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Event structure predicts temporal interpretation of English and German past-under-past relative clauses

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2002; Zacks, Speer, & Reynolds, 2009). In light of such findings, it could also be the case that the structure of the event itself determines which interpretations are acceptable.

Here, we compare predictions on tense understanding by structure-driven and event-driven accounts on tense sequence interpretation in complex sentences containing relative clauses, like (1). The crucial point of theoretical difference is whether the tense of the relative clause is interpreted as dependent only on the utterance time, or on the matrix clause tense.

The two families of theories make different predictions. In particular, structure-driven accounts would predict that past-under-past sentences like (1) would be judged true for any of the event structures in (2-4). This prediction arises due to the special status of relative clauses: *that was near the mushroom* is a modification of the syntactic object, not of the verb describing an event. Consequently, relative clauses are not governed by the matrix verb (Enç, 1987), they can move out of the matrix verb's scope to a higher position (Ogihara, 1996; Stowell, 2007), and they are not arguments to intensional predicates (Abusch, 1997; Von Stechow & Grønn, 2013a).

A structural side effect of this special status is that relative clause tense is predicted to be independent of the matrix clause's tense. On the same grounds, temporal adjunct clauses have been argued to be interpreted independently from the matrix tense (cf. Arregui & Kusumoto, 1998; Von Stechow & Grønn, 2013b but see Ogihara, 1996).

By contrast, complement clauses are verbal arguments such that they need to be evaluated relative to the time denoted by the matrix sentence (cf. Abusch, 1997; Enç, 1987; Kusumoto, 1999; Ogihara, 1996; Stowell, 2007 for a detailed discussion on tense interpretation in complement clauses; note that, aside from relative, complement and temporal clauses, no further subordinate clauses have been analyzed with respect to temporal interpretation).

From an event structural point of view, however, complex sentences such as (1) do not only pick out single time spans for each described event and order them relative to another temporal interval (i.e., the utterance time). Instead, each temporal expression provides information about more complex temporal structures (Carroll & von Stutterheim, 2010; Klein, 1994, 2000; von Stutterheim, Carroll, & Klein, 2003): Firstly, the time of situation is a cluster of one or more temporal intervals characterized by the lexical description of the event.

(5) *The girl fed the rabbit.*

What is important for the question here is that in (5), the time of the situation is equivalent to the time of the feeding event. A second parameter in this theory is topic time, which describes a time span about which a speaker makes an assertion: While the girl could be still feeding the rabbit (i.e., time of situation is unrestricted relative to the utterance time), the past tense marking *fed* indicates that the speaker wants to talk about a certain time in the past. The topic time of (5) thus

only relates to a particular period within the time of situation which is relevant to the speaker. As a third parameter, a so-called temporal anchor links events to other temporal intervals. Importantly, while temporal anchors can in principle relate to the utterance time such as in (5), they often refer to an interval that is either derived from context or provided by the discourse (e.g., by means of temporal adverbs, previously mentioned events). In complex sentences with relative clauses like in (1), one of the events can serve as the temporal anchor for the other one.

Crucially, events can anchor each other irrespective of the sentence's syntactic properties. In fact, the main clause event in (1) which describes an activity (*The girl fed the rabbit*) should function as an anchor for the state description given that actions are cognitively more salient than stable states, and command people's attentional resources (Clewett, Gasser, & Davachi, 2020; Kurby & Zacks, 2008; Zacks, Speer, Swallow, Braver, & Reynolds, 2007). This view also resonates with the fact that semantic distinctions, rather than syntactic properties, determine how well people recall complex temporal sentences (Clark & Clark, 1968).

Overall, the event structural approach makes the following prediction: Forward shift interpretations (4) should be unacceptable in past-under-past relative clauses such as (1), because here, the embedded past tense describes a situation (i.e., the rabbit being near the mushroom) which happens later than the anchor (i.e., the girl feeding the rabbit).

