Constituent order and semantic parallelism in online comprehension: eye-tracking evidence from German

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Running head: Constituent order and semantic parallelism

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Abstract

Reading times for the second conjunct of *and*-coordinated clauses are faster when the second conjunct parallels the first conjunct in its syntactic or semantic (animacy) structure than when its structure differs (Frazier, Taft, Roeper, & Clifton, 1984; Frazier, Munn, & Clifton, 2000). What remains unclear, however, is the time course of parallelism effects, their scope, and the kinds of linguistic information to which they are sensitive. Findings from the first two eye-tracking experiments revealed incremental constituent order parallelism across the board – both during structural disambiguation (Experiment 1) and in sentences with unambiguously case-marked constituent order (Experiment 2), as well as for both marked and unmarked constituent orders (Experiments 1 and 2). Findings from Experiment 3 revealed effects of both constituent order and subtle semantic (noun phrase similarity) parallelism. Together our findings provide evidence for an across-the-board account of parallelism for processing *and*-coordinated clauses, in which both constituent-order and semantic aspects of representations contribute towards incremental parallelism effects. We discuss our findings in the context of existing findings on parallelism, and priming, as well as mechanisms of sentence processing.

Keywords: psycholinguistics, sentence processing, syntactic coordination, constituent order and semantic parallelism, eye tracking

Acknowledgements

This research was funded by grant CR 135/1-2 awarded to the second author by the German Research Council (Deutsche Forschungsgemeinschaft). We thank Patrick Sturt for his advice.

Introduction

A central goal in psycholinguistic research on online sentence comprehension has been to ascertain the mechanisms underlying sentence comprehension (e.g., Crocker, 1996; Frazier & Clifton, 1996; Gibson, 1998; van Gompel, Pickering, & Traxler, 2001; Jurafsky, 1996; MacDonald, Pearlmutter, & Seidenberg, 1994; Mitchell, Cuetos, Corley, & Brysbaert, 1995; Pickering, Traxler, & Crocker, 2000; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995; Townsend & Bever, 2001). Findings from existing studies show that lexical constraints such as verb frequency (e.g., Trueswell, 1996), as well as semantic cues such as animacy (Trueswell et al, 1994) and thematic fit (McRae, Spivey-Knowlton, & Tanenhaus, 1998) influence sentence comprehension incrementally as they become available. In addition, it has been shown that information from a preceding discourse context (Altmann & Steedman, 1988), the syntactic structure of a preceding sentence (e.g., Arai, van Gompel, & Scheepers, 2007; Branigan, Pickering, McLean, 2005; Ledoux, Traxler, & Swaab, 2007, Scheepers & Crocker, 2004, Traxler, 2008), and information structural constraints (e.g., Bader & Meng, 1999; Bornkessel, Schlesewsky, & Friederici, 2003) rapidly affect online sentence comprehension.

Much less is known, in contrast, about the time course and mechanisms with which recently built structure influences sentence comprehension in syntactic environments such as coordinate constructions (e.g., Frazier, Taft, Roeper, & Clifton, 1984, Frazier, Munn, & Clifton, 2000): Findings from self-paced reading studies have revealed that processing of the second conjunct in *and*-coordinated clauses is facilitated, as evidenced by shorter reading times, when the syntactic structure of that conjunct parallels the structure of the first conjunct. For example, the second clause is read faster when it is preceded by an active clause, which is similar in structure, (see (1a)), as compared to when the first conjunct has a different (passive) structure as in (1b). This effect has been dubbed the ‘parallelism effect’, and has been observed for different kinds of parallel structure among them syntactic (constituent structure), semantic (animacy, e.g., Frazier et al., 1984), and phonological structure (Carlson, 2001).

(1a) The tall gangster hit John and the short thug hit Sam.

(1b) The tall gangster was hit by John and the short thug hit Sam.

Evidence regarding the scope of parallelism effects has been used to delineate the mechanisms underlying parallel structure processing: Parallelism effects have been observed in *and*-coordinated constructions both when the first conjunct contained a local structural ambiguity that required revision of the first conjunct (e.g., minimal versus non-minimal attachment) and when the first conjunct contained no local structural ambiguity (e.g., *John* in 1a is unambiguously attached as a direct object to *hit*, and *by John* in 1b is unambiguously the prepositional subject of *was hit*). Based on finding parallelism effects in these unambiguous cases (1a/b), Frazier et al. (1984) excluded the possibility that parallelism reflected an exclusive reliance upon experience of structural misanalyses in the first conjunct in making choices about structure building at similar decisions points in the second conjunct. In addition, they observed parallelism effects when two conjuncts were parallel with respect to non-syntactic structure such as noun phrase animacy. From these findings, Frazier et al. concluded that parallelism effects do not result from a speeding-up in specific parsing strategies. Rather, they suggested a more general comprehension mechanism (including syntactic and semantic processing) underlies parallelism effects such that when a person has just constructed a representation for part of a sentence, cognitive demands for constructing the representation of the remaining sentence will be reduced to the extent that the recent and current representations share common features.

Some open questions remain, however, about the time course of parallelism effects (A); about the scope of the mechanism across ambiguous and unambiguous structures (B) as well as across marked and unmarked structures (C); and about how different kinds (constituent order versus semantic) of parallel linguistic structures facilitate processing of the second conjunct (D). The extant conclusions about the mechanisms underlying parallelism effects as described above (i.e., characterizing it as a fairly general comprehension mechanism that applies to phonological, syntactic and semantic processing) further warrant discussion of parallelism in the context of similarly pervasive processing facilitation through repetition of lexical and syntactic material outwith coordinate structure environments ('priming', see (E) and General Discussion). Below we first discuss these open questions and then outline how three eye-tracking studies addressed them.

(A) The time course of parallelism effects

While the account by Frazier et al. (1984) is a first step towards a theory of how recently built structure facilitates parsing of the second conjunct in *and*-coordination, more detailed questions regarding the time course and mechanism of parallelism effects remain to be answered. The studies by Frazier et al. provide only limited insights into precisely when prior structure influences processing of the second conjunct, since their findings are based on analyses of reading times for the entire second conjunct (*the short thug hit Sam*) in parallel (1a) versus nonparallel (1b) coordinate clause structures. From such analyses, it is unclear whether facilitation through parallel structure reflects incremental comprehension mechanisms or rather later stages of interpretation, once processing of the second conjunct is completed. A more fine-grained analysis of data for early (e.g., *the short thug*) and late (e.g., *Sam*) regions of the second conjunct would permit us to better understand the time course with which recently built constituent order and semantic structure is re-used during online sentence comprehension. Using eye tracking as a method rather than self-paced reading as in Frazier et al. (1984) would furthermore provide insights into whether parallel structure affects processing of the second conjunct when people first inspect the second conjunct or rather only upon re-reading of relevant left context (see, e.g., Rayner, 1998 for an overview of relevant eye-tracking measures in reading).

(B) Parallelism as an exclusive ambiguity resolution mechanism?

A further question, as to the mechanism underlying parallelism effects, is whether constituent order parallelism effects arise both in conjuncts that contain local structural ambiguity and conjuncts for which linguistic cues (e.g., auxiliaries, case marking or prepositions) immediately clarify the syntactic structure (see 1a/b). One possibility is that parallelism effects manifest themselves exclusively when parsing decisions must be made at some point of structural ambiguity (e.g., prepositional phrase attachment ambiguities, reduced relative clause ambiguity, or constituent order ambiguity). Observing such exclusive ambiguity-based parallelism effects would suggest a different mechanism for ambiguity resolution compared with syntactic structure building in sentences that do not contain such ambiguities. An argument in favour of an ambiguity-resolution account is that using the most recently built syntactic structure to inform current parsing would be a useful heuristic in the absence of disambiguating bottom-up cues at the word currently processed. Alternatively, parallelism effects may be triggered by a more inclusive and general syntactic structure building mechanism (see Frazier et al., 1984) and thus occur in both structurally ambiguous and unambiguous conjuncts.

To test the ambiguity-resolution account, Frazier et al. (1984) examined the effects of parallel structure when people read coordinate sentences in which the first clause was structurally unambiguous such as in (1a) and (1b) compared with sentences in which the first clause contained a local syntactic ambiguity such as (2a) and (2b). As outlined above, in (1a) and (1b), the second argument (*John,* 1a*; by John*, 1b) is unambiguously attached as the direct object of *hit* in (1a), forming an active clause, and it is attached as the prepositional subject of *was hit* in (1b), building a passive clause. In contrast, the second noun phrase of the first clause in (2a) and (2b) (*Tom's stories*) can either temporarily attach as a direct object to the first verb phrase (as resolved in 2a by *and*) or as the subject of a complement sentence (as resolved by *were true* in 2b). Analyses of reading times for the entire second conjunct revealed parallelism effects – shorter reading times for parallel (1a/2a) than corresponding non-parallel (1b/2b) clauses – in sentences both for which the first conjunct did (2a/b) and did not (1a/b) contain local structural ambiguity. This finding was interpreted as evidence for the view that recent parallel structure is not only used when processing of the first conjunct required the resolution of clear local structural ambiguity, which might bias towards a re-use of the same structure at choice points in the second conjunct, but rather more inclusively for syntactic structure building.

(2a) Jim believed all Tom's stories and Sue believed Jim's stories.

(2b) Jim believed all Tom's stories were literally true and Sue believed Jim's stories.

One concern, however, in light of the claim that these findings show parallelism to be an inclusive syntactic structure building rather than disambiguation mechanism is that the second conjunct contained local structural ambiguity in at least some of these sentences (1a/b, 2a). For instance, in (1a/b), the phrase *the short thug* in the second clause can either be attached to the verb *hit* in the first clause (as a direct object in (1a) and as the prepositional subject of *was hit* in (1b)), or it can be temporarily attached as the subject of a new, conjoined clause. In addition, this noun phrase can temporarily be interpreted as the agent of an active clause (*and the short thug hit*) or the patient of a passive clause (*and the short thug was hit by*). Crucially, these sentences (1a/b) were the structures for which Frazier claimed that they showed parallelism effects in the absence of local structural ambiguity. While the local structural ambiguity on *the short thug* in the second conjunct of (1a/b) is eventually resolved by the verb *hit* in the second clause, the presence of a prolonged structural ambiguity in the second conjunct (i.e., on *the short thug*) compromises interpreting reading times of the entire second conjunct as reflecting the re-use of previously built structure in unambiguous sentences.

Moreover, in the study by Frazier and colleagues, the ambiguity manipulation between the supposedly unambiguous sentences (1a/b) and the locally structurally ambiguous sentences (2a/b) occurred in the first conjunct (*all Tom's stories* in 2a/b was locally structurally ambiguous while *John / by John* in 1a and 1b respectively was not locally structurally ambiguous) and not at the point in time when the previous structure is actually re-used (i.e., in the second conjunct). To examine whether parallel structure is applied only at a decision point in the second conjunct or in more inclusive parsing, we would instead need to compare parallelism effects in sentences for which the first conjunct is structurally unambiguous while the *second* (rather than as in Frazier et al. the first) conjunct is either locally structurally ambiguous or unambiguous.

In addition to these local structural ambiguities, the stimuli used in existing studies by Frazier et al. (1984, 2000) and Carlson (2001) permitted ellipsis at the point of coordination (see also Callahan, Shapiro, & Love, submitted). For sentence (2a), for instance, at the point of the coordinating conjunct *and*, the sentence could continue with a verb phrase ellipsis like *and Jim's* or *and Sue Jim's*. Frazier et al.'s study thus did not test whether constituent structure parallelism facilitates processing in fully unambiguous coordinate constructions. Such examination is, however, crucial for determining whether parallelism effects arise from structural ambiguity and ellipsis resolution or more general structure building and interpretation mechanisms.

(C) Parallelism and structural markedness

A further unresolved issue concerns the scope of syntactic parallelism effects across marked and unmarked structures. Can parallelism be observed with all kinds of syntactic configurations, or is it dependent upon other linguistic properties of a structure, such as markedness? In their study, Frazier et al. observed a marginal interaction of parallelism effects with the markedness of a clause. For marked coordinate clause sentences (heavy NP shift and non-minimal attachment of a noun phrase, e.g., 2b), the second conjunct was processed faster when it also had a marked structure (heavy-NP shift / non-minimal attachment respectively) than when it did not have that marked structure. For sentences with corresponding unmarked constituent structure, in contrast, parallelism effects were smaller for minimal attachment and absent for no heavy NP-shift constructions. A reversed pattern was observed for other sentence types (e.g., active-passive clause coordination) for which larger parallelism effects were found for a second conjunct with unmarked active than with marked passive structure (Frazier et al., 1984).

Frazier et al. attribute the observation of parallelism facilitation for the marked non-minimal attachment ambiguities to a parallelism mechanism that prevents garden-pathing for the marked structure after a misanalysis in the first clause, while not inducing a garden-path in the unmarked minimal attachment cases. In contrast, the larger parallelism effects for active than passive second conjuncts were accounted for via the discourse role of the passive (see Anisfeld & Klenbort, 1973). The passive – unlike the active - explicitly marks the topic of the clause, and the passive is likely employed in a discourse context in which the patient of the passive sentence is the topic of discourse (i.e., given). Frazier et al. further argue that the conceptual parallelism of their clausal coordination sentences entails that any discourse context that licenses a passive to mark the patient of the first conjunct as the topic will also constrain the voice in the second clause. An initial active conjunct, in contrast, does not entail the same constraints on the voice of the second conjunct. From this, Frazier et al. derive the prediction that processing of the second conjunct for coordinate constructions in which the unmarked precedes the marked structure should be easier to process than when a marked structure precedes an unmarked structure ("discourse account"). As Frazier et al. point out, however, their study was not designed to directly investigate interactions between parallelism and the markedness of a structure, and effects of markedness were confounded with the length of the second conjunct. As a result, whether, and if so, to which extent, parallel structure facilitates comprehension both when the second conjunct is marked versus when it is unmarked remains to be investigated.

