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Monique Lamers
Peter de Swart *Editors*

Case, Word Order and Prominence

Interacting Cues in Language Production and Comprehension

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Preface

This volume grew out of a series of workshops held at the Radboud University Nijmegen in the period 2005–2007, and culminating in the meeting entitled "Case, Word Order, and Prominence" in November 2007. These workshops were part of the project Incremental interpretation of case and prominence (2005–2008), a research project financed by the NWO-DFG bilateral cooperation programme as a collaboration between Helen de Hoop and Monique Lamers (Radboud University Nijmegen) in the Netherlands and Matthias Schlesewsky (Phillips University of Marburg, now at the Johannes Gutenberg University Mainz) and Ina Bornkessel-Schlesewsky (MPI for Cognitive Neuroscience Leipzig, now at the Phillips University of Marburg) in Germany.

We would like to thank all participants of these workshops for making them a success. The contributors to this volume are thanked for their enthusiastic cooperation, their patience and all their efforts in helping to bring this volume about. Thanks as well to the editors of the series for giving us the opportunity to make this book, and to the reviewers of the book manuscript for their helpful suggestions. A huge thank you goes to Helen van der Stelt and Jolanda Voogd at Springer who provided invaluable help during the entire process. We also thank Marije Zegwaard (VU University Amsterdam) for her help in preparing the final manuscript for publication. Special thanks go to our (by now former) colleagues of the research group Optimal Communication at the Radboud University Nijmegen, in particular Helen de Hoop, without whom we would have never started this book.

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Amsterdam — Monique J.A. Lamers
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Prominence Facilitates Ambiguity Resolution: On the Interaction Between Referentiality, Thematic Roles and Word Order in Syntactic Reanalysis

Franziska Kretzschmar, Ina Bornkessel-Schlesewsky, Adrian Staub, Dietmar Roehm, and Matthias Schlesewsky

1 Introduction

Over the past decades, research in sentence comprehension has focused on how the relative ease or difficulty of understanding a sentence is influenced by the interplay of different linguistic information types. In this regard, there is an ongoing debate on whether the human sentence parser draws on all available information during initial processing stages (e.g., MacDonald et al. 1994) or whether its initial decisions are primarily based on syntactic information, with other linguistic domains not taken into account until a later stage (e.g., Frazier and Rayner 1982; Rayner et al. 1983). Models of sentence comprehension based on these alternative architectural assumptions have been tested primarily against data from experiments that investigated the processing of garden path sentences in a variety of languages. In this vein, a major instance of garden-pathing in German, so-called subject-object ambiguities, have been examined in various sentence structures with both on-line and off-line methods (cf. Bader and Meng 1999; Bornkessel et al. 2004; Knoeferle et al. 2008; Mecklinger et al. 1995; Scheepers et al. 2000). An uncontroversial key finding of previous

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research in this domain is that, given an ambiguous clause-initial noun phrase, the parser adopts a subject-initial analysis (the "subject preference"). For example, Schriefers et al. (1995) showed in a series of self-paced reading experiments that a case-ambiguous relative pronoun is preferentially interpreted as the (nominative) subject of the clause. Later disambiguation towards an object-before-subject structure engenders a significant increase in processing costs that is visible in substantially longer reading times for the disambiguating verb. This finding accords well with traditional views claiming that subject-initial structures are the unmarked base order in both unambiguous and ambiguous strings (cf. Lenerz 1977; Gorrell 2000).

Yet, syntactic reanalysis is affected by information types other than syntax. There is ample evidence that word order in the medial part of German clauses (the *Mittelfeld*) is subject to semantic constraints such as the thematic role hierarchy or the relative semantic "prominence" of arguments in terms of features such as animacy or definiteness/specificity. These factors interact with the syntax such that unmarked word order may be determined by numerous constraints (cf. Lenerz 1977; Müller 1999; Primus 1999, for theoretical arguments; and Bornkessel et al. 2003, 2005; Grewe et al. 2005, 2006; Haupt et al. 2008; Schlesewsky and Bornkessel 2004, for empirical evidence). The present paper aims to further extend these findings by examining the interaction of the subject preference with thematic-role assignments and noun phrase specificity/referentiality in natural reading.

Although most previous studies of semantic word order constraints have examined unambiguous sentences, some linking-based accounts of sentence processing have recently provided an indication as to how these information types might apply in the incremental interpretation of locally ambiguous sentences (cf. Bornkessel and Schlesewsky 2006; Bornkessel-Schlesewsky and Schlesewsky 2009; de Hoop and Lamers 2006). These models assume to a greater or lesser extent that, based on their inherent properties (e.g. animacy, definiteness/specificity), verbal arguments can be characterized as more or less prominent and that the interpretation of an argument as "more Agent-like" (Actor) or "more Patient-like" (Undergoer) involves a relational assessment of relative argument prominence. For example, Bornkessel-Schlesewsky and Schlesewsky (2009) argue that semantic prominence features are not only used to determine an argument's role prototypicality during incremental sentence processing (i.e. the goodness of fit between an argument and the Actor or Undergoer role) but that they may also influence role assignments (i.e. which argument is analyzed as the Actor and which is analyzed as the Undergoer). The degree to which role assignments depend on different types of semantic prominence information is assumed to differ from language to language (cf. Wang et al., this volume, for evidence of animacy-based role assignments in ambiguous verb-final structures in Chinese).

A complete survey of all (cross-linguistic) prominence scales is beyond the scope of the present paper (see Aissen 2003 and Comrie 1989, for a typological approach; Bornkessel-Schlesewsky and Schlesewsky 2009, for a psycholinguistic perspective). Rather, we concentrate on the interaction between the thematic hierarchy (higher-ranking thematic role > lower-ranking thematic role), and the definiteness/specificity hierarchy (definite/specific > indefinite/nonspecific) in the processing of word order variations.[1] For present purposes, we define an argument's prominence status as the sum of its rankings on all accessible prominence hierarchies. Sentences are easiest to process when the hierarchies converge, i.e. when they all pick out the same argument as being more prominent (see Primus 1999, for theoretical arguments; and Bornkessel-Schlesewsky and Schlesewsky 2008, for psycholinguistic motivations). In addition, there is a preference for more prominent arguments to precede less prominent arguments in terms of linear order (Bornkessel et al. 2005; Grewe et al. 2005, 2006; Haupt et al. 2008; Wolff et al. 2008). Hence prominence information serves a twofold purpose during language comprehension: it is used (a) to determine and assess role assignments, and (b) to render word order variations (e.g. object-initial orders) more accessible. By measuring eye movements during reading, the present study aims to investigate the interplay between these two functions of prominence information in the comprehension of locally ambiguous structures.

A number of previous studies support the hypothesis that the reanalysis towards an object-initial order is influenced by the interaction of multiple prominence hierarchies. For example, Bornkessel et al. (2004) measured visually evoked event-related potentials (ERPs) in order to examine subject-object reanalyses in sentences with accusative (e.g. *stören*, 'to disturb') and dative-active verbs (e.g. *danken*), and found qualitative differences between the reanalyses engendered by both verb types. While disambiguation towards an object-initial order via an accusative verb elicited a P600 (a positive deflection in the electrical brain activity peaking around 600 ms post word-onset), disambiguation towards the same order via a dative verb elicited an N400 (a negative deflection peaking at approximately 400 ms). Bornkessel and colleagues interpreted the P600 as reflecting the revision of phrase structure representations, i.e. the establishment of an additional position targeted by the movement of the accusative NP. For the dative structures, by contrast, they conjectured that only a reassignment of case labels was required because of the principled availability of unmarked (base-generated) dative-initial structures in German (e.g., impersonal passives, sentences with object-experiencer verbs). These findings relate to the prominence hierarchies described above because unmarked dative-initial sentences occur when the dative argument bears a higher-ranking thematic role than its nominative co-argument (e.g., dative Experiencer – nominative Stimulus).

More recently, Haupt et al. (2008) measured auditory ERPs and found a biphasic N400-late positivity pattern for subject-object reanalyses with both accusative and dative verbs. They attributed the N400 to syntactic reanalysis and considered this process to be independent of object case. The late positivity, by contrast, was interpreted as a correlate of the markedness of scrambled word orders. By assuming a movement-independent account of scrambling in German (cf. Fanselow 2001; Heck 2000), Haupt et al. (2008) posit that the late positivity observed in their

[1] '>' reads as 'is more prominent than'. Note that these hierarchies directly translate into corresponding linearization principles. In the following, we will subsume both usages under the cover term 'hierarchy'.

studies is functionally distinct from the monophasic P600 observed for phrase structure revisions in other garden paths (e.g., the subordinate clause object/main clause subject ambiguity in English). In this way, Haupt and colleagues extended the phrase-structure-independent account proposed by Bornkessel et al. (2004) for subject-object reanalyses in dative constructions to all verb types in German.

Interestingly, they also argued that ERP components for accusative verbs may be more susceptible to task-specific strategies in visual ERPs using word-by-word presentation with RSVP (rapid serial visual presentation). In our first eye-tracking experiment, we thus aimed to investigate the relevance of different object cases in the reanalysis of the subject preference in order to examine whether data obtained in a more natural reading environment align with previous auditory ERP results or with visually evoked ERPs. Specifically, by comparing accusative verbs with dative-active verbs in an eye-tracking experiment we tested to what extent the verb-type effects described above generalize across further on-line methods using visual stimuli.

The interaction between syntactic reanalysis and the thematic hierarchy has also been tested more directly. In a second ERP study, Bornkessel et al. (2004) examined the processing of dative object-experiencer verbs (e.g., *gefallen* 'be appealing to') that link the higher-ranking Experiencer role to the syntactically lower-ranking object NP and the thematically lower-ranking Stimulus role to the syntactically more prominent subject NP (cf. Primus 1999; Wunderlich 1997). This mismatch eventually results in a preference for object-before-subject structures as the object outranks the subject on the thematic hierarchy (see the rating study in Haupt et al. 2008, for empirical evidence). In terms of ERP correlates, Bornkessel et al. (2004) found that the reanalysis towards an object-initial structure appears to be less costly for sentences with dative object-experiencer as opposed to dative active verbs, since a dispreferred disambiguation via an object-experiencer verb yielded a less pronounced N400 (cf. Bornkessel et al. 2005, for corresponding evidence from neuroimaging). From this finding, Bornkessel and colleagues concluded that the object-initial order is more easily reconstructed with these verbs as it conforms to the preferred linearization of thematic roles.[2] Following up on these findings, our second experiment focused on the interaction between word order and thematic roles by comparing subject-object reanalyses induced by dative-active and dative object-experiencer verbs.

Finally, previous research on the influence of argument prominence suggests that the costs of a reanalysis towards an object-initial order may be modulated by the arguments' relative rankings on nominal hierarchies such as the animacy hierarchy or the definiteness/specificity hierarchy (for theoretical motivations, see Lenerz 1977, 2001; Müller 1999; for empirical evidence from unambiguous sentences, see Grewe et al. 2006; for initial evidence from ambiguous sentences, see Wang et al., this volume). For example, Scheepers and colleagues found in a questionnaire study that compliance with the animacy hierarchy can promote object scrambling in

[2]Note that this facilitation in reanalysis is reduced if the object-experiencer verbs permit an agentive reading of the nominative argument, as is the case with accusative object-experiencer verbs in German (see Scheepers et al. 2000).

ambiguous structures containing accusative object-experiencer verbs (see Footnote 2) by excluding the agentive reading for the inanimate Stimulus and supporting the mapping of the higher-ranking thematic role (animate Experiencer) onto the syntactic object function. (For findings concerning animacy and definiteness in unambiguous structures, see the rating study in Haupt et al. 2008).

