

# Disambiguation by Information Structure in DRT

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## Abstract

Text understanding and high quality machine translation often necessitate the disambiguation of ambiguous structures or lexical elements. Drawing inferences from the context can be a means for resolving semantic ambiguities. However, often, this is an expensive strategy that, in addition, not always comes up with a clear preference for one of the alternatives. In this paper, we argue that in a number of cases deep semantic analyses can be avoided by taking into account the constraints that the alternative readings impose onto the information structure. To this end, we present a study of the ambiguous German adverb *erst* and point out the particular circumstances under which the given information structure disambiguates the adverb without further semantic analysis.

## 1 Introduction

German *erst* is ambiguous. Consider the following examples:

- (1) Peter zeigte erst auf die vierte Glückszahl.

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This paper describes research done within the *Sonderforschungsbereich 340* at IMS. I would like to thank Anette Frank, Hans Kamp, Michael Schiehlen and the other members of the IMS semantics group for helpful discussion.

- a) *Und dann auf die zweite.*  
(Peter first pointed to the fourth lucky number.  
And then to the second.)
- b) *Nicht zuvor auf die erste, zweite oder dritte.*  
(Peter only pointed to the fourth lucky number.  
Not to the first, second or third.)
- c) *Noch nicht auf die fünfte.*  
(Peter only pointed to the fourth lucky number  
so far. Not yet to the fifth.)

The alternative contexts a) - c) determine the meaning of the first sentence of (1) according to the disambiguating translations presented. The example testifies the following three uses of *erst*:

- In the context (1.a), the recipient understands the introduced event as the first of a sequence of events that he expects to be completed by the following text. We call this reading:  
the First of a Sequence-reading (FS).
- In the context (1.b), the recipient understands *erst* as a signal of the speaker/writer that the occurrence of the reported event is not preceded by the occurrence of similar (alternative) events. We call this reading:  
the Exclusion of Preceding Alternatives-reading (EPA).
- In the context (1.c), the recipient understands the event as element of a sequence of events, and the realization of the sequence, in particular the reported realization of the event at the textual perspective time, seems to be in retardation,

with regard to some (previous) expectation about the realization dates of the sequence. We call this reading: the Retardation-reading (R).

As can be seen from the example, the contextual disambiguation not only is needed for understanding the text, but is a prerequisite for high quality translation.

In the literature, different formalizations have been discussed ((Kön79), (Löb89), (Kön91), (HR81) (the latter one for the similar *noch* and *schon*) and others). With respect to the focus adverb use (the cases (1.b) and (1.c); (1.a) being an example of the temporal adverb use), modellings are prevailing that associate *erst* with different scales (cf. (Löb89)). However, a precise evaluation of the context that can decide about the relevant reading (for instance, what information defines which scale) is still missing. We tackle this problem in the framework of Discourse Representation Theory (DRT) (Kam81), assuming that discourse representations (DRSs) may be augmented by information structure.

## 2 The *erst*-readings, their entailments, presuppositions and implicatures

### 2.1 The *First of a Sequence* interpretation

In this paper, we cannot go into detail with tests that partition the meaning of a sentence into presuppositions, assertions proper and implicatures the recipient is allowed to draw from the sentence (cf. (Lev83) for an overview of the notions used, the tests associated with them and the problems connected to them). We directly come up with the DRSs that, to our opinion, represent the impact of the different readings. We begin with the FS-reading of (1):

$$(1.a) \quad \boxed{\begin{array}{l} \text{peter now e t} \\ \text{TP}(t) \\ t < \text{now} \\ \alpha_{def}(x, \boxed{\text{4te\_glückszahl}(x)}) \\ e: \text{zeigen\_auf}(\text{peter}, x) \\ e \circ t \\ \alpha_{re}(e', \boxed{e'}) \\ e \text{ starts } e' \end{array}}$$