(D) Constituent order versus / and fine-grained semantic parallelism

In addition to issues of ambiguity and markedness, a central question regarding parallelism effects concerns the kinds of linguistic representations that lead to such facilitation. Frazier et al., (1984) examined whether parallel structure facilitation is limited to syntactic structure (e.g., constituent structure) or whether it extends to non-syntactic representations. They observed parallelism effects across a range of structures and even with non-syntactic manipulations such as noun phrase animacy, suggesting that parallelism effects are not limited to syntactic representations and structure building (see also Carlson, 2001; Frazier et al., 2000). What is still unclear is whether findings of semantic parallelism extend to more subtle semantic manipulations, and whether processing would benefit from the joint effects of parallel semantic and constituent order structure.

(E) Parallelism and priming

One further interesting issue about parallelism concerns its relationship to other forms of processing facilitation in comprehension such as ‘priming’. Priming is the facilitative influence of a context (‘prime’) word or sentence on the processing or production of an ensuing word or sentence (‘target’). Unlike parallelism, priming in comprehension occurs between successive sentences, rather than within a specific syntactic environment such as *and*-coordination. Similar to parallelism effects, however, priming has been observed for various linguistic levels (e.g., semantic and syntactic): Meyer and Schvanefeldt (1971), for instance, reported that participants spent less time processing associated (e.g., *bread-butter*) relative to unassociated word pairs (e.g., *bread-doctor*) in a lexical decision task.

Recent studies have further provided evidence for syntactic priming in comprehension: In a study by Branigan, Pickering, and McLean (2005), participants read a globally ambiguous prime sentence (e.g., *The policeman prodding the doctor with the gun*), in which the prepositional phrase *with the gun* could either modify the verb (*prodding*) or the noun phrase (*the doctor*). In a subsequent picture choice task, only one out of two pictures was a correct choice, and that picture disambiguated the prime sentence towards either a verb or noun phrase attachment. For the ensuing target trials, participants also read a globally ambiguous sentence; however, in the picture task both pictures were correct and offered people a choice between a picture that was compatible with a verb phrase or one that was compatible with a noun phrase attachment analysis. Branigan et al. found that participants were more likely to follow the prime picture disambiguation in their target picture choice when the verb was repeated between prime and target than when it wasn’t repeated.

Using the visual world paradigm, Arai, van Gompel, & Scheepers (2007) similarly found syntactic priming when the verb was identical between prime and target (*send*), but not when prime verb (*send*) and target verb (*give*) differed: For target sentences such as *The pirate will send the princess the necklace*, participants' first gaze on picture objects that had a recipient role in the sentence (the princess) was longer after a prime with direct object (*the princess the necklace*) than prepositional object (*the necklace to the princess*) structure; in contrast, first gaze on the theme object (e.g., the necklace) was longer after a prepositional than direct object prime. Analyses of inspection probabilities confirmed these findings.

More recent research has provided contradictory evidence on the role of verb repetition for syntactic priming. Traxler (2008) asked participants to read sentences with modifier–goal ambiguities. Half of the target sentences (e.g., *The engineer tested by the board passed with flying colors*) were preceded by sentences with the same structure, and half were preceded by sentences with a different structure. Traxler reported eye-tracking evidence for syntactic priming of adjunct relations (longer total reading times for different-structure versus same-structure prime-target sentences) both when the verb was (*tested*) and when it wasn't (*examined* vs. *tested*) identical between prime and target. In an event-related brain potentials study by Ledoux, Traxler, and Swaab (2007), subjects read a reduced relative clause sentence that was preceded by either a main clause or reduced-relative clause prime sentence. The verb in prime and target sentence was identical. Reduced-relative clause targets elicited a greater positivity approximately 600 ms after onset of the disambiguating second argument (P600) when they followed a main clause than a reduced relative prime. In addition, lexical repetition priming, evidenced by a reduction in N400 amplitude from the verb in the prime sentence to the verb in the target sentence, revealed effects of lexical priming that were clearly distinct from those of syntactic priming as evidenced by a reduction in P600 amplitude. Together these priming findings suggest that many effects of syntactic priming depend on repetition of the verb.

Interestingly, in existing studies on parallelism the verb was either repeated in the first and second conjunct (e.g., Frazier et al., 1984), or elided (e.g., Carlson, 2001; Frazier et al., 2000). In light of the important and somewhat controversial role that the verb plays for structural priming (see Arai et al., 2007; Branigan et al., 2005 but Traxler, 2008), finding out whether parallelism effects can be observed in the absence of repeating the verb in two conjoined clauses may provide important insights into the relationship between parallelism and priming (see Dunbey, Keller, & Sturt, 2008).

Investigating (A) to (E), will permit us to gain a more complete picture of how parallelism effects facilitate online language comprehension. We conducted three eye-tracking experiments to examine the time course and mechanisms with which parallel versus non-parallel constituent order (Experiments 1 to 3) and semantic (Experiment 3) structure facilitate processing of the second conjunct in coordinate clause sentences. To shed some light on (E), the verb was never repeated between the first and second conjuncts in these three studies.

Experiment 1 examined the time course of parallelism effects for constituent order in locally structurally ambiguous sentences, thus investigating whether findings by Frazier et al. (1984) generalize to German and to constituent order parallelism. In addition, it examined whether parallelism effects are modulated by markedness of constituent order, and by implication, information structure. An example sentence consisted of two ‘and’-coordinated clauses:

(3) Vor einer Stunde bezwang der Titelhalter den Sumoringer und gerade besiegt die Weltmeisterin den Degenfechter, wie der Journalist schreibt.

‘An hour ago defeated the title holder (subject) the sumowrestler (object) and currently overwhelms the world champion (subject, amb.) the sword fencer (object), as the journalist writes’.

The first clause was structurally unambiguous in terms of the underlying linguistic analysis while the second conjoined clause contained a local structural ambiguity on the first noun phrase (*die Weltmeisterin*, ‘the world champion’). The structural ambiguity arose from constituent order and case ambiguity in German: In German both subject-object and object-subject constituent orders are grammatical; subject-object is canonical while object-subject order is marked (e.g., Hemforth, 1993, Traxler, Morris, & Seely, 2002, Schriefers, Friederici, & Kuhn, 1995). Marking of subject (nominative) and object (accusative) case on the determiner is ambiguous for feminine noun phrases (*die*, ‘the’, nominative/accusative). Resolution of the ambiguity took place through unambiguous object (*den*, ‘the’) or subject (*der* ‘the’) case marking on the determiner of the ensuing second noun phrase in the second clause.

A first manipulation concerned constituent order parallelism (A). The constituent order of the second clause (e.g., subject-object) either paralleled that of the first (subject-object), or it had a different (e.g., object-subject) constituent order. As a consequence of constituent order parallelism, the two conjuncts are furthermore parallel vs. non-parallel in terms of thematic roles (with the subject corresponding to the agent and the direct object to the patient role) and information structure: It has been suggested that information structure coincides with constituent order (see, e.g., Steedman, 2000, Selkirk 1984). Generally, information structure accounts for German and English assume that old / given / theme information (often the grammatical subject) appears early in the sentence while new / rheme information (often conveyed by the grammatical object) appears late in the sentence (e.g., Clark and Haviland, 1977; see Carlson, Dickey, Frazier, & Clifton, 2008; Bader & Meng, 1999; Bornkessel et al., 2003 for relevant findings). Object-subject order is thus coextensive with fronting of the object to a position ahead of the subject (implying givenness), while subject-object order has no such pragmatic force. It is therefore possible that parallelism at this pragmatic level, namely fronted- versus non-fronted-object, may facilitate processing. Together, these various levels at which the first and second conjunct are parallel should create a strong manipulation for the investigation of parallelism effects: Based on findings by Frazier and colleagues (1984), we would expect faster reading times during the second conjunct when the constituent order of the second conjunct is parallel to that of the first compared with when it differs from that of the first clause. Analyzing individual regions of the second conjunct will permit us to see whether parallelism effects occur at the disambiguating region once it has become clear which structure is being built, and if so, with which time course (e.g., early versus later eye-gaze measures). We would expect reading times for that region to be faster when the second conjunct is parallel to the first compared to when it has a different constituent order.

In addition to constituent order parallelism, we manipulated constituent order markedness (see (C)): a clause either had an unmarked subject-object or a marked object-subject order. Prior eye-tracking and self-paced reading research has found evidence for increased processing difficulty, as evidenced by longer reading times, when people processed clauses with marked object-subject compared with subject-object order (e.g., Hemforth, 1993, Traxler, Morris, & Seely, 2002, Schriefers, Friederici, & Kuhn, 1995). Based on these findings, we would expect increased reading times for object-subject compared with subject-object order in our eye-tracking studies, an effect that may also be enhanced by the absence of a licensing discourse context for the object-subject order in terms of information structure.

Crucially, if parallelism affects the processing of marked and unmarked constituent orders similarly, then we would expect to see faster reading times during the second conjunct for parallel than non-parallel clausal constituent order independent of markedness. Alternatively, if there are differences in parallelism effects for marked versus unmarked constituent orders then we should either replicate the pattern that Frazier et al (1984) observed for active-passive constructions (discourse account, see (C)), or, alternatively, replicate parallelism effects for the marked constituent order based on findings for non-minimal attachment and heavy NP shift sentences by Frazier et al. (markedness account). The discourse account predicts by extension that for German constituent order a subject-object-and-object-subject coordination (i.e., when the unmarked precedes the marked structure) should be easier to process than an object-subject-and-subject-object coordination (i.e., for which the marked precedes the unmarked structure). The alternative, markedness account of parallelism, in contrast, would predict that parallelism applies to alleviate the processing difficulty associated with marked constituent orders such that we should find parallelism effects only for marked and not, or only to a lesser extent, for unmarked second conjuncts. Experiment 1 will furthermore allow us to examine whether parallelism completely eliminates the processing difficulty that is typically associated with object-initial order, or whether it only alleviates it to a certain extent.

Experiment 2 examined whether the presence of local structural ambiguity is a pre-requisite for the occurrence of parallelism effects, or whether constituent order parallelism effects are rather triggered by more inclusive structure building mechanisms (see (B)). It also provided further opportunity to obtain insights into the incremental time course of parallelism effects (A) as well as into potential interactions with markedness (C). We retained both the constituent order parallelism and markedness manipulations of Experiment 1. In contrast to Experiment 1, however, we eliminated the local structural ambiguity in the second conjunct by replacing the ambiguous feminine noun phrase with a masculine noun phrase that was unambiguously case-marked through the determiner as either the subject (*der*, 'the') or object (*den*, 'the') of the second conjunct. A first question is whether we find parallelism effects in such unambiguous sentences at all. Finding evidence for parallelism effects with unambiguously case-marked constituent order in both conjuncts would provide strong evidence against an ambiguity-resolution account and – assuming we find parallelism effects in Experiment 1 – in favor of a parallelism mechanism that applies both for structurally ambiguous (Experiment 1) and for unambiguously object or subject case-marked second conjuncts (Experiment 2).

The unambiguous case-marking cues on the first noun phrase of the second conjunct that rapidly clarified the constituent order of the second conjunct also permitted us to examine the incremental nature and time course of parallelism effects. In Experiment 1, severe garden-pathing could lead to a delayed application of recent structure and might thus delay the time course of parallelism effects; the use of unambiguously case-marked coordinate structures in Experiment 2 permits us to examine parallelism effects in the absence of such garden-path effects. Parallelism effects on the first noun phrase of the second conjunct (and / or in first pass times) would provide corroboratory evidence for highly incremental effects of parallel structure. In contrast, if parallelism effects in Experiment 2 emerged only later, on the second noun phrase of the second clause (and / or in later gaze measures), this would be compatible with the view that parallelism is a "meta-level" mechanism that rather operates with some delay due to interpreting and reconciling coordinands. Inspecting different eye-tracking measures (first pass, regression path, total times, and probability of first-pass regressions) will inform us about the rapidity with which parallelism effects influence online processing for the unambiguously case-marked sentences in Experiment 2.

Experiment 2 also examined potential interactions between parallelism and markedness in more detail. When the second conjunct is structurally ambiguous (as in Experiment 1), participants may re-use recent structure for both marked and unmarked structures to maximize chances of correct disambiguation. In the presence of disambiguating case marking on the first noun phrase of the second conjunct, however, the comprehension system may rely to a lesser extent on previously built structure for the processing of unmarked structure (i.e., when it does not experience processing difficulty). If this were indeed the case, we would expect to find parallelism effects only for the marked conditions. If, alternatively, parallelism facilitates processing of the second conjunct for both unmarked (subject-object) and marked (object-subject) constituent orders, we would expect to find shorter reading times for parallel compared with non-parallel clauses independent of markedness. Finally, Experiment 2 also permits us to once more examine whether we find any evidence that would support the discourse account of parallelism (see Frazier, 1984 for active vs. passive sentences).

