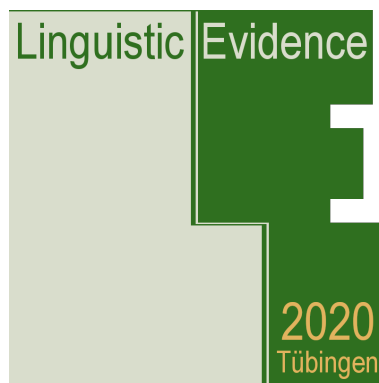


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Incrementality in the Processing of Adverbial Order Variations in German

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Abstract

Research on the processing of word order variations has shown that deviations from the canonical word order in German induce processing difficulties (see e.g., Rösler et al. 1998, among many others). These findings provide evidence for a high degree of incrementality in complement processing. Furthermore, the results can be interpreted as evidence for the claim that complement processing is guided by syntactic information (Frazier, 1987). Studies concerned with the processing of adjuncts, however, show that their interpretation is influenced by non-syntactic information and that the degree of incrementality differs for adjuncts and complements (Clifton Jr. et al., 1994).

The current study focuses on the role of incrementality in the processing of adverbials. Previous experimental studies provided evidence for base positions of adverbials in the German middle field. Processing of adverbials in non-base positions leads to higher processing costs. However, the studies also yielded mixed results with regard to the time course of adverbial processing (Gauza, 2018; Störzer, 2017; Stolterfoht et al., 2019). Movement of certain adverbial types led to an immediate increase in reading times. The attested increase in reading times, however, was not found for all types of adverbials. In two online reading time experiments, we tested two different explanations for the heterogeneous results with regard to the time course. The first is a syntactic explanation based on different configurations of the adverbial and its modified domain at LF; the second one refers to the semantic type of the modified entity (i.e., proposition, event, or process). Our results speak in favour of the second approach.¹

1 Background: Processing of Adverbial Order Variation

Several studies have shown that sentence processing proceeds in a highly incremental fashion. The notion of incrementality in sentence processing refers to the well-attested assumption that the human parser performs a fine-grained analysis of a linguistic structure in which each input element is being analyzed immediately (e.g., Marslen-Wilson, 1973; Altmann & Kamide, 1999). One influential model of sentence processing is the *Garden-Path Theory* (Frazier, 1987) according to which syntactic information influences the initial stage of processing. The Garden-Path Theory is a modular two-stage language processing approach, which states that initial processing is guided by purely syntactic parsing principles. However, it has been observed that adjuncts and arguments differ in several respects when it comes to processing (see e.g., Clifton Jr. et al., 1991). The Garden-Path Theory, as a syntax-first model, cannot account for adjunct processing to the same extent as it does for complements. The overall picture seems to be that in many cases no clear structural preferences for adjunct attachment can be

¹ All studies reported in this article were funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – SFB 833 – Project ID 75650358.

found. To fill the explanatory gap, Frazier & Clifton Jr. (1997) proposed *Construal* as a complementary theory to the Garden-Path Theory. Within *Construal*, the authors distinguish between *primary-relations* (roughly complements), which are parsed highly incrementally according to the syntactic principles of the Garden-Path Theory and *non-primary relations* (adjuncts), which are at first only loosely associated to the domain of the last theta-assigner i.e., most recent theta-assigner before the adjunct is encountered. Attachment occurs only in later processing steps in which all sorts of non-syntactic information is available. Consequently, no immediate effects are expected for adjuncts.

Word order processing in German, a language with a relatively flexible word order, provides evidence for the mechanisms proposed by the Garden-Path Theory. Several studies have shown that topicalization as well as scrambling of complements leads to processing costs. Furthermore, online processing studies have provided evidence that processing costs for non-canonical argument order can be modulated by non-syntactic factors such as context or focus, but are not entirely overridden (e.g., Meng et al., 1999; Bornkessel et al., 2003; Stolterfoht, 2005).

Only very few studies investigated word order variations with adverbials. The studies conducted so far yield a mixed pattern of results with regard to the time course of processing. Stolterfoht et al. (2019) report a series of online and offline studies on adverbial order variations in German with different types of adjacent adverbials. Order preferences in the studies were either tested between different adverbial types (Störzer, 2017) or between adverbials and arguments (Gauza, 2018; Störzer & Stolterfoht, 2018). The hypotheses for the reported studies were derived from base position accounts for adverbials (e.g., Frey & Pittner, 1999; Frey, 2003), assuming that adverbials, like complements, are assigned to base positions in the German middle field and can undergo scrambling. Frey & Pittner (1999) and Frey (2003) argue that adverbials in German and English are categorized into five semantically defined classes. Each class has a syntactic base position whereas adverbials within the same class are not ordered syntactically, but might exhibit a semantically driven preference for a certain order. The base positions of the adverbials are reflected in c-command relations to other adverbials, the arguments, and the finite verb. The postulation of base positions for adverbials has implications for language processing. Movement of adverbials thus should lead to higher processing costs, and acceptability ratings should reflect a preference for the base order. A more detailed overview on the predictions for adverbial positions derived from the base order account is given in Section 1.2. As the studies presented in this paper are an attempt to reconcile the mixed pattern of results exhibited in the studies mentioned earlier, we will give an overview of relevant findings on adverbial order processing. Based on these findings we will develop our hypotheses and present our study.

1.1 Previous Experimental Studies

Störzer & Stolterfoht (2013) compared reading times for the base order to the reverse (henceforth: derived) order of speaker-oriented sentence adverbials (e.g., *leider* ‘unfortunately’, *wahrscheinlich*, ‘probably’) and locative frame adverbials. Locative frame adverbials are frame-setting modifiers that restrict the validity of a proposition to certain places given by the adverbial (Maienborn, 2001). The frame adverbial in Example (1) restricts the validity of the proposition to Majorca.