This raises the question of whether such influences also apply in on-line comprehension. Although it has not been demonstrated that lower prominence of the clause-initial NP affects the application of the subject preference in German, there is evidence that the resolution of subject-object ambiguities is more difficult if nominal hierarchies are additionally violated. For example, in Haupt et al.'s (2008) materials, a specific proper name was clause-initial in one half of all sentences and a nonspecific bare plural NP in the other. In sentences with initial bare plurals, reanalysis towards an object-initial order was more difficult, as reflected in lower acceptability ratings and a more pronounced reanalysis N400. This suggest that the recovery from a subject-object ambiguity is also influenced by the relative ranking of the arguments on nominal prominence hierarchies.

A similar investigation from Dutch suggests that definiteness/specificity may even affect the initial subject preference. Using self-paced reading, Kaan (2001; see also Kaan 1998) observed that the subject preference in Dutch is reduced substantially when the second ambiguous noun phrase was a second person pronoun outranking the clause-initial common noun in terms of definiteness and specificity. However, in contrast to the German studies described above, the definiteness/specificity hierarchy was additionally supported by the person hierarchy (1st/2nd person > 3rd person) in Kaan's critical sentence materials. This might have contributed to the different findings.

In sum, nominal hierarchies appear to affect the ease with which word order variations are processed. At the same time, there is diverging evidence as to the phase in which these effects emerge. In both of the present experiments, we examined the influence of the definiteness/specificity hierarchy on syntactic ambiguity resolution. In particular, we aimed to clarify whether a violation of this hierarchy may reduce the subject preference or whether it only impedes reanalysis. Whereas Experiment 1 investigated the interplay between this hierarchy and different types of object case, Experiment 2 examined the role of the thematic hierarchy.

2 Testing the Interaction of Syntactic Reanalysis and Prominence Hierarchies

2.1 Experiment 1

Experiment 1 investigated the resolution of word order ambiguities in German embedded clauses, when disambiguation is effected by either accusative (cf. 1a,b) or dative-active verbs (cf. 1c,d). Furthermore, and in accordance with the considerations outlined in the introduction, we manipulated argument prominence along the definiteness/specificity hierarchy by presenting the same sentence types with the bare plural preceding the proper name.[3]

(1) a. *Dass Erich Nachbarinnen stört, hat jeden verwundert.*
that Erich-AMB.SG neighbors-AMB.PL disturb-ACC.SG, has everyone surprised
'It surprised everyone that Erich disturbs neighbours.'

b. *Dass Erich Nachbarinnen stören, …*
that Erich-AMB.SG neighbors-AMB.PL disturb-ACC.PL
'It surprised everyone that neighbors disturb Erich.'

c. *Dass Erich Nachbarinnen dankt, …*
that Erich-AMB.SG neighbors-AMB.PL thank-DAT.SG
'It surprised everyone that Erich thanks neighbors.'

d. *Dass Erich Nachbarinnen danken, …*
that Erich-AMB.SG neighbors-AMB.PL thank-DAT.PL
'It surprised everyone that neighbors thank Erich.'

Like Haupt et al. (2008), we chose not to manipulate definiteness directly, e.g. by comparing noun phrases with definite and indefinite determiners, because the indefinite determiner *ein(e)* ('a') is also compatible with a numeral reading ('one') in German. It could therefore be interpreted as a quantifier (Fodor and Sag 1982), thereby leading to a confound during word order processing (cf. the results of the rating study in Haupt et al. 2008, for a first indication of such an influence). Specificity is also difficult to manipulate directly in German as it is not morphologically expressed (in contrast to languages such as Turkish, e.g. Comrie 1989). Hence, we drew upon a subpart of the definiteness/specificity hierarchy, which, following Croft (2003), can be termed the "referentiality hierarchy" (cf. 2).

(2) Referentiality hierarchy (Croft 2003, p. 130)
pronoun>proper name>common noun

In accordance with the hierarchy in (2), the present study manipulated the referentiality of the arguments by contrasting proper names with bare plural common nouns at the position of NP1 vs. NP2, thereby allowing for word order disambiguation via number agreement at the position of the clause-final verb.[4] Furthermore, proper names and bare plurals introduce a three-way ambiguity between nominative, accusative and dative case, which was required for the implementation of the object case manipulation.

[3] Abbreviations: SG – singular; PL – plural; AMB – ambiguity between nominative, accusative, and dative case; ACC – accusative verb; DAT – dative-active verb.

[4] Whereas bare plurals may lead to an ambiguity between a non-specific and a specific (generic) reading (Carlson 1977), it suffices for the purposes of the present manipulation that, even under a specific reading, they are still outranked by proper names on the definiteness/referentiality scales. In contrast to bare plurals, which denote sets of entities, proper nouns are uniquely identifiable.

In accordance with previous results, we expected to observe robust reanalysis effects for the disambiguating verb region and likely also for the spillover region (i.e., the region following the verb) in early and late eye movement measures. In addition, we hypothesized that these effects should be influenced by the type of object case. If there is indeed an interaction between the two factors, the crucial question is where it should be expected to emerge. Following grammatical theories which consider the dative as a non-default case that signals deviations from either the ideal Actor or the ideal Undergoer role in the semantic representation of a verb (cf. Van Valin 2005), a disadvantage for dative verbs should emerge as soon as information about the verb's argument structure is retrieved. Since argument structure information typically affects early eye movement measures (e.g. see Staub 2007, Experiment 3), this predicts early effects of case assignment in the present experiment. If these (lexically specified) non-default role properties of dative verbs serve to render word order reanalysis more difficult, an additional early interaction between case and word order might be expected. By contrast, if word order reanalysis is unaffected by case information or if the licensing of dative-initial structures in German is accomplished in a post-initial step, there may be no interaction effect at all or comprehensive measures of eye movements may be more suited to detecting this effect.

2.1.1 Method

Participants

Forty students (20 females; mean age: 23.1 years, range: 18–30) from the University of Marburg participated in the experiment. Participants were native speakers of German and had normal or corrected-to-normal vision. Four further participants had to be excluded from all analyses due to technical problems during the experiment (2), low performance in the comprehension task (1), or alcohol misuse prior to the experiment (1).

Materials

In order to maximize comparability with previous results, we employed a modified subset of Bornkessel et al.'s (2004) materials (cf. 1a–d). Crucially, syntactic disambiguation and case information are both provided by the embedded verb. We fully crossed the factors CASE (accusative [ACC] vs. dative [DAT]), ORDER (subject-before-object [SO] vs. object-before-subject [OS]), and NP (proper name-before-bare plural [PN] vs. bare plural-before-proper name [BP]), yielding eight conditions. We constructed 8 sets of 32 sentences, which were distributed across 8 lists such that 4 items occurred per condition. Subjects were allocated to one of these lists, and none of them read the same sentence twice. The experimental items were interspersed with 138 unrelated filler sentences from other experiments, and all sentences were presented in a randomized order. A yes/no question appeared after 25% of all trials. As the main purpose of these comprehension questions was to assure participants' attention, we balanced the required answers within a list such that participants had to answer yes or no to an equal number of questions. The average accuracy was 84%.

Apparatus

Participants' eye movements were recorded via an Eyelink 1000 eye-tracker with an angular resolution of 10–30 min of arc. The sampling rate was 1,000 Hz. Viewing was binocular, with the right eye recorded. Stimuli were displayed on a 21-in. monitor and participants were seated 60 cm in front of the computer screen. At this distance, 2.7 characters equalled 1° of visual angle. The experiment was run using the EyeTrack software provided by the University of Massachusetts, Amherst (http://www.psych.umass.edu/eyelab/software).

Procedure

Participants were tested individually. They were instructed to read the stimuli for comprehension and at their usual reading rate. A calibration routine was performed that lasted approximately 5 min. Every session started with ten practice trials each followed by a comprehension question. None of these practice items was related to the experimental or filler items. Subsequently, calibration was checked again and the experiment started. Calibration accuracy was checked after every trial and calibration was repeated after a break or as warranted by the calibration check. The entire experimental session lasted about 75 min.

Analysis

Prior to all analyses, less than 2% of all trials were excluded because of track losses or presentation problems. In addition, short fixations of less than 80 ms in duration were incorporated into an adjacent fixation if the distance between these two did not exceed one character, and fixations less than 40 ms in duration were treated similarly if they were within three characters of an adjacent fixation. Short fixations (less than 80 ms) that did not meet these criteria were excluded. Fixations longer than 800 ms were also excluded, as they are likely to reflect track losses (Rayner and Pollatsek 1989). In total, less than 1% of fixations was eliminated based on these criteria. For the purpose of analysis, we divided the sentences into six regions as shown for a subject-before-object clause in (3), where "/" indicates regions of analysis and "|" indicates the counterbalancing of lexical material across conditions. Region 4 contained the disambiguating verb, while regions 2 and 3 were counterbalanced with regard to NP type (with number agreement on the verb adjusted accordingly). The spillover region (region 5) comprised two words because the short auxiliary *hat* was very likely to be skipped.

(3) Dass_1/ Erich | Nachbarinnen_2/ Nachbarinnen | Erich_3/ stört | stören_4/ hat jeden_5/ verwundert._6

We computed the following measures (cf. Clifton et al. 2007): (1) first fixation duration (the duration of the first fixation on a region regardless of whether additional fixations followed); (2) first pass time (the sum of all fixations in a region from first entering it until leaving it to the right; referred to as gaze duration for single words); (3) first-pass regressions, (or 'regressions out'; the percentage of trials in which a region was terminated by a regressive saccade to earlier parts of the sentence); (4) go-past time (or regression path duration; includes first-pass reading time as well as any time spent re-reading material to the left of the critical region up to the point where the reader leaves the critical region with a progressive saccade.); (5) 'regressions in' (the probability of a region being the landing site of a regressive saccade; cf. Staub and Rayner 2007), and (6) total time (the sum of all fixations in a region). Measures 1–3 are typically considered early measures, whereas measures 4–6 are assumed to reflect later processing stages (cf. Clifton et al. 2007). Note that, because both NP types and verb types differ significantly in length (mean lengths: 6.12 characters for accusatives vs. 8.62 characters for dative-active verbs; 11.18 characters for bare plurals vs. 5.84 characters for proper names), we report first-pass and total reading times with both unadjusted times and with residual times that are corrected for length by subtracting obtained reading times from reading times predicted on the basis of a region's length (cf. Ferreira, and Clifton 1986; Trueswell et al. 1994).[5] For residual times, negative values indicate faster-than-predicted reading times, whereas positive values indicate slower-than-predicted reading times.

Note that for brevity, effects for the complementizer region are not reported for this and the second experiment. The effects for this region did not reveal any reliable

[5]Bare plurals and proper names also differed with respect to word frequency. Specifically, bare plurals were less frequent than proper names (mean log frequency class 15.37 vs. 10.97, where higher values indicate lower frequency; cf. www.wortschatz.uni-leipzig.de). A main effect of NP type on the critical noun phrases in unadjusted and residual reading times would thereby be confounded by lexical processing of a low-frequency vs. a high-frequency word. Accordingly, we could expect a main effect of NP on the verb region with longer reading times if the verb immediately followed a bare plural (as the preview benefit is limited because of enhanced foveal load on the long, low-frequency plural; cf. Henderson and Ferreira 1990; Rayner 1998). However, throughout both experiments, this prediction was not borne out, as we found increased reading times if the verb immediately followed the high-frequency proper name. Additionally, there were interactions of NP type with the other two factors suggesting that the disadvantage for bare plurals is locally resolved while fixating the respective NP. More importantly, syntactic reanalysis effects affected fixation durations on both NP regions regardless of NP order in Experiment 1 (cf. total times on NP1) and there were differential effects for bare plurals and proper names depending on the verb in Experiment 2. Overall, these effects cannot be accounted for by frequency differences.