We conducted two preregistered studies using past-under-past relative clauses to test the predictions derived from these two lines of research. The studies were inspired by the experimental set up of Dermidache and Lungu (2008) who investigated temporal construals of different subordinative clauses in French child language. In our experiments, we closely followed Dermidache and Lungu's (2008) design, but reduced the experimental manipulations to test the predictions made by the structure-driven and the event-driven accounts: In Experiment 1 (English), we contrasted event sequences in which the event described by the relative clause was back-shifted with sequences in which the event described by the relative clause was forward shifted. Stimuli were designed such that there was one salient action, and one state, which were expressed by the main clause and the relative clause, respectively. *While*-clauses served as controls for which no shifted interpretations should be available. Experiment 2 was a replication in German, to understand whether effects were due to any property specific to the English system of grammatically expressing tense.

Experiment 1

Participants

We recruited 61 English speakers from Amazon Mechanical Turk through the platform CloudResearch (Litman, Robinson, & Abberbock, 2017). The experiment lasted approximately 20 minutes and participants were only included in the analysis if all trials had been completed.

Based on this criterion, we excluded 11 participants, resulting in 50 full datasets submitted to analysis.

Materials

Critical sentences consisted of two clause types: First, a main clause describing an activity was combined with a relative clause that further specified a state (6). Second, *while*-clause constructions consisted of an activity verb in the main clause and a state description in the *while*-clause (7).

(6) *The girl fed the rabbit that was near the mushroom.*

(7) *The girl fed the rabbit while it was near the mushroom.*

In addition to 4 critical pairs like (6) and (7), we created 16 filler sentences that either connected two events with a coordinating conjunction (e.g., *The dog barked and the bird flew away*) or identified a single event's location by use of a prepositional phrase (e.g., *The ghost scared the boy in front of the houses*). All sentence stimuli consistently used simple past.

For visual materials, we animated video clips that lasted between 8 and 12 seconds and matched the linguistic material: Critical video stimuli showed an actor acting on another one (e.g., a girl feeding a rabbit). Crucially, the event sequence was manipulated such that the activity event either happened before the patient moved to the described location, here, the mushroom (i.e., forward shifted event sequence) or after it moved away from it (backwards shifted event sequence). The temporal arrangement of the two events is illustrated in Figure 1.

Importantly, this made all critical *while*-clauses unambiguously false, allowing us to test the acceptance of relative clauses as backward and forward shift interpretations of the events.

Filler videos showed event sequences corresponding to the descriptions in the filler sentences. Furthermore, four animated videos that showed two events taking place simultaneously were matched to two *while*- and relative clauses, each of which served as unambiguously true sanity checks. The videos also contained distractor locations (i.e., a tree) and distractor characters (i.e., another animal). All critical linguistic and visual materials can be found at <https://osf.io/6ae5m>.

Procedure

In each trial, participants first watched the video. After that, the corresponding sentence as well as a 5-point rating scale were presented on the screen. Participants were asked to indicate on the scale how adequately the sentence described the preceding animation.

There were two practice trials in the beginning of the experiment to familiarize participants with the experimental procedure. After practice trials, participants completed eight critical trials (2 clause types x 2 event sequence, 2 trials per

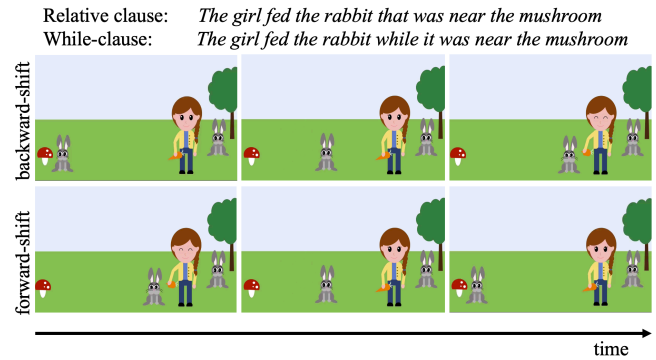


Figure 1: Temporal arrangement of the embedded event (i.e., location description) relative to the main clause event (i.e., activity).

condition), 16 filler trials and four sanity check trials, presented in a randomized order.

We constructed four lists using a Latin-square design (sentence type, event sequence, video content) and assigned participants randomly to each list to counterbalance between subjects. Experiment 1 was programmed in PsychoPy and ran online on Pavlovia.org.