- (1) *Eva meint, dass wahrscheinlich_{Adv} auf Mallorca_{Adv} alle Urlauber betrunken sind.*
 Eva thinks that probably_{Adv} on Majorca_{Adv} all tourists drunk are.
 ‘Eva thinks that probably on Majorca all tourists are drunk.’

(Störzer & Stolterfoht, 2013: 61)

Störzer and Stolterfoht tested whether movement of the frame adverbial out of its base position as illustrated in Example (1), across the sentence adverbial², leads to processing costs. They found an immediate reading time penalty in the region of the adverbials with significantly lower ratings for the derived order. Similar online effects and the offline preference for the base order in the rating data were found by Störzer & Stolterfoht (2018) who compared order preferences for sentence adverbials and the subject in the base and the derived order. It should be noted though that in this case, the immediate effect on reading times might be caused by the subject and not by the movement of an adverbial. The studies conducted so far suggest that the parser integrates high adverbials, like sentence and frame adverbials, immediately.

Finally, Gauza (2018) tested order preferences for manner adverbials and the direct object. Unlike the aforementioned studies, he did not find an effect on reading times caused by the movement of the manner adverbial out of its base position across the direct object. Example (2) shows the manner adverbial in its base position below the direct object. However, the preference for the base order was observed in the offline judgment data.

- (2) *Elisabeth sagt, dass Björn das Gedicht laut_{Adv} vorgetragen hat.*
 Elisabeth says that Björn the poem loudly_{Adv} performed has
 ‘Elisabeth says that Björn performs the poem loudly.’

(Gauza, 2018: 30)

Based on the previous findings, and with the assumption of a tight syntax-semantics mapping, we derived two possible explanations for the data pattern in adverbial order processing, namely a syntactic and a semantic explanation. The syntactic explanation refers to the position of the adverbials in relation to their modified domain at LF. Beck & Tiemann (2019) observed that LF domains play an important role in incremental language processing. The adverbials in the aforementioned studies differ with regard to their position at LF: the adverbials in Störzer & Stolterfoht (2013, 2018) yielded immediate effects in reading times. Both adverbials are base generated in CP and modify the TP, hence they are located outside of the domain they modify. Gauza (2018), however, attested no online effects for order variations of a manner adverbial, which is base generated within the LF domain it modifies (the VP). From our syntactic explanation, we derived the following two predictions:

- 1) Adverbials that are base generated external to the LF domain (CP, TP, VP) they modify, can be processed incrementally; adverbials located within their modification domain are processed with delay
- 2) Two adverbials distributed across an LF boundary (above and below) will be processed with delay

We tested these syntactic predictions in two self-paced reading experiments. In our first experiment, two adjacent adverbials were either located inside or outside the VP. In a second experiment, we tested two adjacent adverbials, one of them was located in CP and the other one in TP, and compared them to conditions with two adverbials within the same LF domain.

The semantic explanation refers to the entity the adverbial modifies (i.e., proposition, event, process). Immediate effects were attested for propositional adverbials while no online effects were caused by the movement of event-modifying adverbials. The adverbials do not only differ with regard to the syntactic LF configurations as explained above, but also in what they modify: while the former adverbials modify an entire proposition, the latter modify an event. At first glance, the explanations seem similar to each other. Event-modifiers, however, can modify the event while being located inside or outside of their modified domain (VP), while propositional adverbials in their base position are always located above the domain they modify. Across our two experiments, we tested whether processing of proposition-modifying adverbials

² In all of the reported experiments, the adverbials were adjacent to each other.

proceeds incrementally while event modifiers are processed with delay. In Experiment 1, we focussed on event-modifying adverbials (e.g., temporal, locative, and manner adverbials) and in Experiment 2 on proposition modifiers (sentence and domain adverbials). We tested whether the time course of processing is shaped by the semantic type of the modified entity. High adverbials such as sentence adverbials express the speaker's attitude towards the proposition and do not depend on specific lexical information conveyed by the proposition. Event-modifying adverbials, however, depend on specific lexical information that is conveyed by the verb and can only be integrated as soon as this information is available, which results in delayed processing for event-related adverbials such as for the manner adverbials in Gauza (2018). Possibly, a place holder for the event is established and full interpretation is only possible when the entire event is unfolded and the place holder can be filled with the actual event. This explanation dovetails with Bott & Gattnar's (2015) finding on aspectual processing in Russian and German. They investigated aspectual mismatches and found delayed effects for German, which does not exhibit grammatical aspect encoded by the verb. Mismatches in their study were caused by a combination of a temporal adverbial and verb information. They observed that aspectual mismatch detection in German was delayed when the temporal adverbial preceded the verb and the object, but no delay was attested when the adverbial followed the verbal information. Hence, processing only takes place after the verb has received all its argument, i.e., the entire event is unfolded.

We therefore formulated the alternative semantic explanation, namely that the semantic type of the modified entity modulates the time course of adverbial order processing and the degree of incrementality. The results of our two studies speak in favour of the alternative semantic explanation. Before presenting our results, we will shortly introduce the adverbials under investigation.

1.2 Event- and Proposition-Modifying Adverbials

As there are several types of adverbials introduced throughout this article, we provide a brief overview of the adverbials and the respective classifications that are relevant for the following two experiments.