Here, TP stands for the actual (past) temporal perspective that holds for the given utterance/text situation. With respect to the representation and resolution of presuppositions in DRT, we relate to (vdS92). We slightly deviate from the approach suggested there, however, in that we use a notation for the presupposition triggers that is akin to the suggestion of (BES<sup>+</sup>94): we use so-called  $\alpha$ -conditions which describe the presupposed objects and their characterization. In our framework  $\alpha$ -conditions subsume different types of projection problems. The type is characterized by the  $\alpha$ -index (*presp* stands for 'classical' presuppositions, *def* for definite descriptions, *rt* for reference time, *re* for reference event etc., compare (Ebe95) for an overview). This index triggers the projection routine that is specific to the respective resolution problem. The first argument of the condition schema highlights the distinguished discourse referent (DRF) of the structure to be projected.<sup>1</sup> The representation, thus, requires a definite description style resolution for the  $x$  that is characterized as a *fourth lucky number* (with respect to the given setting,  $x$  together with its description will be accomodated at the main level DRS), and it presupposes a reference event  $e'$  such that the sentence event  $e$  is the first event of a possible elaboration sequence of  $e'$  (cf. (Ebe92) for the computation and storing of discourse relations like *elaboration*).

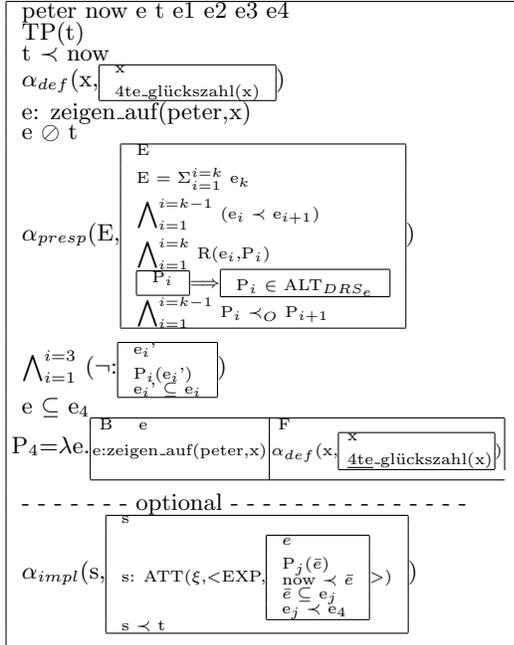
### 2.2 The *Exclusion of Preceding Alternatives* interpretation

In the EPA-reading, *erst* is used as a focus adverb, i.e. it structures its argument into focus and background. In the following representation of (1), we consider the case where the numeral is focused only, not the NP containing the numeral or the entire event description in the scope of *erst*:

<sup>1</sup>As regards definite descriptions, the distinguished DRF is the DRF of the head noun; in any case it is the DRF the  $\alpha$ -information is centered around.

Modeltheoretically the relation between the presuppositional part and the assertional part of a DRS can be seen as a function from information states into information states, see (Kam95).

(1.b)



Besides the assertion that Peter points to the fourth lucky number at the temporal perspective  $t$ , the representation presupposes a sum  $E$  consisting of a sequence of events  $e_1 - e_k$  that are related via a non further specified relation  $R$  to predicates  $P_1 - P_k$ . These  $P_i$  are required to be alternatives of the event description in the scope of *erst* (which is called  $\lambda e. \text{DRS}_e$ ). In this paper, we cannot go into detail with the computation of the alternatives of event descriptions.  $P_i \in \text{ALT}_{DRS_e}$ , where  $\text{ALT}_{DRS_e} = \{\lambda e. \text{DRS}_e[\text{FOC}_{e_i}(\text{DRS}_e)]_Q \mid Q \in \text{ALT}(\text{FOC}_{el}(\text{DRS}_e))\}$ , sketches the claim that the  $P_i$  are event descriptions that develop from  $\lambda e. \text{DRS}_e$  by exchanging the focused element by an alternative (Compare (Roo85), (Roo92) for the underlying focus theory and (BE95) for an algorithm that calculates the concrete alternatives). As mentioned, the focused element, which is marked by the underline, is assumed to be the numeral adjective. This choice triggers the structuring of the  $P_s$  into the background event type  $\lambda e. \text{BAC}(\text{DRS}_e)$  (which is  $\lambda e. \text{zeigen\_auf}(\text{peter}, x)$ ) and the focused semantic constituent  $\lambda x. \text{FOC}(\text{DRS}_e)_{[4|n]}$  (which is  $\lambda x. \alpha_{def}(x, \lambda e. \text{nte-glückszahl}(x))$ , where  $n$  is a number from the set of alternatives of 4). The relation  $R$  has to be understood as character-