Statistical Analysis

A linear mixed effects regression was conducted in the R statistics environment (R Core Team, 2014) with clause type and event sequence as contrast-coded fixed effects and participants and items as random intercepts to control for variance potentially caused by these factors. We included random intercepts, but not random slopes (i.e., a minimal intercept-only structure) to ensure model convergence. Furthermore, we ran planned pairwise comparisons to investigate the interaction of the linear mixed effects model. A preregistration of both experiments can be found at <https://osf.io/6ae5m>.

Results

Acceptance rates from Experiment 1 are shown in Figure 2. There was a main effect of sentence type as well as a main effect of event sequence: As predicted, for both backwards and forward shifted event sequences, *while*-clause descriptions were rated significantly lower (mean=1.84, SD=1.26) than relative clause constructions (mean=3.39, SD=1.57, $Df=1$, $\chi^2=129.5$, $p<0.001$). This demonstrates that the task was easy to understand, and that participants responded to unacceptable video-sentence pairings as predicted. Furthermore, each participant rated 75% or more of the sanity checks as true, indicating that they understood the task correctly, and did not lose interest during the course of the trials.

In addition, we found a main effect of event sequence: Participants rated forward shifted event sequences (mean=2.26, SD=1.48) as significantly less acceptable than backward shifted event sequences (mean=2.96, SD=1.68, $Df=1$, $\chi^2=29.4$, $p<0.001$). Importantly, the interaction between clause type and event sequence was significant as

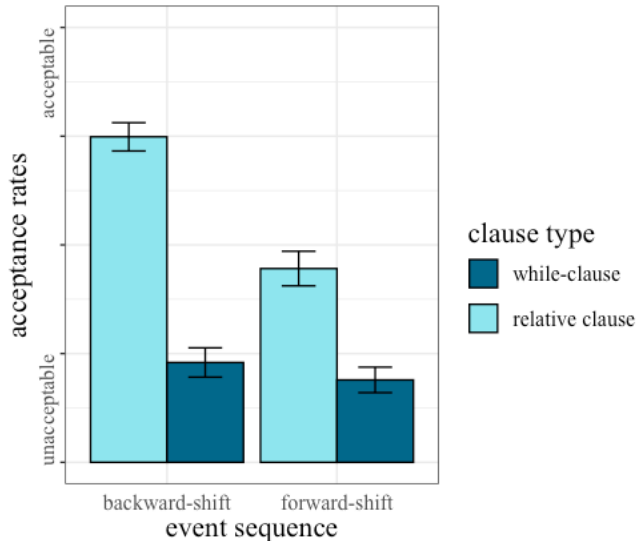


Figure 2: Mean acceptance rates for English clause types describing shifted event sequences in Experiment 1, error bars represent Standard Errors.

well ($Df=1$, $\chi^2=17.65$, $p<0.001$). Planned pairwise comparisons revealed that the interaction was driven by the relative clauses: Sentences containing *while*-clauses were rated unacceptable irrespective of whether animations showed a forward or a backwards shift ($\beta=-.08$, $t=-0.9$, $p>0.37$). However, participants rated relative clauses significantly more acceptable when they described a backshifted animation compared to video clips that depicted a forward shifted event sequence ($\beta=-.06$, $t=-5.9$, $p<0.001$).

Discussion of Experiment 1

Our results show that, in sentences where the matrix sentence describes an action and the relative clause is a state description, the embedded tense is interpreted relative to the matrix clause: Participants judged event sequences that ordered the relative clause description after the matrix clause (i.e., forward shifted event sequences) significantly less acceptable compared to event sequences in which the relative clause event preceded the event described by the relative clause (i.e., backshift event sequences).

This pattern of results indicates that syntactic relations are not the sole determinants of temporal interpretation: While from a syntactic point of view, both interpretations should be equally available to comprehenders, this was not the case in our data. Rather in line with the event structural approach, interpretations were preferred where a salient event in the main clause anchored the backgrounded situation described by the relative clause.