Event-modifying adverbials like *temporal* or *locative adverbials* locate events in time and space or give more specific information about a process described by the event such as *manner adverbials*. According to Davidson (1967) event-modifiers are licensed by an event-variable provided by the verb. Event-modifiers can be classified as **event-external modifiers** which are assumed to be base generated outside the VP (event) and **event-internal modifiers**, which are base generated within the VP. Based on Frey's (2003)³ syntactic base position account for adverbials, we selected four different adverbials that fulfilled our requirements with regard to their relation to the modified LF domain. Event-external adverbials such as temporal adverbials and *external locative adverbials* c-command event-internal adverbials such as manner adverbials. Frey (2003) applied a battery of base position tests to adverbials to find evidence for his claim. Based on Frey we assume that temporal adverbials have a higher base position than external locatives, both, however, are located outside VP, and therefore outside the LF domain they modify. For the event-internal conditions, two lower adverbials, that are base generated within VP, were chosen. In order to replicate the results by Gauza (2018), we selected manner adverbials. According to Frey (2003), they are base generated below the direct object and above V⁰. Gauza (2018) found experimental evidence for the assumed base position. In addition to the event-related adverbials discussed by Frey we also included so-called *internal locative adverbials* introduced by Maienborn (2001). She makes a more fine-grained distinction

³ Note that Frey & Pittner (1999) and Frey (2003) distinguish between *event-related*, *event-internal*, and *process-related* adverbials. We do not stick to this terminology as for us only the relation to the VP is relevant, a more fine-grained distinction is not necessary. Our terminology, however, partly overlaps with theirs.

within the class of locative modifiers. Internal locative modifiers modify only parts of the event, and are base generated above V^0 and are to be distinguished from external locatives which are base-generated above VP and locate the entire event.

We applied the focus projection test (Höhle, 2018) as a first indicator that manner adverbials and internal locatives exhibit an order preference. The focus projection test states that following a wide focus question a constituent has to be in its base position in order to project wide sentence focus, as illustrated in Example (3).

- (3) *Was ist passiert?*
What happened?
- a. *Das Mädchen hat [mit Elan_{manner}] [auf den FINGERN_{Loc.int}] gepfiffen.*
The girl has with *verve_{manner}* on the *fingers_{Loc.int}* whistled
- b. ??*Das Mädchen hat [auf den Fingern_{Loc.int}] [mit ELAN_{manner}] gepfiffen.*
The girl has on the *fingers_{Loc.int}* with *verve_{manner}* whistled
'The girl whistled vigorously on her fingers.'

Proposition-modifying adverbials are located high in the LF structure as they operate on the entire proposition but are not part of it. Their syntactic position is assumed to be below the C head and above the TP. *Sentence adverbials* (see e.g., Pittner, 1999) are not part of the proposition, but describe the attitude of the speaker towards the proposition. In the assumed base order, sentence adverbials precede all other adverbial types including *frame adverbials*, as well as the subject (Frey, 2003). *Speaker-oriented sentence adverbials* provide a speaker's comment on the expressed proposition (e.g., Schäfer, 2013) which could be of an evaluative, epistemic or evidential nature. As it is not entirely clear whether evaluatives have the same syntactic and semantic properties as epistemics and evidentials (Axel-Tober & Müller, 2017; Störzer, 2017; Krifka, to appear), we limit the discussion to epistemic and evidential speaker-oriented sentence adverbials, for the sake of readability, however, we only use the term *sentence adverbial*. We further want to introduce another type of proposition-modifying adverbials, so-called *domain adverbials* which function akin to frame adverbials introduced in Section 1.1. Unlike frame adverbials, they do not restrict the proposition to a locative or temporal frame but to a certain interpretation domain (Bellert, 1977; Ernst, 2004). The proposition does not necessarily hold true outside of the mentioned domain. As Example (4) shows, the assertion that Tina is fine is restricted to the domain of physical health and does not give information about e.g., her financial situation. Examples (1) and (4) furthermore exhibit that propositional adverbials unlike event-modifying adverbials do not depend on an event variable. Their licensing restrictions are less severe than for event-modifiers.

- (4) *Gesundheitlich_{Adv} geht es Tina gut.*
Healthwise_{Adv} goes it Tina good
'With regard to her health situation Tina is fine.'

Concerning the ordering of sentence adverbials and domain adverbials, we assume domain adverbials to behave like frame adverbials and to also occupy the same base position. It is debated whether frame adverbials are located higher than sentence adverbials (Frey & Pittner, 1999; Pittner, 1999; Maienborn, 2001; Salfner, 2014) or vice versa (Schäfer, 2005; Hohaus, 2015). We follow Frey (2000, 2003) and Steube (2005) who claim that frame adverbials are located below sentence adverbials and can move across the sentence adverbial into the designated topic position in the middle field directly above the sentence adverbial. Experimental evidence in favour of this analysis is obtained by Störzer & Stolterfoht (2013).

In the following, we will present two self-paced reading experiments, in which we tested how the location at LF affects the time course of adverbial processing.

2 Experiment 1: Event-Modifying Adverbials

In Experiment 1, we focused on event-modifying adverbials. The aim of the experiment was to provide an explanation for the differences with regard to the temporal processing dynamics in earlier studies. More precisely, whether adverbials outside the VP can be integrated incrementally and therefore lead to an immediate increase in reading times, while VP-internal adverbials do not. According to the findings of earlier studies and the assumed base positions for adverbials in the German middle field, we formulated the following hypothesis for the first self-paced reading study:

Experimental hypothesis 1: For adverbials that are located outside of their modified domain at LF (here VP) we expect longer reading times for the derived order in the critical region compared to the base order. Adverbials located within the modified domain should not cause longer reading times immediately but delayed processing difficulties. Statistically, we expect a corresponding interaction of the relation to the modified domain and adverbial order. We interpret effects on the critical region as immediate effects and effects on the spill-over region as delayed effects⁴

2.1 Method

2.1.1 Participants

44 students of Tübingen University (mean age = 22.9; $sd = 7.4$) participated in the experiment for either course credit or a financial reimbursement of 5 € / 30 minutes. All were native speakers of German and naive with respect to the purpose of the experiment.