izing the  $e_i$  as opportunities for Peter to point to (specific) numbers. In (1), these opportunities may be situations that can be described by: *The first<sub>e1</sub> / second<sub>e2</sub> / third<sub>e3</sub> number is presented to Peter*. The order of the opportunities is inherited from the order of the  $P_s$ ,  $<_O$ , which conforms to the intrinsic order of the set of alternatives of the focused element (i.e.  $O = \text{order}(\text{ALT}(\text{FOC}_{el}(\text{DRS}_e)))$ ). In (1), this is the canonical order of the numbers.

The negation test, which is commonly used to detect presuppositions, supports these structural assumptions.

Now, we think that the EPA-reading interpretes the asserted event, which is backed by the described scenario, as the first one that is indeed realized within the range of possible instantiations that the sequence of opportunities provides, i.e. the asserted event presents the first positive outcome to the test about the instantiation of the  $\lambda e. \text{BAC}(\text{DRS}_e)$ -type that is connected to the  $e_i$ -sequence, where each test situation  $e_i$  is characterized by its own specific additional test criterion  $\lambda x. \text{FOC}(\text{DRS}_e)_{[4|n]}$ .<sup>2</sup>

Further linguistic tests, that we must omit here, support the assumption that the information about the negative tests is an entailment. Therefore, in the representation, the negated DRSS for the pointing-opportunities  $e_1 - e_3$  are part of the main DRS.

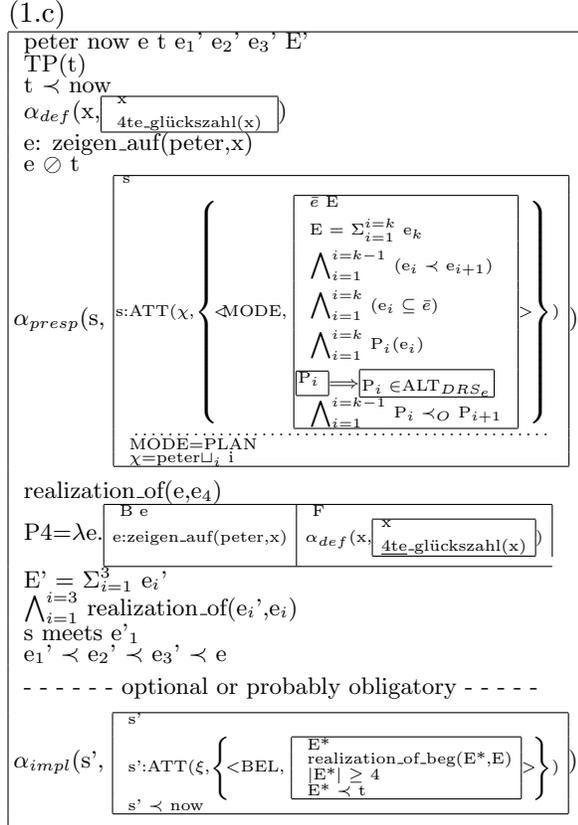
In the literature the representation of the focusing use of *erst* (and corresponding uses of *noch* and *schon*) often comprises the information that the reported realization of the event is earlier or later (depending on the reading and the adverb) than the speaker/writer and/or the recipient (or even a third person) would have expected. We think that such an expectation, in the case of the EPA-reading of *erst*, is only optional. Following (Kön91),

<sup>2</sup>Depending on the focus structure of the phrase in the scope of *erst* in (1) and depending on the contextual restrictions of the admissible alternatives, other sets of  $P_s$  might result. It is clear that depending on this choice, the focus conditions may characterize a thematic role, as in the described example, or the event variable. It is also clear, as we will argue in the next section, that not all of these sets of alternatives can accept the EPA-reading.

we think that, if present, it is not a presupposition but a conventional implicature. In (1.b), we use the specific  $\alpha_{impl}$ -format and the representation convention of (Kam95) for attitudinal states in order to express the EPA-expectation of a previous test to be successful.