Naturally, these findings could also arise due to some special features of the English language system: English tenses have been famously argued to giving rise to quirky temporal interpretations in other embedded contexts (i.e., complement clauses), generally referred to as the sequence of tense phenomenon (e.g. Abusch, 1997; Enç, 1987; Ogihara, 1995). To further investigate this possibility, we conducted a

second experiment in German where such temporal ambiguities have not been documented for relative clauses, and can be resolved by using conjunctive verb forms in complement clauses (Helbig & Buscha, 2001).

Experiment 2

Participants

19 German speakers were recruited from the researchers' personal environment. Similar to Experiment 1, the task lasted around 20 minutes and all trials had to be completed in order to be included into analysis. We excluded 1 participant due to an incomplete data set, resulting in 18 full datasets for analysis (the effect sizes of Experiment 1 allowed us to decrease the sample size).

Materials and Procedure

We used the same visual materials as in Experiment 1. Regarding linguistic materials, we constructed German versions of the English sentence stimuli with main clauses always describing activities and relative clauses (8) or *während*-clauses (9) always describing a state of the direct object (the sentences are close translations of (6) and (7)).

- (8) *Das Mädchen fütterte den Hasen,*
The girl fed the rabbit
der neben dem Pilz saß.
that next to the mushroom sat
- (9) *Das Mädchen fütterte den Hasen,*
The girl fed the rabbit
während er neben dem Pilz saß.
while he next to the mushroom sat

Again, fillers either contained coordinating conjunctions, or prepositional phrases, and we included unambiguously true *während*- and relative clause statements, using different sets of videos, as additional controls. All sentence stimuli used preterite which is, diachronically and structurally speaking, the German equivalent to simple past tense in English (Klein, 2000). The experimental procedure was the same as in Experiment 1. All critical linguistic and visual materials can be found at <https://osf.io/6ae5m>.

Statistical Analysis

The same statistical analysis as in Experiment 1 was conducted in Experiment 2 (i.e., mixed effect model with minimal intercept-only structure, planned pairwise comparisons).

Results

As in Experiment 1, each participant rated the additional control trials acceptable at least 75% of the times, suggesting that they had no difficulty understanding the task. Furthermore, we found a similar pattern of results as in Experiment 1 (for illustration, see Figure 3): There were main

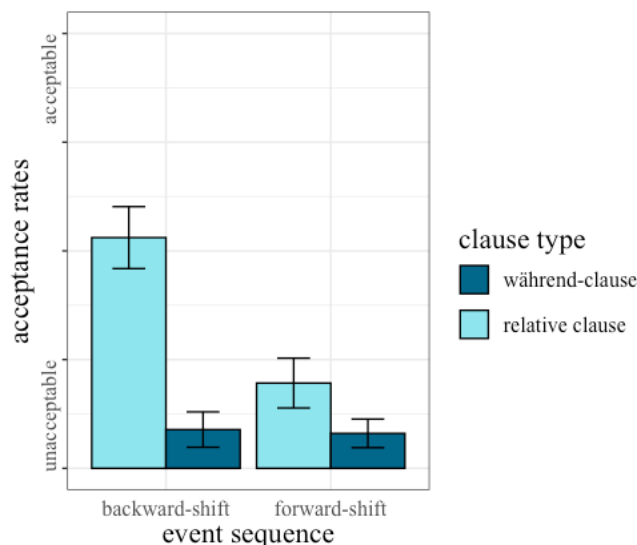


Figure 3: Mean acceptance rates for German clause types describing shifted event sequences in Experiment 2, error bars represent Standard Errors.

effects of sentence type ($Df=1, \chi^2=28.1, p<0.001$) and event sequence ($Df=1, \chi^2=10.9, p<0.001$) as well as an interaction between the two independent variables ($Df=1, \chi^2=10.4, p<0.01$). Pairwise comparisons revealed that the interaction resulted from the relative clauses such that *während*-clauses were rated unacceptable across event sequences ($\beta=-.001, t=-0.17, p>0.87$), whereas relative clauses were significantly more acceptable combined with backward shifted event sequences ($\beta=-.07, t=-3.7, p<0.001$).

