent with the sentence word order: Whereas the post-verbal NP is always egophoric in object-initial sentences, it is always allophoric in subject-initial sentences. Since this information type has a much stronger influence in experiencer verb sentences than in volitional verb sentences, the evidence for the given word order at the post-verbal NP is always stronger in the former sentences than in the latter. In object-initial sentences, the probability for the object-initial word order at the post-verbal NP is significantly larger in experiencer verb sentences ($M = 0.987$) than in volitional verb sentences ($M = 0.92, t(30) = 3.27, p <$
In subject-initial sentences, the probability for the object-initial word order at the post-verbal NP is significantly smaller in experiencer verb sentences (M = 0.0023) than in volitional verb sentences (M = 0.0064, t(30) = -2.39, p < .05). The uncertainty regarding the sentence word order is therefore consistently somewhat greater in volitional verb sentences than in experiencer verb sentences at the post-verbal NP. This in turn might be reflected in somewhat longer reading times in the former sentences in comparison to the latter in the subsequent region.

The results are therefore at least qualitatively consistent with the model predictions and provide evidence for the following conclusions: Locally ambiguous transitive sentences that are disambiguated toward the object-initial word order are more costly to process at the position of the disambiguating information, in comparison to equivalent but unambiguous subject-initial sentences. The processing of a locally ambiguous transitive sentence can also be more costly at the verb if the prominence-based and verb-semantic information provides enough evidence against the subject-initial word order and instead speak in favor of an object-initial interpretation. This is the case when an initial inanimate and allophoric NP co-occurs with an experiencer verb. The cost of disambiguation can further be reduced when the prominence-based and verb semantic information is consistent with the disambiguating information, and therefore provides additional evidence for the sentence word order prior to disambiguation. In sentences with volitional verbs, disambiguation is therefore less costly when the initial NP is inanimate in comparison to when it is animate. In sentences with experiencer verbs, on the other hand, the cost of disambiguation is independent of the animacy of the initial NP. But it is in general equal to that of object-initial sentences with initial inanimate NPs, by virtue of the initial NP being allophoric.
8. Conclusions

In this dissertation, I have investigated grammatical functions in written transitive sentences in Swedish with respect to grammatical function assignment (GF assignment) during on-line comprehension, the distribution of NP argument prominence properties across grammatical functions in language use, and whether grammatical function assignment is influenced by the availability of prominence properties during on-line comprehension. The underlying idea of the dissertation is that both prominence-based and morphosyntactic information function as argument interpretation cues during the on-line comprehension of transitive sentences that are utilized in a probabilistic fashion. More specifically, it is based upon and tests the following hypotheses:

1. The on-line comprehension of grammatical functions involves the assignment of role-semantic functions to the NP arguments.

2. The encoding of grammatical functions in language use is influenced by a trade-off between the motivation to avoid redundant information and the motivation to provide unambiguous information regarding the argument functions.

3. Morphosyntactic and prominence-based information function as argument interpretation cues whose weightings, interplay and availability vary in systematic ways that are reflected in their distribution in language use.

4. Argument interpretation cues are utilized in an incremental and probabilistic fashion during on-line grammatical function assignment. The distribution of argument interpretation cues in language use therefore predicts processing difficulties in incremental grammatical function assignment.

In this chapter, I will discuss and draw some conclusions about these hypotheses on the basis of the empirical results of the studies. I will start by giving a recap of grammatical functions in the functional / typological perspective and the functional motivations for why prominence properties are used as argument interpretation cues (Section 8.1). I then discuss empirical evidence for the idea that GF assignment involves the assignment of role-semantic properties to the NP arguments found in the ERP experiment on grammatical function reanalysis (Section 8.2). I then go on to discuss the findings regarding the distributions of argument interpretation cues in written Swedish, with respect to the functional motivations for object-initial word order, but primarily in relation to the hypotheses that the encoding of grammatical functions is influenced by a motivation for avoiding ambiguities (Hypothesis 2) and that the distribution of argument interpretation cues is systematic such that they can potentially be utilized during GF assignment (i.e., to predict the sentence word order) (Hypothesis 3) (Section 8.3). I finally discuss the hypothesis that the distribution of argument interpretation cues can be used to make predictions.
regarding processing difficulties in incremental GF assignment and the empirical evidence for this hypothesis (Section 8.3). This discussion will be focused on the three models of incremental argument interpretation presented in this dissertation, and the empirical evidence for them (Section 8.4). I will also discuss the results of the study in relation to the functional and usage-based perspective of linguistics as well as to earlier empirical findings and theoretical accounts. I finally discuss some future directions to take that are suggested by the results of this dissertation (Section 8.6).

8.1. Grammatical functions in the typological perspective

In Chapter 2, I presented the view that grammatical functions are morphosyntactic encoding devices that align the S-, A- and P-arguments into sets (e.g., the \{SA\} alignment set) that are grammatically differentiated from each other (Bickel 2010). Alignment patterns vary widely across (and in some cases even within) languages and must ultimately be considered to be language-specific (Van Valin & LaPolla 1997:282-285). I also argued that grammatical functions either express the semantic roles of argument NPs (i.e., Actor and Undergoer), their discourse pragmatic status (e.g., topic or focus), or a combination of these two functions (Andrews 2007; Foley 2007). In syntactically accusative pivot languages such as English or Swedish, the S- and the A-arguments constitute an alignment set, that is, the subject, that is differentiated from the P-argument, the object. This alignment pattern is most likely a reflex of the fact that the role-semantic and discourse pragmatic functions of NP arguments in transitive sentences tend to be correlated with each other. Actors tend to be topical and therefore highly prominent in natural discourse. In prototypical, active transitive sentences, the subject argument therefore expresses the Actor participant, which is also the topical referent of the sentence. The grammatical encoding of the Actor therefore converges with that of the topic in the unmarked case. If, on the other hand, it is the Undergoer that is the topic, a marked construction such as passivization, topicalization or left dislocation (Foley 2007) must be used. The accusative alignment pattern can therefore be seen to be economically motivated: additional information regarding the information status of the participants in a transitive event only needs to be provided in less frequent cases where it is the Undergoer that is the topic rather than the Actor.

The functions that grammatical functions express correlate with prominence properties of the NP arguments in transitive sentences (e.g., Comrie 1989:128). Subjects are more frequently animate than objects, because Actors are often volitional, in control and/or sentient and therefore more commonly human or animate. Subjects are also more discourse prominent than objects in terms of definiteness, person and pronominality, because Actor participants are more frequently topical. These correlations are reflected both in the encoding of grammatical functions across languages and in the discourse distributions within individual languages. The morphological marking or syntactic behavior of NP arguments is in many languages influenced by whether one or both NP arguments are aprototypical in terms of some prominence property or set of properties, given their functions. Subjects are more frequently high in prominence than objects in unmarked transitive sentences in the discourse distribution of individual languages.
8.2. Evidence for the functional account of GF assignment

In Chapter 4, I presented an ERP study designed to test Hypothesis 1: that the on-line comprehension of grammatical functions involves the assignment of role-semantic functions to the NP arguments. This was done by investigating the neurophysiological response to grammatical function reanalysis in Swedish. More specifically, I contrasted this functional account of GF assignment with the structurally oriented account, according to which grammatical function assignment instead is primarily concerned with interpretation of the phrase structure of the sentence.

Importantly, these two views make different predictions regarding the processing mechanisms underlying grammatical function reanalysis. Grammatical function reanalysis involves a revision of a tentative assignment of grammatical functions to NP arguments during real-time incremental language comprehension (Haupt et al. 2008). In the structural account, grammatical function reanalysis is conceived as a reinterpretation of the syntactic structure of the sentence towards a dispreferred structural representation (e.g., de Vincenzi 1991; Frazier & Flores D’Arcais 1989). On this view, grammatical function reanalysis therefore does not qualitatively differ from other syntactic reanalyses. In more functionally oriented accounts such as that advocated in the eADM (Bornkessel-Schlesewsky & Schlesewsky 2009c) or the Competition model (MacWhinney & Bates 1989a) of language comprehension (see Section 2.4.3), grammatical function reanalysis is instead assumed to involve a revision of the mapping between thematic roles and argument NPs. On this view, grammatical function reanalysis is concerned with revision processes at the thematic level of language interpretation, rather than the syntactic, and is functionally distinct from other syntactic reanalyses.

A possible way of settling the question of whether grammatical function reanalysis is functionally distinct from other syntactic reanalyses in terms of involving a revision at the thematic rather than the syntactic level is by investigating the ERP response that is engendered by grammatical function reanalysis. Whereas disambiguation of syntactic ambiguities has been shown to engender a P600 effect (e.g., Osterhout et al. 1994), problems with the mapping of thematic roles to argument NPs have been found to engender an N400 response (Frenzel et al. 2011; Frisch & Schlesewsky 2005; Haupt et al. 2008). The structural account of grammatical function reanalysis therefore predicts a P600 effect and the functional account an N400 effect.

The ERP experiment in Chapter 4 investigated the ERP response to grammatical function reanalysis in Swedish and thereby whether the reanalysis processes involve a phrase structure revision, as suggested by the former account, or a thematic role remapping, in accordance with the latter. This was done on the basis of the comprehension of object-topicalized sentences with a lexical object and a pronominal subject (i.e., the OLex-V-SPro sentence condition, see Section 4.2.2 and Table 4.1 for an example). Such sentences are locally ambiguous with respect to the argument functions, but will initially be assumed to be subject-initial on the basis of the subject-first preference (see Sections 2.4 and 4.1.1). Upon encountering the post-verbal subject pronoun, however, this assumption needs to be revised, resulting in a grammatical function reanalysis. The post-verbal subject pronouns of the critical sentences were found to engender a locally distributed, right-lateralized N400 effect in comparison to the post-verbal NPs of unambiguous and
subject-initial control sentences. No significant differences were found in the P600 time window. These results therefore speak in favor of the view that grammatical function reanalysis is functionally distinct from other types of syntactic reanalyses and instead involves a revision of the mapping of thematic roles to the argument NPs, in line with the functional account of grammatical function reanalysis. This in turn provides evidence for the idea that the on-line comprehension of grammatical functions involves the assignment of role-semantic functions to NP arguments.

It should be pointed out that this experiment also provides some evidence for the view that GF assignment during on-line comprehension is a highly incremental process that initiates even before unambiguous information regarding the grammatical functions of the NP arguments has been provided (Hypothesis 3). The N400 reanalysis response indicates that participants initially committed to a subject-initial interpretation of the locally ambiguous sentences. This interpretation needed to be revised when the post-verbal pronoun disconfirmed this interpretation. Importantly, no reanalysis response was engendered in object-initial sentences with a pronominal object (i.e., OPro-V-SPro, see Table 4.1 for an example), in which unambiguous information regarding the sentence word order was provided directly by the initial NP on the basis of case marking. No reanalysis response was engendered in subject-initial sentences with a lexical subject either (i.e., SLex-V-OPro, see Table 4.1 for an example). These sentences were also locally ambiguous in the sense that the initial NP lacked case marking. However, in these sentences, the subject-initial interpretation is confirmed by the post-verbal pronoun, and no reanalysis is required.