Table 1 Mean reading times (in ms) and percent regressions (in %) for the ambiguous regions in Experiment 1

Measure	NP1	NP2	Measure	NP1	NP2
First fixation			*Go-past time*		
ACC-SO-PN	195 (5)	228 (5)	ACC-SO-PN	310 (15)	483 (24)
ACC-SO-BP	217 (6)	249 (7)	ACC-SO-BP	617 (24)	393 (25)
ACC-OS-PN	213 (7)	228 (6)	ACC-OS-PN	323 (15)	500 (21)
ACC-OS-BP	202 (5)	258 (8)	ACC-OS-BP	576 (22)	416 (25)
DAT-SO-PN	207 (6)	224 (5)	DAT-SO-PN	350 (16)	500 (24)
DAT-SO-BP	214 (5)	255 (8)	DAT-SO-BP	606 (28)	384 (20)
DAT-OS-PN	207 (6)	233 (6)	DAT-OS-PN	345 (16)	557 (27)
DAT-OS-BP	209 (6)	252 (7)	DAT-OS-BP	630 (33)	369 (21)
First pass time			*Residual first pass time*		
ACC-SO-PN	232 (9)	409 (18)	ACC-SO-PN	–85 (10)	–50 (16)
ACC-SO-BP	444 (22)	303 (11)	ACC-SO-BP	–15 (21)	–14 (10)
ACC-OS-PN	248 (10)	434 (18)	ACC-OS-PN	–67 (10)	–19 (17)
ACC-OS-BP	387 (20)	319 (14)	ACC-OS-BP	–70 (18)	1 (13)
DAT-SO-PN	259 (11)	432 (18)	DAT-SO-PN	–60 (11)	–25 (17)
DAT-SO-BP	457 (25)	295 (10)	DAT-SO-BP	–1 (24)	–25 (9)
DAT-OS-PN	252 (10)	452 (20)	DAT-OS-PN	–64 (10)	–5 (19)
DAT-OS-BP	421 (22)	297 (12)	DAT-OS-BP	–33 (19)	–22 (11)
Total time			*Residual total time*		
ACC-SO-PN	331 (18)	615 (32)	ACC-SO-PN	–134 (16)	–84 (27)
ACC-SO-BP	766 (35)	420 (19)	ACC-SO-BP	62 (28)	–55 (15)
ACC-OS-PN	425 (23)	756 (36)	ACC-OS-PN	–46 (20)	64 (29)
ACC-OS-BP	919 (46)	571 (31)	ACC-OS-BP	218 (38)	102 (27)
DAT-SO-PN	395 (20)	648 (31)	DAT-SO-PN	–78 (18)	–53 (28)
DAT-SO-BP	754 (36)	427 (22)	DAT-SO-BP	55 (29)	–46 (18)
DAT-OS-PN	444 (25)	776 (38)	DAT-OS-PN	–29 (19)	75 (32)
DAT-OS-BP	889 (46)	503 (30)	DAT-OS-BP	195 (39)	35 (25)
Regressions out			*Regressions in*		
ACC-SO-PN	22 (3)	10 (2)	ACC-SO-PN	23 (3)	35 (4)
ACC-SO-BP	29 (4)	13 (3)	ACC-SO-BP	42 (4)	24 (4)
ACC-OS-PN	25 (4)	10 (3)	ACC-OS-PN	42 (4)	47 (4)
ACC-OS-BP	34 (4)	14 (3)	ACC-OS-BP	58 (4)	34 (4)
DAT-SO-PN	25 (4)	8 (2)	DAT-SO-PN	32 (4)	34 (4)
DAT-SO-BP	22 (3)	13 (3)	DAT-SO-BP	40 (4)	28 (4)
DAT-OS-PN	27 (4)	15 (3)	DAT-OS-PN	45 (4)	45 (4)
DAT-OS-BP	28 (4)	11 (3)	DAT-OS-BP	51 (4)	34 (4)

Standard error is given in parentheses

SO subject-before-object, *OS* object-before-subject, *ACC* accusative verb, *DAT* dative-active verb, *PN* proper name-before-bare plural, *BP* bare plural-before-proper name

effects in early eye movement measures and they did not differ significantly from the effects for the critical NP regions in comprehensive measures. Factorial 2×2×2 repeated-measures ANOVAs were calculated treating participants (F_1) and items (F_2) as random factors. Tables 1 and 2 present the mean reading times for the critical regions, and Table 3 summarizes the statistical tests.

Table 2 Mean reading times (in ms) and percent regressions (in %) for the verb and the following regions in Experiment 1

Measure	Verb region	Spillover region	Final region
First fixation			
ACC-SO-PN	278 (9)	210 (4)	274 (10)
ACC-SO-BP	275 (9)	218 (5)	271 (10)
ACC-OS-PN	287 (10)	232 (7)	275 (11)
ACC-OS-BP	293 (10)	227 (7)	296 (12)
DAT-SO-PN	289 (9)	211 (5)	284 (10)
DAT-SO-BP	274 (10)	217 (6)	286 (12)
DAT-OS-PN	290 (10)	234 (8)	282 (11)
DAT-OS-BP	279 (10)	234 (8)	290 (12)
First pass time			
ACC-SO-PN	334 (11)	383 (14)	426 (24)
ACC-SO-BP	364 (15)	386 (13)	425 (21)
ACC-OS-PN	375 (15)	445 (20)	420 (24)
ACC-OS-BP	389 (19)	435 (16)	457 (24)
DAT-SO-PN	415 (17)	379 (13)	400 (19)
DAT-SO-BP	470 (19)	414 (15)	409 (20)
DAT-OS-PN	501 (23)	463 (19)	422 (20)
DAT-OS-BP	486 (26)	441 (20)	411 (20)
Residual first pass time			
ACC-SO-PN	3 (10)	−31 (13)	9 (23)
ACC-SO-BP	16 (14)	−30 (13)	5 (20)
ACC-OS-PN	28 (14)	36 (20)	2 (23)
ACC-OS-BP	56 (17)	23 (16)	41 (23)
DAT-SO-PN	28 (16)	−32 (13)	−19 (20)
DAT-SO-BP	49 (17)	3 (15)	−12 (19)
DAT-OS-PN	86 (21)	50 (20)	1 (20)
DAT-OS-BP	93 (23)	30 (19)	−9 (20)
Go-past time			
ACC-SO-PN	462 (27)	440 (21)	818 (51)
ACC-SO-BP	470 (23)	450 (23)	1,032 (71)
ACC-OS-PN	564 (34)	591 (38)	1,077 (73)
ACC-OS-BP	742 (51)	657 (50)	1,303 (94)
DAT-SO-PN	583 (29)	474 (27)	940 (66)
DAT-SO-BP	622 (34)	461 (21)	1,026 (74)
DAT-OS-PN	688 (37)	671 (46)	1,046 (68)
DAT-OS-BP	846 (60)	611 (43)	1,180 (98)
Total time			
ACC-SO-PN	419 (17)	533 (24)	509 (30)
ACC-SO-BP	501 (26)	591 (23)	538 (28)
ACC-OS-PN	572 (28)	656 (31)	511 (26)
ACC-OS-BP	693 (37)	698 (32)	558 (28)
DAT-SO-PN	597 (26)	558 (22)	507 (27)
DAT-SO-BP	634 (28)	604 (27)	523 (29)
DAT-OS-PN	725 (32)	696 (31)	514 (23)
DAT-OS-BP	820 (45)	678 (33)	528 (27)

(continued)

Table 2 (continued)

Measure	Verb region	Spillover region	Final region
Residual total time			
ACC-SO-PN	−75 (16)	−87 (23)	−124 (31)
ACC-SO-BP	−22 (21)	−34 (22)	−105 (30)
ACC-OS-PN	53 (23)	43 (29)	−126 (30)
ACC-OS-BP	201 (30)	74 (30)	−78 (28)
DAT-SO-PN	2 (21)	−64 (23)	−135 (30)
DAT-SO-BP	3 (23)	−18 (26)	−126 (28)
DAT-OS-PN	96 (27)	72 (29)	−125 (26)
DAT-OS-BP	225 (35)	62 (30)	−112 (30)
Regressions out			
ACC-SO-PN	21 (3)	8 (2)	46 (4)
ACC-SO-BP	20 (3)	8 (2)	55 (4)
ACC-OS-PN	23 (3)	12 (3)	57 (4)
ACC-OS-BP	32 (4)	13 (3)	56 (4)
DAT-SO-PN	20 (3)	11 (2)	54 (4)
DAT-SO-BP	19 (3)	7 (2)	50 (4)
DAT-OS-PN	23 (3)	15 (3)	62 (4)
DAT-OS-BP	32 (4)	13 (3)	53 (4)
Regressions in			
ACC-SO-PN	8 (2)	34 (4)	–
ACC-SO-BP	16 (3)	38 (4)	
ACC-OS-PN	16 (3)	34 (4)	
ACC-OS-BP	17 (3)	33 (4)	
DAT-SO-PN	20 (3)	38 (4)	
DAT-SO-BP	16 (3)	33 (4)	
DAT-OS-PN	20 (3)	36 (4)	
DAT-OS-BP	17 (3)	38 (4)	

Standard error is given in parentheses
SO subject-before-object, *OS* object-before-subject, *ACC* accusative verb, *DAT* dative-active verb, *PN* proper name-before-bare plural, *BP* bare plural-before-proper name

Table 3 Summary of the statistical analyses for Experiment 1

	Verb region		Spillover region		Final region	
	F_1	F_2	F_1	F_2	F_1	F_2
First fixation						
Case	<1	<1	<1	<1	1.29	<1
Order	1.62	2.76	11.39**	12.80***	1.13	<1
NP	1.49	<1	<1	<1	1.03	1.04
First pass time						
Case	85.79***	22.03***	2.17	1.21	2.66	2.07
Order	20.78***	11.93**	17.43***	17.91***	1.26	<1
NP	2.29	2.12	<1	<1	<1	<1
Order × NP	2.97	4.28*	3.07	2.11	<1	<1

(continued)

Table 3 (continued)

	Verb region		Spillover region		Final region	
	F_1	F_2	F_1	F_2	F_1	F_2
Residual first pass time						
Case	14.35***	5.15*	2.25	1.4	2.74	2.28
Order	20.13***	13.16***	17.54***	21.26***	1.32	1.08
NP	1.99	2.67	<1	<1	<1	<1
Go-past time						
Case	22.21***	17.09**	<1	1.06	<1	<1
Order	28.24***	43.50***	26.73***	52.76***	9.28**	14.45***
NP	14.32***	12.93***	<1	<1	9.51**	9.89**
Order × NP	6.46*	5.14*	<1	<1	<1	<1
Total time						
Case	57.90***	28.93***	<1	<1	<1	<1
Order	54.06***	108.20***	27.25***	56.32***	<1	<1
NP	14.23***	11.72**	3.96†	4.59*	2.1	3.5
Residual total time						
Case	6.60*	5.21*	<1	<1	<1	<1
Order	55.58***	114.32***	27.85***	57.61***	1.04	<1
NP	15.83***	19.26***	3.66†	3.91†	2.28	1.38
Order × NP	10.59**	7.97**	1.41	<1	<1	<1
Regressions out						
Case	<1	<1	<1	1.27	<1	<1
Order	8.36**	9.51**	4.72*	6.58*	3.19	5.42*
NP	2.1	1.73	<1	<1	<1	<1
Order × NP	8.67**	6.20*	<1	<1	1.96	1.72
Case × NP	<1	<1	<1	1.86	4.04†	5.91*
Regressions in						
Case	3.73†	3.64†	<1	<1	–	–
Order	<1	1.1	<1	<1		
NP	<1	<1	<1	<1		
Case × NP	3.94†	3.45	<1	<1		