Discussion of Experiment 2

The German data replicated the findings from Experiment 1: Participants judged forward shifts significantly worse than backward shifted interpretations of the relative clause relative to the matrix clause. These results thus indicate that tense in relative clauses is interpreted relative to the matrix clause event, irrespective of the syntactic properties of the embedded clause.

More importantly, Experiment 2 showed that the lack of a forward shift interpretation in the English data cannot be reduced to particularities of the English grammatical tense system. In fact, forward shift interpretations were equally unacceptable in German – a language in which temporal interpretations of complement clauses are rendered less ambiguous due to obligatory mood specifications (Helbig & Buscha, 2001).

General Discussion

In our study, we asked which temporal interpretations are available to comprehenders for past-under-past relative clauses: Are complex sentences containing past tense relative clauses true if the event described by the relative clause happened before the main clause event (i.e., a backshift interpretation) or if the embedded event took place after the event in the main clause (i.e., forward shifted interpretation)?

In two experiments, we found that forward shifted event sequences were significantly less acceptable for past-under-past relative clauses than back shifted event sequences. While event-driven accounts of temporal interpretation would predict such a pattern of results since, here, a formerly mentioned event is expected to act as the temporal anchor of a subsequent event (Carroll & Stutterheim, 2010; Klein, 1994, 2000; von Stutterheim et al., 2003), structure-driven accounts are not supported by our findings: Formal approaches trace temporal relationships between events back to underlying structural dependencies. As relative clauses modify the object of a sentence and are therefore syntactically independent of the matrix verb, tense in relative clauses should be interpreted only relative to the utterance time, rendering both backward and for forward shifted event sequences acceptable interpretations of past-under-past relative clauses (Abusch, 1997; Enç, 1987; Kusumoto, 1999; Ogihara, 1996; Stowell, 2007; Von Stechow & Grønn, 2013a). Clearly, our results indicate that in understanding the temporal order of a matrix clause and a relative clause, the mapping between temporal structure and linguistic form is not correctly predicted by standard accounts of tense interpretation.

One conceivable reason why standard approaches fail to make the right predictions for temporal interpretations of past-under-past relative clauses is that they are, for the most part, concerned with other types of dependent clauses. In fact, most research on embedded tense focuses on explaining dependent interpretations between matrix tenses and embedded tenses in complement clauses (but see Arregui & Kusumoto, 1998; Ogihara, 2015; Von Stechow & Grønn, 2013a, 2013b). Relative clauses and other types of subordinations (e.g., temporal adjunct clauses), on the other hand, are often merely treated as independently interpreted counterexamples, or gain importance only when they are embedded under complement clauses (e.g., ‘Sue believed that she would marry a man that loved her’, see Abusch, 1997, p.17) or in the scope of a future auxiliary (e.g., ‘John will meet a man who lost his money’, see Ogihara, 1996, p.161, but also Von Stechow & Grønn, 2013a). In this regard, a dedicated account which develops a principled model of temporal interpretation of past-under-past relative clauses is still a desideratum in the literature.

Secondly, and relatedly, such a dedicated account would have to clarify under which circumstances relative clause descriptions cannot denote a forward shifted event sequence. Whereas some formal approaches might integrate our findings into their theory of embedded tense (e.g., in some cases, relative clause tense remains in the scope the matrix verb, see Ogihara, 1996; Stowell, 2007), neither of them spells out what might have caused forward shifted event sequences to be considerably less accessible in relation to past-under-past relative clauses in both our experiments. To capture this data, standard approaches would need to be augmented with further stipulations, explaining how event structural or pragmatic factors might shift people’s

preferences to simultaneous and back-shifted temporal interpretations.

By contrast, event structural approaches can neatly account for the different acceptance rates for forward shifted and backward shifted event sequences in our data from their first principles: Whenever comprehenders decode the temporal structure conveyed by a complex sentence, they need to anchor each occurring temporal expression by relating it to another temporal interval. In principle, the anchoring interval can be identified with the utterance time of the sentence. However, previously mentioned or contextually salient events are more likely to be chosen, in particular, when such events describe actions rather than states and successfully draw people's attention to the respective time span (Clewett et al., 2020; Kurby & Zacks, 2008; Zacks et al., 2007).