2.1.2 Materials

We constructed 24 sentence quadruplets according to 2×2 -within-item and within-subject design. We manipulated two factors: ORDER of two adjacent adverbials ('base' or 'derived') and DOMAIN ('internal' or 'external') which reflects the location of the adverbials in relation to the modified domain at LF, here the VP. The DOMAIN manipulation was achieved by choosing four adverbial types (2 per condition) that were either base generated above the VP (temporal adverbials and external locatives), or within the VP (manner and internal locatives). In order to keep the lexical material homogeneous with respect to part of speech and length, all four adverbials were realized as PPs. Each experimental sentence consisted of a matrix clause and an embedded sentence. With regard to verb position, the embedded sentence structure reflected the base order with the verb in sentence-final position. Each manner adverbial occurred three times within one experimental list, since the set of genuine manner adverbials is limited. The other adverbials were not repeated. The experimental sentences were segmented into eight regions as depicted in Example (5). The critical region was the segment including the two adverbials. The subsequent spill-over regions consisted of the verb and the auxiliary and were followed by a coordinated sentence in order to provide spill-over areas for possibly delayed effects. The spill-over regions remained equal within the item.

The items were distributed over four lists according to a Latin square design. Each list contained one version of each item. The items were randomized and presented along with 72 additional filler sentences. Participants were asked a comprehension question about the preceding sentence in 50 % of the trials. Half of the comprehension questions required a 'yes' and the other half required a 'no' answer. In order to prevent participants from creating a strategy

⁴ An anonymous reviewer pointed out that immediate effects on the critical region are not expected in the self-paced reading paradigm for this type of manipulation. However, effects on the critical region for adverbial order processing are reported in Störzer & Stolterfoht (2013, 2018); see also Tiemann et al. (2011) for immediate effects on the critical region in the processing of presuppositions.

to answer questions and therefore read the items in a sloppy manner, questions were constructed to ask for information that could be conveyed by every constituent of the experimental item.

(5) Maren sagt, | dass | die Mutter |
Maren says that the mother

- | | | |
|----|---|---------------------------|
| a. | <i>am Vortag</i> _{temporal} – <i>in der Küche</i> _{locative.external} | <i>external – base</i> |
| b. | <i>in der Küche</i> _{locative.external} – <i>am Vortag</i> _{temporal}
in the kitchen _{locative.external} – the day before _{temporal} | <i>external – derived</i> |
| c. | <i>mit Routine</i> _{manner} – <i>auf dem Herd</i> _{locative.internal} | <i>internal – base</i> |
| d. | <i>auf dem Herd</i> _{locative.internal} – <i>mit Routine</i> _{manner}
on the stove _{locative.internal} – with routine _{manner} | <i>internal – derived</i> |

*gekocht hat*_{spill-over1} | *und danach*_{spill-over2} | *zur Tür hinaus* | *gegangen ist.* |
cooked has and afterwards through the door left.

‘Maren says that the mother [adv + adv] cooked and left afterwards through the door.’

2.1.3 Procedure

The experiment was presented on a computer using the software E-Prime 2.0. Sentences were presented segmentwise, using a self-paced reading task with moving window technique. Participants were instructed to read at their natural pace. By pressing the space bar, participants started the experiment: lines of dashes appeared on the screen, each dash representing a character of the stimulus sentence. By each pressing of the space bar, the sentence was uncovered segment by segment. When a new segment was uncovered the previous segment changed back to dashes. One half of the sentences was followed by a *yes/no* comprehension question. Before the actual experiment started participants were presented with five practice trials and were invited to ask clarification questions. The entire session lasted approximately 20 minutes.

2.2 Analysis and Results

First, we analyzed the responses to the comprehension questions to exclude participants who did not read the items thoroughly. Data of participants who answered more than 25 % of the questions incorrectly were excluded. This treatment led to a loss of six participants. The data of 38 participants entered the statistical analysis. Furthermore, reading times were corrected for outliers by removing all data points above 3 standard deviations of a mean per participant and segment. This treatment led to a loss of 1.7 % of the data.

The remaining reading times were log-transformed and analyzed using the R statistics software (R Core Team, 2021) by means of a linear mixed effects model (LMEM) using the *lmer*-function of the *lme4*-package (Bates et al., 2015). The experimental factors and the interaction thereof were entered into the model. We used sum coding, which means that the intercepts reflect the unweighted grand mean and fixed effects compared the factor levels against each other. The model included random intercept for items and participants, we use the same random effect structure within and across the experiments to allow for comparisons of the data. The model and the results for both the critical region and the spill-over region are reported separately in the following. We obtained *p*-valued by Satterthwaite’s method using the *lmerTest*-package (Kuznetsova et al., 2017).

The descriptive reading times for the critical region and the spill-over regions are given in Figure 1. For the critical region we observed a tendency for the base order to be read faster than the derived order. The full model summary is given in Table 1. The differences in reading times for the base and the derived order were not significant, neither did the factor DOMAIN nor the interaction approach significance. The statistical analysis and the full model summary for the spill-over region which contained the auxiliary and the main verb is given in Table 2. The

analysis showed a main effect ORDER with significantly longer reading times for the derived order. The interaction, however, was not significant.