It should be pointed out, finally, that the evidence for the functional account of grammatical function assignment provided by this ERP experiment to some extent hinges on the assumption that the P600 is engendered by syntactic reanalyses and the N400 by thematic (re-)interpretations. However, the P600 effect has been claimed to be identical to the P300 effect (Coulson, King, & Kutas 1998a; Coulson et al. 1998b), which is related to domain-general processes of ‘context-updating’ and is effected by unexpected stimuli, or stimuli which are expected and task-relevant. The P300 is, for example, engendered by predictable target items that are needed to perform an experimental task (such as, e.g., the classification of a sentence as ‘good’ or ‘bad’) (Roehm et al. 2007), or by stimuli that are infrequent in the experimental context (Coulson et al. 1998b). Other studies have further found that the P600 can be engendered by anomalies that have to be considered to be semantic and that stem from a conflict between semantic and syntactic information (i.e., semantic reversal anomalies, see, e.g., Bornkessel-Schlesewsky et al. 2011; Kim and Osterhout 2005; Kuperberg, Caplan, Sitnikova, Eddy, and Holcomb 2006; Kuperberg, Kreher, Sitnikova, Caplan, and Holcomb 2007; Kuperberg et al. 2003; van Herten, Chwilla, and Kolk 2006; van Herten, Kolk, and Chwilla 2005 and Bornkessel-Schlesewsky and Schlesewsky 2008 and Kuperberg 2007 for reviews). These findings make the interpretation of the P600 effect to only correlate with syntactic anomalies and ambiguities hard to maintain. The P600 engendered by semantic reversal anomalies has therefore been suggested to be a late, target-related P300 component that reflects processes of categorizing the sentence at hand as well- or ill-formed (Bornkessel-Schlesewsky et al. 2011; Frenzel et al. 2011). Recent evidence suggests that the P600, in fact, is a late P300 (Sassenhagen, Schlesewsky, & Bornkessel-Schlesewsky 2014). As such, it could either have been engendered
8.3 The distribution of prominence properties in language use

In Chapter 5, I presented a corpus study of the distribution of prominence properties and morphosyntactic properties in written Swedish discourse. It examined differences in the distribution of prominence features between object- and subject-initial sentences, with respect to the functions of the object-topicalized construction in Swedish. It also investigated whether unambiguous morphosyntactic information is used more frequently in potentially ambiguous sentences, thereby indicating that the encoding of grammatical functions is influenced by a motivation for avoiding ambiguities regarding the argument functions (Hypothesis 2). Primarily, however, the purpose of this study was to investigate to what extent prominence properties can be considered to function as cues to argument interpretation, in the sense of predicting the sentence word order (Hypothesis 3). I discuss the latter two issues first and then return to the first one.

8.3.1 Prominence properties in object-topicalized sentences

As discussed in, for instance, Section 2.1.2 and 8.1, the Actor of a transitive event is, in the unmarked case also highly discourse given and topical, and is therefore encoded as the subject of an active transitive sentence. A marked construction such as a passive, a topicalization, scrambling or left dislocation construction is often used in cases when, on the other hand, the Undergoer outranks the Actor in terms of discourse prominence (Foley 2007). This is in some sense the function of these constructions: they are used to signal that the pragmatic functions of sentence arguments are marked in some way. As discussed in Section 2.2.3, several studies of differences in the distribution of discourse prominence features in different constructions in language use provide evidence for this view. For instance, English passives are used more frequently when the Undergoer out-

by target-predictability in the experimental context, by the relative infrequency of the critical items in comparison to their controls, or a combination of the two. However, even if findings such as these make the evidence provided by the ERP study somewhat weaker, they do not invalidate them completely. There is recent evidence for the view that the N400 is engendered by problems of assigning thematic roles in terms of competition for the Actor role (Frenzel et al. 2011). Recent intriguing findings indicate further that the Actor category is a multi-faceted concept that varies in several semantic dimensions relevant for actorhood potential, and that the N400 amplitude is modulated with respect to the extent that individual nouns are high in actorhood potential (Frenzel et al. 2015). Thus it is clear that the N400 is engendered by problems of assigning thematic roles. The fact that grammatical function reanalysis in the ERP experiment engendered an N400 effect therefore provides positive support for the view that the reanalysis involved a remapping of thematic roles. The absence of the P600 effect indicates that the critical post-verbal NPs did not function as predictable target items in the experiment that allowed for the sentences to be classified as good or bad (which also was the intention of the experimental design, see Section 4.2.2). Its absence does not necessarily entail, however, that the reanalysis did not also involve a revision of the syntactic structure.
ranks the Actor on the person and referentiality hierarchies (e.g., Dingare 2001; Estival & Myhill 1988; Svartvik 1966). In German and Dutch, the ordering of subjects and objects in the middlefield are more frequently scrambled when the latter outranks the former in prominence (Bouma 2008; Kempen & Harbusch 2004). Studies in several languages have further shown that objects are more frequently placed in sentence-initial position when they are highly discourse prominent or when they outrank the subject in discourse prominence (Bouma 2008; Snider & Zaenen 2006; Øvrelid 2004; Weber & Müller 2004). Similar results were found in the present corpus study: Objects were more frequently given, definite and pronominal when positioned in the initial position. In cases where an initial object instead is low in discourse prominence, it appears to either to function as a sentence topic which has not been recently mentioned in the previous discourse (as in Example 5.5) or to express contrastive focus (as in Example 5.6), in line with the functional motivations of the object-initial word order proposed in SAG (Teleman et al. 1999:4:431-432). Post-verbal subjects in object-topicalized constructions were also found to consist more frequently of personal pronouns in comparison to when they occur sentence-initially. Bouma (2008) made a similar finding in his corpus study of Dutch. I assume that this reflects a preference for using the object-initial construction when the remainder of the sentence following the initial object is predictable, as suggested in the SAG (Teleman et al. 1999:4:432). But in particular, this seems to reflect a preference for the object-topicalized construction when the final subject is a case-marked pronoun, and thereby provides unambiguous information regarding the argument functions.

8.3.2. Ambiguity avoidance

Writers therefore seem to more frequently use potentially ambiguous object topicalization constructions in cases where the subject referent can be encoded with a case marked and therefore unambiguous NP. In other words, they seem to be inclined towards avoiding ambiguous structures in order to accommodate the understanding of their recipients (see Section 2.3.1, and, for instance, MacDonald 2013). Rahkonen (2006) found that OVS sentences are somewhat more frequently case marked than SVO sentences and that case marking is somewhat more common in semantically ambiguous / reversible OVS sentences (such as Example 8.1a, repeated from Chapter 3) than in semantically unambiguous / irreversible OVS sentences (such as Example 8.1b, repeated from Chapter 3).

(8.1) (a) Den stora björnen såg bilisten inte
   the big beer.the saw driver.the not
   ‘The driver did not see the big bear’

(b) Det såg bilisten inte
   it saw driver.the not
   ‘The driver did not see it’

In other words, writers use case marking to a greater extent in potentially ambiguous sentences. This is expected if they are inclined to balance their production efforts by avoiding redundant information in order to reduce production and processing costs, while at the same time providing unambiguous information in order to facilitate comprehension.
8.3 The distribution of prominence properties in language use

(i.e., the ambiguity avoidance hypothesis, see Section 2.3.1, and, for instance, MacDonald 2013). As mentioned in Section 5.1, however, there are several language production studies that have failed to find any evidence for the ambiguity avoidance hypothesis (see, e.g. Arnold et al. 2004; V. S. Ferreira and Dell 2000; Jaeger 2006, 2010; Roland et al. 2006, and V. S. Ferreira 2008 for a review). There is also evidence that suggests that sentence-level ambiguities that are resolvable in context can be beneficial for communication (Plantadosi et al. 2012).

With these conflicting findings in mind, I specifically tested the ambiguity avoidance hypothesis in this study, by investigating whether writers more frequently use disambiguating information in potentially ambiguous transitive sentences, in a manner similar to Rahkonen (2006). The results were in line with the findings of Rahkonen (2006) and therefore spoke in favor of the ambiguity avoidance hypothesis (see Section 5.3.3). Both case marking and auxiliary verbs were used more often in OVS sentences than in SVO sentences. These formal markers also occurred more frequently in semantically reversible sentences than in semantically irreversible sentences. The propensity for using formal markers given the sentence word order and whether it is semantically ambiguous or not was investigated using logistic mixed effects modeling. The model found a significant influence of both word order and semantic reversibility on the probability of formal marking. Formal markers were about 2.15 times more likely in object- in comparison to subject-initial sentences, and about 3.5 times more likely in semantically reversible sentences than in semantically irreversible ones. The model made very good predictions regarding the probability for a given sentence to be formally marked, as illustrated in Figure 5.1. These results therefore provide evidence for the idea that writers indeed tailor their productions in order to avoid redundancies and ambiguities.

These results are in line with the finding of the present and other studies that the animacy difference between subjects and objects is more pronounced in object-initial sentences, thereby providing additional information regarding the argument functions in cases where they cannot be inferred on the basis of word order (see Section 2.3.1 and Bader and Häussler 2010; Bouma 2008; Snider and Zaenen 2006; Øvrelid 2004). They are also in line with the findings of Kurumada and Jaeger (2015). They found Japanese speakers to be more prone to using overt object case marking in sentences where the function of the object argument was harder to infer on the basis of animacy or plausibility information (see Section 2.3.1).

8.3.3. Prominence properties as argument interpretation cues

The main purpose of the corpus study in Chapter 5 was to determine how prominence-based and verb-semantic information is distributed across subjects and objects in language use, and further, whether and to what extent these information types can be used as cues in order to predict the sentence word order (Hypothesis 3). To this end, the study investigated the distribution of a number of semantic and discourse prominence properties, namely givenness, animacy, definiteness, number, egophoricity, pronominality and case marking / person of the NPs in transitive sentences. Since the distribution of prominence features will to some extent depend on the Actor and Undergoer entailments assigned by the verb (see Section 5.2.4 and Dowty 1991; Primus 2006), the distribution of verb
semantic categories (i.e., volitionality, sentience, causation and possession, see Table 5.4) and their interactions with NP prominence properties was also investigated. For example, verbs that entail volitionality and/or sentence (e.g., action or mental state main verbs) require an animate Actor argument, which is very commonly egophoric (see Section 5.2.3 and Dahl 2000, 2008). The semantics of the verb in transitive sentences is therefore likely to function as a cue to argument interpretation, at least in conjunction with some or several argument prominence properties. As far as I am aware, this corpus study is the first to investigate the interplay between prominence features and verb semantic categories in this manner, and it therefore provides a novel contribution to the field.

In general, the results of the study show that subjects tend to be more prominent than objects in terms of givenness, animacy, definiteness, egophoricity and pronominality. These results confirm the results of the studies presented in Section 2.2.2, which have found that subjects are more prominent than objects in terms of animacy (Bouma 2008; Dahl 2000; Dahl & Fraurud 1996; Kempen & Harbusch 2004; Øvrelid 2004), definiteness (Bouma 2008; Øvrelid 2004), and pronominality / givenness (e.g., Dahl 2000; Du Bois 1987; Kumagai 2006).

The strength by which prominence features, verb semantic features and their interactions predict the sentence word order was further investigated on the basis of mixed effects logistic regression modeling, which estimates the change in the odds for object-initial word order as a function of prominence features. The model results found that the odds for object-initial word order significantly increase when the initial NP is low in prominence (in terms of animacy, definiteness and case marking), or when the final NP argument is high in prominence (with respect to givenness, animacy, definiteness, number, egophoricity and referentiality). These results show that the distribution of individual prominence features in natural discourse is unevenly balanced between subjects and objects even when confounding factors are controlled for. Prominence features can therefore potentially be used as reliable cues to the argument functions during GF assignment.

The results of the model showed that in particular it is the interplay between verb semantic categories and prominence features of the NPs that is of the greatest importance. The increase in the odds for the object-initial word order associated with either an inanimate initial NP or an animate final NP was much higher in sentences with volitional and causative verbs. In other words, the animacy cue functions as a very strong predictor of the sentence word order in sentences with volitional or causative verbs. Given that these verbs in most cases require an Actor participant that is human or animate, these results are hardly surprising. Their co-occurrence with an initial inanimate NP is highly predictive of the object-initial word order, and their co-occurrence with a final inanimate argument is predictive of the subject-initial word order.

The influence of case marking / person of the initial NP was also found to be extra strong in sentences with experiencer verbs. The odds for object-initial word order was substantially increased when the initial NP is unmarked and the verb at hand is an experiencer verb. Since experiencer verbs require the Actor participant to be sentient, Actors of experiencer verbs need to be animate. Actors of experiencer verb sentences can therefore be expected to very frequently be realized as personal pronouns (which are ‘on top of’ the extended animacy hierarchy; see, e.g., Silverstein 1976). In fact, as mentioned in Section 2.2.2, experiencer verbs very frequently occur with subjects that are realized as 1st
or 2nd person pronouns (Dahl 2000). Since experiencer verbs frequently express private knowledge and subjective experiences, they are more likely to be used from the perspective of the speaker (Dahl 2000) or the protagonist of written narratives (see Section 5.5.3 and Ricoeur and McLaughlin 1985:89), and therefore more frequently occur with subjects that are personal pronouns.