### 2.3 The Retardation interpretation

As for the EPA-reading, we consider the case where the numeral is focussed only:



In contrast to the EPA-reading, we assume that, in the R-reading, the predicates  $P_i$  that we obtain from the information structure of the *erst*-argument are not related to a sequence of opportunities for doing something, but describe events  $e_i$  of an expectation about the ongoing of the world  $\bar{e}$  or a plan  $\bar{e}$ . The context (1) doesn't provide further information about the identity of the person or persons  $\chi$  to whom the introduced attitudinal state has to be ascribed, to the speaker/writer, to the recipient, to Peter, to someone else or to some group of salient people. Also it doesn't provide information about the nature of the attitude MOD. The con-

ditions that are introduced below the dotted line exemplify possible resolutions. According to this, Peter and the speaker/writer (i for the distinguished DRF for the self) share the attitude of having a plan for realizing  $\bar{e}$ . Such resolutions may be available by an inference component that operates over richer contextual knowledge. Again, the order of the  $P_i$  and the corresponding  $e_i$  is inferred from the implicit order of the alternatives of the focused element. From this setting and the assertion of an occurrence of *Peter pointing to the fourth lucky number* at the temporal perspective  $t$ , the representation entails realizations of those events of the presupposition line that precede the counterpart of  $e$  in the presupposed sequence. As a further (possibly optional) constraint, the R-reading introduces the implicature that a non further specified person or group  $\xi$  expected for the perspective time  $t$  that the planned or expected sequence of events should be realized to a greater degree. Without further information about the identity of  $\xi$ , it is difficult to say something more precise about the temporal location of the  $\xi$ -expectation than that an instance  $s'$  of the corresponding attitudinal state holds at some time before the actual *now*.

## 3 Disambiguating Criteria

### 3.1 The Syntax Criterion

In German focus adverbs cannot be topicalized as such, i.e. they cannot occur in the vorfeld position without an accompanying constituent (cf. (Kön91)). If the sentence shows such a topicalization of *erst* - which is marked by the inversion of the basic Subj-Vfin-order - *erst* can only be used as a time adverb, i.e. its meaning can only be the FS-reading, as exemplified by (2):

- (2) *Erst gab Peter Maria den Brief.*  
(First, Peter handed the letter to Maria.)

Thus, this type of topicalization disambiguates between the FS-reading on the one hand and the EPA- and R-reading on the other. Whether there are other syntactic criteria that further disambiguate between the

three readings also depends on the structural description assigned to the focus particle use. There are suggestions of analysing focus adverbs as syntactic co-constituents of their foci, and there are suggestions for analysing them only as co-constituents of the verb or its projections (see (Bay85), (Bay88), (Jac89), (Jac84), (Kön91) among others for a discussion). We have nothing specific to say about this here. We just note that, under the common assumption that the *vorfeld* in German introduces at most one constituent and under the ensuing assumption that focus adverbs modify their foci, in sentences like (3), *erst* must be interpreted as focus adverb.

- (3) *Erst den Brief gab Peter Maria.*  
 (Peter only handed the letter to Maria.)

As concerns the FS-reading, we add that, provided it is syntactically licensed, this reading is strongly supported if the sentence S2 following the *erst*-sentence S1 contains an adverb of temporal succession (like *dann/then, danach/after this* etc.) that modifies a verbal projection of similar tense and information structure as the *erst*-argument. This latter heuristics is expensive however, in that it checks extra-sentential information. The following criteria avoid this.

### 3.2 The Focus-Background Criterion

If the assumption of section 2.2 is true that in the EPA-scenario the background event type is tested for specific realizations, it is natural to think of this scenario to be reasonably conceptualized only if the background event type merits testing. This is not the case if there is no background event type at all (i.e.  $\lambda e.BAC(DRS_e)$  is the most general event predicate). There is no background event type if the entire argument of *erst* - the verb or a verbal projection - is in focus, or, though not in focus, the verb does not carry enough substance in order to provide an event type: this is the case for the copula without the predicative complement. Instead of technically working out the criterion, we content ourselves with some motivating examples which are critical in this respect. In order

to avoid interfering effects from the syntactic structure that might complicate matters with regard to determine the scope of *erst*, we only list examples with verb final position. In (4), the parentheses mark the argument of *erst*, the brackets annotated by F the focus element from which the semantic focus constituent is developed. As an example, (4.a) and (4.b) present their resulting structured event types. We omit this rather canonical structuring for the other examples.