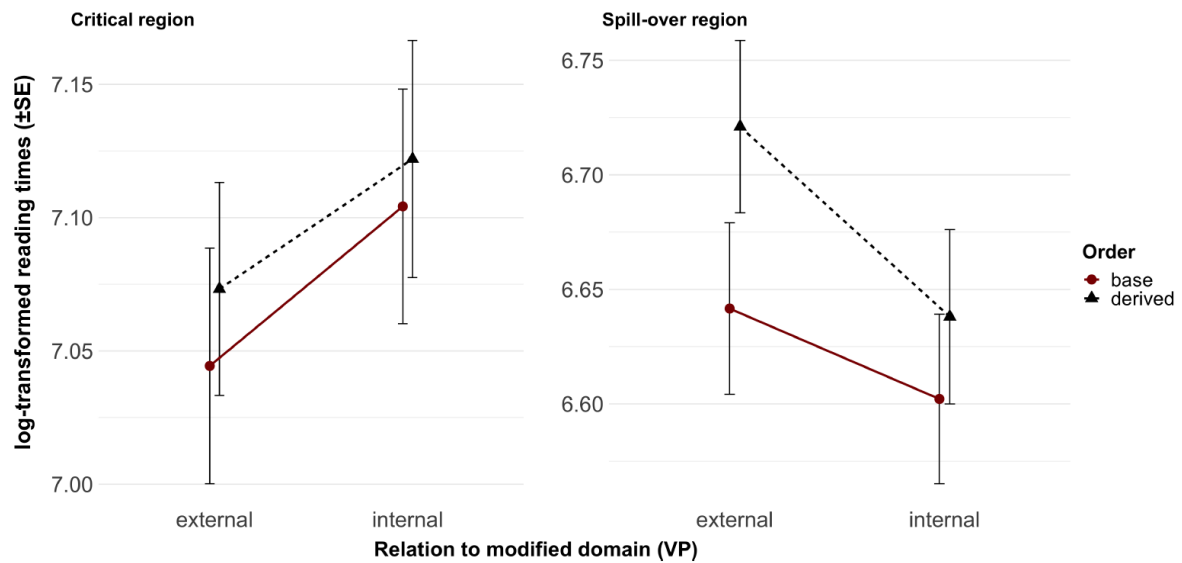


Figure 1. Log-transformed mean reading times on critical region (left panel) and on spill-over region (right panel) in Experiment 1, including standard errors calculated on aggregated data

Table 1. LMEM of reading times on critical region (adverbial + adverbial) in Experiment 1

Formula: $\log(\text{reading time}) \sim \text{order} * \text{domain} + (1 | \text{participant}) + (1 | \text{item})$

	Coefficient	se	df	t-value	p
(Intercept)	7.089	0.08	40	85.93	
ORDER	-0.007	0.01	832	-0.53	n.s.
DOMAIN	-0.023	0.01	835	-1.68	.09
DOMAIN:ORDER	-0.002	0.01	834	-0.15	n.s.

Table 2. LMEM of reading times on spill-over region (verb and auxiliary) in Experiment 1

Formula: $\log(\text{reading time}) \sim \text{order} * \text{domain} + (1 | \text{participant}) + (1 | \text{item})$

	Coefficient	se	df	t-value	p
(Intercept)	6.65	0.07	44	95.8	
ORDER	-0.03	0.01	829	-2.1	.04
DOMAIN	0.03	0.01	831	2.8	.01
DOMAIN:ORDER	-0.008	0.01	831	-0.7	n.s.

2.3 Discussion

The major result of Experiment 1 is a reading time penalty for the derived order of adverbials in the spill-over region following the two adverbials. The base order was processed faster than the derived order for temporal and external locative adverbials, as well as for manner adverbials and internal locative modifiers. As already attested for complements (e.g., Rösler et al., 1998), our

findings show that the movement of adverbials comes with processing costs. Another interesting finding is that the processing costs show with a delay; the significant effect is only visible in the spill-over region following the adverbials. Our findings are in line with the Construal theory for the processing of adjuncts. Frazier & Clifton Jr. (1997) state that adjuncts, unlike arguments, are processed in a later processing phase. When they are first encountered, the parser loosely associates them to the current processing domain (in this case the VP) and only attaches them during a later processing step.

As the interaction of the ORDER of the modifiers and the relation to the modified DOMAIN did not reach significance, we did not find evidence for the experimental hypothesis 1 that the placement of adverbials inside or outside the LF domain they modify plays a role for incremental processing. Accordingly, we were not able to gather evidence for our syntactic explanation 1. We cannot conclude that movement of VP-external and VP-internal adverbials seem to tax the processing system in different ways. In order to understand the mechanisms behind the processing pattern, it is worthwhile to take a further look at the semantic properties of the adverbial types that have been used in our experiment. Following a Davidsonian approach (Davidson, 1967) for event-modifying adverbials, temporal, locative, and manner adverbials target the event argument which is provided by the verb. External locatives locate events in space, and they are ungrammatical with stative verbs and individual level predicates, which lack an event argument (Maienborn, 2001; Maienborn & Schäfer, 2011). The internal locative and the manner adverbial need access to the internal dimensions of the event in order to modify the event, as Schäfer (2013) proposes for manner adverbials. Hence, the modifiers require information given by the verbal predicate. Therefore, the parser might wait for this verbal information in order to attach the modifiers, as they depend on the entire event information. The spill-over region contained the main verb, which delivers semantic information about the event type and dimensions about the event. It seems that the parser does not commit to a final decision before the verbal information is available. Thus, the attachment of adverbials is delayed until the parser has access to semantic information conveyed by the verb. This interpretation conforms with the Construal theory (Frazier & Clifton Jr., 1997) and also resemble the findings by Bott & Gattnar (2015), who also found that processing of an event-modifying adverbial depends on verbal information and is delayed.

So far, we did not find evidence for our syntactic explanation 1, namely that adverbials external to the modified domain are processed immediately whereas the processing of adverbials internal to the modified domain is delayed. We observed, however, that the movement of both types of event-modifying adverbials (VP-internal and VP-external) led to an increase in reading times. In a second self-paced reading experiment, we tested whether the distribution across two LF domains affects processing. Furthermore, we investigated, whether the semantic type of the modified entity shows a different pattern when it comes to the time course of processing.

3 Experiment 2: Semantic Type of Modified Entity

The experimental materials for Experiment 2 are based on the materials and the findings of the studies reported in Störzer (2017) and Störzer & Stolterfoht (2018). The former found immediate effects for the derived order with high adverbials that were both located within CP and outside the domain they modify (TP). The latter study reported immediate effects when the subject (in TP) had moved across an adverbial located in CP and henceforth across an LF boundary. We tested exactly the same configuration with two adjacent adverbials across two LF domains, namely CP and TP. We only manipulated the order of adverbials relative to each other in order to control for potential effects due to the argumenthood of the subjects that might have caused the immediate increase in reading times in Störzer & Stolterfoht (2018). In Experiment 1 we did not find evidence for the syntactic explanation that the relation to the modified LF domain (internal vs. external) affects the time course of processing. In fact, the time course was the same for the different adverbial types. We furthermore gathered first evidence for our semantic

explanation, namely, that the time course of processing is not modulated by the syntactic LF position but by the semantic type of the modified entity since we found delayed effects for event-modifying adverbials, as predicted. By comparing the results of Experiment 1 with the results of Experiment 2, we gathered further evidence for the semantic explanation.