The influence of definiteness and givenness was finally found to be somewhat stronger in sentences with possessive verbs. The increase in the odds for object-initial word order associated with NP1 indefiniteness, on the one hand, and NP2 givenness, on the other, was stronger in possessive verb sentences and therefore functions as a marker of a topic shift. In other words, discourse prominence is of extra importance in predicting the sentence word order in sentences with possessive verbs. These results were unexpected. My suggestion for this finding is that possessive constructions in some cases can be used to introduce a new discourse topic, thereby functioning as a ‘topic shift’ (James 1995) construction. The topical object NP of such constructions would be low in discourse prominence, but positioned in sentence-initial position in order to emphasize its topic function. The final subject, on the other hand, would be highly discourse prominent in order to serve as a reference point or a ‘ground’ for the introduction of the new topic. Such a sentence was exemplified in Example 5.8. Some indirect evidence for this account comes from a study by Qian and Jaeger (2011). They found the information content of full sentences, that is, the in-context predictability of whole sentences, to be negatively correlated with the strength of the topic shift in sentences, as estimated on the basis of topic modeling. In other words, speakers appear to avoid unpredictable information in sentences with new topics, in order to keep the level of information flow as constant as possible throughout the continuation of the sentence (Jaeger 2010; Shannon 1948). These findings provide a functional motivation for the topic shift possessive construction: they are used to introduce new and therefore ‘informationally heavy’ topics using a sentence that in all other respects is informationally light: it contains a highly discourse-prominent and therefore highly predictable final subject (i.e., the ‘ground’) together with an ‘informationally light’ verb such as possessive ‘ha’ (‘have’).

All in all, these results indicate that although individual prominence features by themselves may serve as reliable cues in predicting the sentence word order, it is their interaction with verb semantic features that is by far of the greatest importance. For example, the increase in the odds for object-initial word order associated with an animate final argument is more than eight times higher when the sentence verb is also volitional. These findings might be unsurprising but are nonetheless highly novel. As far as I know, this is the first quantitative study of the interplay between prominence features and verb semantic categories. It should be stressed, finally, that the strong relationships between prominence features and verb semantic features observed here are most likely reflexes of verb specific selectional restrictions (e.g., Carnie 2001). That is, individual verbs set up verb specific semantic restrictions on their arguments (e.g., ‘eat’ requires an animate Actor with a mouth). Verb semantic entailments such as volitionality and sentience are generalizations over related classes of verbs (see, e.g., Van Valin 2005:66), but it is likely that more fine-grained semantic relationships between nouns and verbs can be utilized as cues during argument interpretation.
8.4. Probabilistic and prominence-driven incremental argument interpretation

The results of the corpus study discussed in the previous section provide evidence for the hypothesis that the distribution of prominence-based and verb-semantic information across grammatical functions is systematic and therefore can predict the sentence word order, that is, the argument functions (Hypothesis 3). Whether these information types and their interactions are utilized as probabilistic cues to grammatical functions and therefore can predict processing difficulties during on-line GF assignment (Hypothesis 4) was further investigated in the following two steps. The first step involved establishing a way of deriving predictions regarding processing difficulties during on-line GF assignment that takes the weighting and interaction between probabilistic cues into account. The three models of incremental argument interpretation presented in Chapter 6 serve this purpose: These models make predictions regarding overall change in the processing difficulty during incremental GF assignment, as predicted on the basis of the corpus distributions of argument interpretation cues. In the second step, these predictions were tested empirically. This was done in the self-paced reading experiment of the comprehension of transitive sentences presented in Chapter 7. In the following section, I start out by discussing the model specifications and their predictions. In Section 8.4.2, I then discuss the results of the self-paced reading experiment.

8.4.1. Incremental argument interpretation models

In the three incremental models (the Random Noise (RN) model, the Penalized Regression (PN) model, and the Categorical Disambiguation (CD) model), the change in processing difficulty during incremental GF assignment is assumed to depend on the change in the expectedness of a particular GF assignment, or, in other words, on the change in the expectedness of a particular word order (subject- or object-initial). The models estimate the on-line change in the expectation of an object-initial word order on the basis of surprisal (Hale 2001; Levy 2008, 2013). Surprisal is quantified as the relative entropy between the probability for the object-initial word order given the features of the constituents available at time \( t_i \) with respect to the probability given the features of the constituents presented at time \( t_{i-1} \). As such, each time point corresponds to the subsequent presentation of the three constituents NP1, the predicate, and NP2, whose orderings can vary depending on the sentence type (e.g., whether it is subject-, object- or adverbial-initial, see Section 6.2.2 and Table 6.1). The probabilities for the object-initial word order associated with the constituents presented at each time point are estimated on the basis of mixed effects or fixed effects-only logistic regression models. For example, the probability for the object-initial word order at time point \( t_2 \) in SVO sentences was estimated by regression models that used all features of NP1, the verb and their interactions as predictors (see Table 5.10 for an overview of all the predictors included in the full regression models).

The three models primarily differ with respect to their treatment of disambiguating information. In the RN and the PR models, disambiguating information is assumed to be processed and integrated in exactly the same manner as other probabilistic cues such as animacy or definiteness during GF assignment: The disambiguating information is in-
8.4 Probabilistic and prominence-driven incremental argument interpretation

cluded in the underlying regression models upon which probability estimation is done, and is therefore treated in the same way as prominence features and verb semantic features. These two models differ with respect to how the regression modeling was implemented. The RN model uses mixed effects logistic regression modeling with random noise in the data for the disambiguating predictors, and the PR model uses penalized logistic regression. In the CD model, disambiguating information is instead treated as categorical, and assumed to be distinct from and take precedence over probabilistic information. This is implemented by associating the disambiguating information with a probability close to 0 in subject-initial sentences and 1 in object-initial sentences. The surprisal effect of the disambiguating constituent is then determined with respect to this probability, adjusted for the extent to which the probabilistic cues of the disambiguating constituent bias towards the disambiguating information\(^1\). The surprisal effects of constituents presented after the point of disambiguation are determined by the extent to which they bias against the disambiguating information\(^2\). Figure 6.6 graphically illustrates how the surprisal effect at and beyond disambiguation takes place in the CD model.

Model performance was evaluated on locally ambiguous SVO and OVS sentences that were disambiguated towards OVS or SVO by the final NP, on the one hand, as well as unambiguous SVO and OVS sentences, disambiguated directly on the initial NP argument, on the other.

In the locally ambiguous sentences, all three models make more or less similar predictions. Given that the three models differ primarily with respect to their treatment of disambiguating information at and after the point of disambiguation, this is to be expected. In these sentences, the models make the same predictions in OVS and SVO sentences up until the presentation of the disambiguating final NP. The models predict surprisal effects at NP1 when it is either inanimate or text deictic, as well as a small effect when it is indefinite. At the verb, small surprisal effects are engendered when the verb at hand is either experiencer and volitional, and also when the initial NP is inanimate and the verb is either volitional or causative. When the final NP disambiguates the sentence towards OVS, all three models predict a large surprisal effect due to the disambiguation towards the highly unexpected object-initial word order. This surprisal effect is mitigated when the NP1 prominence features and the verb semantic features of the previous constituents speak in favor of the object-initial interpretation. Conversely, When the final NP disambiguates towards the expected subject-initial word order, small surprisal effects are instead engendered when the features of the previous constituents bias towards the object-initial interpretation.

Overall, the predicted surprisal effects found in locally ambiguous sentences correspond with the effects found in the corpus study. Animacy has by far the strongest influence on the surprisal effect, and this is especially the case in sentences with volitional or causative verbs. The influence of the co-occurrence of an unmarked / non-person initial NP and an experiencer verb is also particularly strong\(^3\). All three models seem to make the kind of predictions that one would expect in locally ambiguous sentences. Surprisal

\(^1\)As determined by the difference in the probability between the disambiguating and the previous constituent.

\(^2\)As determined by the difference in the probability between the present and the previous constituent.

\(^3\)Which manifests itself as a ‘main effect’ of the verb class in these sentences.
effects are engendered by the extent to which the prominence information available at a given time point speaks against the evidence for the subject-initial word order at the previous time point.

In unambiguous subject-initial sentences, the models predict little to no surprisal effects whatsoever, both at and beyond the point of disambiguation. This is also expected since the subject-first preference is confirmed directly at the initial NP in these sentences, and the influence of any upcoming information is not strong enough to invalidate this.

In some cases, the three models did predict very different effects, however, reflecting the fact that the models differ from each other in important ways. Whereas the RN and PR models predict a large reduction in surprisal when NP2 is low in prominence in these sentences, the CD model predicts a small reduction when NP2 is high in prominence (see Figure 6.13). These different predictions reflect the two different conceptions of disambiguating information assumed by the RN and PR models in comparison to the CD model. In the RN and PR models, disambiguating information is treated in the same way as all other probabilistic cues. It is therefore assumed to be processed and integrated in exactly the same manner as the probabilistic cues during GF assignment. The probability for the object-initial word order at the point of disambiguation is, accordingly, determined by the sum of the weights of both the probabilistic and the disambiguating cues. The probability for the object-initial word order is therefore reduced when NP2 is low in prominence in comparison to when it is high. It is therefore closer to the probability at the verb, resulting in a reduced surprisal effect. The RN and the PR models therefore predict lower processing costs when NP2 is low in prominence in comparison to when it is high. This also entails greater uncertainty regarding the sentence word order at NP2, which has been shown to incur processing, over and above surprisal (Linzen & Jaeger 2014, 2015).

In the CD model, conversely, disambiguating information is instead assumed to be categorical and temporarily precede the processing of probabilistic cues. The disambiguating information can be seen as re-setting the baseline probability either close to 1 or to 0. The surprisal effect is then determined by the extent to which the probabilistic cues of the disambiguating constituent speak against the disambiguating information with respect to the probabilistic cues available at the previous constituent, as determined by the difference in the probability at the disambiguating and previous constituent. There is therefore a small increase in NP2 surprisal as NP2 prominence is reduced, thereby speaking against the disambiguating information. The CD model therefore instead predicts somewhat higher processing costs when NP2 is low in prominence in comparison to when it is high.

The difference between the three models is also reflected in differences in their predictions in unambiguous object-initial sentences. Here, the RN model predicts no surprisal effects at the initial NP, followed by a small surprisal effect engendered by experiencer verbs due to their additional support for the object-initial word order, and, finally, in some cases a moderate to high surprisal effect engendered by the final NP when it is high in prominence. The PR model, on the other hand, predicts moderate surprisal effects at the initial NP, no surprisal effect at the verb, and small surprisal effects at the final NP.

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4 Which is very high at the initial constituent due to the subject-first preference, i.e., a low baseline assumption for the object-initial word order, and changes as function of the evidence for the object-initial word order at the subsequent constituents.
consistently when it is low in prominence. The CD model, finally, predicts high surprisal effects at the initial NP and little to no surprisal effects at the subsequent constituents. The difference between the RN and PR models, on the one hand, and the CD model, on the other, once again stems from their different treatment of disambiguating information. The CD model treats disambiguating information as categorical in the sense of assuming a probability close to 1. The surprisal effect in the unambiguous region is then determined by the extent to which the difference in the probability for the object-initial word order between the present and previous constituents bias against the disambiguating information. However, since the CD model hardly predicts any surprisal effects in the unambiguous region, this method seems to be inadequate. As mentioned in Sections 2.4.1 and 6.4, several studies have found that an unambiguous subject in an object-initial sentence is more costly to process when inanimate (and therefore low in prominence) than when animate (and therefore high in prominence) (Bornkessel-Schlesewsky & Schlesewsky 2009c; Philipp et al. 2008; Roehm et al. 2004; Weckerly & Kutas 1999). An animacy-induced surprisal effect should therefore be expected at the final subject in unambiguous object-initial sentences. This suggests that the predictions of the CD model are wrong.