	NP1		NP2	
	F_1	F_2	F_1	F_2
First Fixation				
Case	<1	<1	<1	<1
Order	<1	<1	<1	<1
NP	2.28	1.12	16.77***	14.31***
Order × NP	11.93***	5.89*	<1	<1
First pass time				
Case	5.21*	2.6	<1	<1
Order	1.87	3.32	2.85	2.12
NP	93.84***	84.03***	108.78***	55.50***
Order × NP	3.96†	4.51*	<1	<1

(continued)

Table 3 (continued)

	NP1		NP2	
	F_1	F_2	F_1	F_2
Residual first pass time				
Case	4.45*	2.94*	<1	<1
Order	1.6	2.34	2.9	2.24
NP	9.54**	4.03†	<1	<1
Order × NP	4.79*	4.68*	<1	<1
Case × NP	<1	<1	4.84*	3.76†
Go-past time				
Case	5.88*	2.32	<1	<1
Order	<1	<1	2.58	1.24
NP	230.70***	120.15***	62.39***	35.66***
Case × NP	<1	<1	5.47*	6.01*
Total time				
Case	<1	<1	<1	<1
Order	25.43***	29.55***	30.21***	36.44***
NP	171.37***	233.49***	95.55***	50.04***
Order × NP	6.32*	3.31	<1	<1
Residual total time				
Case	<1	<1	<1	<1
Order	25.57***	35.13***	30.29***	40.09***
NP	57.30***	60.96***	<1	<1
Order × NP	6.06*	5.07*	<1	<1
Regressions out				
Case	<1	<1	<1	<1
Order	2.68	3.12	<1	<1
NP	2.62	1.26	1.11	<1
Regressions in				
Case	<1	<1	<1	<1
Order	35.55***	29.13***	13.36***	15.72***
NP	21.01***	36.13***	11.03**	13.98**
Case × NP	5.19*	6.16*	1.07	<1

For participant analyses df = 1,39 (except spillover region with df = 1,38); for item analyses df = 1,31. Interactions are not reported unless significant for at least one of the critical regions
†$p \leq .07$; *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

2.1.2 Results

Regions 2 and 3: The Two Case-Ambiguous Noun Phrases (NP1, NP2)

Both NP1 and NP2 showed effects of NP from early measures onwards. These effects were mostly due to longer fixation durations for bare plural NPs vs. proper names and could therefore be explained via the length/frequency differences between the two NP types. By contrast, the first fixation duration on NP2 was longer for proper names.

This could be regarded as a spillover effect from the bare plural NP1 as the first fixation after a low-frequency word can be modestly inflated (cf. Inhoff and Rayner 1986). Later measures (unadjusted and residual total times, 'regressions in') additionally showed effects of ORDER that were due to longer fixations/higher proportions of regressions to the NP regions for object-initial sentences.

At the position of NP1, the effects of ORDER and NP were qualified by an interaction between the two factors in several measures. For early measures, resolving this interaction by NP did not reveal any fully reliable effects (first fixation duration: the effect of ORDER was only reliable by participants in both the PN-first ($p_1 < .04$, $p_2 < .2$), and the BP-first conditions ($p_1 < .05$; $p_2 < .08$); first pass analyses: no significant effects for PN-first conditions; effects of ORDER only significant by items for the BP-first conditions (unadjusted: $p_1 < .09$, $p_2 < .04$; residual: $p_1 < .08$, $p_2 < .05$). For residual total times, by contrast, the resolution of the interaction revealed significant effects of ORDER for both levels of NP, with the interaction due to a larger difference between object-initial and subject-initial structures in the BP conditions (PN: $F_1(1,39) = 14.61$, $p < .001$; $F_2(1,31) = 9.09$, $p < .01$; BP: $F_1(1,39) = 20.55$, $p < .001$; $F_2(1,31) = 23.26$, $p < .001$).

In sum, the pattern of eye movements on both NP regions confirms that object-initial orders caused processing disruption, suggesting that readers regressed to the two case-ambiguous NPs in order to recover from their initial (subject-initial) misanalysis.[6]

Region 4: The Disambiguating Verb

First fixation durations showed no significant main effects or interactions. ORDER affected all remaining measures for this region except 'regressions in',

[6] At a first glance, the interaction between word order and NP type in the early eye-tracking record for NP1 could be taken to suggest that readers already obtained syntactic cues to guide their initial structural interpretation while fixating the first case-ambiguous NP. This information would need to be obtained parafoveally from the second word (word $n+2$) to the right of the currently fixated word, which is known as a parafoveal-on-foveal effect (for a recent overview, see Kennedy 2008). The effect was most apparent when the short proper name intervened between bare plural and disambiguating verb, which is in accordance with previous results showing that parafoveal-on-foveal effects from word $n+2$ especially occur when word $n+1$ is rather short (cf. Kliegl et al. 2007). However, several points render the assumption of a parafoveal-on-foveal effect less likely. First, we still observed reanalysis costs on the disambiguating region in the same conditions that showed the supposed parafoveal-on-foveal effect. In fact, the data in go-past time for the disambiguating verb suggest that reanalysis was even more difficult to accomplish in these cases. Second, the proper name (word $n+1$) in our experiment was almost about twice as long as the length usually reported for word $n+1$ when there were parafoveal-on-foveal effects from word $n+2$. Apparently, these effects are most likely to occur when word $n+1$ does not exceed more than three letters in length (cf. Angele et al. 2008). Finally, there is no corresponding effect on NP1 in our second experiment which used an identical set of NPs. Altogether, these facts speak against a parafoveal-on-foveal effect.

with higher fixation durations for object-initial orders. The effect of ORDER was modified by an interaction with NP in unadjusted first pass time (marginal), first-pass regressions, go-past time, and in residual total reading times. Resolving the fully significant interactions revealed that, for both go-past time and residual total times, ORDER had a significant influence in both NP conditions (go-past time: PN: $F_1(1,39)=19.94$, $p<.001$, $F_2(1,31)=12.06$, $p<.01$; BP: $F_1(1,39)=19.31$, $p<.001$; $F_2(1,31)=26.28$, $p<.001$; residual total time: PN: $F_1(1,39)=19.99$, $p<.001$; $F_2(1,31)=22.41$, $p<.001$; BP: $F_1(1,39)=49.74$, $p<.001$; $F_2(1,31)=76.17$, $p<.001$). The interaction reflected the fact that, while reanalysis costs were apparent for both PN and BP conditions, the difference between OS and SO conditions was larger in plural-first sentences. Object-initial clauses also led to significantly more regressions in BP sentences ($F_1(1,39)=17.20$, $p<.001$; $F_2(1,31)=12.65$, $p=.001$; 32% for OS vs. 20% for SO), whereas there was no difference for conditions with an initial proper name (Fs <1).

CASE influenced reading times from first pass time onwards. Whereas the significant effects in residual measures suggest that these differences were not due to length, length confounds cannot be ruled out for the marginally higher rater of 'regressions in' for dative verbs. Crucially, the interaction between CASE and ORDER did not approach significance in any measure.

Region 5: The Spillover Region (Auxiliary Plus Indefinite Pronoun)

The main effect of ORDER consistently spilled over from the disambiguating region to the spillover region, where it affected early and late measures of eye movements. Object-initial vs. subject-initial sentences led to increased fixation durations or a higher probability of making a regressive saccade. The factors ORDER and CASE did not interact in any measure. Furthermore, unadjusted and residual total times evidence a marginal main effect of NP, which resulted from longer reading times for plural-first sentences.

Region 6: The Final Region (Past Participle of the Matrix Verb)

Our analyses only revealed effects for regressive eye movement measures. Go-past time revealed main effects of ORDER and NP, with object-initial clauses and initial bare plurals engendering increased reading times. First-pass regressions showed an almost significant interaction between CASE and NP ($p_1=.051$; $p_2<.03$). Resolving this interaction by NP showed that readers were somewhat more likely to regress in the PN conditions when the disambiguating region contained a dative-active verb, but not in the corresponding BP conditions (PN: $F_1(1,39)=3.68$, $p<.07$; $F_2(1,31)=4.06$, $p=.06$; BP: $F_1(1,39)=1.28$, $p<.3$; $F_2(1,31)<1$). This effect appeared to result from the OS-PN condition, in which the proper name is linked to the less prominent object function, yielding additional processing efforts.

2.1.3 Discussion

Overall, the results of Experiment 1 confirmed our hypothesis concerning reanalysis costs for the dispreferred object-before-subject structure. Evidently, readers followed the subject preference upon encountering the first case-ambiguous NP in the embedded clause. When the supposed subject did not meet the agreement requirements of the clause-final verb, the entire structure had to be revised, which led to clearly visible reanalysis costs on the verb and the immediately following region. This garden path effect already appeared in early eye movement measures and lasted until late processing stages. Object-initial sentences also engendered more first-pass regressions. Thus, word order ambiguities elicited strong garden path effects (including increased fixation times and regressions) that were difficult to overcome (cf. Frazier and Rayner 1982). Late eye tracking measures additionally showed that readers spent more time re-reading both ambiguous noun phrases, likely due to the need for reanalysis. This pattern adds to the large body of results confirming the robust effects of the subject preference and subsequent syntactic reanalysis across different stimuli and experimental methods.

Although we observed reanalysis effects across several regions, they did not interact with case information at any time. Thus, there is no evidence to suggest that syntactic reanalysis was easier with dative verbs. Rather, we found a general disadvantage for dative case on the verb as early as in (residual) first pass time. One possible interpretation of this finding is that it reflects the need to interpret a two-argument relation that is not ideally transitive: dative-active verbs do not assign all possible generalized semantic roles (cf. dative as a non-macrorole case: Van Valin 2005; Bornkessel and Schlesewsky 2006) or call for the assignment of a generalized role with only a low number of prototypical features (cf. the "dative default" principle in Primus 1999).[7] The additional effect on first-pass regressions in the sentence-final region suggests that the dative disadvantage affected sentence wrap-up processes as well. In particular, this effect was evident in the condition in which the more highly referential proper name had to be mapped to the less prominent object (OS-PN). This observation could be viewed as evidence for a linking mismatch between the referentiality hierarchy and the syntactic hierarchy that is more severe for marked transitive events. The interaction between object case and referentiality provides additional support for an interpretation of the case effect in terms of thematic processing: if it were simply due to lexical or formal differences between the two verb types (e.g. the assignment of lexical vs. structural object case

[7] Note that the verb types did not differ with respect to token frequency. Hence, the prolonged fixation durations for dative verbs do not reflect a lexical frequency effect. Nevertheless, since the class of dative-assigning verbs is less frequent than the class of accusative-assigning verbs, the disadvantage for dative verbs could also be due to type frequency. However, in contrast to a thematically-based account (see the main text), a frequency-based account does not provide an explanation for the interaction between verb type and noun phrase prominence.

or type frequency), it is not clear why it should interact with a semantic prominence hierarchy such as referentiality.