- (4) *Petra war überrascht, weil*  
 (Petra was surprised because)
- a) *Peter erst (in [Stuttgart]<sub>F</sub> war)* \*(EPA)  
 $\lambda s. \left[ \begin{array}{c|c} \text{B} & \text{F} \\ \hline s & \text{stuttgart} \\ \hline s: & \text{in(peter,stuttgart)} \end{array} \right]$
- b) *Peter erst (in [Stuttgart]<sub>F</sub> anwesend war)* (EPA)  
 $\lambda s. \left[ \begin{array}{c|c} \text{B} & \text{F} \\ \hline s & \text{stuttgart} \\ \hline s: & \text{in(s,stuttgart)} \end{array} \right] \left[ \begin{array}{c} \text{anwesend(peter)} \end{array} \right]$   
 (being in Stuttgart / being present in Stuttgart)
- c) *es erst ([12.00]<sub>F</sub> war)* \*(EPA)
- d) *es erst (in [Stuttgart]<sub>F</sub> 12.00 war)* (EPA)  
 (being 12 o'clock / being 12 o'clock in Stuttgart)
- e) *Peter erst ([arbeitete]<sub>F</sub>)* \*(EPA)
- f) *Peter erst (in [Stuttgart]<sub>F</sub> arbeitete)* (EPA)  
 (working in Stuttgart)

The indications (EPA) and \*(EPA) mean that one can conceive contexts that allow for EPA or that one can not. Without further comment, we think that the criterion is confirmed by the data.

#### Focus-Background-criterion:

The EPA-reading is acceptable only if the scope of *erst* is structured into focus and background in such a way that the background is a specific event type.

### 3.3 The Temporal Location Criterion

The R-reading presupposes a sequence of events (conceptualized as a plan or an expectation about the ongoing of the world) and it assumes that, from the perspective of the contextual perspective time, a part of the sequence is realized, according to the ordering of the plan or expectation. The reported event refers to the event of the presupposition line that marks the boundary between the instantiated and the non-instantiated event concepts, and it does this in right the same

way as definite descriptions do with respect to their antecedents. Now, if this is true and if the event description contains a temporal location in the focus, this information cannot be used attributively, because it contributes to the antecedent description and to the distinction of this antecedent from its alternatives. Because of this setting, it acts as a restriction on the referring expression that helps to pick up the right antecedent from the presupposition line. This means that, against the background of the presupposition, this information is not new. We add that nothing of the *erst*-argument is new information against this background. New is the information about the progress of the instantiation of the presupposed event concepts. But then, stating that an event of the corresponding antecedent type indeed was realized (the assertional impact of the R-reading), and stating that it occurred at a time as was expected (consequence of the specific description of 'antecedent' and 'anaphor'), and simultaneously insinuating that it could have been realized earlier (presuppositional structure of the R-reading supported by implicature) results in a contradiction. This, to our opinion, seems to be the explanation of why the R-reading is not possible in case the description in the scope of *erst* comes with a temporal location in the focus. Compare the following examples to this end.

- (5) *Petra war überrascht, weil*  
 a) *Peter erst (in [Stuttgart]<sub>F</sub> war)* (R)  
 b) *Peter erst (um [12.00]<sub>F</sub> in Stuttgart war)*  
 \*(R)

(5) confirms what we have said so far. Note, by the way, that the features of the Focus-Background-criterion are not characteristic of the R-reading.

What about temporal locations in the background part? At first glance, it seems that what we have said above applies to this case also. However, there are some (relatively marginal) cases that possibly contradict to this assumption. The following example (6) is an instance of this:

- (6) . . . *weil Peter erst (in [München]<sub>F</sub> um*  
*3 ein Bier getrunken hat)*

(because only in Munich, Peter drank a beer at three (so far))

In a context that continues this information, for instance, by *und noch nicht in Köln (am nächsten Tag) um 3 / and not yet in Cologne (the next day) at 3* the R-reading seems acceptable. Because of the granularity of the presuppositional event sequence that develops from the presupposition construction in such cases - in (6), the iteration must satisfy to a one-day-rhythm at least- the temporal adjunct cannot truly act as a restrictive referential constraint, and because of what we have said above about novelty, it is not the best attributive information also. This may explain why the example is felt to be a bit odd. The decisive feature, however, why the above argumentation for the incompatibility of the R-reading and the presence of temporal localizations does not go through, is the fact that the background temporal localization does not uniquely fix the occurrence time of the event with regard to the time frame of the presupposed plan or expectation. This, of course, is so, only if the localizing predicate allows for multiple (periodic) instantiation. (Times of day allow for this, also adjuncts like *after lunch* etc.).