In addition, the time course of parallelism effects in relation to constituent order markedness effects may provide more detailed insights into the timing of these two processes: Based on the first conjunct's constituent order people likely have expectations about constituent order prior to reaching the first constituent of the second conjunct. Once they encounter the unambiguous case marking on the determiner of the first noun phrase in the second conjunct, there are at least three possible options: First, people may either assign grammatical case based on recent structure and only subsequently integrate unambiguous case marking on the first noun phrase of the second conjunct; alternatively, they may rely on case marking on the determiner of that noun phrase first, and only subsequently use recent constituent order structure; or, finally, they may employ both of these information sources simultaneously. The order with which constituent order parallelism versus markedness effects appear in eye-gaze measures will provide insights into this question.

Experiment 3 continued to investigate the time course with which parallelism affects the comprehension of unambiguously case-marked coordinate structures, with a focus on comparing the parallelism effects of semantic versus constituent order structure. An example sentence set was:

(4a) Vor einer Stunde bezwang den Fechter (obj) der Gegner (subj) und gerade besiegt den Ringer (obj) der Erzfeind (subj), wie der Journalist schreibt.

‘An hour ago defeated the fencer (obj) the adversary (subj) and currently overwhelms the wrestler (obj) the arch-enemy (subj), as the journalist writes.’

(4b) Vor einer Stunde bezwang den Gegner (obj) der Fechter (subj) und gerade besiegt den Ringer (obj) der Erzfeind (subj), wie der Journalist schreibt.

‘An hour ago defeated the adversary (obj) the fencer (subj) and currently overwhelms the wrestler (subj) the arch-enemy (obj), as the journalist writes.’

(4c) Vor einer Stunde bezwang der Fechter (subj) den Gegner (obj) und gerade besiegt den Ringer (obj) der Erzfeind (subj), wie der Journalist schreibt.

‘An hour ago defeated the fencer (subj) the adversary (obj) and currently overwhelms the wrestler (obj) the arch-enemy (subj), as the journalist writes.’

(4d) Vor einer Stunde bezwang der Gegner (subj) NP1 den Fechter (obj) und gerade besiegt den Ringer (obj) der Erzfeind (subj), wie der Journalist schreibt.

'An hour ago defeated the adversary (subj) the fencer (obj) and currently overwhelms the wrestler (obj) the arch-enemy (subj), as the journalist writes.'

Constituent order of the second conjunct either paralleled the constituent order of the first conjunct (4a/b) or not (4c/d). In addition, we manipulated semantic parallelism by varying whether noun phrases that shared the same position in linear order and information structure in the first and second conjuncts were semantically similar in very subtle semantic category distinctions (e.g., 'fencer' and 'wrestler' are both sportsmen while 'opponent' and 'arch-enemy' denote an opponent) or not. Thus in an example item for the semantically parallel conditions ((4 a) and (4c)), the first constituent in both conjuncts is a sportsman (*fencer* and *wrestler*) and the second an opponent (*opponent* and *arch-enemy*). In contrast, for the semantically non-parallel conditions ((4b) (4d)), the first constituent in the first (*opponent*) and second (*wrestler*) conjuncts belongs to subtly different semantic categories (opponents and sportsmen, respectively).

Note that we – drawing on the constituent order parallelism manipulation - conceptualized the semantic parallelism manipulation in terms of linear constituent order and information structure (topic – rheme). If such parallelism procures processing facilitation, we should see faster reading times during the second conjunct for sentences (4a) and (4c) compared with (4b) and (4d). Another possibility is that parallel semantic structure is computed not per the similarity of constituents that share the same position with respect to linear order and information structure of a clause but rather semantic similarity of constituents with corresponding grammatical function and / or thematic role. If so, then we should find shorter reading times when the subject in the first (e.g., *opponent*) and second (e.g., *arch-enemy*) clause and the object in the first (*fencer*) and second (*wrestler*) conjuncts belong to the same semantic category ((4a) and (4d)) relative to when they don't ((4b) and (4c)).

Either way, the semantic parallelism manipulation permits us to explore facilitation through a different type of linguistic structure. If we were to find evidence for incremental semantic parallelism such as described above, this would support the view that the representations involved in parallel structure facilitation encode detailed semantic features that are activated rapidly to facilitate comprehension of the second conjunct. If, alternatively, semantic parallelism only facilitates structures that are parallel in constituent order, we would expect an interaction between the two. Finally, no effect of semantic parallelism would suggest the mechanisms underlying parallelism effects are simply insensitive to such a fine-grained semantic manipulation.

Manipulating two kinds of parallel structure within one study furthermore permits us to establish whether or not these two kinds of parallelism have an additive effect. If so, then we should find the greatest facilitation when both constituent order and semantic structure are parallel. The greatest difficulty, in contrast, should appear when conjoined clauses are non-parallel in both semantic structure and constituent order. The design in Experiment 3 thus complements the first two experiments – in which the focus was on the scope of parallelism mechanisms across different structural configurations – with a more detailed investigation of the representations underlying parallelism effects.

Experiment 1

Method

Participants

Forty-eight native speakers of German with normal or corrected-to-normal vision received 7.50 euros each for participating in the experiment.

Materials and Design

There were 32 experimental items. An item sentence consisted of two clauses each of which had an ADV-V-NP-NP constituent order. The two clauses were conjoined with the coordinating conjunction *und* (‘and’) (see Table 1). The words at the beginning of the second conjunct (adverb verb) unambiguously signalled a clausal coordination and ensured that no ellipsis was possible. Constituent order in the first clause was unambiguously case-marked as either subject-object or object-subject through nominative-accusative and accusative-nominative case marking respectively. The second clause, however, contained a local constituent order ambiguity on the first noun phrase (*die Weltmeisterin*, ‘the world champion’) that followed the ‘conj adverb verb’ sequence. Recall that both subject-object and object-subject constituent orders are grammatical, with subject-object order being preferred (e.g., Hemforth, 1993; Mecklinger, Schriefers, Steinhauer, & Friederici, 1995; Schlesewsky, Fanselow, Kliegl, & Krems, 2000). Word order variation was combined with case ambiguity (nominative and accusative forms of feminine noun phrases are identical in German), resulting in constituent order ambiguity for the first noun phrase in the second conjunct. Resolution of the ambiguity took place on the second, masculine noun phrase of the second conjunct which was unambiguously case marked through its determiner as either the object (*den*, ‘the’) or subject (*der* ‘the’).

We manipulated markedness and parallelism of the coordinated clauses. *Markedness* refers to whether the second conjunct had subject-object (‘unmarked’) or object-subject (‘marked’) constituent order. *Parallelism* identifies whether the constituent order of the conjoined, second clause was parallel to that of the first clause (‘parallel’) or not (‘non-parallel’). To give an example, when the constituent order of the first clause was subject-object, and the constituent order of the second conjoined clause was also subject-object, the second clause is considered parallel to the first. In contrast, when the constituent order of the first clause was object-subject, and the order of the second clause was subject-object, the second clause is non-parallel to the first in terms of constituent order. Crossing markedness and parallelism created four conditions that are illustrated in Table 1 (a-d), providing an example item. The length of corresponding words and their lemma frequency were matched between conditions within an item.

Table 1: about here

To minimize differences between the conjoined clauses beyond constituent order, we kept the semantic relations between the two noun phrases that share the same linear order position in clause one and two similar (see Table 1). For example, in condition (a), the first noun phrase of each conjunct is filled with *der Titelhalter* und *die Weltmeisterin*, both denoting a person that holds a title in sports. The second position in each clause of example (a) is filled with noun phrases that both express a more specific fighting sport (*der Sumoringer*, ‘the sumowrestler, *der Degenfechter*, ‘the sword fencer’). This means that for the non-parallel cases, constituent order and associated thematic role and information structure were the only aspects that were non-parallel. We will examine the effects of constituent order parallelism when other aspects of the coordinated clauses (e.g., the semantics) are non-parallel in Experiment 3.

There were four experimental lists. Each list contained 32 experimental items, an equal number of experimental trials in each condition, and only one condition of an item. In addition to the experimental items there were 95 filler items. Experimental items were separated from one another by at least one intervening filler trial. The order of items was individually randomized for each participant.

Procedure

An SMI Eye-Link head-mounted eye-tracker monitored participants' eye movements at a frequency of 250 Hz. Sentences were presented on a 21-inch multi-scan colour monitor at a font size of 24 pt. The background was white, and sentences appeared in black font. Participants were seated approximately 50 centimetres from the screen. Before the experiment, participants received written instructions about the experiment procedure and task: Each trial started with a fixation dot that appeared at the centre of the screen. Participants were instructed to always focus on that dot so as to allow the system to perform drift correction when necessary. Then, a black square appeared at the position of the first word in the sentence for a fixed duration of 1500 ms. Participants were asked to fixate the black square to ensure that they started reading at the beginning of the sentence. The presentation duration of 1500 ms was chosen since it proved to be a suitable time for participants to shift their gaze from the central fixation dot to the black square that marked the sentence beginning. Then the sentence was presented. People were asked to read the sentence attentively and silently, and to indicate successful comprehension by pressing the down-arrow button on the keyboard in front of them. To minimize eye movements in search of the down-arrow button during reading, participants were encouraged to keep their index finger on that button. Participants were further informed that on some trials after sentence presentation, there would be a yes / no question concerning the sentence they had just read. Such questions occurred on 46 filler trials. Participants were asked to reply to the question by pressing either the left-arrow key (signalling a "no" reply) or the right-arrow key (signalling a "yes" reply). After the experiment, participants were debriefed. The entire experiment lasted approximately 45 min with a short break after approximately half of the trials.

Analysis

The eye-tracker software recorded the X-Y co-ordinates of participants' fixations. To analyse the output of the eye tracker, contiguous fixations of less than 80 ms were pooled and incorporated into larger fixations: blinks and out-of-range fixations (i.e., with negative x/y-coordinates that are invalid) were added to previous fixations. We computed three standard reading time measures of eye-movement data: first-pass time, regression-path duration, and total time. *First-pass time* in a region was calculated as the duration of all fixations in a region from first entering it up to the point of first leaving the region. *Regression-path duration* (RPD) was defined as including all of the time that a reader's gaze - after first entering the region - stayed in that region or to the left of the region in question, but before leaving that region to the right. It has been interpreted as reflecting the time that a reader needs to sufficiently process text before moving on to processing new information (see, e.g., Konieczny, Hemforth, Scheepers, & Strube, 1997; Liversedge, Paterson, & Pickering, 1998; Rayner, 1998; Rayner & Duffy, 1986; Traxler, Pickering, & Clifton, 1998). We in addition report proportions of first pass regressions out of a region (defined as the proportion of trials on which a participant made a regression from the region before any word to the right of that region was fixated), a measure that has been associated with difficulty in the resolution of temporary ambiguity (e.g., Altmann, Garnham, & Dennis, 1992; Clifton, Traxler, Mohamed, Williams, Morris, & Rayner, 2003; Frazier & Rayner, 1982; but Rayner & Sereno, 1994). Finally, *total time* is the sum of all fixations in a region and has been associated with overall processing difficulty in a region (Rayner, 1998).

For analysis purposes, we defined one primary region of interest, the second (‘NP4’, ‘the sword fencer’) noun phrase of the second conjunct (see Table 1). This region was chosen since people have processed the first conjunct, the coordinating conjunction, and the local structural ambiguity at the onset of the second clause (ADV-VERB-NP3) at this point. We can assume people are aware of reading a coordinate clause construction as they enter the disambiguation region (NP4), and thus the possibility to use recent structure is maximized. Analyses of reading times for the fourth noun phrase will provide insights into parallelism effects during disambiguation. If on-line processing is facilitated for parallel versus non-parallel constituent order during disambiguation in response to bottom-up case marking cues, we should observe main effects of parallelism in first pass, regression path, total times on, or first-pass regressions out of, NP4. The kinds of measures in which we find parallelism effects may further inform us about the time course of constituent order parallelism effects.

In addition, we analysed reading times for the ambiguous first noun phrase of the second conjunct (‘NP3’, ‘the world champion’) since people might rely on recent structure even earlier than on NP4 and precisely at a point during the second conjunct where the bottom-up input does not inform them on constituent order structure. To ensure that parafoveal preview of the disambiguating fourth noun phrase did not influence analyses of reading times for the third noun phrase, the ambiguous (NP3) region excluded the three characters before the fourth noun phrase (e.g., for *die Weltmeisterin*, the analysis region would comprise *die Weltmeister*, but exclude the *in* ending and the subsequent space). Since there is local structural ambiguity during NP3, we would not necessarily expect clear differences between parallel and non-parallel and between marked and unmarked conditions for that time region. It is, however, possible that people adopt either the canonical constituent order (i.e., subject-object), or the most recently built constituent order in the face of local structural ambiguity. In addition to NP3 and NP4, we report reading time analyses for the two noun phrases of the first clause (‘NP1’ and ‘NP2’). Analyses for NP1 and NP2 should replicate prior findings of longer reading times for marked object-subject compared with unmarked subject-object clauses (e.g., Traxler, Morris, & Seely, 2002; Schriefers, Friederici, & Kuhn, 1995).