Let us finally turn to linearization and the definiteness/specificity hierarchy. Our data showed a preference for proper nouns, which are higher in referentiality (as a subtype of definiteness/specificity), to precede bare plurals across all eye movement measures under investigation (see Clifton and Frazier 2004, for a similar observation regarding definiteness in English double-object constructions). These observations are in accordance with theoretical assumptions about the definiteness/specificity hierarchy and word order in German (cf. Lenerz 1977; Müller 1999). Crucially, however, our findings suggest that noun phrase referentiality does not reverse the subject preference. If bare plurals were preferentially analyzed as objects due to their lower semantic prominence status, we should have observed an advantage for an object-before-subject order in BP-sentences. However, this prediction was not borne out. Rather, supporting evidence from the referentiality hierarchy only appeared to aid reanalysis (e.g. in residual total times at the verb, the difference between SO and OS in the PN conditions was approximately 38 ms, whereas it amounted to 203 ms for BP conditions).[8] This result provides converging evidence for the assumption (see the introduction) that Kaan's (2001) apparent finding of a referentiality-based reduction of the subject preference was likely due to the person hierarchy, i.e. to the dissociation between a second person-speech act participant and a third person referent (cf. DeLancey 1981).

2.2 *Experiment 2*

Experiment 2 investigated the interaction between the thematic hierarchy and the syntactic (subject-object) hierarchy. In particular, we aimed to examine whether the reanalysis effects for object-initial structures are modified by an interaction

[8]This is also expected under the assumption that scrambled bare-plural objects in German entail a generic, nonspecific interpretation, whereas non-scrambled bare plural objects can only receive an existential interpretation (cf. Kratzer 1995). With regard to bare plural subjects, it has been proposed that the interpretation of bare plurals depends on whether they appear as subjects of either stage-level or individual-level predicates, with only stage-level predicates allowing for a generic interpretation (Diesing 1992; Kratzer 1995). By contrast, more recent investigations assume only non-existential readings for bare plural subjects (cf. Kallulli 2006). A post-hoc inspection of the verbs used here revealed that the majority of them in fact belonged to stage-level predicates. However, in our experiment, bare plurals were semantically ambiguous because case-ambiguous NPs in a verb-final clause cannot provide information about word order. Due to this inherent ambiguity, and since we presented isolated sentences, we cannot rule out that readers preferred to give initial bare plurals an existential and specific interpretation. Nevertheless, as argued in the introduction to Experiment 1, bare plurals are still lower in referentiality than proper names even under these circumstances and therefore lower on the overall definiteness/specificity hierarchy.

between verb type and word order. Specifically, object-initial structures should be less costly with dative object-experiencer verbs, whereas subject-initial sentences should be easier to process with dative-active verbs. Predictions concerning referentiality as a subtype of the definiteness/specificity hierarchy remained identical to Experiment 1.

2.2.1 Method

Participants

Forty students (20 females; mean age: 23.5 years, range: 18–28) from the University of Marburg participated in the experiment. Participants were native speakers of German and had normal or corrected-to-normal vision. None of them had participated in Experiment 1. Four further participants had to be excluded from all analyses due to low performance in the comprehension task (1), technical problems during the experiment (1), or excessive track losses (2).

Materials

The stimuli differed from the sentences used in Experiment 1 with regard to the verb types used, as we replaced accusative verbs with dative object-experiencer verbs. All other experimental factors, sentence construction and allocation to lists remained identical. In each list, the experimental items were interspersed with 112 filler items from other experiments. A yes/no question appeared after 25% of all trials. The average accuracy was 86%. The entire experiment lasted 60 min.

Apparatus and Procedure

Apparatus and procedure were the same as in Experiment 1.

Analyses

Prior to all analyses, less than 3% of all trials had to be removed due to track losses or presentation problems. Less than 1% of fixations was eliminated based on the criteria described for Experiment 1. Sentences were divided into the same regions as in Experiment 1. We computed the same eye movement measures and repeated-measures ANOVAs with the following two exceptions: first, as the crucial verbs did not differ with respect to length (8.62 characters for dative-active verbs vs. 8.73 characters for dative object-experiencer verbs), we only report unadjusted reading

Table 4 Mean reading times (in ms) and percent regressions (in %) for the ambiguous regions in Experiment 2

Measure	NP1	NP2	Measure	NP1	NP2
First fixation			*Go-past time*		
EXP-SO-PN	215 (7)	245 (7)	EXP-SO-PN	334 (15)	502 (21)
EXP-SO-BP	215 (7)	256 (8)	EXP-SO-BP	553 (31)	383 (21)
EXP-OS-PN	225 (7)	249 (6)	EXP-OS-PN	337 (16)	545 (24)
EXP-OS-BP	215 (6)	252 (7)	EXP-OS-BP	525 (24)	327 (12)
DAT-SO-PN	212 (7)	241 (6)	DAT-SO-PN	329 (16)	568 (33)
DAT-SO-BP	208 (6)	251 (8)	DAT-SO-BP	546 (26)	326 (14)
DAT-OS-PN	217 (6)	246 (7)	DAT-OS-PN	343 (13)	531 (27)
DAT-OS-BP	214 (6)	240 (6)	DAT-OS-BP	547 (23)	343 (19)
First pass time			*Residual first pass time*		
EXP-SO-PN	289 (13)	443 (20)	EXP-SO-PN	−27 (12)	−32 (18)
EXP-SO-BP	473 (24)	302 (12)	EXP-SO-BP	−5 (20)	−18 (12)
EXP-OS-PN	291 (13)	479 (20)	EXP-OS-PN	−33 (11)	3 (17)
EXP-OS-BP	470 (24)	290 (9)	EXP-OS-BP	−4 (22)	−22 (9)
DAT-SO-PN	301 (15)	479 (21)	DAT-SO-PN	−12 (14)	26 (22)
DAT-SO-BP	479 (23)	295 (10)	DAT-SO-BP	−4 (20)	−26 (10)
DAT-OS-PN	292 (11)	460 (17)	DAT-OS-PN	−23 (12)	−10 (17)
DAT-OS-BP	467 (19)	286 (11)	DAT-OS-BP	2 (21)	−34 (11)
Total time			*Residual total time*		
EXP-SO-PN	353 (15)	602 (30)	EXP-SO-PN	−58 (14)	−14 (26)
EXP-SO-BP	650 (33)	389 (19)	EXP-SO-BP	31 (28)	−26 (17)
EXP-OS-PN	374 (19)	630 (29)	EXP-OS-PN	−39 (17)	12 (26)
EXP-OS-BP	657 (32)	402 (18)	EXP-OS-BP	42 (28)	−4 (16)
DAT-SO-PN	360 (17)	646 (34)	DAT-SO-PN	−52 (16)	24 (30)
DAT-SO-BP	616 (29)	351 (14)	DAT-SO-BP	−1 (25)	−64 (14)
DAT-OS-PN	392 (17)	690 (37)	DAT-OS-PN	−18 (14)	70 (34)
DAT-OS-BP	691 (36)	371 (17)	DAT-OS-BP	70 (30)	−42 (14)
Regressions out			*Regressions in*		
EXP-SO-PN	8 (2)	11 (3)	EXP-SO-PN	20 (3)	25 (4)
EXP-SO-BP	8 (2)	14 (3)	EXP-SO-BP	26 (4)	14 (3)
EXP-OS-PN	9 (2)	10 (2)	EXP-OS-PN	19 (3)	23 (3)
EXP-OS-BP	9 (2)	9 (2)	EXP-OS-BP	33 (4)	23 (3)
DAT-SO-PN	6 (2)	8 (2)	DAT-SO-PN	17 (3)	23 (3)
DAT-SO-BP	8 (2)	6 (2)	DAT-SO-BP	21 (3)	15 (3)
DAT-OS-PN	13 (3)	6 (2)	DAT-OS-PN	22 (3)	31 (4)
DAT-OS-BP	12 (3)	10 (2)	DAT-OS-BP	33 (4)	13 (3)

Standard error is given in parentheses

SO subject-before-object, *OS* object-before-subject, *EXP* dative object-experiencer verb, *DAT* dative-active verb, *PN* proper name-before-bare plural, *BP* bare plural-before-proper name

times for the disambiguating verbs; second, since both verbs assign dative case, we substituted the factor CASE with VERB (dative-object experiencer verb [EXP] vs. dative-active verb [DAT]). Tables 4 and 5 present the mean reading times for the critical regions, and Table 6 summarizes the statistical tests.

Table 5 Mean reading times (in ms) and percent regressions (in %) for the verb and following regions in Experiment 2

Measure	Verb region	Spillover region	Final region
First fixation			
EXP-SO-PN	296 (10)	239 (6)	317 (13)
EXP-SO-BP	297 (10)	247 (8)	312 (12)
EXP-OS-PN	283 (10)	248 (7)	277 (10)
EXP-OS-BP	305 (11)	246 (8)	303 (13)
DAT-SO-PN	271 (7)	221 (6)	312 (12)
DAT-SO-BP	282 (9)	231 (6)	327 (13)
DAT-OS-PN	290 (8)	241 (8)	319 (12)
DAT-OS-BP	280 (9)	241 (8)	306 (12)
First pass time			
EXP-SO-PN	398 (19)	382 (14)	516 (27)
EXP-SO-BP	429 (19)	406 (16)	495 (27)
EXP-OS-PN	424 (18)	415 (15)	452 (27)
EXP-OS-BP	456 (22)	419 (21)	476 (27)
DAT-SO-PN	392 (15)	352 (13)	484 (26)
DAT-SO-BP	453 (22)	362 (13)	470 (23)
DAT-OS-PN	454 (20)	422 (18)	473 (25)
DAT-OS-BP	440 (17)	403 (16)	519 (30)
Go-past time			
EXP-SO-PN	500 (28)	502 (37)	914 (64)
EXP-SO-BP	498 (25)	442 (23)	838 (65)
EXP-OS-PN	527 (28)	520 (35)	756 (54)
EXP-OS-BP	639 (42)	486 (28)	975 (73)
DAT-SO-PN	491 (24)	429 (22)	736 (44)
DAT-SO-BP	524 (25)	450 (25)	791 (66)
DAT-OS-PN	624 (35)	592 (43)	892 (61)
DAT-OS-BP	559 (30)	520 (36)	855 (52)
Total time			
EXP-SO-PN	556 (31)	525 (22)	622 (31)
EXP-SO-BP	536 (28)	486 (21)	556 (29)
EXP-OS-PN	537 (23)	525 (21)	535 (33)
EXP-OS-BP	637 (34)	567 (32)	608 (35)
DAT-SO-PN	477 (17)	462 (18)	557 (29)
DAT-SO-BP	561 (27)	497 (22)	551 (31)
DAT-OS-PN	645 (33)	579 (28)	554 (29)
DAT-OS-BP	570 (25)	513 (22)	589 (31)
Regressions out			
EXP-SO-PN	13 (3)	11 (3)	39 (4)
EXP-SO-BP	9 (2)	4 (2)	30 (4)
EXP-OS-PN	14 (3)	9 (2)	35 (4)
EXP-OS-BP	20 (3)	8 (2)	41 (4)
DAT-SO-PN	13 (3)	11 (2)	30 (4)
DAT-SO-BP	13 (3)	10 (3)	34 (4)
DAT-OS-PN	21 (3)	14 (3)	38 (4)
DAT-OS-BP	12 (3)	10 (2)	36 (4)

(continued)

Table 5 (continued)