Another aim of Experiment 2 was to test whether we can find evidence for our syntactic explanation, that is the LF position affects the time course of processing. Therefore, we included a condition with one adverbial below and one above the LF boundary. The main purpose to include this configuration, was to replicate the findings of Störzer & Stolterfoht (2018) who found immediate effects for the order manipulation of sentence adverbial and subject in a similar configuration. In the present experiment, both constituents were adverbials which are assumed to be located in CP and TP, respectively. Besides the syntactic manipulation we also tested semantically different adverbials. While Experiment 1 only included event-modifying adverbials, we tested whether we can find different temporal dynamics for proposition modifiers in Experiment 2.

We constructed a new set of experimental items to test the effect of different relations between adverbials and their modified domain, which in this experiment was the TP. In order to establish these configurations, different adverbial combinations were required. To create the across LF domain condition, we again used temporal adverbials as event-modifying adverbials which are located within TP.

The following hypotheses were tested:

Experimental hypothesis 2.a: We expect an interaction of the factors DOMAIN ('external' vs. 'across' LF domain) and ORDER ('base' vs. 'derived') due to our syntactic explanation 2, that is the position of the adverbials at LF affects processing.

Experimental hypothesis 2.b: If the semantic type of the modified entity (proposition vs. event) plays a role for the immediacy of effects, we expect, in contrast to Experiment 1, immediate effects of the derived word order.

3.1 Method

3.1.1 Participants

44 students of Tübingen University (mean age = 22.9; *sd* = 7.4) participated in the experiment for either course credit or a financial reimbursement of 5 € / 30 minutes. All were native speakers of German and naive to the purpose of the experiment.

3.1.2 Materials

As in Experiment 1, we constructed 24 sentence quadruplets according to a 2×2-within-item and within-subject design, with the factors ORDER and DOMAIN. An example item is shown in Example (6). ORDER followed the same pattern as in Experiment 1: two adjacent adverbials were either presented in their 'base' order or in a 'derived' order, in which the lower adverbial has moved across the higher one. The factor of DOMAIN manipulated whether the two adverbials were located outside ('external') of their modified domain (TP) or in two different LF domains ('across') with domain adverbials in CP and temporal adverbials in TP.

We used eventive verbs to allow for the temporal modifiers. Domain adverbials are potentially ambiguous between a domain restricting reading and a manner reading. The materials were constructed in such a way that a manner reading is highly implausible. The adverbials preceded the subjects of the sentences as their base positions are assumed to precede the subject. Each domain adverbial occurred twice on one experimental list, whereas the sentence adverbials occurred six times and temporal adverbials four times. We applied the same list distribution as

in Experiment 1, and added 72 filler sentences and comprehension questions after 50 % of the trials.

- (6) Hanna sagt,*l* dass*l*
Hanna says that
- a. *wahrscheinlich*_{sentence adverbial} – *gesundheitlich*_{domain adverbial} | *external – base*
 b. *gesundheitlich*_{domain adverbial} – *wahrscheinlich*_{sentence adverbial} | *external – derived*
 healthwise_{domain adverbial} – probably_{sentence adverbial}
 c. *gesundheitlich*_{domain adverbial} – *gestern*_{temporal} | *across – base*
 d. *gestern*_{temporal} – *gesundheitlich*_{domain adverbial} | *across – derived*
 yesterday_{temporal} – healthwise_{domain adverbial}

*Tim etwas*_{spill-over1} | *vorgetäuscht hat*_{spill-over2} | *und sich deshalb entschuldigt.**l*
 Tim something pretended has and himself therefore excuses

‘Hanna says that healthwise Tim probably faked something and thus apologizes.’

3.1.3 Procedure

The procedure of Experiment 2 is identical to the procedure of Experiment 1.

3.2 Analysis and Results

Before analyzing reading times, we analyzed the responses to the comprehension questions as we did in Experiment 1. Participants with error rates higher than 25 % were discarded from the data analysis. This led to a loss of six participants. 38 participants entered the statistical analysis. Reading times were corrected for outliers by removing all data points above 3 standard deviations of a mean per participant and segment. This treatment led to a loss of 1.4 % of the data. The remaining data set was analyzed using the R statistic software R Core Team (2021). To test for significant effects, the log-transformed reading times were analyzed by linear mixed modelling following the same procedure as in Experiment 1. The full model summaries are reported separately for the critical region and the spill-over region in Tables 3 and 4, respectively.

The statistical analysis and the model summary for the critical region, which was the two adverbials, are reported in Table 3. We observed a statistical main effect for ORDER as well as for DOMAIN. The corresponding descriptive data for both regions are plotted in Figure 2. The main effect for DOMAIN was not interpretable, as the condition included different lexical elements which means that the attested effect could be caused by other lexical properties e.g., frequency or word length. An effect caused by DOMAIN would only be meaningful in an interaction with ORDER.

Table 3. Statistical results of reading times on the critical region in Experiment 2

Formula: $\log(\text{reading time}) \sim \text{order} * \text{domain} + (1 | \text{participant}) + (1 | \text{item})$

	Coefficient	<i>se</i>	<i>df</i>	<i>t</i> -value	<i>p</i>
(Intercept)	6.81	0.07	45	102.55	
ORDER	-0.07	0.03	838	-2.25	.02
DOMAIN	-0.11	0.03	839	-3.72	<.001
DOMAIN:ORDER	0.06	0.06	839	1.0	n.s.