The first-pass, regression-path and total-time data for the ambiguous region of the second conjunct (NP3) and the disambiguating region (NP4) summarized by participants (*F1*) or items (*F2*) were subjected to repeated-measures Analyses of Variance (ANOVA) with the factors *markedness* (marked versus unmarked second conjunct), and *parallelism* (parallel vs. non-parallel constituent order). To further verify that we replicate existing findings of higher reading times for non-canonical marked compared with unmarked constituent structure for the first conjunct, we conducted repeated measures ANOVAs with the factor *markedness* (marked versus unmarked *first* conjunct) on reading time data for the two noun phrase regions (NP1 and NP2) in the first conjunct. Since tests of normality revealed reliable effects for some of the independent terms, the raw data were log-transformed to improve the normality of the distribution (see, e.g., Tabachnik & Fidell, 2007, 246f.). F-tests were performed on both raw and log-transformed data. The overall pattern of results and related conclusions did not differ between these two analyses. The F-values reported in the paper are from analyses on the log-transformed data. We verified that assumptions of sphericity were met for all analyses. Results are reported as significant if the null hypothesis was rejected at the .05 level in both the participants and items analyses. We further report partial eta squared η^2 to provide some insight into the size of effects when other sources of variance are separated out (see Cohen, 1973; Pierce, Block, & Aguinis, 2004).

To analyze the proportions of first-pass regression out of a region, we relied upon mixed-effects regression (a generalized linear model with a logit link function), using the lme4 package of R (Bates, 2005, Pinheiro & Bates, 2000). We coded whether a regression took place ("1") or not ("0") for a given region. Predictors of first-pass regression likelihood (markedness and constituent order parallelism) were coded as "0" (marked / non-parallel for the markedness and parallelism factors respectively) and "1" (unmarked / parallel); predictors were centered. Participants and items were included as random factors, and either markedness of the first clause (for regions in the first conjunct), or markedness of the second clause and constituent order parallelism (for regions in the second conjunct) as fixed effects. Note that our design was balanced, and correlations of fixed effects were very low (< |0.16|; collinearity assessment showed that multicollinearity of predictor variables was not an issue for our analyses; see Baayen, 2008). To assess the contribution of a predictor or an interaction between predictors to a model, we report χ^2 of the comparison between a given model (e.g., with the interaction term and the two main effects) relative to a model that contained one predictor less (e.g., without the interaction term, see e.g., Jaeger, 2008). For comparisons between levels of a predictor we report the coefficients and Wald's z. For our coding, a negative coefficient indicates that the odds of a regression are less likely for unmarked / parallel than marked / non-parallel conditions while a positive coefficient indicates the odds of a regression are more likely for unmarked / parallel than marked / parallel conditions.

Results and discussion

Response accuracy on the questions for the filler trials was high (of the questions that had a "yes" reply, 91 percent were answered correctly, and of the questions with a "no" reply, 87 percent were answered correctly). Prior to further analysis of the reading time data, we removed missing values and individual data points that were more than +/- 2 standard deviations (SD) from the mean of a participant or item in a condition separately for first-pass, regression path, and total times (< 3.1 percent of the data).

Table 2 presents the mean reading times for the four dependent measures – first pass, regression path, total times, and first-pass regressions - by condition and analysis region. Table 3 presents the statistical results from repeated measures ANOVAs with the factor *markedness* (marked vs. unmarked first conjunct) for the first conjunct (NP1 and NP2), and from a 2 x 2 repeated measures ANOVA with the factors *markedness* (marked versus unmarked second conjunct), and *parallelism* (parallel versus non-parallel constituent order) for the second conjunct (NP3 and NP4). Table 4 presents results of the inferential analyses of first-pass regressions.

First Conjunct: NP1 and NP2

For NP1, analyses revealed reliably longer reading times when the first conjunct had marked versus unmarked constituent order in first pass times (523 vs. 476 ms), regression path (757 vs. 621 ms), and total times (1536 vs. 1147 ms, see Table 2). For NP2, we observed longer reading times for marked compared with unmarked sentences in regression path (972 vs. 770 ms) and total times (1444 vs. 1229 ms). These main effects of markedness were confirmed by inferential analyses (Table 3). In the analyses of first-pass regressions, markedness contributed reliably to the model as compared to a model with only the intercept at both NP1 and NP2 ($\chi^2(1)=10.81$, $p < 0.01$ and $\chi^2(1)= 44.23$, $p < 0.001$ respectively). Participants made a first-pass regression out of NP1 and NP2 on more trials for marked than unmarked constituent orders (Table 2), as confirmed by reliable main effects of markedness (Table 4).

Table 2: about here

Table 3: about here

Table 4: about here

Second conjunct: NP3 and NP4

For the ambiguous NP3 region, no reliable main effects of markedness (of the second conjunct) were found in first pass and regression path times. Total reading times, in contrast, were reliably longer for marked object-subject than unmarked subject-object sentences (1063 vs. 843 ms, see Table 2 for reading times in all four conditions). An interaction between parallelism and markedness in first pass and regression path times was marginal by participants and items respectively (Table 3). Analyses of first-pass regressions at NP3 revealed that models with the two main effects of constituent order and markedness and with their interaction had no higher log likelihood than respective nested models without these predictors (χ^2s < 1). Effects of markedness and constituent order parallelism on the probability of first-pass regressions were not reliable, all $|z|$s < 1 (Table 4).

Crucially, we found clear evidence for parallelism effects at the disambiguating fourth noun phrase. Regression path times on NP4 were shorter for parallel than non-parallel conditions (1134 vs. 1024 ms), a finding that was confirmed by a reliable main effect of parallelism (Table 3). There was, however, no clear difference in the proportion of regressions as a function of constituent order parallelism (Tables 2 and 4), and a model with constituent order parallelism did not differ reliably from the intercept-only model ($\chi^2(1)=2.88$, $p = 0.09$). Analyses at NP4 further revealed longer reading times for marked than unmarked conditions in first pass (649 vs. 558 ms), regression path (1241 vs. 917 ms), and total times (1456 vs. 1088 ms). Main effects of markedness in all three reading time measures confirmed these findings. For first-pass regressions, a model with just the intercept had lower likelihood than a model with markedness, suggesting it contributes significant information ($\chi^2(1)=41.90$ $p < 0.001$): Participants made more first-pass regressions out of NP4 for marked than unmarked constituent order (Table 2) as evidenced by reliable effects of markedness on the likelihood of first-pass regressions. There was no reliable interaction between parallelism and markedness in any measure on NP4, all Fs < 2 and $|z|<1$ (Tables 2 - 4), and a model with the two main effects and the interaction did not differ reliably from a model that contained the two main effects ($\chi^2<1$).

The key finding of Experiment 1 is the facilitative effect of parallel constituent order structure on processing of the second conjunct, as revealed by analyses of regression path duration for the disambiguating fourth noun phrase. The main effect of parallelism in regression path times confirms that comprehension of the fourth noun phrase and its integration with preceding context is facilitated incrementally when the constituent order of the second conjunct is parallel to the constituent order of the first conjunct compared to when it has a different, non-parallel constituent order. There was, however, no strong evidence for the view that the constituent order parallelism effect in regression path duration at NP4 was brought about by the probability of first-pass regressions out of that region. The main effect of markedness in all measures on NP4 strongly suggests that case marking is immediately used to disambiguate constituent order while the absence of an interaction between constituent order parallelism and markedness in all measures on NP4 is consistent with the view that parallelism effects for marked (subject-object) and unmarked (object-subject) constituent orders do not differ strongly in the disambiguating region. Finally, it is worth noting that Experiment 1 is the first study to our knowledge that finds parallelism effects based on stimuli in which the verb was not repeated in the two conjuncts (see Traxler, 2008 on related findings for priming; but Arai et al., 2007).

Analyses of reading times at NP3 further confirmed a main effect of markedness of the second conjunct in later, total reading times. It seems plausible that this effect in total times at

NP3 resulted from the more frequent regressive eye movements when NP4 disambiguated towards marked than unmarked constituent order (see Table 4). Parallelism thus did not fully eliminate the difficulty associated with processing of the marked object-subject order, suggesting it only has an attenuating but not overriding effect on the processing of marked structures. The marginal interaction of parallelism and markedness in first pass and regression path times is due to NP3 being read slower whenever the first clause has marked order (namely in the marked-parallel and unmarked-nonparallel conditions). However, when the preceding regions (the adverb and verb that precede NP3) were examined, we found a similar gaze pattern for those regions as for NP3, suggesting this may well be a spill-over effect. Analyses of reading times during the first conjunct further confirmed previous findings of processing difficulty for object-subject compared with subject-object constituent order (e.g., Hemforth, 1993, Traxler, Morris, & Seely, 2002, Schriefers, Friederici, & Kuhn, 1995).

Experiment 2

Method

Participants

Thirty-two further participants from the same population as in Experiment 1 were paid 7.50 euros for taking part in the experiment.

Materials, Design, Procedure and Analysis

Design, presentation, analysis, and instructions were identical to Experiment 1, and the materials were similar to Experiment 1: The ambiguously case-marked first noun phrase of the second conjunct in Experiment 1 (*die Weltmeisterin* 'the world champion') was replaced with an unambiguously nominative (subject, *der Ringer*, 'the wrestler') or accusative-case marked noun phrase (object, *den Ringer*, 'the wrestler'). Nominative (subject) and accusative (object) case of a noun phrase was marked through the determiner of that noun phrase (*der* and *den* respectively). Since the new masculine noun phrases were often slightly shorter than the previously-used feminine noun phrases, and since we wanted to keep the number of syllables for the four noun phrases constant within an item sentence to minimize any differences between the noun phrases in the two conjuncts, we replaced many of the masculine noun phrases used in Experiment 1 with semantically similar noun phrases (e.g., *Sumoringer*, 'sumowrestler', *Degenfechter*, 'sword fencer', and *Titelhalter*, 'titleholder' were replaced by *Ringer*, 'wrestler', *Fechter*, 'fencer', and *Erzfeind*, 'arch enemy', see Table 5).

Table 5: about here

Since it was possible to fully counterbalance the design for Experiment 2, we created a counter-balancing version for each of the four sentences in Table 5. To create the counterbalancing sentences, the first and third noun phrases of sentences a-d (Table 5) became the second and fourth noun phrases in the counter-balancing sentences, and the second and fourth noun phrases of sentences a-d in Table 5 became the first and third noun phrases for the counter-balancing sentences. In this way, any effects of the order of NPs (e.g., 'defeated fencer adversary' being easier to process than 'defeated adversary fencer') are counterbalanced.

As a result of the counter-balancing an item consisted of eight sentences. There were eight experimental lists. Each list contained 32 experimental items, an equal number of experimental trials in each condition, and only one condition of an item. In addition to the experimental items there were 95 filler items of which 46 were followed by a yes/no question just as for Experiment 1. Experimental items were separated from one another by at least one intervening filler trial.

The order of items was individually randomized for each participant.

Results and discussion

Accuracy on the filler questions was high (87 percent of correctly answered “yes”-questions, and 86 percent of correctly answered “no”-questions). Prior to analysis, we removed individual data points that were more than +/- 2 SD from the mean of a participant or item in a condition as well as missing values (< 3.5 percent of the total data). We present mean reading times (first pass times, regression path duration, and total times), as well as the probability of first-pass regressions by condition and analysis region (Table 6), and the corresponding inferential analyses (Tables 4 and 7).

First conjunct: NP1 and NP2

For the NP1 region in Experiment 2 - just as in Experiment 1 - reading times were longer when the first clause had a marked object-subject compared with an unmarked subject-object constituent order, as apparent in first pass (308 vs. 272 ms), regression path (434 vs. 354 ms), and total times (995 vs. 777 ms). For the NP2 region, reading times were longer in marked compared with unmarked conditions in regression path (555 vs. 393 ms) and total times (953 vs. 790 ms, see Table 7). In analyses of first-pass regressions, the overall contribution of markedness was evidenced by reliable differences between a model with just the intercept versus a model with markedness, for both NP1 ($\chi^2(1)=5.67$, $p < 0.05$) and NP2 ($\chi^2(1)=25.50$, $p < 0.001$): Participants’ proportion of first-pass regressions out of NP1 and NP2 was higher for marked than unmarked constituent order of the first conjunct (Table 4).

Second conjunct: NP3 and NP4

Analyses of reading times for the unambiguously case-marked NP3 region revealed reliable effects of parallelism, however, only in a late measure: Total times were reliably longer for non-parallel conditions than parallel conditions (1213 vs. 1042 ms). Analyses of first pass times and regression path duration for NP3, revealed only a descriptive trend by participants and items respectively towards shorter reading times for parallel versus non-parallel conditions but no reliable effect (Table 7). Analyses of first-pass regressions also revealed no reliable effects of constituent order parallelism on the proportion of trials with a first-pass regression out of NP3 (Table 4), and a model with constituent order parallelism did not differ reliably from one with just the intercept (χ^2<1). For NP3, all reading time measures further revealed a reliable effect of markedness (Table 7): First pass (424 vs. 362 ms), regression path (696 vs. 536 ms), and total times (1276 vs. 980 ms) were longer for the marked conditions than for the unmarked subject-object order. There was a marginal effect of markedness on the probability of first pass regressions out of NP3 (Tables 4 and 6) and a marginal difference between a model with just the intercept and a model with markedness as predictor ($\chi^2(1)=3.29$, $p= 0.07$). Crucially, there was no reliable interaction between parallelism and markedness in any reading time measure, all Fs < 1 (see Table 7), only a marginal contribution of the interaction effect in first pass regressions to the model ($\chi^2(1)=2.89$, $p = 0.09$), and a marginal interaction in the effects of constituent order and markedness on the probability of first pass regressions (Table 4). Marked structures triggered slightly more first-pass regression for non-parallel than parallel constituent order while for unmarked structures, there were more trials with regressions for parallel than non-parallel constituent order (Table 4).