Measure	Verb region	Spillover region	Final region
Regressions in			
EXP-SO-PN	19 (3)	23 (3)	–
EXP-SO-BP	9 (2)	15 (3)	
EXP-OS-PN	13 (3)	23 (3)	
EXP-OS-BP	13 (3)	21 (3)	
DAT-SO-PN	10 (2)	19 (3)	
DAT-SO-BP	12 (3)	25 (4)	
DAT-OS-PN	19 (3)	24 (3)	
DAT-OS-BP	12 (3)	16 (3)	

Standard error is given in parentheses
SO subject-before-object, *OS* object-before-subject, *EXP* dative object-experiencer verb, *DAT* dative-active verb, *PN* proper name-before-bare plural, *BP* bare plural-before-proper name

Table 6 Summary of the statistical analyses for Experiment 2

	Verb region		Spillover region		Final region	
	F_1	F_2	F_1	F_2	F_1	F_2
First fixation						
Verb	5.53*	3.53†	4.69*	6.60*	1.02	1.68
Order	<1	<1	4.59*	2.74	3.63†	4.39*
NP	1.07	<1	<1	1.29	<1	<1
Verb × Order × NP	3.74†	3.22	2.26	<1	3.50†	5.47*
First pass time						
Verb	<1	<1	4.36*	4.51*	<1	<1
Order	5.53*	4.72*	10.94**	8.74**	<1	1.15
NP	2.95	2.73	<1	<1	<1	<1
Verb × Order	<1	<1	3.31	2.36	4.00†	2.09
Go-past time						
Verb	<1	<1	<1	<1	3.07	1.16
Order	11.86***	32.65***	7.42**	6.98*	2.15	<1
NP	<1	<1	2.09	1.57	<1	<1
Verb × Order	<1	<1	4.90*	2.87	2.48	2.72
Verb × NP	4.30*	2.75	<1	<1	<1	<1
Verb × Order × NP	6.59*	6.46*	2.4	1.04	7.04*	4.41*
Total time						
Verb	<1	<1	<1	<1	1.34	<1
Order	16.57***	15.50***	13.25***	12.92**	<1	<1
NP	1.05	1.71	<1	<1	<1	<1
Verb × Order	1.3	4.80*	<1	<1	<1	<1
Order × NP	<1	<1	<1	<1	3.66†	5.04*
Verb × Order × NP	11.41**	11.61**	7.89**	8.47**	3.31	1.42

(continued)

Table 6 (continued)

	Verb region		Spillover region		Final region	
	F_1	F_2	F_1	F_2	F_1	F_2
Regressions out						
Verb	<1	<1	6.01*	2.6	<1	<1
Order	3.83†	6.39*	<1	<1	1.76	2.29
NP	<1	<1	3.18	2.86	<1	<1
Verb × NP	3.77†	1.93	<1	<1	<1	<1
Verb × Order × NP	6.15*	4.77*	1.83	<1	5.11*	5.77*
Regressions in						
Verb	<1	<1	<1	<1	–	–
Order	<1	<1	<1	<1		
NP	5.52*	3.33	1.23	<1		
Verb × Order × NP	7.19**	4.75*	4.41*	4.41*		

	NP1		NP2	
	F_1	F_2	F_1	F_2
First fixation				
Verb	1.57	<1	1.74	1.87
Order	2.91	1.74	<1	<1
NP	<1	<1	<1	<1
First pass time				
Verb	<1	<1	<1	<1
Order	<1	<1	<1	<1
NP	76.86***	70.04***	124.31***	54.68***
Verb × Order	<1	<1	3.71†	2.78
Residual first pass time				
Verb	<1	<1	<1	<1
Order	<1	<1	<1	<1
NP	1.86	1.68	2.68	<1
Verb × Order	<1	<1	4.49*	4.01†
Go-past time				
Verb	<1	<1	<1	<1
Order	<1	<1	<1	<1
NP	80.48***	107.02***	84.11***	57.64***
Verb × Order × NP	<1	<1	5.84*	4.24*
Total time				
Case	<1	<1	2.35	<1
Order	5.72*	2.11	2.93	4.27*
NP	98.65***	98.18***	85.79***	56.06***
Verb × NP	<1	1.92	4.94*	5.60*
Residual total time				
Verb	<1	<1	<1	<1
Order	4.87*	3.74†	2.63	5.62*
NP	16.49***	11.85**	5.50**	3.43
Verb × NP	<1	<1	5.30*	5.26*

(continued)

Table 6 (continued)

	NP1		NP2	
	F_1	F_2	F_1	F_2
Regressions out				
Verb	<1	<1	3.71†	5.22*
Order	4.16*	4.59*	<1	<1
NP	<1	<1	<1	<1
Regressions in				
Verb	<1	<1	<1	<1
Order	7.89**	4.06†	2.49	2.08
NP	9.67**	15.54***	10.23**	11.81**
Verb × NP	<1	<1	4.42*	2.54
Verb × Order × NP	<1	<1	4.86*	6.47*

For participant analyses df = 1,39; for item analyses df = 1,31 (except sentence-final region with df = 1,30). Interactions are not reported unless significant for at least one of the critical regions
†$p \leq .07$; *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

2.2.2 Results

Regions 2 and 3: The Two Case-Ambiguous Noun Phrases (NP1, NP2)

At both NP positions, unadjusted total times revealed an effect of ORDER, which also reached significance in residual total times for NP1, but was only significant by items at NP2. For NP1, an almost significant effect of ORDER was also observed for 'regressions in'. Thus, as in Experiment 1, object-initial orders triggered additional re-reading of the NP positions. (An additional effect of ORDER for first-pass regressions from NP1 is difficult to account for, since disambiguating information was not yet available in this region).

Analyses for NP2 additionally revealed several interactions. Go-past time showed a significant three-way interaction, which, when resolved by VERB, showed a marginal interaction NP × ORDER for dative object-experiencer verbs only ($F_1(1,39) = 8.44$, $p < .01$; $F_2(1,31) = 3.61$, $p < .07$). This effect was mainly due to longer reading times for subject-initial vs. object-initial orders in BP conditions ($F_1(1,39) = 4.00$, $p < .06$; $F_2(1,31) = 4.42$, $p < .05$; in the PN-first conditions: $F_1(1,39) = 4.15$, $p < .05$; $F_2(1,31) = 1.14$, $p < .3$). Both total time measures revealed interactions between VERB and NP. Resolving these by VERB showed a robust NP effect for both verb types (unadjusted total times: EXP: $F_1(1,39) = 61.04$, $p < .001$; $F_2(1,31) = 48.51$, $p < .001$; DAT: $F_1(1,39) = 61.38$, $p < .001$; $F_2(1,31) = 45.92$, $p < .001$; residual total times: EXP: Fs < 1; DAT: $F_1(1,39) = 8.83$, $p < .01$; $F_2(1,31) = 6.10$, $p < .02$). In all cases, bare plurals engendered longer reading times than proper names (as is expected based on length and frequency differences) and this difference was more pronounced with dative-active verbs. Finally, the 3-way interaction observed for 'regressions in' showed no fully reliable effects for either verb type when resolved (EXP: $F_1(1,39) = 4.36$, $p < .05$; $F_2(1,31) = 2.89$, $p < .1$; DAT: $F_1(1,39) = 1.94$, $p < .2$; $F_2(1,31) = 3.59$, $p < .07$).

In summary, the late eye movement measures revealed an overall pattern largely similar to the one found in Experiment 1 in that readers refixated both case-ambiguous noun phrases in order to recover from their initial misanalysis.

Region 4: The Disambiguating Verb

First fixation durations revealed a main effect of VERB which was only significant by participants and a marginal 3-way interaction approaching significance by participants and almost by items, which did not yield any reliable effects when resolved. First pass time revealed a reliable main effect of ORDER, with longer reading times for object-initial clauses, but no interactions. First-pass regressions and go-past time exhibited similar results in that both showed a main effect of ORDER (though only marginal for first-pass regressions), suggesting a higher regression rate for OS sentences (first pass regressions: 12% for SO vs. 17% for OS; go-past time: 503 vs. 587 ms). The interaction of VERB and NP in first-pass regressions approached significance by participants, but fell far short of significance by items. In addition, both first-pass regressions and go-past time showed significant 3-way interactions, which did not yield consistent results across the participants and items analyses when resolved by VERB (first-pass regressions: EXP: $F_1(1,39)=5.17$, $p<.03$; $F_2(1,31)=1.81$, $p<.2$; DAT: $F_1(1,39)=2.44$, $p<.2$; $F_2(1,31)=3.77$, $p<.07$; go-past time: EXP: $F_1(1,39)=5.55$, $p<.03$; $F_2(1,31)=2.97$, $p<.1$; DAT: $F_1(1,39)=2.45$, $p<.2$; $F_2(1,31)=3.65$, $p<.07$).

The results in unadjusted total times revealed a main effect of ORDER and an interaction between VERB and ORDER that was only significant in the analysis by items. The 3-way interaction reached full significance and resolving it by VERB indicated a marginal interaction between ORDER and NP for dative object-experiencer verbs ($F_1(1,39)=7.37$, $p=.01$; $F_2(1,31)=3.62$, $p<.07$) and a fully reliable 2-way interaction for dative-active verbs ($F_1(1,39)=7.77$, $p<.01$; $F_2(1,31)=13.12$, $p=.001$). We further resolved these 2-way interactions by NP and found an effect of ORDER in BP conditions containing dative object-experiencer verbs (PN: Fs <1; BP: $F_1(1,39)=9.26$, $p<.01$; $F_2(1,31)=6.29$, $p<.02$), and an effect of ORDER in PN conditions with dative-active verbs (PN: $F_1(1,39)=15.53$, $p<.001$; $F_2(1,31)=28.91$, $p<.001$; BP: Fs <1). Both of these effects were due to extra processing costs for object-initial sentences (EXP-BP: SO 534 ms vs. OS 637 ms; DAT-PN: 477 ms vs. 645 ms), but the difference between subject-initial and object-initial sentences was smaller for dative object-experiencer verbs (103 vs. 168 ms). Recall, however, that for dative object-experiencer verbs, each word order involves a mismatch between the syntactic and the thematic hierarchy (see Introduction). Hence, the attenuation of the reanalysis effect may be due to increased fixation durations for subject-initial structures.

For ‘regressions in’, we found a main effect of NP significant in the analysis by participants and a reliable 3-way interaction for regressions into the verb region. Resolving this interaction by VERB revealed no fully significant 2-way interactions for either verb type (EXP: $F_1(1,39)=3.46$, $p<.07$; $F_2(1,31)=3.13$, $p<.09$; DAT: $F_1(1,39)=2.65$, $p<.2$; $F_2(1,31)=2.29$, $p<.2$).

Region 5: The Spillover Region (Auxiliary Plus Indefinite Pronoun)

Effects of VERB and ORDER were apparent from first fixation durations onwards, due to longer reading times for experiencer verbs and object-initial structures. By contrast, a marginal effect of VERB in first-pass regressions was due to a higher proportion of regressions for dative-active verbs.

Whereas the interaction between VERB and ORDER was only significant by participants in go-past time, total times exhibited a significant interaction between all three factors. Resolving the 3-way interaction by VERB showed an interaction of ORDER × NP only for the conditions containing dative-active verbs (EXP: $F_1(1,39)=2.64$, $p<.2$; $F_2(1,31)=2.61$, $p<.2$; DAT: $F_1(1,39)=5.66$, $p<.03$; $F_2(1,31)=4.18$, $p<.05$). This interaction was due to the fact that the dative-active conditions showed reanalysis effects in the PN conditions (PN: $F_1(1,39)=17.40$, $p<.001$; $F_2(1,31)=8.58$, $p<.01$), but not in the BP conditions (BP: Fs<1). The 3-way interaction was also significant for the 'regressions in' measure. Resolving it by VERB revealed no differences for dative-object-experiencer verbs (Fs<1), and only a very marginal effect for dative-active verbs ($F_1(1,39)=3.34$, $p<.08$; $F_2(1,31)=3.44$, $p<.08$).