Note that an event-structural perspective can also account for examples where forward shifted interpretations are indeed feasible: One of the key motivations for the claim that relative clauses need to be interpreted independently from the matrix tense are sentences such as (10) or (11) where the embedded event unquestionably happened after the main clause event:

(10) *A child was born that became king.*

(11) *Hillary Clinton married a man who became president.*

Under an event structural view, the search for a conceptual anchor for the embedded tense in (10) and (11) might be influenced by extra-linguistic context (i.e., an unborn child cannot be coronated, the Clintons got married before Bill Clinton's presidency) or – assuming that syntactic dependencies do not determine temporal parameters – the anchoring relation might be inverted: In such a case, the event in the subordinate clause might be more salient and, as a consequence, act as the temporal anchor of the matrix clause verb.

Further experiments are planned to investigate such questions more thoroughly: For instance, are forward shifts equally unacceptable to comprehenders when the mapping between syntax and event structure is switched (e.g., 'The rabbit that the girl fed was next to the mushroom')? Can forward shifted event sequences be ameliorated in contexts with discourse focus on the subject of the relative clause (e.g., 'This story is about a rabbit') or when the relative clause and main clause description are equally salient (e.g., two event descriptions 'The girl fed the rabbit that hopped towards the mushroom', or two state descriptions 'The girl stood next to the rabbit that was next to the mushroom')? While none of these manipulations should change temporal interpretations according to standard accounts of embedded tense, event structural approaches would predict an amelioration of forward shifts for past tense relative clauses that can serve as temporal anchors of the main clause event.

Another open question remains: Following the experimental design of Dermidache and Lungu (2008), we included a distractor character in each video clip, consisting

of a second version of the patient who stood at a distractor location (e.g. a second rabbit near a tree, see Figure 1). The video materials thus evoked contrast alternatives for the object NP. In this regard, reference resolution might have tampered with people's temporal judgements in two different ways: For one thing, people may have identified the matrix event as the relevant time span that determines to which entity the object NP refers. The relative clause description would thus have to be true at the time of the matrix event which, in turn, would make forward shifted interpretations less acceptable only in the context of reference resolution. Conversely, introducing contrast alternatives could also have distracted from the temporal structure of the sentence: People might have evaluated past-under-past relative clauses with regard to whether the modified NP identified the correct character, with the temporal relations being less decisive for their adequacy judgements. This would explain the fact that forward shifted event sequences were rated still more acceptable for relative clauses than for *while*-clauses. In follow up experiments, we will address these possibilities by removing the distractor character from the critical video clips.

Furthermore, for the forward shifted event sequence, videos generally stopped after the object referent moved to the location described by the relative clause. Though the video was followed by a 1 second blank screen and the subsequent judgement task did not include visual materials (e.g., still frames of the scene), our design does not exclude the possibility that states were perceived as not terminated. To rule out such an alternative explanation for the lower acceptability ratings of forward shifted interpretations, a follow-up experiment will include forward shifted event sequences where the state is unambiguously in the past (i.e., the rabbit hopping away from the mushroom).

Finally, our predictions regarding temporal relations in past-under-past relative clauses draw on independent evidence, suggesting that stable states are cognitively less salient than actions and events (Clewett et al., 2020; Kurby & Zacks, 2008; Zacks et al., 2007). In additional control experiments, we will examine whether this asymmetry also holds for our materials: For that purpose, participants will be asked to watch the animated clips from Experiment 1 and 2 and give a short description after each video. In line with previous findings, we should expect a significantly larger number of references to events than to states in people's spontaneous summaries.

In sum, in this paper, we present the first attempt to empirically test formal and event-driven models of how language maps onto complex events in language comprehension. We have shown that forward shifted event sequences seem to be less acceptable for past-under-past relative clauses than back shifted event sequences – a result that would not have been predicted by standard formal accounts of temporal sequence but were in line with a model of linguistic event comprehension that takes an event's internal structure and salience as starting point.

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