For the NP4 region, analyses revealed a reliable main effect of constituent order parallelism (Table 7). Reading times in regression path (870 vs. 966 ms) and total times (964 vs. 1089 ms) on NP4 were faster for parallel than non-parallel conditions. Participants further made reliably more regressions out of the NP4 region for non-parallel than parallel constituent order (Tables 4 and 6), and a model with constituent order differed reliably from a model with just the intercept ($\chi^2(1)=7.57$, $p < 0.01$). In addition, reading times were shorter when the second conjunct had an unmarked subject-object compared with a marked object-subject order as evidenced by analyses of both regression path (768 ms vs. 1068 ms) and total times (958 ms vs. 1095 ms). Participants also made more regressions out of the NP4 region for marked than unmarked constituent order (Tables 4 and 6), and a model with markedness differed reliably from one with just the intercept ($\chi^2(1)=32.83$, $p < 0.001$). There was no reliable interaction between parallelism and markedness in the reading time measures Fs < 2. In the analyses of first-pass regression likelihood, a model with the interaction had only a marginally higher likelihood than a model with just the two main effects ($\chi^2(1)=2.96$, $p =0.09$), and there was only a marginal interaction between parallelism and markedness (Table 6; effects of parallelism were slightly greater for unmarked than marked structures).

Table 6: about here

Table 7: about here

Findings from Experiment 2 (i.e., effects of parallelism on NP4) importantly provide support for the view that parallelism mechanisms apply in structurally unambiguous sentences. In addition, they corroborate the view that parallelism mechanisms apply across the board for marked and unmarked structures: We found reliable main effects of parallelism in total times at the third noun phrase and in regression path, total times, and first-pass regression probability at the fourth noun phrase, and no strong evidence for differences of parallelism effects as a function of the markedness of the second conjunct. Reliable effects of markedness in all reading time measures on NP3 indicate that case marking is rapidly used to establish the constituent order of the unfolding second clause as either subject-object or object-subject. We failed, however, to find parallelism effects at NP3 in first pass, regression path, and probability of first-pass regression measures, despite the evidence that case-marking constraints were rapidly applied (i.e., and thus were, in principle, available for parallelism processing). These findings are consistent with an account in which parallelism mechanisms apply on-line but only once processing of the parallel structures is complete (i.e. at NP4).

Experiment 3

Method

Participants

Another thirty-two participants from the same population as in Experiment 1 received 7.50 euros for participating in the experiment.

Materials, Design, Procedure, and Analysis

Procedure and instructions were identical to Experiments 1 and 2. The materials were based on the stimuli from Experiment 2. There were thirty-two items all of which were fully structurally unambiguous just as in Experiment 2. We retained the constituent order parallelism manipulation while adding semantic parallelism as a factor. Crossing the two factors resulted in the four conditions displayed in Table 8 (a-d).

For the constituent order parallelism manipulation, the first conjunct was either parallel (object-subject) or non-parallel (subject-object) to the second clause (object-subject). The second clause was thus, unlike in Experiment 2 – always in marked object-subject order. We chose the marked order since we found clear parallelism effects for it in the reading time measures of Experiment 2. Note that 32 filler sentences were coordinate-clause constructions for which both the first and second conjunct was in subject-initial order. This ensured people could not follow a strategy of always expecting a parallel clausal coordination when they encountered an object-initial sentence beginning in the experimental items and a non-parallel coordination when encountering a subject-initial sentence beginning.

We created semantic parallelism between two conjuncts by manipulating the similarity of the noun phrases that had the same position in the linear order of a coordinate clause. We first describe the similarity manipulation and then outline how it was verified in a rating study. Sentences were considered semantically parallel when the first noun phrase in the first clause (NP1, ‘the fencer’) was most similar to the first noun phrase in the second clause (NP3, ‘the wrestler’), and the second noun phrase in the first conjunct (NP2, ‘the opponent’) was most similar to the second noun phrase in the second conjunct (NP4, ‘the arch-enemy’). In contrast, a sentence was considered semantically non-parallel when noun phrases that shared the same position in linear order in the first and second conjunct (e.g., ‘the opponent’ and ‘the wrestler’, (b)) were less similar to one another than two noun phrases that did not share the same position (e.g., ‘the opponent’ and ‘the arch-enemy’, (b)).

To verify the similarity manipulation, twenty additional participants rated four noun phrase pairs for each item. For the example item in Table 8, ratings on a scale from 1 to 7 were obtained for the two similar noun phrase pairs in the two conjuncts (‘fencer’ and ‘wrestler’; ‘opponent’ and ‘arch-enemy’), and for the two dissimilar noun phrase pairs (‘fencer’ and ‘opponent’; ‘wrestler’ and ‘arch-enemy’). The mean rating for similar noun phrase pairs was 4.48 compared with 3.31 for the non-similar pairs, a difference that was reliable, $F1(1, 19) = 50.63$, $p < 0.0001$,

$F2(1, 31) = 39.35$, $p < 0.0001$.

Table 8: about here

Results and discussion

Accuracy on the questions was high (87 percent of questions with “yes”- and 88 percent of question with “no”-responses were answered correctly). Prior to analysis, we removed missing values as well as individual data points that were more than +/- 2 SD from the mean of a participant or item in a condition (< 2.5 percent of the total data). Table 9 shows the mean reading times (first pass, regression path and total times) and first-pass regression probabilities per condition and analysis region. The corresponding inferential analyses of 2x2 repeated measures ANOVAs with the factors constituent order parallelism (yes vs. no) and semantic parallelism (yes vs. no) at NP3 and NP4, as well as the results of repeated measures ANOVAs with markedness of the first conjunct as a factor (NP1 and NP2) are reported in Table 10, and the results of the first-pass regression inferential analyses are included in Table 11.

First conjunct: NP1 and NP2

For the NP1 region of the first conjunct, marked object-subject compared with subject-object constituent order triggered longer reading times in first pass (585 vs. 494 ms), regression path (857 vs. 712 ms), and total times (1758 vs. 1498 ms). Analyses of regression path times (1163 vs. 848 ms) on the NP2 region also revealed longer reading times for marked than unmarked sentences. The inferential analyses presented in Table 10 confirm this descriptive pattern. For analyses of first-pass regressions, a model with markedness had a higher log likelihood compared with an intercept-only model at NP2 ($\chi^2(1)=33.69$, $p < 0.001$) but not at NP1 ($\chi^2(1)< 2$). The probability of first-pass regressions was reliably higher for marked than unmarked constituent order at NP2 but not at NP1 (Tables 9 and 11).

Table 9: about here

Table 10: about here

Table 11: about here

Second conjunct: NP3 and NP4

For the third noun phrase region, we found main effects of constituent order parallelism, as evidenced by longer regression path (744 vs. 635 ms), and total times (1571 vs. 1400 ms) for non-parallel compared with parallel constituent order (Tables 9 and 10). Constituent order parallelism effects in first pass times were reliable only by participants. For first-pass regressions out of NP3, constituent order parallelism contributed reliably to the model relative to an intercept-only model ($\chi^2(1)=4.16$, $p < 0.05$). There were fewer regressions for parallel than non-parallel constituent order (Tables 9 and 11). In addition, there was a trend towards semantic parallelism effects at NP3: regression path (678 vs. 701 ms) and total (1538 vs. 1433 ms) times were marginally longer by items and participants respectively for semantically non-parallel than parallel conditions. Semantic parallelism, however, did not reliably influence the likelihood of first pass regressions (Table 11). Constituent order and semantic parallelism did not interact in any measure at NP3 (Fs < 1.1 and |z|s < 1).

Analyses of the NP4 region revealed a constituent order parallelism effect by participants, with longer reading times for non-parallel relative to parallel constituent order in regression path times (1221 vs. 1033 ms). In total times, the constituent order parallelism effect was reliable by items (1284 vs. 1190 ms). There was no reliable effect of constituent order parallelism in analyses of first-pass regressions ($\chi^2<1$, $|z| < 1.1$, Table 11). Analyses of the NP4 region, however, yielded additional evidence for semantic parallelism effects (marginal by participants), with longer total times for semantically non-parallel relative to parallel conditions (1262 vs. 1212 ms, see Table 9). The marginal effect of semantic parallelism in total times on NP4 turned reliable by participants when analysing a combined NP3-NP4 region, $F1(1,31)=6.11$, $p < 0.03$, $F2(1,31)=2.16$, $p = 0.15$. Semantic parallelism effects in first-pass regression analyses were not reliable ($\chi^2<1$, Table 11). The interaction between constituent order and semantic parallelism was not reliable in any reading time measure ($Fs < 2.5$, see Table 10). There were, however, reliable effects of an interaction between constituent order and semantic parallelism on first-pass regression probability (Table 11) and the model with the interaction differed reliably from a nested model without the interaction ($\chi^2(1)=5.19$, $p < 0.05$), with parallel constituent order triggering more regressions out of NP4 when semantic parallelism also applied than when it didn't while for non-parallel constituent order, regressions out were more frequent when semantic parallelism did also not apply, than when it applied.

To summarize, a first important finding of Experiment 3 was the constituent order parallelism effects in regression path, total times, and first-pass regressions for NP3, and in regression path times for NP4 (reliable by participants). In addition, there was some evidence for facilitation through subtle semantic structure as evidenced by shorter reading times for semantically parallel compared with non-parallel conditions in regression path times on the third noun phrase (marginal by items) and in total times on the fourth noun phrase (marginal by participants). Analyses for a combined NP3-NP4 region found reliable effects of semantic parallelism by participants, suggesting that representations underlying parallelism effects encode detailed and fine-grained semantic features. A further finding was that while constituent order and semantic parallelism did not interact in any of the reading time measures, $Fs < 1.2$ for NP3 and $Fs < 2.5$ for NP4, they interacted in the analyses of first-pass regressions out of NP4 with the pattern suggesting that computing either two parallel or two non-parallel structures may be more costly (i.e., trigger more regressions) than when only one parallel structure must be computed. We discuss these findings and those from Experiments 1 and 2 further in the General Discussion.

General Discussion

Findings from three eye-tracking experiments have provided strong evidence for online parallelism mechanisms that operate incrementally and across-the-board, extending previous results (Carlson, 2001; Frazier et al., 1984, 2000): We observed parallelism effects in both structurally ambiguous and unambiguous sentences, with no clear difference in effects as a function of constituent order markedness, and on the basis of both constituent order and – to some extent – also fine-grained semantic similarity. Furthermore, these are to our knowledge the first studies to have shown parallelism without repetition of the verb in the two conjuncts, and in another language (German). The across-the-board nature of parallelism mechanisms is also supported by the fact that semantic and constituent order parallelism did not interact in any reading time measure, although this finding must be interpreted with some caution.

Additionally, analysis of three different reading time measures (first pass, regression path and total times) for two different regions (the third and the fourth noun phrase) in the second conjunct provided more detailed insights into the time course of parallelism effects than previous research that analysed first pass and total times for the entire second conjunct (Frazier et al., 1984, 2000). In the following we summarize how the findings of each study extend our knowledge on the five open issues (A) to (E) outlined in the introduction, and subsequently discuss our findings in light of sentence processing mechanisms.

(A1) The time course of constituent order parallelism effects

Findings from Experiment 1 provided clear support for the view that parallel constituent order incrementally facilitates processing of the second conjunct during disambiguation of locally structurally ambiguous German coordinate clause sentences: Regression path time during disambiguation on the final noun phrase of the second conjunct (NP4) was shorter when the second conjunct was parallel in constituent order to the first, than when it had a different constituent order. This view was further confirmed by reliable parallelism effects in regression path times and probability of first-pass regressions at the final noun phrase of the second conjunct (NP4) in Experiment 2 and by parallelism effects in regression path times and probability of first-pass regressions on the first noun phrase of the second conjunct (NP3) in Experiment 3.

The data from these three experiments add to the results from Frazier et al. (1984) who only report analyses of total reading times for the entire second conjunct. In a later study, Frazier et al. (2000, Experiments 1 and 3) analysed both first pass and total times, and report clear parallelism effects for the entire second conjunct only in total times. The absence of clear evidence for constituent order parallelism in first pass measures for our experiments is consistent with the findings of Frazier et al. (2000, Experiments 1 and 3) who similarly found no reliable effects of constituent order parallelism in first pass times. On the one hand this finding might be seen as evidence in favour of the view that parallelism does not affect initial construction of constituent order, especially since in both Experiments 2 and 3 the constituent order of the second conjunct became unambiguous as soon as people read the third noun phrase. However, we cannot entirely exclude the possibility that parallelism does affect syntactic structure building immediately but only affects eye-movement behaviour with a certain delay, since parallelism effects in first pass times were relatively small (η^2 was between 0 and 0.03 in Experiment 1, between 0.01 and 0.11 in Experiment 2, and 0 and 0.27 in Experiment 3).