Region 6: The Final Region (Past Participle of the Matrix Verb)

For the sentence-final region, there was a marginal main effect of ORDER in first fixation durations. The 3-way interaction also approached significance, but failed to yield significant effects when resolved. The 3-way interaction was also significant for first-pass regressions and, when resolved by VERB, revealed no effects for dative-active verbs (Fs<1), but an interaction NP × ORDER for dative object-experiencer verbs that was marginal by items ($F_1(1,39)=4.60$, $p<.04$; $F_2(1,31)=3.32$, $p<.08$). Further inspection of this effect showed that it was mainly due to differences in the BP conditions (PN: $F_1(1,39)=1.21$, $p<.3$; $F_2<1$; BP: $F_1(1,39)=3.37$, $p<.08$; $F_2(1,31)=4.13$, $p=.051$), with more regressions initiated in the object-initial than in the subject-initial condition (41% vs. 30%). Similarly, the 3-way interaction reached full significance in go-past time. Resolving this interaction by VERB revealed no further effects for dative-active verbs (Fs<1), whereas the interaction of ORDER by NP was significant for dative object-experiencer verbs ($F_1(1,39)=13.10$, $p=.001$; $F_2(1,31)=3.88$, $p<.06$). Further inspection of this interaction did not reveal any effects that were reliable by both subjects and items (PN: $F_1(1,39)=7.76$, $p<.01$; $F_2(1,31)=2.74$, $p<.2$; BP: $F_1(1,39)=4.06$, $p=.051$; $F_2(1,31)=1.87$, $p<.2$).

In total times, there was an almost significant interaction between ORDER and NP, which, when resolved by NP, again did not yield consistent results across participants and items (PN: $F_1(1,39)=2.88$, $p<.1$; $F_2(1,30)=4.38$, $p<.05$; BP: $F_1(1,39)=1.52$, $p<.3$; $F_2(1,30)=1.42$, $p<.3$).

2.2.3 Discussion

The purpose of Experiment 2 was to determine whether thematic role information is able to reduce reanalysis costs. As in Experiment 1, there were consistent effects of syntactic reanalysis towards the object-initial structure. In the verb and spillover regions, first pass times showed that disambiguation towards an object-initial order led to reading time increases that were independent of other information types. In contrast to Experiment 1, however, reanalysis effects were more susceptible to the semantic influences: late measures of eye movements revealed interactions between all three experimental manipulations, indicating that thematic role information and referentiality information are both taken into account in conflict resolution. In particular, object-experiencer verbs only showed a processing disadvantage for object-initial vs. subject-initial sentences with initial bare plurals in total times at the verb and a similar pattern was observed for first-pass regressions from the sentence-final region. This pattern contrasts with Experiment 1, in which noun phrase referentiality attenuated the reanalysis effect in late measures, but did not eliminate it. The results of Experiment 2 demonstrate that, when the object-initial order is supported both by referentiality and by the thematic hierarchy, the processing conflict for object-initial structures is resolved relatively rapidly and hence no longer apparent in comprehensive reading time measures such as total times for the disambiguating region. An explanation along these lines is consistent with the proposal by Bornkessel et al. (2004), who argued that the thematic information provided by dative object-experiencer verbs renders the object-initial target structure more readily accessible during reanalysis.

The facilitative effect of dative object-experiencer verbs on the processing of object-initial orders is achieved by a principled conflict between the grammatical function hierarchy (subject>object) and the thematic hierarchy. This conflict is reflected in longer reading times for dative object-experiencer verbs, as shown by early measures on the spillover region. Interestingly, this hierarchy mismatch was also visible in Bornkessel et al.'s (2004) ERP study, which revealed a distinctive electrophysiological component for subject-initial structures containing dative object-experiencer verbs (a left-anterior negativity, LAN).

For dative-active verbs, the definiteness/specificity hierarchy has a different impact than for dative object-experiencer verbs. Here, the syntactic and thematic hierarchies converge and, consequently, object-initial structures are marked both syntactically and thematically, while the subject-before-object order is supported by both hierarchies. Not surprisingly, there is thus no facilitative effect of the definiteness/specificity hierarchy in scrambled clauses. Rather, sentences involving a marked linearization in terms of referentiality led to a general increase in reading times, which may have masked the continuing effects of word order reanalysis (e.g., SO-BP: 561 ms vs. OS-BP: 570 ms for the verb region in total times, in comparison to 477 ms for SO-PN). This resembles the effect found in Experiment 1, where bare plural-preceding-proper name was dispreferred regardless of grammatical function order.

Finally, it is worth noting again that the interaction of syntax with the thematic and the definiteness/specificity hierarchy above only reached significance in later eye movement measures on the critical verb. This observation provides further converging support for the assumption that that prominence in argument linking exerts a late influence on readers' eye movements. In particular, it seemed to affect syntactic reanalysis and the final linking stages that may comprise well-formedness evaluations. This finding concurs with the similarly late effects in Experiment 1 and also with late effects reported for other instances of prominence variation (e.g., Foraker and McElree 2007; Mak et al. 2006).[9]

3 General Discussion

With two eye-tracking experiments, we have provided further evidence for the pervasive and autonomous occurrence of the subject preference in German. We found evidence for a strong disruption in participants' eye movement records when they had to revise an initial misanalysis in order to establish the correct object-initial structure. Despite this clear reanalysis effect, the influence of other (non-syntactic) factors was also apparent, with their precise impact varying according to the type of information.

In particular, we did not find evidence that any of the (semantic) prominence hierarchies lowered the parser's preference to adopt a subject-initial analysis when encountering a case-ambiguous noun phrase. Rather, our results are in line with previous research by emphasizing the influence of semantic prominence hierarchies on disambiguation and reanalysis, and by showing that the prominence of verbal arguments modulates late eye movement measures. Our first experiment demonstrated that the linear order of NPs that differed in referentiality interacted with syntactic reanalysis such that the dispreferred order of NPs made reanalysis more difficult. Experiment 2 went one step further and showed that the syntactic hierarchy interacted with the thematic-role hierarchy and the definiteness/specificity hierarchy. Our data suggest that the human parser preferably links the unmarked variants of each hierarchy to one another when computing the final sentence meaning. In the case of conflicting hierarchies, verbs show different weightings as to which hierarchy outranks another. We replicated the finding that the thematic hierarchy may partly override the syntactic hierarchy by modulating the preferred word order

[9]Note, however, that this conclusion may require some refinement when applied to *unambiguously* case marked arguments. In a series of eye-tracking experiments in Korean, Lee et al. (2007) found effects of both the definiteness and the person hierarchy as early as in gaze duration on the critical noun phrases that were unambiguously marked for nominative case. Despite this temporal difference, their findings are by and large in accordance with our results reported above as they confirm that the convergence of prominence hierarchies facilitates comprehension.

for dative object-experiencer verbs. Furthermore, the syntax-semantics mismatch inherent to these verbs is crucial in paving the way for an influence of definiteness/specificity in aiding reanalysis. If, by contrast, thematic and syntactic hierarchies converge (as in the case of dative-active verbs), specificity violations affect both word orders equally, thereby masking word order reanalysis. Since these effects occurred in fairly late eye movement measures and partly at the sentence ending, they may have been boosted by sentence or clause wrap-up processes on the critical verb. It therefore remains to be tested whether eye movements may reveal similar mismatch effects for clause-medial verbs.

Finally, let us turn to the question of how the present findings relate to previous ERP results. First, the eye movement patterns observed in Experiments 1 and 2 are highly compatible with previous results on the 'reanalysis N400': Bornkessel et al. (2004) and Haupt et al. (2008) demonstrated that this effect is modulated by the thematic hierarchy and the definiteness/specificity hierarchy, respectively. As in the present findings, a reanalysis effect (in the form of an N400 for object-initial vs. subject-initial orders) was present for all disambiguations towards an object-initial order, but the magnitude of this effect was influenced by the semantic prominence hierarchies. By contrast, the late positivity effects observed by Haupt and colleagues were not modulated by the prominence manipulation. Hence, the present results provide strong converging evidence for a reanalysis-based interpretation of the N400 in word order manipulations. As argued by Bornkessel et al. (2004) on the basis of an SAT study, this effect appears to reflect both dynamic and non-dynamic aspects of the comprehension process (i.e. both the speed of computing the alternative analysis and the likelihood that it will be computed correctly).

Second, with regard to the discrepancies in previous ERP studies regarding the role of object case in reanalysis, the findings of Experiment 1 are most consistent with previous auditory ERP results, since they showed no interactions between word order and object case in the disambiguating or post-disambiguating region. This may be due to the fact that natural reading, as in the present study, differs fundamentally from the type of reading behavior adopted in a visual ERP setting. In this way, the present findings are compatible with Haupt et al.'s (2008) conjecture that the differing ERP patterns for subject-object reanalysis in accusative and dative structures in previous studies using visual presentation (Bornkessel et al. 2004; Schlesewsky and Bornkessel 2006) might be due to the increased susceptibility of accusative sentences to task- and strategy-related influences (which are augmented in settings using rapid serial visual presentation).

Third, the present findings also show an interesting mismatch with regard to previous ERP results: Whereas Experiment 1 showed increased fixation durations for dative-active verbs, previous ERP studies have consistently revealed increased N400 effects for *accusative* in comparison to dative-active verbs. This observation was first made by Bornkessel et al. (2004) for sentences in which word order disambiguation was effected by the main verb and confirmed by the results in Schlesewsky and Bornkessel (2006) using structures in which disambiguation occurred at a clause-final auxiliary. In the latter case, the past participle provided semantic (and case) information, while word order disambiguation depended on the number marking of the following auxiliary.[10] Crucially, the N400 only emerged on the accusative participle, and this was interpreted as a correlate of the more complex semantic representation for accusative verbs, which contain both an Actor and an Undergoer role while dative verbs generally lack one of these (cf. Van Valin 2005 and see above). The computation of unmarked transitive events is thus accompanied by a higher degree of neuronal activity that is not reflected in the behavioral output. This intriguing result, namely an inverse correlation between neural activity (in the form of an increase in N400 amplitude) and fixation durations, indicates that the correlation between ERPs and eye movements is less straightforward than is typically assumed. Tentatively, this could be taken to suggest that ERPs and eye movements are sensitive to different aspects of the comprehension process or that there are certain differences between natural reading and the processing of sequentially presented linguistic input (as in auditory presentation or in rapid serial visual presentation). However, both of these conjectures clearly require further investigation in future research, for example by means of a combination of ERPs and eye-tracking in a single experiment.

To conclude, the present findings demonstrate that word order processing in German is influenced by a range of non-syntactic information types. However, rather than influencing the initial analysis of an ambiguous clause, these semantic prominence hierarchies step in to modulate the relative ease or difficulty of the reanalysis towards an object-initial order.

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References

Aissen, J. 2003. Differential object marking: Iconicity vs. economy. *Natural Language and Linguistic Theory* 21: 435–483.

Angele, B., T.J. Slattery, J. Yang, R. Kliegl, and K. Rayner. 2008. Parafoveal processing in reading: Manipulating n+1 and n+2 previews simultaneously. *Visual Cognition* 16: 697–707.