The difference between the RN and the PR model, on the other hand, depends on a difference in their ability to accurately estimate the influence of the disambiguating information of the initial NP. In particular, the RN model severely underestimates the probability for the object-initial word order at the initial NP. From this perspective, the PR model therefore seems to be the model that makes the most accurate predictions in unambiguous, object-initial sentences: Overall, it predicts small surprisal effects at the final NP when the final NP is low in prominence, and therefore speaks against the disambiguating information of the initial NP, as expected.

Although the incremental models are capable of predicting processing difficulties for transitive sentences of a number of different syntactic configurations (i.e., NP- versus adverbial-initial, with or without auxiliary verbs, and with or without sentential adverbials), they are very limited in their ability to predict processing difficulties during actual language processing. In particular, they do not take into account the effects of the discourse context, which most likely will be of massive importance for the processes underlying GF assignment. As a case in point, all three models predict rather high surprisal effects for initial NPs that are text deictic (as in Example 3.6). Out of context, such anaphoric NPs might very well be surprising: there is no antecedent that they can refer to. In context, however, the antecedents of text deictic anaphoras are presumably highly discourse prominent, in most cases being introduced in the previous sentence. They can therefore be expected to be highly predictable in their discourse contexts. It is therefore important to stress that the incremental models are not meant to generate predictions regarding processing difficulties of language comprehension in actual discourse. They are only intended to model processing difficulties in the GF assignment in transitive sentences presented in isolation. Their purpose is to test the hypothesis that the distribution of argument interpretation cues in corpora can be used to derive predictions regarding processing difficulties in incremental GF assignment (Hypothesis 4).

It should finally be pointed out that the incremental models bear some resemblance to the computational model proposed by Alday et al. (2014) (see Section 2.4.3). In their model, the competition for the Actor role between the NP arguments in German SVO sen-
sentences was estimated as either the unweighted or the weighed summed distance between the prominence features of the two NP arguments, in terms of animacy, person, number, case marking and position. Language specific weightings of the prominence cues were not determined on the actual distributions in language use, however, but instead on the relative ranking of the cues found in Kempe and McWhinney (1999). Both of their measures of competition correlated significantly with the N400 amplitude engendered by the disambiguating NP in locally ambiguous transitive sentences: the degree of competition predicted the N400 amplitude. The incremental models presented in this dissertation expand on Alday and colleagues’ model in several important ways: 1) The language-specific weightings of cue strengths are empirically determined on the basis of their distributions in naturally occurring discourse. 2) They apply to transitive sentences with a number of different structural and morphological configurations. 3) They account for the incremental change in the processing difficulty of GF assignment during the presentation of sentence constituents over time. 4) They are able to model predicted processing difficulties after the presentation of disambiguating information. 5) They take a greater amount of prominence and morphosyntactic information into account. 6) They are grounded in a well established probabilistic model of incremental language comprehension (Hale 2001; Levy 2008), whose predictions have been confirmed in a number of studies (Boston et al. 2008; Linzen & Jaeger 2014; Smith & Levy 2013). 7) Perhaps most importantly, they account for verb-specific entailments, as proposed by Primus (2006), and their interactions with prominence-based features of the NP arguments.

8.4.2. Empirical evidence for the model predictions

The self-paced reading experiment presented in Chapter 7 was conducted in order to test some of the most prominent predictions of the incremental models. To this end, participants read transitive sentences with a pronominal subject and a lexical object. These sentences varied with respect to word order (object- vs. subject-initial), verb class (volitional verb vs. experiencer) and object animacy (inanimate vs. animate). The object-initial sentences were locally ambiguous with respect to grammatical function up until the presentation of the post-verbal subject. The subject-initial sentences, on the other hand, were disambiguated directly by the initial subject NP. The PR model predicted significantly faster reading times in the unambiguous subject-initial sentences than in object-initial sentences. In experiencer verb sentences only, the model also predicted slower reading times in the verb region when the initial NP was inanimate in comparison to when it was animate. In the NP2 region, on the other hand, reading times were expected to be faster when the initial NP was inanimate versus animate in all sentence types. This animacy influence was also expected to be stronger in volitional verb sentences in comparison to experiencer verb sentences. NP2 region reading times were finally expected to be faster for object-initial sentences with experiencer verbs than object-initial sentences with volitional verbs (see Table 7.3 for a summary of the predicted results.).

Most, but not all, of these predictions were confirmed. Reading times were faster in the subject-initial sentences in comparison to the object-initial sentences. Verb region reading times in object-initial sentences were significantly slower when the initial NP was inanimate in comparison to when it was animate, but only in sentences with experiencer verbs. NP2
reading times of object-initial sentences were faster when the initial NP was inanimate versus animate, but only in volitional verb sentences. In the corresponding experiencer verb sentences, NP2 reading times did not significantly differ as a function of the animacy of the initial NP. They were, however, equally as fast as those of volitional verb sentences with an inanimate initial noun. These results are consistent with the prediction that the influence of NP1 animacy on NP2 reading times should be stronger in sentences with volitional verbs than in sentences with experiencer verbs. They are not consistent with the prediction of a general reduction in NP2 reading times as a function of animacy, however. Also, NP2 reading times of object-initial sentences did not differ between experiencer verb and volitional verb sentences, contrary to the predictions. Reading times of experiencer verb sentences were instead found to be somewhat faster than reading times of volitional verb sentences in the Adverbial region, following the final NP.

These results can, however, be expected if the effect of encountering an experiencer verb is stronger than predicted by the PR model. Given that experiencer verbs much more frequently co-occur with egophoric NPs in spoken language than in written (see Dahl 2000), this scenario is in fact quite likely. Since the models are based upon written data only, they might underestimate the influence of egophoric initial NPs in experiencer verb sentences. The reduction in verb region reading times in experiencer verb sentences with an initial inanimate NP is on this account due to the combined effect of encountering a sentence-initial inanimate noun as well as an experiencer verb. The combination of these information types provide rather strong evidence for the object-initial word order, and is therefore surprising. At the final NP, the disambiguation toward the object-initial word order is instead generally less costly in experiencer verb sentences, because this word order is expected already at the verb. In line with this account, NP2 reading times in experiencer verb sentences were found to be equally as fast as in the corresponding volitional verb sentences with inanimate NPs. The cost of disambiguation in experiencer verb sentences therefore seems to be significantly reduced, independently of the animacy of the initial NP, and to be equal to that of volitional verb sentences with an initial inanimate NP, in which the co-occurrence of the inanimate NP and the volitional verb renders the object-initial word order highly expected. In experiencer verb sentences, it is instead the co-occurrence of an experiencer verb together with an initial allocophoric NP that provides additional support for the object-initial interpretation, independent of the animacy of the initial NP, thereby reducing the cost of disambiguation.

The somewhat faster adverbial region reading times in experiencer verb sentences in comparison to volitional verb sentences, finally, seem to depend on the interaction between the experiencer verb class and NP2 egophoricity. The influence of NP2 egophoricity is therefore always stronger in sentences with experiencer verbs than in sentences with volitional verbs. This renders the evidence for the given word order at NP2 consistently somewhat stronger in experiencer verb sentences than in volitional verb sentences (see Section 7.4.3 for further details). Reading times can therefore be expected to be somewhat faster in the region following NP2 in experiencer verb sentences in comparison to volitional verb sentences.

All in all, the results of the SPR experiment are at least qualitatively consistent with the predictions of the SPR model, and confirm most but not all of them. They do seem to suggest that the incremental model underestimates the importance of egophoricity as
Chapter 8. Conclusions

8.4.1. Cues to GF assignment in experiencer verb sentences.

An important point is that the experimental results qualitatively confirm the model predictions regarding the interactions between animacy and volitionality, on the one hand, and egophoricity and sentience, on the other. The findings of an influence of ambiguity and animacy on reading times confirm a multitude of previous experimental results. As discussed in Sections 2.4.1 and 4.1.1, plenty of studies have shown that incremental argument interpretation is influenced by both animacy (e.g., Frenzel et al. 2011; Mak et al. 2006; Trueswell et al. 1994; Wegerly & Kutas 1999) and ambiguity (e.g., Bornkessel, McElree, et al. 2004; de Vincenzi 1991; Frazier & Flores D’Arcais 1989; Haupt et al. 2008; Matzke et al. 2002). The reading time patterns related to the interaction between animacy and volitionality, on the one hand, and egophoricity and sentience, on the other, are not, however, expected on the basis of previous experimental results. Predictions regarding these reading time patterns are instead rather specific for the incremental models. The finding that the experimental results confirm the model predictions regarding the interactions between animacy and egophoricity, on the one hand, and volitionality and sentience, on the other, therefore provide rather compelling evidence for 1) the hypothesis that the distribution of argument interpretation cues in corpora can be used to derive predictions regarding processing difficulties (Hypothesis 4), and 2) the hypothesis that argument interpretation cues function as cues during GF assignment that are utilized in a highly incremental and probabilistic fashion (Hypothesis 3).

8.5. Concluding remarks

In this dissertation, I have provided some evidence for the idea that the comprehension of grammatical functions in transitive sentences involves the assignment of role-semantic functions to the NP arguments. I have also shown that overt morphosyntactic information regarding the argument functions is to some extent used more frequently in potentially ambiguous sentences. This indicates that the use of morphosyntactic information about argument functions, that is, the encoding of grammatical functions in language use, is to some extent influenced by a motivation for avoiding argument function ambiguities. I have also shown that the distribution of morphosyntactic and prominence-based information across subjects and objects in transitive sentences is systematic and can be used to predict the sentence word order with a high degree of confidence. I have provided evidence for the idea that both prominence-based and verb-semantic information serve as cues to grammatical functions during the comprehension of transitive sentences, and that the weightings and interplay between these cues is probabilistically dependent on their distribution in transitive sentences in natural discourse. In particular, I have shown that the distribution of both morphosyntactic, prominence-based and verb-semantic features can be used to make predictions regarding processing difficulties during on-line grammatical function assignment, and that some of the most prominent of these predictions are qualitatively consistent with processing difficulties that arise during the on-line comprehension of transitive sentences.

These findings indicate that the interplay and availability of morphosyntactic and prominence-based cues to some extent is functionally motivated. Overt morphosyntactic information is used more frequently in cases where the argument functions cannot be de-
8.5 Concluding remarks

termined on the basis of prominence-based and verb semantic information, but is, on the other hand, used less frequently when these functions can be determined by prominence information and are therefore redundant. Importantly, these patterns also emerge in the variation in the encoding of grammatical functions across languages. Overt morphosyntactic cues to the argument functions are more frequently required when they serve to unambiguously differentiate between the argument functions than when these functions can be determined on the basis of prominence information.

As mentioned at the beginning of Chapter 2, these patterns are consistent with the more general idea that language structure is in part shaped by constraints and motivations of a social, cultural and cognitive nature that underlie efficient language use and communication (e.g. Beckner et al. 2009; Chater & Christiansen 2010; Christiansen & Chater 2008; Gibson et al. 2013; Hawkins 2003, 2007; Ibbotson 2013; Jaeger 2013; Jaeger & Tily 2011; Kirby, Cornish, & Smith 2008; Kirby, Dowman, & Griffiths 2007; Kirby et al. 2007; Kirby, Smith, & Brighton 2004; MacDonald 2013; Piantadosi et al. 2012). These constraints and motivations operate on and shape language varieties both within and across generations of speakers. Linguistic evolution and diversification can from this perspective be seen as a process in which different language varieties evolve in different directions as a consequence of competition between motivations and constraints (Evans & Levinson 2009; Ibbotson 2013). Processes that underlie language learning and language processing set up preferences or prior biases (Culbertson, Smolensky, & Legendre 2012; Kirby et al. 2004) towards a limited range of possible languages. Cognitive factors will permit and in some cases strongly bias towards certain structural configurations (such as a subject-before-object word order), but they will not by necessity entail specific structures (Ibbotson 2013). Consistent with this view, Hawkins (2007) has suggested that grammars can be conceived as ‘conventionalizations of performance preferences’ (p. 88) in language use and language processing. Cross-linguistic distributions of grammatical structures will therefore reflect differences in the use of alternative structures within a language, on the one hand, and differences in the processing difficulty of those structures, on the other. Those structures that occur more frequently in languages that allow for alternatives and that are easier to process will be the ones that are grammaticalized more frequently across languages (Hawkins 2007). And indeed, many statistical regularities that are found in the structural variation across languages seem to mirror cognitive preferences with respect to language comprehension, production and learning (e.g., Christiansen and Chater 2008; Hawkins 2003, 2007; Jaeger 2013; MacDonald 2013, and see Jaeger and Tily 2011 for a review).