Analyses of regression path duration in our studies revealed, however, that parallelism effects occur somewhat earlier than previously reported by Frazier et al. (1984, 2000) who observed parallel structure facilitation only in total times. This difference between their and our findings is enabled by the more fine-grained measures and regions in the second conjunct that we analyzed. The fact that we observed constituent order parallelism in regression path times on NP4 in Experiment 1 and 2 and on NP3 in Experiment 3 suggests that people at this point re-read the left context, before continuing to read past these regions when the constituent order of the first conjunct was parallel to that of the second conjunct than when their constituent order differed. This view is further corroborated by a higher proportion of first-pass regressions out of NP4 in Experiment 2 and NP3 in Experiment 3 for non-parallel relative to parallel constituent order. Overall, the time course of the effects suggests a view of parallelism as an on-line "meta-level" comprehension mechanism that facilitates incremental interpretation of coordinands, but doesn't necessarily guide initial structure building operations.

(B1) Parallelism as an ambiguity-resolution mechanism?

In addition to insights into the time course of parallelism effects, our findings speak to the relevance of parallelism for processing both locally structurally ambiguous and unambiguous constructions. The results from Experiment 1 – parallelism effects on the disambiguating noun phrase in the second conjunct after a preceding locally structurally ambiguous region - are compatible with two views of how parallelism mechanisms operate: They could either apply exclusively in locally structurally ambiguous environments (e.g., the first noun phrase of the second conjunct in Experiment 1), operating as a disambiguation strategy, or parallelism might rather reflect more general processing of coordinate structures, and thus extend to unambiguous constructions such as those examined in Experiment 2.

Analyses of the eye-tracking data from Experiment 2, in which case marking on the first noun phrase of the second conjunct immediately determines the constituent order (object-first versus subject-first), permit us to decide between these two accounts, in favour of the latter alternative. Regression path duration on the fourth noun phrase and total times on the third noun phrase in Experiment 2 were longer for non-parallel compared with parallel conditions, thus replicating the constituent order parallelism effects that we found in Experiment 1, also for the unambiguously case-marked sentences in Experiment 2. Analyses of the data from both Experiments 1 and 2 further show that parallelism effects occur in coordinate sentences at a region in the second conjunct for which no ellipsis was possible. While parallelism effects were clearly pervasive across ambiguous and unambiguous constructions, analyses of first-pass regression probability revealed interesting insights into parallelism effects in the absence (e.g., Experiment 2 and 3) versus presence (Experiment 1) of local structural ambiguity in the second conjunct. For Experiments 2 and 3, we found constituent order parallelism effects in first pass regressions at NP4. The absence of a similar effect on the probability of first-pass regressions in Experiment 1, in contrast, may reflect the severity of garden pathing in the second conjunct for Experiment 1, a view that is confirmed by smaller parallelism (η^2 was around 0.16) and larger markedness effects (η^2 of up to 0.70 at NP4) for Experiment 1 than Experiment 2 (parallelism effects reached $\eta^2$of 0.30 at NP4 while markedness effects were at most η^2 0.47).

Together the findings from Experiments 1 and 2 provide strong evidence for the view that constituent order parallelism effects are the consequence of general comprehension mechanisms rather than some strategy that operates only to assist syntactic disambiguation of local structural ambiguity such as on the third noun phrase in Experiment 1. In this regard, they extend findings from previous studies in which the second conjunct contained local structural ambiguity (Frazier et al. 1984).

(C1) Parallelism and markedness

Additional evidence concerning the scope of parallelism derives from the absence of a reliable interaction between markedness of the second conjunct and constituent order parallelism (Experiments 1 and 2). The failure to observe a reliable interaction of parallelism and markedness, while finding main effects of both parallelism and markedness is consistent with the hypothesis that parallelism facilitates processing of both marked and unmarked constituent orders, although clearly this conclusion must be taken with some caution. Recall that previous findings showed larger parallelism effects for some marked (e.g., heavy NP shift and non-minimal attachment) structures than for the corresponding unmarked structure. For other constructions (e.g., active-passive clause coordination), parallelism effects were more pronounced for the unmarked (active) than marked (passive) structure (Frazier et al., 1984).

Frazier et al. (1984) suggested that parallelism effects are elicited by a number of distinct mechanisms, accounting for the differences across these three types of constructions (active vs. passive, heavy vs. no-heavy NP shift and minimal vs. non-minimal attachment). If constituent order parallelism functioned according to Frazier's account for the minimal vs non-minimal or heavy NP shift constructions, we should have seen parallelism effects for marked structures only. If, alternatively, a discourse account of parallelism applied for constituent order structure, then we should have seen a pattern similar to the one that Frazier et al. observed for active-passive sentences: an object-subject-and-subject-object coordination (i.e., for which the marked precedes the unmarked structure) should have been more difficult to process than a subject-object-and-object-subject coordination (i.e., when the unmarked precedes the marked structure) conjunct (see C). We found no evidence to support either of these two possible accounts. Rather, analyses of the data from Experiments 1 and 2 are compatible with a parallelism mechanism that operates across both marked and unmarked constituent order.

(D1) Kinds of parallelism: constituent order versus / and semantic parallelism

Experiment 3 provided evidence for incremental parallelism effects resulting from subtle semantic parallelism. We observed a reliable advantage by participants in total reading times for processing of the second conjunct when its noun phrases were semantically parallel in linear order, and therefore information structure, to the noun phrases of the first conjunct, than when the noun phrases in the second conjunct were semantically non-parallel in linear order. The semantic parallelism effect suggests that the mental representations that people re-access during processing of the second conjunct encode detailed and fine-grained semantic features that permit the comprehension system to compute accurate similarity between semantically close noun phrase pairs such as 'fencer' and 'wrestler' (both denoting a person practising a specific sports discipline) versus 'adversary' and 'archenemy' (characterizing a contestant in more general terms).

Unlike for Experiment 2, we observed clear effects of constituent order parallelism in regression path times and first-pass regressions out on the first noun phrase of the second conjunct in Experiment 3, and also to a lesser extent in first pass times (reliable only by participants). This is to our knowledge the first study to find some, albeit weak, evidence for (constituent order) parallelism effects in first pass times. We identified two possible, and complementary, explanations for these earlier effects. First, Experiment 3 includes a manipulation of both constituent order and semantic parallelism. The mere presence of two (rather than one) parallel vs. non-parallel structure may have overall increased the sensitivity of the comprehension system to relying on recently built structure during comprehension of the second conjunct, resulting in a greater combined (e.g., η^2 for constituent order parallelism at NP3 in Experiment 3 was between 0.09 and 0.42) and earlier effect than the simple constituent order parallelism manipulations of Experiment 2.

Admittedly, it might be argued that semantic parallelism counters and thus diminishes constituent order parallelism effects in the condition for which only constituent order was parallel. Recall, however, that we only found weak semantic parallelism effects in total times on the NP3-NP4 region (reliable by participants), and also that the greatest facilitation at NP3 across all four measures occurred when both constituent order and semantic parallel structure aligned. Together these findings are compatible with the view that the subtle semantic parallelism that we examined can enhance processing when parallelisms holds, but not actively inhibit processing in the absence of semantic parallelism (e.g., in b, Table 8).

Secondly, the second clause in Experiment 3 always had marked constituent order, possibly further enhancing the parallelism effect, although we found no evidence in Experiments 1 or 2 suggesting greater effects in marked versus unmarked structures. The comparatively delayed (in total times) and weaker semantic effects (effects were reliable by participants on a combined NP3-NP4 region) plausibly reflect the greater subtlety of the semantic manipulation.

When comparing reading times for constituent order and semantic parallelism on NP3, the observation that constituent order parallelism and semantic parallelism did not interact in any reading time measure suggests that these two factors may contribute independently towards facilitating processing of the second conjunct. The fact that we observe similar effects for both of these kinds of parallelism suggests that even if parallelism effects are brought about by a single mechanism, that mechanism operates over multiple levels of representation. Interesting additional insights, however, come from first-pass regression analyses at NP4, for which we found more regressions for parallel constituent order when semantic structure was also parallel then when it was non-parallel, while for non-parallel constituent order, there were more regressions out of NP4 when semantic parallelism was absent than when it was present. While it might be argued that this interaction reflects different underlying mechanisms, we think that an alternative is that it reflects the effort of integrating both doubly parallel and non-parallel structures relative to situations in which only one structure is parallel.

(E1) Parallelism and priming

The findings from all three experiments show parallelism effects in the absence of verb repetition between the first and second conjuncts, thus extending parallelism findings from Frazier et al. (1984) for which the verb was repeated in the first and second conjuncts. Our findings can further be considered in relation to syntactic priming. Recall that in contrast to the constituent order parallelism effects of the present studies previous eye-tracking research on priming (Arai et al., 2007) only revealed syntactic priming of double object and prepositional object dative structure when the verb was identical between prime and target, not, however, when prime and target verb differed (see also Branigan et al., 2005). Arai et al. furthermore suggested that the failure to find a priming effect during comprehension in the absence of verb repetition (while it had previously been reported for production, see Pickering & Branigan, 1998) reflects differences in the magnitude of priming effects with different verbs in comprehension (smaller effects) relative to production (larger effects).

Recall also, however, that more recent priming research using eye tracking during reading, did find priming of adjunct relations both when the verb was repeated, and when it was not repeated (Traxler, 2008). Traxler (2008) suggested that variation in whether or not priming occurs with different verbs in prime and target sentence is related to the nature of the primed structure: While argument relations such as the ones examined in Arai et al. may be part of a verb's lexical entry and hence stored together with the verb, adjunct relations are not, and hence elicit priming even when the verb differs between prime and target. Our finding of constituent order parallelism effects with different verbs in the first and second conjuncts is compatible with Traxler's proposal: constituent order representations are not part of a verb's lexical entry and hence constituent order parallelism effects should occur independently of the verb.

Based on the Traxler (2008) study, verb-independent priming (of adjunct relations) and constituent order parallelism effects might be argued to share the same, or at least a highly similar, underlying mechanism. Potentially important, however, is that the priming effects observed by Traxler appeared to affect comprehension in first pass times and thus more rapidly than constituent order parallelism effects (with the exception of the combined order & semantic parallelism in participant analyses at NP3 for Experiment 3). Differences in size and time course of parallelism and priming effects may be the result of differences in the kinds of structures (constituent order vs. adjunct relations) being repeated, although it is possible that priming and parallelism differ in a more principled manner as a result of their different syntactic environments: loosely ensuing sentences versus conjuncts within a coordinate structure environment (Apel, Knoeferle, & Crocker, 2007; Frazier et al., 2000; but see Dunbey, Keller, & Sturt, 2008). Based on the findings reported here, however, we cannot rule out a priming account.

Parallelism: Copy-α?

The findings from Experiments 1 to 3 have important implications for existing theories of parallelism in the processing of elliptical constructions (Frazier & Clifton, 2001; Martin &

McElree, 2008). Frazier and Clifton outline *copy-α* as a cost-efficient parallelism mechanism that is available at ellipsis sites with unambiguous scope, and that re-uses the syntactic structure of a preceding clause by means of a copy operation. They argue that building more syntactic structure through the copy-α mechanism is – unlike structure building from scratch – low in its associated processing cost since previously built syntactic structure can simply be copied.

Recently, however, Martin and McElree (2008) showed that ellipsis interpretation does not involve a copy-α mechanism and propose the underlying mechanism is instead that of a pointer to structures in memory: Their expectation was that if it functioned like copy-α, then the speed of interpreting the ellipsis should be affected by the length and complexity of the to-be-copied elided material. They manipulated the length and complexity (whether the antecedent to the ellipsis contained a verb and simple vs. complex noun phrase; Exps 3 to 5). While some types of antecedent manipulations (the number of discourse entities in the antecedent) decreased accuracy, none of the manipulations affected the speed of ellipsis interpretation, supporting the parallelism-as-pointer account over copy-α.

Our findings could be taken as extending the above accounts to clausal coordination with no ellipsis: The adverb-verb sequence immediately after the coordinating conjunction and prior to our critical regions excluded the possibility of verb (or any other kind of) ellipsis. The fact that we observed parallelism facilitation in non-elliptical sentences might therefore be interpreted as support for the generality of parallelism across elliptical and non-elliptical sentences.

Analyses of the data from all three experiments, however, do not necessarily support the specifics of the mechanism proposed by Frazier and Clifton. If copy-α were the mechanism underlying parallelism effects, then we would have expected immediate facilitation upon copying recent structure and we should not have seen strong effects of clausal markedness in early measures (e.g., first pass) as people process the second conjunct. Applying a copy-α mechanism to parallelism is also not unproblematic, since lexical material is not copied. While the pointer account by Martin and McElree might be technically possible, with pointers both back to previous structure and then forward to new lexical material at the terminals, it is not at all clear such a mechanism offers greater processing efficiency, although it might reduce demands on working memory. In addition, the observation that both semantic and constituent order parallelism likely enhanced processing (Experiment 3), is suggestive of a parallelism mechanism that draws on both linear order and structural representations in memory.