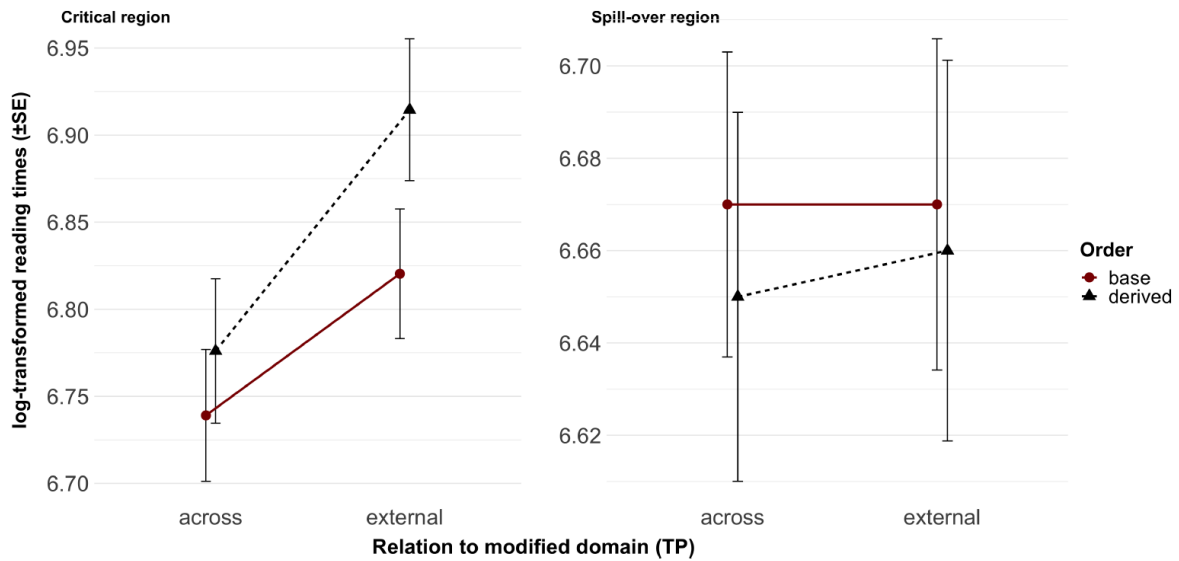


Figure 2. Log-transformed mean reading times on critical region (left panel) and on spill-over region (right panel) in Experiment 2, (including standard errors calculated on aggregated data)

The statistical analysis for the spill-over region is given in Table 4 and the corresponding descriptive data in Figure 2. There was no significant effect for ORDER and also no effect for DOMAIN or the interaction of the factors.

Table 4. Statistical results of reading times on the spill-over region in Experiment 2

Formula: $\log(\text{reading time}) \sim \text{order} * \text{domain} + (1 | \text{participant}) + (1 | \text{item})$

	Coefficient	se	df	t-value	p
(Intercept)	6.66	0.07	43	102.28	
ORDER	-0.014	0.03	829	0.52	n.s.
DOMAIN	-0.002	0.03	831	0.08	n.s.
DOMAIN:ORDER	-0.001	0.05	830	0.02	n.s.

3.3 Discussion

We were not able to confirm the experimental hypothesis 2.a., since there was neither an immediate nor a delayed interaction of ORDER and DOMAIN. As in Experiment 1, we did not find evidence for the two syntactic explanations, namely that only adverbials, that are located outside of their modified domain are processed immediately. Since we found an ORDER effect for both DOMAIN conditions in the critical region, we were able to find evidence for the experimental hypothesis 2.b. and henceforth our semantic explanation, according to which the semantic type of the modified entity modulates adverbial processing. The interaction did not reach the level of statistical significance. Therefore, the LF configuration again does not matter for the temporal dynamics of adjunct processing.

In order to understand the different temporal dynamics between Experiments 1 and 2 we discuss the types of the moved adverbials in more detail. Before, however, we would like to briefly address an objection raised by an anonymous reviewer against the comparability of

the data obtained in the two experiments. The critical regions were of different lengths in Experiment 1 (two PPs summing up to five words, cf. (5)) and Experiment 2 (two words, cf. (6)). This difference might suggest that the greater length of the critical region in Experiment 1 raises the noise in the reading time data to an extent that a difference that may reach significance in Experiment 2 would not reach significance in Experiment 1. In discussing the comparison of the two experiments we will thus act with caution. Yet we point out that the standard errors in the LMEM analyses on the critical regions do not support this suspicion as they are smaller in Experiment 1 (cf. Table 1, all *SEs* = 0.01) than in Experiment 2 (cf. Table 3, *SEs* = 0.03 for the main effects and 0.06 for the interaction). Therefore, the fact that the *t*-values are smaller in Experiment 1 than in Experiment 2 is due to the different coefficients, not to the error variance in the data.⁵ In Experiment 2, we attested a main effect for ORDER. In the ‘external’ condition, a domain adverbial moved across the sentence adverbial. Both types of adverbials operate on the proposition which is mapped on TP. They are not part of the assertion made by the proposition but modify the proposition. For epistemic sentence adverbials, Krifka (to appear) argued for a layered approach and introduced syntactic representations higher than the TP that host epistemic and evidential modifiers, which give information about the speaker’s commitment towards the proposition. Therefore, they are not part of the proposition itself. Maienborn (2001) stated that frame adverbials (which function similar to domain adverbials) should be treated semantically as operators, which only restrict the speaker’s claim and are not part of the assertion itself. The high adverbials in the external condition do not depend on an element within their modified domain. High adverbials take an entire proposition as their argument. Their selectional restrictions regarding the verb type are less severe, since they do not depend on an event argument. An implication for language processing could be that high adverbials can be integrated immediately, as they do not depend on a proposition-internal element. Incremental attachment of high adverbials before the actual proposition unfolds would therefore allow for the immediate attachment and interpretation of the modifiers (i.e., immediately restricting the assertion to an interpretational domain in case of domain adverbials or the respective epistemic or evidential commitment of the speaker in the case of sentence adverbials). We interpret the differences between Experiments 1 and 2 as first evidence for our alternative semantic explanation, that is the time course of processing depends on the semantic type of the modified entity. However, this explanation needs to be further investigated with an experiment with propositional adverbials and event-modifying adverbials as separate experimental conditions.