For instance, there is a strong preference for languages with a dominant word order to order subjects before objects (in 96.3% of the languages surveyed, see Dryer 2005). If, as assumed in this dissertation, the subject in the prototypical case expresses the Actor role, and also refers to a discourse prominent referent that is highly accessible in the discourse, this overwhelming preference for subject-before-object word order is functionally motivated for the following two reasons.

Firstly, the semantic properties of the Undergoer related to its involvement in the event at hand is in some sense asymmetrically dependent on the involvement properties of the Actor (e.g. Primus 2006, 2012). Whereas involvement properties can be assigned to an initial Actor directly when the verb is encountered, involvement properties of an
initial Undergoer are dependent on the properties of the Actor. In object-initial sentences, the assignment of Undergoer properties to the initial object is therefore delayed until the subject is encountered. Object-before-subject word order should therefore be more costly to process than subject-before-object word order, because unassigned properties of the object presumably need to be maintained in working memory until the subject is encountered (e.g., Hawkins 2003:49-50; Hawkins 2007).

Secondly, since subjects are most frequently topical and highly discourse prominent, they tend to be highly predictable and ‘informationally low’ (Fenk-Oczlon 2001). It therefore makes sense to introduce them, or any other highly predictable information for that matter, as early on in the sentence as possible, in order to keep the information flow of the sentence as constant as possible (Fenk-Oczlon 2001; see also, e.g., Jaeger 2010). As a sentence unfolds over time, more information becomes available that constrains the interpretation of the subsequent upcoming information. The uncertainty about the sentence meaning is therefore by necessity at its highest at the beginning of the sentence. It is therefore motivated to provide highly predictable or ‘informationally low’ information as early on in the sentence as possible.

As discussed in Section 2.4, a multitude of experimental studies have shown that the object-before-subject word order is indeed costly to process, in line with these assumptions. In other words, the combination of results from typological studies of word order distributions across languages, corpus studies on word order distributions in the discourse of individual languages, as well as experimental studies of the on-line processing of sentences with varying word orders provide converging evidence for the idea that language structure is in part shaped by constraints and preferences in the processes that underlie language use and language learning. An underlying motivation throughout the work of this dissertation has been to provide further support for this idea.

8.6. Future research

A shortcoming of this dissertation is the lack of experimental testing of the predictions of the incremental models. The self-paced reading experiment tested some of the most prominent predictions regarding the processing difficulties in locally ambiguous object-initial sentences (i.e., ambiguity in itself, animacy, verb class, and animacy × verb class interaction). However, many of the predictions regarding the processing difficulties in these sentences are expected on the basis of the results of many previous experiments. It could therefore be argued that the self-paced reading experiment does not provide solid evidence for the incremental models, and that additional testing of some of the more fine-grained model predictions is needed. Because of problems with spill-over effects (Mitchell 1984), the need to introduce new words with button presses (Mitchell 2004), the potential problem of equating latencies between button-presses with processing difficulties (Witzel, Witzel, & Forster 2012), and the uni-dimensional nature of reading time latency as a measure of processing difficulty (Mitchell 2004), the self-paced reading paradigm might not be sensitive enough to detect the small processing differences predicted by the incremental models. Direct comparison between self-paced reading and eye-tracking has further shown the self-paced reading paradigm to be more error prone, to generate data that is more unevenly distributed (i.e., has a higher kurtosis) (Frank, Fernandez Monsalve,
8.6 Future research

Thompson, & Vigliocco 2013), and to be less sensitive in detecting processing difficulties in various types of temporarily ambiguous sentences (Witzel et al. 2012). Other experimental paradigms might therefore be more suitable to test the more fine-grained predictions of the model. In particular, as described in Sections 2.4.3 and 8.4.1, Alday et al. (2014) found the predictions of their model to significantly correlate with the N400 amplitude engendered by the critical words in an ERP experiment designed to test their model. The ERP technique might therefore be more suitable for testing the predictions of the incremental model.

Since the RN and PR models, on the one hand, and the CD model, on the other, are based upon different assumptions regarding the processing of disambiguating information (i.e., whether it is probabilistic or categorical in nature), these models make rather different predictions at and beyond the point of disambiguation. Further research could be conducted in order to pit these two accounts against each other. This could, for instance, be done by testing the effect of varying the prominence of the disambiguating final NP itself in locally ambiguous object-initial sentences. As illustrated in Figure 6.13 and discussed in Sections 6.4 and 8.4.1, the two model types make opposite predictions regarding the influence of the prominence features of the final NP in such sentences.

Finally, as discussed in Sections 5.5.3 and 6.4, both the results of the corpus study and the predictions of the incremental model showed that the discourse prominence of both NPs is of extra importance in predicting word order in sentences with possessive verbs. A possible explanation for this pattern is that possessive constructions in some cases are used to introduce new discourse topics (i.e., to introduce a topic shift) in order to avoid unpredictable information in sentences with new topics (cf. Qian & Jaeger 2011). The topical object NP of such constructions would be low in discourse prominence by virtue of being new in the discourse, but positioned in the sentence-initial position in order to emphasize its topic function. The final subject, on the other hand, would be highly discourse prominent in order to serve as a reference point or a ‘ground’ for the introduction of the new topic. Such a sentence was exemplified in Example 5.8. The question of to what extent such topic-introducing constructions are used in Swedish also opens up a possible avenue for further research.
A. Reanalysis experiment stimuli

Table A.1. The subject pronouns, nouns, verbs and object pronouns used in each stimulus set of the reanalysis experiment.

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<td>mig</td>
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<td>oss</td>
<td>Ni</td>
<td>kockarna</td>
<td>visad</td>
<td>oss</td>
</tr>
<tr>
<td>2PL</td>
<td>the bakers</td>
<td>showed</td>
<td>1PL</td>
<td>2PL</td>
<td>the chefs</td>
<td>showed</td>
<td>1PL</td>
</tr>
<tr>
<td>Vi</td>
<td>patienten</td>
<td>lämnade</td>
<td>dig</td>
<td>Vi</td>
<td>eleven</td>
<td>lämnad</td>
<td>dig</td>
</tr>
<tr>
<td>1PL</td>
<td>the patient</td>
<td>left</td>
<td>2SG</td>
<td>1PL</td>
<td>the student</td>
<td>leaves</td>
<td>2SG</td>
</tr>
<tr>
<td>Vi</td>
<td>eleverna</td>
<td>störde</td>
<td>er</td>
<td>Vi</td>
<td>patienterna</td>
<td>stór</td>
<td>er</td>
</tr>
<tr>
<td>1PL</td>
<td>the students</td>
<td>disturbed</td>
<td>2PL</td>
<td>1PL</td>
<td>the patients</td>
<td>disturbs</td>
<td>2PL</td>
</tr>
<tr>
<td>Jag</td>
<td>sonen</td>
<td>vårdade</td>
<td>dig</td>
<td>Jag</td>
<td>dottern</td>
<td>vårdad</td>
<td>dig</td>
</tr>
<tr>
<td>1SG</td>
<td>the son</td>
<td>nurtured</td>
<td>2SG</td>
<td>1SG</td>
<td>the daughter</td>
<td>nurtures</td>
<td>2SG</td>
</tr>
<tr>
<td>Jag</td>
<td>döttrarna</td>
<td>skickade</td>
<td>er</td>
<td>Jag</td>
<td>sönerna</td>
<td>skickad</td>
<td>er</td>
</tr>
<tr>
<td>1SG</td>
<td>the daughters</td>
<td>sent</td>
<td>2PL</td>
<td>1SG</td>
<td>the sons</td>
<td>sent</td>
<td>2PL</td>
</tr>
<tr>
<td>Du</td>
<td>grabben</td>
<td>hejdade</td>
<td>mig</td>
<td>Du</td>
<td>ungen</td>
<td>hejdad</td>
<td>mig</td>
</tr>
<tr>
<td>2SG</td>
<td>the guy</td>
<td>stopped</td>
<td>1SG</td>
<td>2SG</td>
<td>the kid</td>
<td>stops</td>
<td>1SG</td>
</tr>
<tr>
<td>Du</td>
<td>ungarna</td>
<td>tvingade</td>
<td>oss</td>
<td>Du</td>
<td>grabbaron</td>
<td>tvingad</td>
<td>oss</td>
</tr>
<tr>
<td>2SG</td>
<td>the kids</td>
<td>forced</td>
<td>1PL</td>
<td>2SG</td>
<td>the guys</td>
<td>forces</td>
<td>1PL</td>
</tr>
<tr>
<td>Ni</td>
<td>politikern</td>
<td>sverk</td>
<td>mig</td>
<td>Ni</td>
<td>ministern</td>
<td>sverkk</td>
<td>mig</td>
</tr>
<tr>
<td>2PL</td>
<td>the politician</td>
<td>betrayed</td>
<td>1SG</td>
<td>2PL</td>
<td>the minister</td>
<td>betrays</td>
<td>1SG</td>
</tr>
<tr>
<td>Ni</td>
<td>ministrarna</td>
<td>stódde</td>
<td>oss</td>
<td>Ni</td>
<td>politikerna</td>
<td>stódder</td>
<td>oss</td>
</tr>
<tr>
<td>2PL</td>
<td>the ministers</td>
<td>supported</td>
<td>1PL</td>
<td>2PL</td>
<td>the politicians</td>
<td>supports</td>
<td>1PL</td>
</tr>
<tr>
<td>Vi</td>
<td>kompisen</td>
<td>välkomnade</td>
<td>dig</td>
<td>Vi</td>
<td>släktigen</td>
<td>välkomnad</td>
<td>dig</td>
</tr>
<tr>
<td>1PL</td>
<td>the friend</td>
<td>welcomed</td>
<td>2SG</td>
<td>1PL</td>
<td>the relative</td>
<td>welcomes</td>
<td>2SG</td>
</tr>
</tbody>
</table>

Continued on next page ...
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vi</td>
<td>släktingarna</td>
<td>roade</td>
<td>er</td>
<td>Vi</td>
<td>kompisarna</td>
<td>roar</td>
<td>er</td>
</tr>
<tr>
<td>1PL</td>
<td>the relatives</td>
<td>amused</td>
<td>2PL</td>
<td>1PL</td>
<td>the friends</td>
<td>amuses</td>
<td>2PL</td>
</tr>
</tbody>
</table>
B. Search strings

Searches were conducted with TIGER search 2.1. (König et al. 2003) with search strings in the TIGER search query language (König & Lezius 2003). Three classes of search patterns were used to find the three general syntactic patterns of subject-initial, object-initial and adverbial-initial sentences. These syntactic patterns are shown and exemplified in Table B.1. The patterns contain noun phrases (NP), adverb phrases (AdvP) and topicalized adverbial phrases (TP), which could consist of nominal, adverb or prepositional phrases. Patterns also contain verbs and verb particles (PT). The initial verbs (V1) were always finite, the second verb (V2) was either an infinite verb or an infinitival marker, and the final verbs (V3 and V4) were infinite. Optional elements are shown within parentheses.

Table B.1. The three general syntactic patterns corresponding to the search patterns searching for subject-, object- and adverbial-initial clauses. Optional constituents / words are shown in parentheses. NP = Nominal Phrase; AdvP = Adverbal Phrase; V = Verb (V1 = finite; V2 = infinite or infinitival marker ‘att’; V3 + V4 = Infinite); PT = Verb particle; TP = Topicalized phrase, which does not constitute a core argument.