We stress that what we have said relates to temporal adjuncts **in the scope of *erst***. The following (7.a) allows for the R-reading, because the most natural analysis gives wide scope to the temporal adjunct, i.e. the sentence is analysed like (7.b), where clearly, the adjunct serves to localize the temporal perspective.

- (7) a) *Erst in München war er gestern.*  
 b) *weil er gestern erst in München war.*  
 (yesterday being in Munich)

We have considered only temporal adjuncts so far. The alternative temporal localization that occurs in the scope of *erst* is the construction 'copula + predicative temporal expression', which accepts the R-reading. Examples are (4.c) and (4.d). We skip the complete explanatory argument here and just say

that (grosso modo) the function of the copula construction is to synchronize calendar knowledge (also information about different calendars: R-reading of (4.d)) with the actual available perspective times, whereas the function of the temporal adjunct is to relate the described event to some predefined time. We take it for granted, that this difference is the reason why the decisive conflict that we mentioned further above only arises if the temporal location is introduced by modification, i.e. in case it is introduced by an adjunct.

We retain the following criterion:

Temporal-Location-criterion:

The R-reading is acceptable only if the focus constituent of the scope of *erst* does not contribute a temporal localization (by modification of a basic event type). In addition, the scope must not contain an adjunct - focused or not - that is a uniquely referring temporal location (like *yesterday*).

### 3.4 The Entailment Criterion

Compare the following examples:

- (8) ... weil  
 a) *Tomba sich erst (an der [Streifalmhütte]F disqualifizierte).*  
 (T. disqualified himself at the S.) \*(R),(EPA)  
 b) *erst ( [drei]F Unterschriften genügten).*  
 (three signatures were sufficient.) \*(R),(EPA).  
 c) *Peter erst ( [vier]F Angestellte kannte).*  
 (P. knew four employees.) (R),\*(EPA)

(8.a) cannot have the R-reading. Why? The intelligent construction of the presuppositional sequence of events for the R-reading outputs a number of disqualification events that are located at particular places of the Hahnenkamm downhill race in Kitzbühel. What is specific with this sequence is the fact that the postconditions of any of these events are such that the preconditions of the successive events never can hold. Therefore such a sequence can never be a reasonable plan or a reasonable expectation about a downhill race. I.e. a constitutive element of the R-reading cannot be constructed in this case. In (8.b) the descriptions of subsequent events (states

in this case) of the presuppositional line are more general predicates than the description of the predecessors, i.e. each such sequence collapses in its first element in essence. This cannot truly be called a sequence. With (8.c), we encounter, so to speak, the symmetric picture with regard to the EPA-reading: *Knowing n employees* entails the previously tested *knowing n-1 employees*. The expectation of some proposition p to be true in a specific situation  $s_n$  cannot be falsified, in case the validity of a particular proposition q in the subsequent test situation  $s_{n+1}$  confirms the validity of p.

We retain the following criterion:

Entailment-criterion:

For the R-reading to be acceptable, first, the postconditions of each event of the presuppositional line must be compatible with the preconditions of the successor and second, (at least for homogeneous descriptions) the description of an event must not subsume the description of the following events.

For the EPA-reading to be acceptable, (at least for homogeneous descriptions) the event description tested at a situation must not subsume the previously tested event description. There are refinements of this criterion that we must omit here.

## 4 Final Remarks

The four criteria of the last section can be used in order to exclude readings of *erst*. It is only the last (entailment) criterion that necessitates some economic semantic inferencing. The others correspond more or less to a structural lookup. Using the convincing structural interdependencies that (Löb89) shows for a subset of the German focus adverbs containing *erst*, the generalization of the approach suggested here to other ambiguous adverbs seems very promising.

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