Bader, M., and I. Lasser. 1994. German verb-final clauses and sentence processing: Evidence for immediate attachment. In *Perspectives on sentence processing*, ed. C. Clifton Jr., L. Frazier, and K. Rayner, 225–243. Hillsdale: Lawrence Erlbaum.

Bader, M., and M. Meng. 1999. Subject-object ambiguities in German embedded clauses: An across-the-board comparison. *Journal of Psycholinguistic Research* 28: 121–143.

[10] Though Haupt et al. (2008), who examined identical sentence structures to Schlesewsky and Bornkessel (2006) using auditory presentation, do not report ERP data for the position of the participle, these can be found in Haupt's (2008) dissertation. Like Schlesewsky and Bornkessel's (2006) findings, the results of this study revealed a negativity for accusative in comparison to dative verbs.

Bornkessel, I., and M. Schlesewsky. 2006. The extended argument dependency model: A neurocognitive approach to sentence comprehension across languages. *Psychological Review* 113: 787–821.
Bornkessel, I., M. Schlesewsky, and A.D. Friederici. 2003. Eliciting thematic reanalysis effects: The role of syntax-independent information during parsing. *Language and Cognitive Processes* 18: 268–298.
Bornkessel, I., B. McElree, M. Schlesewsky, and A.D. Friederici. 2004. Multi-dimensional contributions to garden path strength: Dissociating phrase structure from case marking. *Journal of Memory and Language* 51: 495–522.
Bornkessel, I., S. Zysset, A.D. Friederici, D.Y. von Cramon, and M. Schlesewsky. 2005. Who did what to whom? The neural basis of argument hierarchies during language comprehension. *Neuroimage* 26: 221–233.
Bornkessel-Schlesewsky, I., and M. Schlesewsky. 2008. An alternative perspective on "semantic P600" effects in language comprehension. *Brain Research Reviews* 59: 55–73.
Bornkessel-Schlesewsky, I., and M. Schlesewsky. 2009. The role of prominence information in the real time comprehension of transitive constructions: A cross-linguistic approach. *Language and Linguistics Compass* 3: 19–58.
Carlson, G.N. 1977. Reference to kinds in English. PhD diss., University of Massachusetts, Amherst.
Clifton Jr., C., and L. Frazier. 2004. Should given information come before new? Yes and no. *Memory & Cognition* 32: 886–895.
Clifton, C., and A. Staub. 2008. Parallelism and competition in syntactic ambiguity resolution. *Language and Linguistics Compass* 2: 234–250.
Clifton Jr., C., M.J. Traxler, M.T. Mohamed, R.S. Williams, R.K. Morris, and K. Rayner. 2003. The use of thematic role information in parsing: Syntactic processing autonomy revisited. *Journal of Memory and Language* 49: 317–334.
Clifton Jr., C., A. Staub, and K. Rayner. 2007. Eye movements in reading words and sentences. In *Eye movements: A window on mind and brain*, ed. R.P.G. van Gompel, M.H. Fischer, W.S. Murray, and R.L. Hill, 341–371. Amsterdam: Elsevier.
Comrie, B. 1989. *Language universals and linguistic typology*, 2nd ed. Chicago: Chicago University Press.
Croft, W. 2003. *Typology and universals*, 2nd ed. Cambridge: Cambridge University Press.
DeLancey, S. 1981. An interpretation of split ergativity and related patterns. *Language* 57: 626–657.
Diesing, M. 1992. Bare plural subjects and the derivation of logical representation. *Linguistic Inquiry* 23: 353–380.
Fanselow, G. 2001. Features, Θ-roles, and free constituent order. *Linguistic Inquiry* 32: 405–437.
Ferreira, F., and C. Clifton Jr. 1986. The independence of syntactic processing. *Journal of Memory and Language* 25: 348–368.
Fodor, J.D., and I. Sag. 1982. Referential and quantificational indefinites. *Linguistics and Philosophy* 5: 355–398.
Foraker, S., and B. McElree. 2007. The role of prominence in pronoun resolution: Active versus passive representations. *Journal of Memory and Language* 56: 357–383.
Frazier, L., and K. Rayner. 1982. Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology* 14: 178–210.
Frazier, L., C. Clifton Jr., K. Rayner, P. Deevy, S. Koh, and M. Bader. 2005. Interface problems: Structural constraints on interpretation? *Journal of Psycholinguistic Research* 34: 201–231.
Gorrell, P. 2000. The subject-before-object preference in German clauses. In *German sentence processing*, ed. B. Hemforth and L. Konieczny, 25–63. Dordrecht: Kluwer Academic.
Grewe, T., I. Bornkessel, S. Zysset, R. Wiese, D.Y. von Cramon, and M. Schlesewsky. 2005. The emergence of the unmarked: A new perspective on the language-specific function of Broca's area. *Human Brain Mapping* 26: 178–190.

Grewe, T., I. Bornkessel, S. Zysset, R. Wiese, D.Y. von Cramon, and M. Schlesewsky. 2006. Linguistic prominence and Broca's area: The influence of animacy as a linearization principle. *Neuroimage* 32: 1395–1402.

Haupt, F.S. 2008. *The component mapping problem: An investigation of grammatical function reanalysis in differing experimental contexts using event-related brain potentials.* Leipzig: MPI Series in Human Cognitive and Brain Sciences (Vol. 104).

Haupt, F.S., M. Schlesewsky, D. Roehm, A.D. Friederici, and I. Bornkessel-Schlesewsky. 2008. The status of subject-object reanalyses in the language comprehension architecture. *Journal of Memory and Language* 59: 54–96.

Heck, F. 2000. Tiefenoptimierung: Deutsche Wortstellung und wettbewerbsgesteuerte Basisgenerierung. *Linguistische Berichte* 184: 441–468.

Henderson, J.M., and F. Ferreira. 1990. Effects of foveal processing difficulty on the perceptual span in reading: Implications for attention and eye movement control. *Journal of Experimental Psychology. Learning, Memory, and Cognition* 16: 417–429.

de Hoop, H., and M.J.A. Lamers. 2006. Incremental distinguishability of subject and object. In *Case, valency and transitivity*, ed. L. Kulikov, A. Malchukov, and P. de Swart, 269–287. Amsterdam: John Benjamins Publishing Company.

Inhoff, A.W., and K. Rayner. 1986. Parafoveal word processing during eye fixations in reading: Effects of word frequency. *Perception & Psychophysics* 40: 431–439.

Kaan, E. 1998. Sensitivity to NP-type: Processing subject-object ambiguities in Dutch. *Journal of Semantics* 15: 335–354.

Kaan, E. 2001. Effects of NP type on the resolution of word-order ambiguities. *Journal of Psycholinguistic Research* 30: 59–547.

Kallulli, D. 2006. On existential bare plural 'subjects': They don't exist! In *Bare plurals, indefinites, and weak-strong distinction*, ed. S. Vogeler, 29–58. Amsterdam: John Benjamins Publishing Company.

Kamide, Y., and D.C. Mitchell. 1999. Incremental pre-head attachment in Japanese parsing. *Language and Cognitive Processes* 14: 631–662.

Kennedy, A. 2008. Parafoveal-on-foveal effects are not an artifact of mis-located saccades. *Journal of Eye Movement Research* 2: 1–10.

Kliegl, R., S. Risse, and J. Laubrock. 2007. Preview benefit and parafoveal-on-foveal effects from word n + 2. *Journal of Experimental Psychology. Human Perception and Performance* 33: 1250–1255.

Knoeferle, P., B. Habets, M.W. Crocker, and T.F. Münte. 2008. Visual scenes trigger immediate syntactic reanalysis: Evidence from ERPs during situated spoken comprehension. *Cerebral Cortex* 18: 789–795.

Kratzer, A. 1995. Stage-level and individual-level predicates. In *The generic book*, ed. G.N. Carlson and F.J. Pelletier, 125–175. Chicago: The University of Chicago Press.

Lee, Y., H. Lee, and P.C. Gordon. 2007. Linguistic complexity and information structure in Korean: Evidence from eye-tracking during reading. *Cognition* 104: 495–534.

Lenerz, J. 1977. *Zur Abfolge nominaler Satzglieder im Deutschen*. Tübingen: Gunter Narr Verlag.

Lenerz, J. 2001. Word order variation: Competition or co-operation? In *Competition in syntax*, ed. G. Müller and Wolfgang Sternefeld, 249–281. Berlin: Mouton de Gruyter.

MacDonald, M.C., N.J. Pearlmutter, and M.S. Seidenberg. 1994. Lexical nature of syntactic ambiguity resolution. *Psychological Review* 101: 676–703.

Mak, W.M., W. Vonk, and H. Schriefers. 2006. Animacy in processing relative clauses: The hikers that rocks crush. *Journal of Memory and Language* 54: 466–490.

Mecklinger, A., H. Schriefers, K. Steinhauer, and A.D. Friederici. 1995. Processing relative clauses varying on syntactic and semantic dimensions: An analysis with event-related potentials. *Memory & Cognition* 23: 477–494.

Müller, G. 1999. Optimality, markedness and word order in German. *Linguistics* 37: 777–818.

Primus, B. 1999. *Case and thematic roles. Ergative, accusative and active*. Tübingen: Max Niemeyer Verlag.

Rayner, K. 1998. Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin* 124: 372–422.

Rayner, K., and A. Pollatsek. 1989. *The psychology of reading*. Englewood Cliffs: Prentice Hall.

Rayner, K., M. Carlson, and L. Frazier. 1983. The interaction of syntax and semantics during sentence processing: Eye movements in the analysis of semantically biased sentences. *Journal of Verbal Learning and Verbal Behavior* 22: 358–374.

Scheepers, C., B. Hemforth, and L. Konieczny. 2000. Linking syntactic functions with thematic roles: Psych verbs and the resolution of subject-object ambiguity. In *German sentence processing*, ed. B. Hemforth and L. Konieczny, 95–136. Dordrecht: Kluwer Academic.

Schlesewsky, M., and I. Bornkessel. 2004. On incremental interpretation: Degrees of meaning assessed during sentence comprehension. *Lingua* 114: 1213–1234.

Schlesewsky, M., and I. Bornkessel. 2006. Context-sensitive neural responses to conflict resolution: Electrophysiological evidence from subject-object ambiguities in language comprehension. *Brain Research* 1098: 139–152.

Schriefers, H., A.D. Friederici, and K. Kühn. 1995. The Processing of locally ambiguous relative clauses in German. *Journal of Memory and Language* 34: 499–520.

Staub, A. 2007. The parser doesn't ignore intransitivity, after all. *Journal of Experimental Psychology. Learning, Memory, and Cognition* 33: 550–569.

Staub, A., and K. Rayner. 2007. Eye movements and on-line comprehension processes. In *The Oxford handbook of Psycholinguistics*, ed. G.M. Gaskell, 327–342. Oxford: Oxford University Press.

Trueswell, J.C., M.K. Tanenhaus, and S.M. Garnsey. 1994. Semantic influences on parsing: Use of thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language* 33: 285–318.

Van Valin Jr., R.D. 2005. *Exploring the syntax-semantics interface*. Cambridge: Cambridge University Press.

Wang, L., M. Schlesewsky, M. Philipp, and I. Bornkessel-Schlesewsky. The role of animacy in online argument interpretation in mandarin Chinese, this volume.

Wolff, S., M. Schlesewsky, M. Hirotani, and I. Bornkessel-Schlesewsky. 2008. The neuronal mechanisms of word order processing revisited: Electrophysiological evidence from Japanese. *Brain and Language* 107: 133–157.

Wunderlich, D. 1997. Cause and the structure of verbs. *Linguistic Inquiry* 28: 27–68.