Our preliminary conclusion is that propositional adverbials, unlike event-modifying adverbials that have to wait for the event argument provided by the verb, can be intergrated in the syntactic structure immediately during processing.

The ‘across’ condition, manipulated the order of a domain adverbial and a temporal adverbial, which is an event-modifying adverbial. The movement of the temporal adverbial across the domain adverbial led to an immediate reading time penalty as well. At first glance, this result seems at odds with our preliminary conclusion that propositional adverbials but not event-modifying adverbials can be intergrated immediately. This effect, however, might be caused by the semantic properties of the temporal adverbials since they were of different types across our two experiments. Due to the intention to include only adverbs and not PPs in Experiment 2, temporal adverbials were all *deictic temporals* (*gestern* ‘yesterday’, *morgen* ‘tomorrow’, etc.). In Experiment 1, temporal adverbials were so-called *clock-calender adverbs* (*am Montag* ‘on Monday’, *am Nachmittag*, ‘in the afternoon’). The former are bound to the reference time and are specified for past or present while the latter remain underspecified for tense and are interpreted according to the verb (Smith, 1978; Alexiadou, 2000; Biondo, 2017), which would explain the observed delayed processing in Experiment 1, but not in Experiment 2. A discussion about temporal modification and processing of tense would exceed the scope of this paper, but

⁵ We would like to thank an anonymous reviewer to point this out and Robin Hörnig for helpful comments on the statistical analysis.

our interim conclusion is that the effect of order in Experiment 1 was caused by adverbials that require verb information while the moved domain adverbials and temporal adverbials in Experiment 2 do not depend on this specific information to get finally attached and interpreted.

4 General Discussion and Summary

In this article, we investigated two approaches to account for the heterogeneous findings in prior research with regard to the time course of processing different adverbial orders. The first approach referred to the syntactic position of the adverbials at LF, which assumes that the configuration of the adverbials and their modified domain affects incremental sentence processing. With the alternative semantic approach, we investigated whether the semantic type of the modified entity modulates the temporal dynamics of processing. After bringing the findings of our two online processing studies together, we conclude that the assumed syntactic base positions of the adverbials have an effect on processing: the base position was always processed faster than the derived order. Based on these results, we can conclude that not only complement movement but also adverbial movement leads to increased processing costs. However, our experiments did not confirm the hypotheses regarding the relation between adverbials and their modified domain at LF. There was no evidence suggesting that the internal or the external position at LF affects the time course of processing. In fact, our evidence suggests that the time course is modulated by the semantic type of the modified entity. Hence, proposition modifiers are integrated highly incrementally, and lead to an immediate penalty for the derived order, whereas event-modifying adverbials only show a delayed increase (emerging in the spill-over region) in reading times for the derived order. This conclusion needs to be drawn cautiously as it is only based on the comparison between our two studies, thus further investigation in this regard is needed. We are currently running an experiment, in which the semantic type of the modified entity is entered as an experimental factor.

The interpretation of our findings partly aligns with the predictions of Construal, but this can only account for the findings related to event-modifying adverbials, which showed delayed order effects. To explain our findings, we therefore refer to the semantic properties of the compositional mechanisms connected to the different adverbial types we tested. Adverbials can be divided into operators (high adverbials such as sentence adverbials) and modifiers (event-modifying adverbials), the two classes differ with regard to their compositional mechanisms (McConnell-Ginet, 1982). Operators and modifiers differ among others in their selectional properties. The former category take an entire proposition as their operand and modify the proposition by, e.g., adding the speaker's attitude or comment, or by restricting it to a specific frame or domain. From a processing perspective, one can argue that it is safe to integrate high adverbials in their base position immediately. There is no need to wait for specific information. But this is the case for (event) modifiers, which need specific information about the event to get finally attached and interpreted. They combine with events but not with stative verbs and are thus only licensed if the verb provides an event argument. German is a verb-final language and the base position of all adverbials is higher than the main verb. By the time the parser encounters the event-modifying adverbials, it might loosely associate the adverbials to the structure currently being built, as predicted by Construal. The modifiers will be attached as soon as sufficient lexical information by the verbal head is given to felicitously integrate the adverbial since event-modifying adverbials unlike sentence operators have access to the internal structure of the event. As already discussed in the previous section, we do not take the immediate effects related to temporal adverbials as critical to our interpretation since we assume that, due to the heterogeneity of temporal modifiers, the deictic adverbials in Experiment 2 differ from the clock-calendar temporal adverbials tested in Experiment 1 in relevant aspects.

Nonetheless, our interpretation of the findings has to be understood as preliminary and needs further investigation. A crucial question for upcoming experiments is whether the delayed effect for event-modifying adverbials indeed depends on verbal information or whether it is merely a

spill-over effect that accidentally coincides with the region that contained the main verb. Another question that should be addressed is whether the immediate effects for the high adverbials generalize for other types of high adverbials that operate on the proposition or whether the sample of high adverbials tested share independent features that reinforce immediate integration. One such feature might be veridicality as all high adverbials tested here and in Störzer (2017) are nonveridical sentence adverbials. Veridicality might be a factor driving incremental processing as nonveridical adverbials affect the truth of a proposition: a sentence with a nonveridical adverbial hence does not necessarily entail the sentence without it (Maienborn & Schäfer, 2011), see contrast in Example (7). If veridicality is the driving force in incrementality, evaluative speaker-oriented adverbials (7b) might pattern with event-modifying adverbials and not with epistemic sentence adverbials (7a).

- (7) a. Probably, John ate $\not\Rightarrow$ John ate
 b. Luckily, John ate \Rightarrow John ate

Our conclusion so far is that the syntactic position of the adverbials affects adverbial processing. Furthermore, our results reveal first evidence that the time course of processing is modulated by the semantic type of the adverbial with its respective selectional properties.

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