We therefore tentatively propose that parallelism is a later mechanism that, while operating incrementally, facilitates the integration of constituent order structure only once it has been built. One possibility is that such representational matching across different parallel structures is achieved through accessing several distinct structures (e.g., syntactic, information structure, thematic role structure, and semantic structure). Alternatively, there is a single (rather than several) representation of a recently processed sentence fragment but that encodes distinct features through which parallelism at different linguistic levels (e.g., constituent order vs. semantic) can be identified. Whichever account turns out to be correct, distinction of these different structures – constituent order and semantic noun phrase similarity – must occur in some form or other to account for the independent effects that we observed for these two kinds of parallel structure in the reading time measures. That is, the processing system must have a way of mapping recent semantic (but not constituent order) structure onto current semantic structure.

Parallelism and sentence processing mechanisms

We have argued for an account of parallelism that is on-line, but does not necessarily influence initial structure building. It is interesting to consider how such a parallelism mechanism might operate with respect to existing theories of sentence processing. Most theories of sentence processing have focused on how compositional syntactic parsing mechanisms can explain processing difficulty in the face of ambiguity and revision towards a disfavored marked structure (Altmann & Steedman, 1988; Crocker, 1996; Crocker & Brants, 2000; Fodor & Frazier, 1978; van Gompel et al., 2001; Jurafsky, 1996; MacDonald, Pearlmutter, & Seidenberg, 1994; Pritchett, 1992, Traxler, Pickering, & Clifton, 1998; Trueswell, 1996).

The processing situations that these theories account for differ from those we have considered in that they focus on accounting for the resolution of syntactic ambiguity: Finding similar parallelism effects in the second conjunct both when the first noun phrase of the second conjunct was (Experiment 1) and when it was not (Experiments 2 and 3) ambiguously case-marked suggests that parallelism is not some form of ambiguity-resolution mechanism. Furthermore, the observation of parallelism in the absence of any lexical repetition between the two conjuncts speaks against an account based on lexically driven activations (MacDonald et al., 1994, see also Pickering & Branigan, 1999 for a related account of priming in production).

Rather, it seems that our findings are best accommodated by an account that assumes cues in the linguistic input are immediately used in syntactic structuring, and that the use of recent constituent order and semantic structure is triggered by compositional interpretation of the second conjunct and its integration with preceeding context. This compositional interpretation view of parallelism receives support from the fact that parallelism mechanisms have been shown to depend on the presence of the coordinating conjunction *and* (Apel, Knoeferle, & Crocker, 2007; Frazier et al., 2000). Thus, there appears to be a compositional aspect to parallelism findings where recent structure facilitates processing of incoming structure in the second conjunct once *and* triggers expectations of like structure. Consider more generally the information sources that contribute towards parallelism effects: (i) representations derived from interpretation of the first conjunct, (ii) the presence of the coordinating conjunction, and (iii) bottom-up linguistic material of the second conjunct. The question is: Which mechanism most naturally explains how these informational cues are integrated?

We assume the sentence processor builds an interpretation of the first conjunct and likely still has access to distinct phonological, syntactic and semantic features or representations of that interpretation. Based on the absence of parallelism facilitation outwith coordinate structure environments (e.g., Apel et al., 2007; Frazier et al., 2000), we think that encountering *and* is a crucial cue for activating or actively seeking to identify parallel structure (see Callahan et al., submitted, for related evidence on the re-activation of verb meaning in response to a related versus unrelated probe word following the conjunction *and*).

For the sentences in our experiments ('An hour ago defeated the titleholder (subj) the sumowrestler (subj) and currently overwhelms the world champion (amb) the sword fencer (obj), as the journalist writes'), it is likely that upon encountering 'and', people at first expect either a VP or an NP coordination. Upon encountering "currently", however, people must revise their initial VP / NP structure and by the time they have processed the directly transitive verb in the second conjunct (e.g., 'overwhelms'), they know they should receive a further two noun phrases (those are necessary to complete the second clause and no other input is possible). Those two noun phrases then trigger the re-activation of subject-object and object-subject representations from the first conjunct and if parallel facilitate the integration of constituent order and semantic structure in the second conjunct.

One possible way to characterize the facilitation due to parallelism may be through an extension of mechanisms that assume the difficulty of processing a word is proportional to its *surprisal*, which is characterized as its negative log probability as determined during incremental probabilistic parsing (Hale, 2001, see also Hale, 2003; Levy 2008). While such accounts typically assume that probabilities in the parser are established on the basis of our long-term accrued experience with the language, it would not be unnatural to also increase the likelihood of particular constructions as a function of specific syntactic environments such as coordination. Upon encountering a coordinating conjunction, the structures encountered in the first conjunct (e.g. object-subject order) would be assigned a greater likelihood of re-occurring, thus lowering the surprisal, and thereby reading times, when a parallel structure is subsequently encountered. Indeed, such surprisal accounts are the only theories that, to our knowledge, have the potential to explain processing facilitation of unambiguous structures as a function of preceding linguistic material.

While a surprisal mechanism offers a reasonable overall explanation of our constituent order parallelism findings there are some shortcomings with regard to the findings presented here. Firstly, the surprisal account doesn't offer an explanation for why we found effects on the "informative" (unambiguously case-marked) NP4, in Experiment 1 in regression path durations, but only in total time measures for the informative NP3, in Experiment 2. Moreover, current surprisal accounts offer no explanation for the semantic parallelism effects observed in Experiment 3. Nonetheless, we see the a surprisal-based approach as offering the best explanation, among existing theories, for an across-the-board account of on-line parallel facilitation in ambiguous and unambiguous structures as well as for marked and unmarked constituent orders.

In sum, findings from the three eye-tracking experiments that we reported have shown that (a) parallelism effects in coordinate clauses are obtained across the board, in both ambiguous and unambiguously case-marked environments, and for marked and unmarked structures, (b) parallelism across all three studies was observed incrementally in regression path measures, and (c) parallelism mechanisms must be more complex than just a copying of recent syntactic structure. Rather, it is sensitive to fine-grained semantic parallelism, and is possibly a post-structure building phenomenon, with similarity of the conjoined clauses easing their comparative interpretation. One possible consequence of this mechanism may be a reduction of surprisal when processing parallel structures, which in turn reduces cognitive load and reading times. More generally, our findings together with findings from the priming-in-comprehension literature paint a picture of "relative facilitation through compositional interpretation" in which key factors are the kinds of representations that are parallel or primed and their lexical dependencies; in the case of parallelism the presence of a coordinating conjunction that expresses likeness of conjuncts; and last but not least, the determination - based on compositional interpretation of the second conjunct - of those structure(s) in the first conjunct that are relevant for parallel structure facilitation.

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Tables

Table 1: Example item sentence set for Experiment 1

Condition	Sentences
(a) unmarked, parallel	Vor einer Stunde bezwang | der Titelhalter (subj) $|_{NP1}$ den Sumoringer (obj) $|_{NP2}$ und gerade besiegt | die Weltmeisterin (amb, subj) $|_{NP3}$ den Degenfechter (obj.) $|_{NP4}$, wie der Journalist schreibt.
	‘An hour ago defeated | the titleholder (subj) $|_{NP1}$ the sumowrestler (subj) $|_{NP2}$ and currently overwhelms | the world champion (amb) $|_{NP3}$ the sword fencer (obj) $|_{NP4}$, as the journalist writes.’
(b) unmarked, non-parallel	Vor einer Stunde bezwang | den Titelhalter (obj) $|_{NP1}$ der Sumoringer (subj) $|_{NP2}$ und gerade besiegt | die Weltmeisterin (amb, subj) $|_{NP3}$ den Degenfechter (obj) $|_{NP4}$, wie der Journalist schreibt.
	‘An hour ago defeated | the titleholder (obj) $|_{NP1}$ the sumowrestler (subj) $|_{NP2}$ and currently overwhelms | the world champion (amb) $|_{NP3}$ the sword fencer (obj) $|_{NP4}$, as the journalist writes.’
(c) marked, parallel	Vor einer Stunde bezwang | den Titelhalter (obj) $|_{NP1}$ der Sumoringer (subj) $|_{NP2}$ und gerade besiegt | die Weltmeisterin (amb, obj) $|_{NP3}$ der Degenfechter (subj) $|_{NP4}$, wie der Journalist schreibt.
	‘An hour ago defeated | the titleholder $|_{NP1}$ (obj) | the sumowrestler $|_{NP2}$ (subj) and currently overwhelms | the world champion $|_{NP3}$ (amb) | the sword fencer $|_{NP4}$ (subj), as the journalist writes.’
(d) marked, non-parallel	Vor einer Stunde bezwang | der Titelhalter (subj) $|_{NP1}$ den Sumoringer (obj) $|_{NP2}$ und gerade besiegt | die Weltmeisterin (amb, obj) $|_{NP3}$ der Degenfechter (subj) $|_{NP4}$, wie der Journalist schreibt.
	‘An hour ago defeated | the titleholder (subj) $|_{NP1}$ the sumowrestler (obj) $|_{NP2}$ and currently overwhelms | the world champion (amb) $|_{NP3}$ the sword fencer (subj.) $|_{NP4}$, as the journalist writes.’

Word regions are delimited by vertical slashes ‘|’ (indicating the beginning and end of each of the four NP regions), with ‘NP1’ to ‘NP4’ marking the region name.

Table 2: Mean reading times in ms and proportion of first-pass regression by analysis region and condition for Experiment 1 (Standard error of the mean in brackets)

	First pass time (SE)	Regression-path (SE)	Total time (SE)	Proportion of first-pass regressions
NP1 region				
unmarked	476.44 (18.37)	621.34 (30.23)	1147.33 (74.17)	0.29
marked	523.33 (26.70)	757.65 (42.19)	1536.92 (99.61)	0.41
NP2 region				
unmarked	583.22 (26.41)	770.55 (44.89)	1229.45 (83.06)	0.33
marked	607.40 (25.98)	972.75 (61.43)	1444.09 (87.85)	0.54
NP3 region				
unmarked, parallel	373.49 (15.60)	535.46 (27.00)	791.47 (46.86)	0.34
unmarked, non-parallel	389.06 (14.08)	592.74 (41.13)	894.65 (62.36)	0.34
marked, parallel	409.50 (18.12)	573.56 (36.89)	1073.69 (77.24)	0.31
marked, non-parallel	387.71 (14.66)	546.01 (28.90)	1052.69 (71.82)	0.32
NP4 region				
unmarked, parallel	545.82 (25.22)	829.76 (46.32)	1043.35 (69.72)	0.45
unmarked, non-parallel	571.75 (22.68)	1005.35 (79.60)	1133.42 (72.84)	0.48
marked, parallel	659.10 (34.00)	1218.38 (91.37)	1434.19 (93.06)	0.63
marked, non-parallel	639.38 (35.20)	1264.63 (77.40)	1479.23 (95.83)	0.72

Note: For NP1 and NP2, ‘markedness’ refers to the first clause; for the NP3 and NP4 regions, in contrast, ‘markedness’ relates to the second clause.

Table 3: Inferential analyses for Experiment 1 (*df1* = 1; *df2* = 47 for *F1*; *df2* = 31 for *F2*)

Region	Measure		F1	Partial eta squared η^2	F2	Partial eta squared η^2
NP1	First pass	markedness	4.99*		5.04*	
	Regression path	markedness	23.42***		17.51***	
	Total time	markedness	68.96***		66.96***	
NP2	First pass	markedness	1.76		1.10	
	Regression path	markedness	40.68***		27.30***	
	Total time	markedness	34.28***		13.71**	
NP3	First pass	markedness	1.94	0.04	0.97	0.03
		parallelism	0.01	0.00	0.85	0.03
		m x p	3.02#	0.06	0.25	0.01
	Regression path	markedness	0.04	0.00	0.15	0.01
		parallelism	0.29	0.01	0.54	0.02
		m x p	2.06	0.04	3.70#	0.11
	Total times	markedness	39.30***	0.46	64.14***	0.67
		parallelism	2.10	0.04	0.60	0.02
		m x p	1.10	0.02	0.22	0.01
NP4	First pass	markedness	15.61***	0.25	16.47***	0.35
		parallelism	0.35	0.01	0.83	0.03
		m x p	1.66	0.03	1.09	0.03
	Regression path	markedness	62.87***	0.57	41.02***	0.58
		parallelism	6.71*	0.16	6.67*	0.18
		m x p	1.03	0.02	1.88	0.06
	Total times	markedness	63.52***	0.58	103.36***	0.77
		parallelism	3.50#	0.07	0.55	0.02
		m x p	0.45	0.01	0.01	0.00

p<0.1 = #, p<0.05 = *, p<0.01 = **, p<0.001 = ***

Note: For NP1 and NP2, ‘markedness’ refers to the first clause; for the NP3 and NP4 regions, in contrast, ‘markedness’ relates to the second clause.