<table>
<thead>
<tr>
<th>Search pattern</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>subj. int.</td>
<td>[NP] ([AdvP]) ([AdvP]) [V1] ([AdvP]) ([AdvP]) ([V2]) ([V3]) ([V4]) ([PT]) [NP]</td>
</tr>
<tr>
<td></td>
<td>Du som har examen enligt den tidigare studieordningen och uppfyller de nya kraven för en magisterexamen [NP] [kommenV1] [attenV2] [kunnatV3] [tavV4] [utPT] [en sådanNP]</td>
</tr>
<tr>
<td></td>
<td>‘You who have a degree according to the previous curriculum and is eligible for a magister’s degree will be able to acquire such’</td>
</tr>
<tr>
<td>obj. int.</td>
<td>[NP] [V1] ([AdvP]) ([AdvP]) [NP] ([AdvP]) ([AdvP]) [V2] ([V3]) ([V4]) ([PT])</td>
</tr>
<tr>
<td></td>
<td>Några egentliga genombrott från de informella överläggningarna ute på Bushs lantställe Camp David [NP] [kundeV1] [deNP] [inteAdvP] [redovisaV2]</td>
</tr>
<tr>
<td></td>
<td>‘Any serious breakthroughs from the informal negotiations at Bush’s country house Camp David they were unable to report’</td>
</tr>
<tr>
<td>adv. int.</td>
<td>[TP] [V1] ([AdvP]) ([AdvP]) [NP] ([PT]) ([AdvP]) ([ AdvP]) ([V2]) ([V3]) ([V4]) ([PT]) [NP]</td>
</tr>
<tr>
<td></td>
<td>MöjligenTP [kommerv1] [hanNP] [till och medADVP] [attenV2] [älskaV3] [denna hans, Lauritz’, stora handlingNP]</td>
</tr>
<tr>
<td></td>
<td>‘Possibly will he even love this his Lauritz’ big action’</td>
</tr>
</tbody>
</table>

Due to inconsistencies and errors in the syntactic annotation of the corpus, search strings relied on both hierarchical dependencies as well as linear order. Multi-word constituents were therefore defined with reference to the directly dominating node as well as to the left- and right-most word nodes dominated by the constituent node at hand. Consecutive search queries that defined syntactic relationships between constituents would then make reference to precedence relations between either the right- or the left-most word node of the constituent node at hand and some other node. In order to allow for the structural variation shown in Table B.1, the search queries contained disjunctions of
alternative search patterns that were organized in a nested fashion. For example, search patterns for subject-initial sentences without adverbial phrases had the following simplified structure:

\[\text{[NP}_1\text{]} \text{[V}_1\text{]} \& ( (\text{[V}_1\text{]} \text{[NP}_2\text{]} \mid \text{[V}_1\text{]} \text{[PL]} \text{[NP}_2\text{]}))

\mid \text{[V}_1\text{]} \text{[V}_2\text{]} \& ( (\text{[V}_2\text{]} \text{[NP}_2\text{]} \mid \text{[V}_2\text{]} \text{[PL]} \text{[NP}_2\text{]}))

\mid \text{[V}_2\text{]} \text{[V}_3\text{]} \& ( (\text{[V}_3\text{]} \text{[NP}_2\text{]} \mid \text{[V}_3\text{]} \text{[PL]} \text{[NP}_2\text{]}))

\mid \text{[V}_3\text{]} \text{[V}_4\text{]} \& ( (\text{[V}_4\text{]} \text{[NP}_2\text{]} \mid \text{[V}_4\text{]} \text{[PL]} \text{[NP}_2\text{]})) \) ) )

Which is equivalent to the following pattern, in which parentheses represent optional elements:

\[\text{[NP}_1\text{]} \text{[V}_1\text{]} (\text{[V}_2\text{]} (\text{[V}_3\text{]} (\text{[V}_4\text{]} (\text{[PL]}))) \text{[NP}_2\text{]}\]

In order to limit the time it took to perform searches, multiple search strings were used for subject- and adverbial-initial sentences. For subject-initial sentences, four different search strings were used. The first searched for subject-initial sentences with no adverbial phrase, the second for subject-initial sentences with a preverbal adverbial phrase, the third for sentences with a post-verbal adverbial and the fourth for sentences with both a pre- and post-verbal adverbial phrase. For adverbial-initial sentences, three search strings were used. The first searched for adverbial-initial sentences without sentence-internal adverbials, the second for adverbial-initial sentences with an adverbial preceding the first NP, and the third for adverbial-initial sentences following the initial NP. For object-initial sentences, however, only one search string was required.
## C. Givenness categories

*Table C.1.* A complete list of givenness types in each givenness category, with examples.

<table>
<thead>
<tr>
<th>Category</th>
<th>NP type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New</strong></td>
<td>non-specific indefinite NP</td>
<td>hård hud hard skin</td>
</tr>
<tr>
<td></td>
<td>indefinite NP</td>
<td>en normal svensk sportjournalist a normal Swedish sports journalist</td>
</tr>
<tr>
<td></td>
<td>definite NPs with generic meaning</td>
<td>de flesta ljud vi hör most sounds we hear</td>
</tr>
<tr>
<td></td>
<td>definite NPs with a meaning that implies cataphoric reference</td>
<td>följande tre byggstenar the following three building blocks</td>
</tr>
<tr>
<td><strong>Token identifiable</strong></td>
<td>(full) name + modifier</td>
<td>Hans Svensson i Göteborg Hans Svensson in Gothenburg</td>
</tr>
<tr>
<td></td>
<td>profession/title + modifier</td>
<td>överläkaren som utförde aborten the physician who performed the abortion</td>
</tr>
<tr>
<td></td>
<td>long definite descriptions</td>
<td>den odlade marken i Afrika the cultivated land in Africa</td>
</tr>
<tr>
<td></td>
<td>possessive NP with possessive meaning</td>
<td>Anderssons nya poesi Anderssons' new poetry</td>
</tr>
<tr>
<td></td>
<td>definite NP or personal pronoun with restrictive relative clause</td>
<td>de som inte tycker om hundar those who do not like dogs</td>
</tr>
</tbody>
</table>

Continued on next page ...
<table>
<thead>
<tr>
<th>Category</th>
<th>NP type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiar</td>
<td>full and simple names</td>
<td>Gorbatjov</td>
</tr>
<tr>
<td></td>
<td>simple kinship terms</td>
<td>mamma</td>
</tr>
<tr>
<td></td>
<td>Meta-linguistic expressions and text references</td>
<td>det där ordet ‘fjärdingsman’</td>
</tr>
<tr>
<td></td>
<td>short definite descriptions</td>
<td>‘fjärdingsman’</td>
</tr>
<tr>
<td></td>
<td>simple names or definite nouns with non-defining attributive or non-restrictive relative clause</td>
<td>älgen</td>
</tr>
<tr>
<td></td>
<td>possessive NP with attributive / non-possessive meaning</td>
<td>programmet, som innehåller 13 sånger</td>
</tr>
<tr>
<td></td>
<td>definite descriptions with explicit anaphoric reference or explicit familiarity</td>
<td>årets kongress</td>
</tr>
<tr>
<td></td>
<td>long definite expressions with demonstrative</td>
<td>de tidigare nämnda lugnande medlen</td>
</tr>
<tr>
<td></td>
<td>short NP with distal demonstrative</td>
<td>denna tro på Rättfärdighetens lärare</td>
</tr>
<tr>
<td></td>
<td>short NP with proximal demonstrative</td>
<td>den där jäveln</td>
</tr>
<tr>
<td></td>
<td>definite NPs with relational attribute</td>
<td>det här testamentet</td>
</tr>
<tr>
<td></td>
<td>simple NPs that are co-referential with immediate discourse</td>
<td>this testament</td>
</tr>
<tr>
<td></td>
<td>personal pronouns</td>
<td>den senare metoden</td>
</tr>
<tr>
<td></td>
<td>personal pronouns with non-defining attribute or non-restrictive relative clause</td>
<td>ungefär hälften about half</td>
</tr>
<tr>
<td></td>
<td>pronouns with relational or ordinate attribute</td>
<td>hon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>she</td>
</tr>
<tr>
<td></td>
<td></td>
<td>jag som var yngst</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I who was the youngest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>de förra</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the former</td>
</tr>
</tbody>
</table>
### D. Self-paced reading experiment stimuli

Table D.1. The nouns, verbs and pronouns used in the self-paced reading experiment.

<table>
<thead>
<tr>
<th>Inanimate Noun</th>
<th>Animate Noun</th>
<th>Volitional verb</th>
<th>Experiencer verb</th>
<th>Non-verb</th>
<th>Pronoun</th>
</tr>
</thead>
<tbody>
<tr>
<td>bollen</td>
<td>killen</td>
<td>sparkar</td>
<td>glömmer</td>
<td>träffar</td>
<td>jag / mig</td>
</tr>
<tr>
<td>the ball</td>
<td>the guy</td>
<td>kick</td>
<td>forget</td>
<td>hit</td>
<td>1SG</td>
</tr>
<tr>
<td>kartan</td>
<td>juristen</td>
<td>rådfrågar</td>
<td>behöver</td>
<td>visar</td>
<td>jag / mig</td>
</tr>
<tr>
<td>the map</td>
<td>the lawyer</td>
<td>consult</td>
<td>need</td>
<td>show</td>
<td>1SG</td>
</tr>
<tr>
<td>skorna</td>
<td>döttrarna</td>
<td>vårdade</td>
<td>fann</td>
<td>bar</td>
<td>jag / mig</td>
</tr>
<tr>
<td>the shoes</td>
<td>the daughters</td>
<td>nursed</td>
<td>found</td>
<td>carried</td>
<td>1SG</td>
</tr>
<tr>
<td>sjukdomen</td>
<td>direktören</td>
<td>förbannar</td>
<td>fruktar</td>
<td>smittar</td>
<td>jag / mig</td>
</tr>
<tr>
<td>the decease</td>
<td>the manager</td>
<td>curse</td>
<td>fear</td>
<td>infect</td>
<td>1SG</td>
</tr>
<tr>
<td>arbetet</td>
<td>läraren</td>
<td>berömmar</td>
<td>uppskattar</td>
<td>sysselsätter</td>
<td>jag / mig</td>
</tr>
<tr>
<td>the work</td>
<td>the teacher</td>
<td>praise</td>
<td>appreciate</td>
<td>engage</td>
<td>1SG</td>
</tr>
<tr>
<td>träningen</td>
<td>kompisen</td>
<td>tackar</td>
<td>värdesätter</td>
<td>tilltalar</td>
<td>jag / mig</td>
</tr>
<tr>
<td>the workout</td>
<td>the friend</td>
<td>thank</td>
<td>value</td>
<td>appeal</td>
<td>1SG</td>
</tr>
<tr>
<td>förslaget</td>
<td>politikern</td>
<td>försvarar</td>
<td>förknippar</td>
<td>upprör</td>
<td>jag / mig</td>
</tr>
<tr>
<td>the proposal</td>
<td>the politician</td>
<td>defend</td>
<td>associate</td>
<td>upset</td>
<td>1SG</td>
</tr>
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<td>restaurangen</td>
<td>mäklaren</td>
<td>rekommenderar</td>
<td>betraktar</td>
<td>kompenserar</td>
<td>jag / mig</td>
</tr>
<tr>
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<td>the broker</td>
<td>recommend</td>
<td>regard</td>
<td>compensate</td>
<td>1SG</td>
</tr>
<tr>
<td>filmen</td>
<td>vänner</td>
<td>hyllar</td>
<td>gillar</td>
<td>berör</td>
<td>du / dig</td>
</tr>
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<td>the movie</td>
<td>the friend</td>
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<td>like</td>
<td>affect</td>
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<td>träjan</td>
<td>tjejer</td>
<td>betalar</td>
<td>hittar</td>
<td>passar</td>
<td>du / dig</td>
</tr>
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<td>the sweater</td>
<td>the girl</td>
<td>pay</td>
<td>find</td>
<td>fit</td>
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<td>uppfattar</td>
<td>vägleder</td>
<td>du / dig</td>
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<td>the soldier</td>
<td>defy</td>
<td>perceive</td>
<td>guide</td>
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<td>frågan</td>
<td>patienten</td>
<td>besvarade</td>
<td>missförstod</td>
<td>engagerade</td>
<td>du / dig</td>
</tr>
<tr>
<td>the question</td>
<td>the patient</td>
<td>answered</td>
<td>misunderstod</td>
<td>engaged</td>
<td>2SG</td>
</tr>
<tr>
<td>boken</td>
<td>författaren</td>
<td>nämnde</td>
<td>misstolkade</td>
<td>citerade</td>
<td>du / dig</td>
</tr>
<tr>
<td>the book</td>
<td>the writer</td>
<td>mentioned</td>
<td>misinterpreted</td>
<td>quoted</td>
<td>2SG</td>
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<tr>
<td>klämningen</td>
<td>mannen</td>
<td>väljer</td>
<td>ogillar</td>
<td>klär</td>
<td>du / dig</td>
</tr>
<tr>
<td>the dress</td>
<td>the man</td>
<td>choose</td>
<td>dislike</td>
<td>suit</td>
<td>2SG</td>
</tr>
<tr>
<td>händelsen</td>
<td>offret</td>
<td>beskrev</td>
<td>förväxlade</td>
<td>avskräckt</td>
<td>du / dig</td>
</tr>
<tr>
<td>the event</td>
<td>the victim</td>
<td>described</td>
<td>confused</td>
<td>deterred</td>
<td>2SG</td>
</tr>
<tr>
<td>solen</td>
<td>pojkken</td>
<td>undvek</td>
<td>ålskade</td>
<td>värmdes</td>
<td>du / dig</td>
</tr>
<tr>
<td>the sun</td>
<td>the boy</td>
<td>avoided</td>
<td>loved</td>
<td>heated</td>
<td>2SG</td>
</tr>
<tr>
<td>bilen</td>
<td>kvinnan</td>
<td>övergav</td>
<td>såg</td>
<td>mötte</td>
<td>vi / oss</td>
</tr>
<tr>
<td>the car</td>
<td>the woman</td>
<td>abondoned</td>
<td>saw</td>
<td>met</td>
<td>1PL</td>
</tr>
<tr>
<td>skadorna</td>
<td>ungdomarna</td>
<td>rapporterade</td>
<td>underskattade</td>
<td>begränsade</td>
<td>vi / oss</td>
</tr>
<tr>
<td>the damages</td>
<td>the youngsters</td>
<td>reported</td>
<td>underestimated</td>
<td>confined</td>
<td>1PL</td>
</tr>
<tr>
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<td>läkaren</td>
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Table D.1. (continued)

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Sammanfattning på svenska

Thomas Hörberg

Probabilistic and Prominence-driven Incremental Argument Interpretation in Swedish

Den här avhandlingen handlar om grammatiska funktioner i transitiva satser i svenska, det vill säga ‘subjekt’ och ‘direkt objekt’ (hädanefter kallat ‘objekt’). I satsen ‘Agnes vattnar blommor’ utgör exempelvis egennamnet ‘Agnes’ grammatiskt subjekt och refererar till agenten, det vill säga till den som utför handlingen, medan substantivet ‘blommor’ utgör grammatiskt objekt och refererar till temat, det vill säga det föremål som utsätts för denna handling.

Avhandlingen behandlar de språkförståelseprocesser som gör så att lyssnare och läsare kan bestämma vilken av de två nominalfraserna (dvs ‘Agnes’ och ‘blommor’ i exempelempningen), som utgör grammatiskt subjekt och vilken som utgör objekt. Därför bestämmer man också vem som utför handlingen som satsen uttrycker, och vem eller vad som blir utsatt för denna handling. I de flesta satser kan nominalfrasernas grammatiska funktioner enkelt bestämmas utifrån satsens ordföljd eller den morfologiska formen hos pronomener.


Prominensegenskaper verkar därför fungera som ledtrådar för att bestämma grammatiska funktioner under språkförståelseprocessen vilka systematiskt samverkar med grammatisk information som ordföljd och kasusmarkering. Detta återspeglas i hur grammatiska funktioner kodash rent grammatiskt. Grammatisk information som typisk ordföljd och kasusmarkering är i många språk antingen obligatorisk eller används mer frekvent i satser där nominalfrasernas grammatiska funktioner inte kan bestämmas utifrån prominensbaserad information. En grundläggande hypotes i denna avhandling är därför att prominensegenskaper, å ena sidan, och grammatiska egenskaper, å den andra, fungerar som tolkningsledtrådar för att kunna bestämma grammatiska funktioner. Dessa ledtrådar används på ett probabilistiskt sätt, och deras styrka, samspel och tillgänglighet ber på hur de är fördelade över grammatiska funktioner i språkanvändning.

För att vara mer specifik så undersöks och testas följande fyra hypoteser i avhandlingen:

1. När grammatiska funktioner i transitiva satser tolkas så bestäms vilka rollsemantiska funktioner som nominalfraserna har (dvs vem som utför handlingen som satser uttrycker och vem/vad som utsätts för denna handling).
2. Hur grammatiska funktioner uttrycks eller kodas i språkanvändning påverkas av en strävan hos talare och skribenter att undvika användning av redundant information, å ena sidan, och att undvika tvetydigheter kring nominalfrasernas grammatiska funktioner, å den andra.
4. De språkförståelseprocesser som bestämmer vilka grammatiska funktioner nominalfraser har utnyttjar tolkningsledtrådar på ett inkrementellt och probabilistiskt sätt. Fördelningen av tolkningsledtrådar i språkanvändning kan därför generera förutsägelser om svårigheter under dessa språkförståelseprocesser.


Kapitel 1 ger en introduktion till avhandlingen och dess syfte, presenterar hypoteserna ovan, och ger en kortfattad överblick över innehållet i avhandlingens kapitel.

Kapitel 2 innehåller den teoretiska bakgrunden till avhandlingen. Här presenterar jag en överblick över grammatiska funktioner i det typologiska perspektivet och presenterar forskning som tyder på för att grammatiska funktioner i transitiva satser uttrycker rollsemantiska och diskurs-pragmatiska funktioner hos nominalfraserna (i linje med, t ex
Sammanfattning på svenska


Jag ger också en överblick över studier som tyder på att prominensbaserad information utnyttjas som ledtrådar för de tolkningsprocesser som bestämmer nominalfrasernas grammatiska funktioner (t ex Frenzel et al. 2011; Kaiser & Trueswell 2004). Jag presenterar även några psyko- och neurolingvistiska teorier om dessa tolkningsprocesser som antar att dessa processer beaktar tillgängligheten hos och samspelet mellan prominensbaserad och grammatisk information (t ex Bornkessel & Schlesewsky 2006; Bornkessel-Schlesewsky & Schlesewsky 2013; MacWhinney & Bates 1989a; McRae et al. 1998)).

Kapitel 3 presenterar de typer av svenska transitiva satser som jag undersöker i avhandlingen. Dessa är typiska subjektsinitiala satser, objektsinitiala satser, och adverbialeinitiala satser.


Kapitel 3 ger även en överblick över transitiva satser som är lokalt tvetydiga vad gäller grammatis funktion, och den grammatiska information som gör dem otvetydiga. Sådan information är mer vanligt förekommande i transitiva satser som är potentiellt tvetydiga, än i satser som inte är det (Rahkonen 2006).

Kapitel 4 presenterar ett ERP-experiment (event-related brain potentials) som testar den första hypotesen att tolkning av grammatisk funktioner medför att nominalfrasernas rollsemantiska funktioner bestäms. Experimentet testar detta genom att undersöka
ERP-responsen till *omanalys av grammatisk funktion*, dvs då ny information i satsen gör så att en första tolkning om nominalfrasernas grammatiska funktioner måste revideras. Experimentet undersöker om denna revision är av syntaktisk eller tematisk natur.


Det viktigaste resultatet utgjordes dock av en ’omanalys N400’-effekt, en negativitet som förekom i ett tidsfönster om 375-550 ms, och som hade en lokal, högerparietal fördelning över hjässan. Denna effekt framkallades av subjekt i objektsinitiala satser med ett initialt substantiv, dvs enbart i de satser där omanalys av grammatisk funktion förväntas. Denna effekt korrelerar med (om-)tilldelning av semantiska roller till nominalfraser (Bornkessel-Schlesewsky & Schlesewsky 2009c; Haupt et al. 2008). Dessa resultat talar därför för att tolkning av grammatisk funktion bland annat medför att nominalfrasernas semantiska roller fastställs, och bekräftar därmed den första hypotesen.

**Kapitel 5** presenterar en korpusstudie som undersöker hur prominensegenskaper, verbsemantiska egenskaper och grammatiska egenskaper är fördelade över grammatiska funktioner i transitiva satser i svenska texter. Studien undersöker de tre typer av transitiva satser som presenterades i Kapitel 3, det vill säga subjektsinitiala satser, objektsinitiala satser och adverbialinitiala satser. Satser av dessa typer annoterades för prominensegenskaper hos nominalfraser (huruvida nominalfrasen är given, animat, bestämd, pronominell, egofo-risk, kasusmarkerad, textdeiktisk, och dess längd i antal ord), verbsemantiska egenskaper (huruvida verbet uttrycker en viljestyrda handling, en upplevelse, ett orsakssamband eller en äganderelation), såväl som för några övriga egenskaper hos satserna (huruvida satsen är adverbialinitial, är en huvudsats eller bisats, och huruvida den innehåller hjälperverb).

Korpusstudien testar den andra hypotesen att den grammatiska kodningen av gram-
matiska funktioner i språkanvändning påverkas av en strävan hos talare och skribenter att undvika användning av redundant information och att undvika tvetydigheter om nominalfraserans funktioner. något som skulle stärka denna hypotes är om grammatisk information om grammatiska funktioner (som kasusmarkering och förekomst av hjälpverb) används mer frekvent i potentiellt tvetydiga satser. Resultaten visar att sådan grammatisk information är vanligare i objektsinitiala satser, i vilka ordföljden inte tillhandahåller tillförlitlig information om grammatiska funktioner. De visar också att sådan information är vanligare i semantiskt reversibla satser, som t ex i en sats som ‘Agnes kramar Klara’, i vilken nominalfrasernas grammatiska funktioner inte kan bestämmas utifrån semantiska egenskaper. Med hjälp av logistisk regressionsanalys med slumpmässiga effekter kunde jag också visa att sannolikheten för huruvida en given sats innehåller morfosyntaktisk information om grammatiska funktioner med relativt hög säkerhet kan förutsägas utifrån satsens ordföljd och huruvida den är semantiskt tvetydig. Dessa resultat styrker med andra ord den andra hypotesen.

Korpsstudien undersöker även skillnader i fördelningen av prominens- egenskaper mellan objekts- och subjektsinitiala satser återspeglar de funktioner som den objeksttopikaliserade konstruktionen i svenska antas uttrycka. Resultaten visar att objekt i högre utsträckning är diskursprominenta, dvs de är oftare bestämda, givna och pronominella, när de förekommer i satsinitial position. Detta återspeglar att objektsinitiala satser ofta används för att visa att det är objektet som är satstopik och att det refererar till en referent med hög diskursprominens. Subjekt är också oftare mer prominenta vad gäller animacitet, egoforicitet, pronominalitet och kasusmarkering när de förekommer i objektsinitiala satser. Detta tyder på att även subjekt tenderar att vara mer diskursprominenta i objektttopikaliserade satser, och därmed mer förutsägbara. Detta stämmer överens med antagandet att information som följer på objektet i objektsinitiala satser tenderar att vara förutsägbar. Men det återspeglar också talare och skribenters ökade benägenhet att använda otvetydlig information som kasusmarkering i objeksttopikaliserade satser.