Table 4: Inferential analyses of first-pass regressions for Experiments 1 and 2

Predictor	Coefficient	*SE*	Wald *z*	*p*
Experiment 1				
Intercept NP1	-1.39	0.16	-8.98	p< 0.001
markedness NP1	-0.44	0.13	-3.36	p<0.001
Intercept NP2	-1.12	0.18	-6.38	p< 0.001
markedness NP2	-0.86	0.13	-6.64	p< 0.001
Intercept NP3	-1.43	0.14	-10.51	p< 0.001
markedness NP3	0.05	0.13	0.39	0.70
parallelism NP3	-0.03	0.13	-0.25	0.80
m x p NP3	-0.02	0.27	-0.07	0.94
Intercept NP4	-0.64	0.18	-3.53	p< 0.001
markedness NP4	-0.78	0.12	-6.45	p< 0.001
parallelism NP4	-0.20	0.12	-1.68	0.09
m x p NP4	0.18	0.24	0.74	0.46
Experiment 2				
Intercept NP1	-1.48	0.13	-11.06	p< 0.001
markedness NP1	-0.38	0.16	-2.39	p< 0.02
Intercept NP2	-1.33	0.16	-8.27	p< 0.001
markedness NP2	-0.84	0.16	-5.29	p< 0.001
Intercept NP3	-1.19	0.17	-6.97	p< 0.001
markedness NP3	-0.27	0.15	-1.82	0.069
parallelism NP3	-0.07	0.15	-0.46	0.64
m x p NP3	0.52	0.30	1.73	0.085
Intercept NP4	-0.72	0.18	-4.10	p< 0.001
markedness NP4	-0.84	0.14	-5.86	p< 0.001
parallelism NP4	-0.43	0.14	-2.98	p< 0.01
m x p NP4	-0.50	0.29	-1.74	0.08

Note: For NP1 and NP2, ‘markedness’ refers to the first clause; for the NP3 and NP4 regions, in contrast, ‘markedness’ relates to the second clause.

Table 5: Example item sentence set for Experiment 2

Condition	Sentences
(a) unmarked, parallel	Vor einer Stunde bezwang | der Fechter (subj) $|_{NP1}$ den Gegner (obj) $|_{NP2}$ und gerade besiegt | der Ringer (subj) $|_{NP3}$ den Erzfeind (obj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the fencer (subj) $|_{NP1}$ the adversary (obj) $|_{NP2}$ and currently overwhelms | the wrestler (subj) $|_{NP3}$ the arch-enemy (obj) $|_{NP4}$, as the journalist writes.'
(b) unmarked, non-parallel	Vor einer Stunde bezwang | den Fechter (obj) $|_{NP1}$ der Gegner (subj) $|_{NP2}$ und gerade besiegt | der Ringer (subj) $|_{NP3}$ den Erzfeind (obj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the fencer (obj) $|_{NP1}$ the adversary (subj) $|_{NP2}$ and currently overwhelms | the wrestler (subj) $|_{NP3}$ the arch-enemy (obj) $|_{NP4}$, as the journalist writes.'
(c) marked, parallel	Vor einer Stunde bezwang | den Fechter (obj) $|_{NP1}$ der Gegner (subj) $|_{NP2}$ und gerade besiegt | den Ringer (obj) $|_{NP3}$ der Erzfeind (subj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the fencer (obj) $|_{NP1}$ the adversary (subj) $|_{NP2}$ and currently overwhelms | the wrestler (obj) $|_{NP3}$ the arch-enemy (subj) $|_{NP4}$, as the journalist writes.'
(d) marked, non-parallel	Vor einer Stunde bezwang | der Fechter (subj) $|_{NP1}$ den Gegner (obj) $|_{NP2}$ und gerade besiegt | den Ringer (obj) $|_{NP3}$ der Erzfeind (subj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the fencer (subj) $|_{NP1}$ the adversary (obj) $|_{NP2}$ and currently overwhelms | the wrestler (obj) $|_{NP3}$ the arch-enemy (subj) $|_{NP4}$, as the journalist writes.'

Table 6: Mean reading times in ms and proportion of first-pass regressions by analysis region and condition for Experiment 2 (Standard error of the mean in brackets)

Condition	First pass time (SE)	Regression-path (SE)	Total time (SE)	Proportion of first-pass regressions
NP1 region				
unmarked	272.63 (18.19)	354.48 (31.42)	777.13 (102.07)	0.17
marked	308.84 (24.51)	434.35 (38.97)	995.70 (133.51)	0.23
NP2 region				
unmarked	318.26 (22.84)	393.31 (35.73)	790.06 (92.45)	0.17
marked	346.10 (22.95)	555.00 (46.61)	953.75 (116.42)	0.30
NP3 region				
unmarked, parallel	349.37 (17.50)	530.15 (26.06)	921.69 (86.69)	0.25
unmarked, non-parallel	376.51 (17.86)	542.88 (37.37)	1039.30 (89.18)	0.22
marked, parallel	414.49 (29.57)	668.62 (48.02)	1163.72 (91.45)	0.26
marked, non-parallel	435.39 (24.55)	724.23 (49.53)	1388.59 (135.70)	0.32
NP4 region				
unmarked, parallel	442.43 (22.42)	693.01 (86.31)	896.74 (74.37)	0.22
unmarked, non-parallel	450.14 (21.20)	844.24 (103.68)	1019.67 (88.24)	0.33
marked, parallel	445.04 (22.57)	1047.02 (159.45)	1031.95 (87.55)	0.41
marked, non-parallel	426.40 (25.04)	1089.39 (168.13)	1159.79 (97.45)	0.45

Note: For NP1 and NP2, ‘markedness’ refers to the first clause; for the NP3 and NP4 regions, in contrast, ‘markedness’ relates to the second clause.

Table 7: Inferential analyses for Experiment 2 (*df1* = 1; *df2* = 31)

Region	Measure		F1	Partial eta squared η^2	F2	Partial eta squared η^2
NP1	First pass	markedness	1.56		5.08*	
	Regression path	markedness	4.03#		8.42**	
	Total times	markedness	19.27**		28.60***	
NP2	First pass	markedness	2.95#		2.33	
	Regression path	markedness	16.56***		20.01***	
	Total times	markedness	9.30**		8.20**	
NP3	First pass	markedness	8.01**	0.22	18.96***	0.40
		parallelism	3.69#	0.11	2.86	0.09
		m x p	0.00	0.00	0.57	0.02
	Regression path	markedness	23.07***	0.43	8.73*	0.22
		parallelism	0.54	0.02	2.95#	0.09
		m x p	0.43	0.01	0.58	0.02
	Total times	markedness	45.75***	0.60	28.87***	0.48
		parallelism	8.88*	0.22	14.73**	0.32
		m x p	0.03	0.00	0.01	0.00
NP4	First pass	markedness	0.48	0.02	1.01	0.03
		parallelism	0.14	0.01	0.19	0.01
		m x p	1.42	0.04	2.44	0.07
	Regression path	markedness	27.73***	0.47	11.01**	0.26
		parallelism	6.73*	0.18	7.36*	0.19
		m x p	1.87	0.06	1.80	0.06
	Total times	markedness	10.24**	0.25	3.36#	0.10
		parallelism	11.09**	0.26	13.18**	0.30
		m x p	0.07	0.00	0.76	0.02

p<0.1=#, p<0.05=*, p<0.01=**, p<0.001=***

Note: For NP1 and NP2, ‘markedness’ refers to the first clause; for the NP3 and NP4 regions, in contrast, ‘markedness’ relates to the second clause.

Table 8: Example item sentence set for Experiment 3

Condition	Sentences
(a) fully parallel (+corder, + sem)	Vor einer Stunde bezwang | den Fechter (obj) $|_{NP1}$ der Gegner (subj) $|_{NP2}$ und gerade besiegt | den Ringer (obj) $|_{NP3}$ der Erzfeind (subj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the fencer (obj) $|_{NP1}$ the adversary (subj) $|_{NP2}$ and currently overwhelms | the wrestler (obj) $|_{NP3}$ the arch-enemy (subj) $|_{NP4}$, as the journalist writes.'
(b) syntactically parallel (+corder, -sem)	Vor einer Stunde bezwang | den Gegner (obj) $|_{NP1}$ der Fechter (subj) $|_{NP2}$ und gerade besiegt | den Ringer (obj) $|_{NP3}$ der Erzfeind (subj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the adversary (obj) $|_{NP1}$ the fencer (subj) $|_{NP2}$ and currently overwhelms | the wrestler (subj) $|_{NP3}$ the arch-enemy (obj) $|_{NP4}$, as the journalist writes.'
(c) semantically parallel (-corder, + sem)	Vor einer Stunde bezwang | der Fechter (subj) $|_{NP1}$ den Gegner (obj) $|_{NP2}$ und gerade besiegt | den Ringer (obj) $|_{NP3}$ der Erzfeind (subj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the fencer (subj) $|_{NP1}$ the adversary (obj) $|_{NP2}$ and currently overwhelms | the wrestler (obj) $|_{NP3}$ the arch-enemy (subj) $|_{NP4}$, as the journalist writes.'
(d) fully non-parallel (-corder, -sem)	Vor einer Stunde bezwang | der Gegner | (subj) $_{NP1}$ den Fechter (obj) $|_{NP2}$ und gerade besiegt | den Ringer (obj) $|_{NP3}$ der Erzfeind (subj) $|_{NP4}$, wie der Journalist schreibt.
	'An hour ago defeated | the adversary (subj) $|_{NP1}$ the fencer (obj) $|_{NP2}$ and currently overwhelms | the wrestler (obj) $|_{NP3}$ the arch-enemy (subj) $|_{NP4}$, as the journalist writes.'

Table 9: Mean reading times in ms and proportion of first-pass regressions by analysis region and condition for Experiment 3 (Standard error of the mean in brackets)

Condition	First pass time (SE)	Regression-path (SE)	Total time (SE)	Proportion of first-pass regressions
NP1 region				
unmarked	494.69 (29.73)	712.10 (45.29)	1498.74 (97.19)	0.21
marked	585.57 (36.48)	857.66 (58.21)	1758.94 (106.96)	0.25
NP2 region				
unmarked	589.71 (36.21)	848.00 (61.28)	1467.42 (98.26)	0.23
marked	612.83 (41.41)	1163.67 (101.49)	1584.64 (103.77)	0.39
NP3 region				
fully parallel (+corder + sem)	504.68 (27.20)	612.46 (35.73)	1351.18 (96.24)	0.12
syntactic parallel (+corder, -sem)	526.04 (29.68)	658.53 (39.33)	1450.08 (111.06)	0.16
semantic parallel (-corder,+sem)	570.99 (35.16)	745.41 (37.56)	1515.58 (109.99)	0.17
fully non-parallel (-corder, -sem)	570.64 (31.42)	743.62 (40.25)	1627.36 (111.27)	0.20
NP4 region				
fully parallel (+corder, +sem)	508.30 (27.78)	1036.78 (100.82)	1144.76 (78.89)	0.42
syntactic parallel (+corder, -sem)	564.98 (32.77)	1029.38 (103.92)	1236.76 (80.07)	0.38
semantic parallel (-corder, + sem)	505.18 (27.56)	1148.12 (106.48)	1280.53 (88.83)	0.38
fully non-parallel (-corder, -sem)	511.18 (27.26)	1293.95 (158.86)	1288.35 (69.02)	0.47

Table 10: Inferential analyses for Experiment 3 (*df1* = 1, *df2* = 31 for the *F1* and *F2* analyses)

Region	Measure		F1	Partial eta squared η^2	F2	Partial eta squared η^2
NP1	First pass	markedness	11.91**		19.81***	
	Regression path	markedness	15.64***		14.05**	
	Total times	markedness	24.55***		25.15***	
NP2	First pass	markedness	0.60		0.63	
	Regression path	markedness	25.76***		18.63***	
	Total times	markedness	4.23*		5.17**	
NP3	First pass	corder parallel	11.62**	0.27	3.23#	0.09
		sem parallel	0.57	0.02	0.31	0.01
		corder x sem	0.24	0.01	0.00	0.00
	Regression path	corder parallel	15.60***	0.34	10.40**	0.25
		sem parallel	1.08	0.03	3.36#	0.10
		corder x sem	1.01	0.03	1.02	0.03
	Total times	corder parallel	22.67***	0.42	13.28**	0.30
		sem parallel	3.67#	0.11	1.81	0.06
		corder x sem	0.03	0.00	0.06	0.00
NP4	First pass	corder parallel	1.98	0.06	0.10	0.00
		sem parallel	2.55	0.08	1.80	0.06
		corder x sem	2.45	0.07	1.40	0.04
	Regression path	corder parallel	4.87*	0.14	2.91#	0.09
		sem parallel	0.42	0.01	0.27	0.01
		corder x sem	0.80	0.03	0.94	0.03
	Total times	corder parallel	4.17#	0.12	6.15*	0.17
		sem parallel	3.98#	0.11	1.29	0.04
		corder x sem	0.33	0.01	0.04	0.00

p<0.1=#, p<0.05=*, p<0.01=**, p<0.001=***

Table 11: Inferential analyses of first-pass regressions for Experiment 3

Predictor	Coefficient	*SE*	Wald *z*	*p*
Intercept NP1	-1.30	0.14	-9.60	p<0.001
markedness NP1	-0.21	0.15	-1.36	0.17
Intercept NP2	-0.88	0.15	-6.00	p<0.001
markedness NP2	-0.84	0.14	-5.78	p<0.001
Intercept NP3	-1.82	0.16	-11.35	p<0.001
corder parallel NP3	-0.37	0.18	-2.05	p<0.05
sem parallel NP3	-0.28	0.18	-1.56	0.12
corder x sem NP3	-0.07	0.36	-0.20	0.84
Intercept NP4	-0.39	0.18	-2.20	p<0.05
corder parallel NP4	-0.14	0.14	-1.03	0.31
sem parallel NP4	-0.10	0.14	-0.77	0.44
corder x sem NP4	0.64	0.27	2.33	p<0.05

Note: For NP1 and NP2, ‘markedness’ refers to the first clause; for the NP3 and NP4 regions, in contrast, ‘markedness’ relates to the second clause.