Men det är framför allt interaktionen mellan animacitet och verbsemantiska egenskaper (huruvida verbet uttrycker en viljestyrd handling eller ett orsakssamband) som ger starka förutsägelser om ordföljd. Transitiva satser med ett verb som uttrycker en viljestyrdf handling eller ett orsakssamband är i mycket högre utsträckning objektsinitiala.
om antingen den första nominalfrasen är inanimat eller den andra nominalfrasen är ani-
mat. Detta beror på att satser med sådana verb ofta kräver ett animat subjekt, och därför
mycket sällan har ett inanimat subjekt.

I satser med upplevelseverb förutsägs ordföljden med stor säkerhet av huruvida den
första nominalfrasen är ett personligt pronomen. Sannolikheten för objektsinitial ordföjd
är stor i satser med upplevelseverb då den första nominalfrasen inte är ett personligt
pronomen. Detta beror på att upplevelseverb ofta uttrycker subjektiv kunskap eller sub-
jektiva upplevelser. Därför brukar upplevelseverb utgå ifrån talarens, lyssnarens eller en
diksursprominent tredjepersons perspektiv. Det är därmed mycket vanligt att upplevelse-
verb förekommer med subjekt som är 1a, 2a eller 3e personspronomen.

Bestämmhet och givenhet (dvs diskursprominens) är också av extra stor vikt för att
förutsäga ordföljden i satser med ägandeverb. Sådana satser är mycket ofta objektsinitiala
om antingen den första nominalfrasen är låg i diskursprominens eller den andra är hög.
Konstruktioner med ägandeverb verkar användas för att introducera nya diskursreferenter,
och därigenom markera topiskskifte (James 1995). I sådana konstruktioner är den första
nominalfrasen — vilken introducerar en ny referent till diskursen — låg i diskursprominens,
medan den andra nominalfrasen är given och därmed mycket diskursprominent, eftersom
den fungerar som en referenspunkt för introducerandet av den nya informationen.

Kapitel 6 presenterar tre statistiska modeller, ‘the random noise model’ (RN-modellen
nedan), ‘the penalization regression model’ (PR-modellen nedan) and ‘the categorical di-
sambiguation model’ (CD-modellen nedan), av bestämmning av grammatisk funktion un-
der inkrementell språkförståelse, som baseras på hur argumenttolkningsledtrådar är dis-
tribuerade i transitiva satser i textdiskurs. Dessa modeller genererar förutsägelser om svä-
righet hos de processer som bestämmer nominalfrasernas grammatiska funktioner,
och testar därmed delvis den fjärde hypotesen. Detta sker utifrån förändringar i förväntan av
— eller sannolikheten för — en viss ordföljd, som sker som en följd av att presentationen
av satsens konstituenter (den första nominalfrasen, verbet, och den andra nominalfrasen)
över tid tillhandahåller mer information om ordföljden. Modellerna uppskattar överrask-
ningseffekten av att påträffå egenskaper hos den aktuella konstituenten, givet egenskaper-
na hos föregående konstituenter. Modellerna kvantifierar denna överraskningseffekt som
den relativa entropin mellan sannolikheten för en objektsinitial ordföljd vid den nuvaran-
de konstituenten och sannolikheten för denna ordföljd vid föregående konstituent. De tre
modellerna skiljer sig åt i fråga om hur sannolikheterna för en viss ordföljd (och därmed
överraskningseffekten) beräknas och integreras. Men i alla tre modeller sker sannolikhet-
beräkningar för respektive konstituent sker med hjälp av regressionsanalys.

I RN- och PR-modellen antas otvetydig information om nominalfrasernas funktioner
(som t ex kasusmarkering) processas och integreras på samma sätt som annan probabilis-
tisk information (som t ex animacitet och bestämmhet). I dessa modeller ingår otvetydig
information direkt i regressionsmodellerna som utför sannolikhetsberäkningarna. Otvet-
ydig information behandlas därför på samma sätt som prominensbaserad och verbsemantisk
information. Det största problemet för dessa modeller är hur regressionsmodellerna han-
terar problem med kolinjäritet och överanpassning av modellparametrar.

De två modellerna skiljer sig åt i fråga om hur dessa problem hanteras. I RN-modellen
används logistisk regressionsanalys med slumpmässiga effekter. För dessa modeller har
de otvetydiga kategorierna (som t ex kasusformen på en kasusmarkerad nominalfras) i den underliggande datan slumpmässigt förväxlas med varandra med en sannolikhet på 1%. Detta tillför en mindre mängd brus i datan, vilket i sin tur motverkar kolinjäritets- och överanpassningsproblemen i regressionsmodellerna. I PR-modellen används istället penaliserad logistisk regressionanalyser. Denna metod hanterar problem med kolinjäritet och överanpassning genom att ’krympa’ modelparametrar i proportion till hur starkt korrelerade de är med den beroende variabeln (vilket i detta fall är ordföljden i en given transitiv sats).

Till skillnad från RN- och PR-modellerna, hanterar istället CD-modellen otvetydiga information som kategorisk information som är skiljda från och har prioritet över probabilistisk information. Modellen antar en sannolikhet för objektsinitial ordföljd som ligger nära 0 eller 1, när otvetydig information om antingen subjekts- eller objektsinitial ordföljd påträffas. Överraskningseffekten för konstituenter som följer på otvetydig information bestäms sedan utifrån vilken grad den nya informationen talar emot den otvetydiga som redan påträffats.

Modellernas förutsägelser utvärderas utifrån å ena sidan lokalt tvetydiga transitiva satser och å andra sidan otvetydiga satser i vilka den första nominalfrasen är kasusmarkerad. Utvärderingen av effekter i lokalt tvetydiga satser fokuserar på hur effekten av och samspelet mellan prominens- och verbsemantiska egenskaper förutsätter påverka inkrementell tolkning av grammatisk funktion, medan utvärderingen av effekter i otvetydiga satser i första hand undersöker skillnader mellan de tre modellerna.

I lokalt tvetydiga satser gör alla tre modeller liknande förutsägelser. I objektsinitiala satser återföljer höga överraskningseffekter på den första nominalfrasen och verbet av låga överraskningseffekter på den andra nominalfrasen.


1Direktöversättning av engelskans ’shrink’ - det var svårt att komma på en passande svensk term här.
med resultaten från korpusstudien. Överraskningseffekter vid den första nominalfrasen och verbet beror på i vilken utsträckning informationen i fråga talar emot grundantagandet om subjektsinitial ordföljd. I objektsinitiala satser minskar överraskningseffekten av den andra nominalfrasen, beroende på i vilken utsträckning som all tidigare information talar för en objektsinitial tolkning, och därmed gör den otvetydiga informationen om en objektsinitial ordföljd mindre överraskande. I subjektsinitiala satser ger den andra nominalfrasen istället upphov till små överraskningseffekter då information talar för en objektsinitial tolkning, och alltså inte stämmer överens med den otvetydiga informationen om subjektsinitial ordföljd.

I otvetydiga satser med en kasusmarkerad första nominalfras gör alla tre modeller mycket olika förutsägelser. Utvärderingar av modellernas effekter i dessa satser tyder på att RN-modellen och CD-modellen underskattar respektive överskattar inflytandet av otvetydig information. PR-modellen verkar göra bäst förutsägelser i sådana satser. PR-modellens förutsägelser är i linje med tidigare experimentella resultat som har visat att otvetydig information kan ge upphov till förväntningar om prominensen hos kommande information, och att det är kostsamt då dessa förväntningar inte uppfylls (Bornkessel-Schlesewsky & Schlesewsky 2009c; Philipp et al. 2008; Roehm et al. 2004; Weckerly & Kutas 1999).

Kapitel 7 presenterar ett läsningsexperiment där försökspersonerna själva bestämmer takten för presentationen av satsernas enskilda ord, genom att själva trycka fram nästa ord2. Experimentet testar dom mest framträdande förutsägelser som de tre statistiska modellerna gör, och därmed också testar den fjärde hypotesen. Experimentet undersöker om processning av transitiva satser påverkas av tillgängligheten hos både grammatiska och prominensbaserade tolkningsledtrådar under inkrementell språkförståelse. I experimentet fick försökspersonerna läsa transitiva satser med ett subjekt bestående av ett personligt pronom och ett objekt bestående av ett substantiv. Dessa satser varierade i fråga om ordföljd (subjekts- vs. objektsinitial), verbklass (viljestyrt verb vs. upplevelseverb) och animacitet hos objektet (animat vs. inanimat).

Av dessa satser är de objektsinitiala tvetydiga i fråga om grammatisk funktion fram tills att den andra nominalfrasen påträffas. De subjektsinitiala satserna, å andra sidan, är otvetydiga eftersom de satsinitiala subjetken är kasusmarkerade. De statistiska modellerna förutsäger därför överskningar av effekter i de objektsinitiala satserna enbart. Dessutom förutsäger modellerna att överraskningseffekten i objektsinitiala satser varierar som en funktion av samspelet mellan animacitet och verbklass på följande vis. Vid verbet förutsäger modellerna små överraskningseffekter då den första nominalfrasen är inanimat och verbet består av ett upplevelseverb. Vid den andra nominalfrasen förutsägs överraskningseffekten av den otvetydiga informationen vara mindre då den första nominalfrasen är inanimat än då den är animat. Denna effekt av animacitet förväntas dessutom vara större i satser med viljestyrd verb än i satser med upplevelseverb. Överraskningseffekten vid den andra nominalfrasen förutsägs även generellt vara svagare i satser med upplevelseverb än i satser med viljestyrd verb.

Dessa överraskningseffekter förväntades stämma överens med skillnader i reaktions- tider i experimentet. Så var också fallet för de flesta, men inte alla, av överskningar av effekterna. Reaktionstider var signifikant snabbare i subjektsinitiala satser än i objektsinitiala

2Ett så kallat self-paced reading'-experiment
Sammanfattning på svenska

satser. I objektsinitiala satser var reaktionstider för verbet långsammare då den första nominalfrasen var inanimat och verbet utgjordes av ett upplevelseverb, vilket var förväntat. Reaktionstider för den andra nominalfrasen, å andra sidan, var signifikant längre i satser med en animat första nominalfras och ett viljestyrkt verb, men skiljde sig inte signifikant åt mellan övriga satstyper. Reaktionstider i regionen som följde på den andra nominalfrasen visade sig emellertid vara signifikant kortare i satser med upplevelseverb än i satser med viljestyrdt verb. Experimentets resultat är därför rent kvalitativt enhetliga med de förutsägelser som de statistiska modellerna gör. Resultaten från experimentet ger därför ytterligare belägg för den fjärde hypotesen.

Kapitel 8 sammanfattar och presenterar slutsatserna av avhandlingens studier. Resultaten från ERP-experimentet talar för den första hypotesen att tolkning av grammatisk funktion medför att nominalfrasernas rolemantiska funktioner bestäms.


De statistiska modellerna i Kapitel 6 tillsammans med läsningsexperimentet i Kapitel 7 ger ytterligare belägg för denna idé. Tillsammans visar de att de processer som ligger till grund för bestämmandet av grammatisk funktion tar fasta på statistiska regelmässigheter i fördelningen av grammatisk, prominensbaserad och verbsemantisk information i språkanvändning. Processvärderingar vid tolkning av transitiva satser i svenska kan förutsägas utifrån hur dessa informationstyper är fördelade i korpora, i enlighet med den fjärde hypotesen.

Mer generellt så talar dessa resultat för att samspelet och tillgängligheten hos grammatiska och prominensbaserade ledtrådar är funktionellt motiverat. Grammatisk information om nominalfrasernas grammatiska funktioner används oftares därför att dessa funktioner inte kan bestämmas utifrån prominensbaserad och verbsemantisk information, men används mer sällan då dessa funktioner kan avgöras utifrån prominensinformation och därför är överflödig. Dessa mönster är gärna även att observera i variationer i hur kodningen av grammatiska funktioner skiljer sig mellan olika språk. Grammatisk information om nominalfrasernas funktioner krävs oftares därför att denna information tjänar till att otvetydigt skilja mellan nominalfrasernas funktioner än när dessa funktioner kan bestämmas utifrån prominensbaserad information.

Dessa resultat talar för idén att språklig struktur delvis formas av sociala, kulturella och kognitiva begränsningar och motiv som ligger till grund för effektiv språkanvändning.
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