# Planning Word–order Dependent Focus Assignments*

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## Abstract

Word order and accent placement are the primary linguistic means to indicate focus/background structures in German. This paper presents a pipelined architecture for the generation of German monologues with contextually appropriate word order and accent placements for the realization of focus/background structures. Our emphasis is on the sentence planner that extends the respective propositional contents with discourse–relational features and decides which part will be focused. Such an enriched semantic input for an HPSG–based formulator allows word order variations and the placement of prenucleus and nucleus accents. Word order is realized by grammatical competition based on linear precedence (LP) rules which are based on the discourse–relational features. Accent placement is realized by a syntax–driven focus principle that determines the focus exponent and possible bearers of prenucleus accents within the syntactically realized focus, the so–called focus domain.

## 1 Focus and word order determination as sentence planning tasks

This paper addresses aspects of the control of intonation belonging to the area of sentence planning [Beale *et al.*, 1998; Wanner and Hovy, 1996]. In many languages, intonation can reflect pragmatically motivated conceptual decisions. In particular, focus/background structures (FBSs) reflect the speaker's beliefs of the listener's information state. Since FBSs are realized in German primarily by word order dependent accent placements, focus planning and word order determination are subtasks of sentence planning.

Due to the complex interactions among the various subtasks of sentence planning [Hovy and Wanner, 1996] proposed a blackboard–based sentence planner instead of a pipelined architecture. However, we will demonstrate – as a byproduct of our approach to focus planning – that in some cases the complexity of interactions can be realized by a traditional top–down expansion process. The intertwined clause–internal organization of focus planning and word order determination for the realization of FBSs in German is obtainable by hierarchical planning.

In what follows, we will first give examples of the interplay of focus and word order in German. We will present the architecture of our NLG system that realizes FBSs and describe in more detail hierarchical sentence planning for FBSs. By means of some examples we are finally showing how word order dependent focus assignment works.

## 2 The interplay of focus and word order

The pragmatic function of the FBS is to indicate to the listener of an utterance that a certain part of that utterance has been put into the foreground. The semantic information of this foregrounded part has either been selected from a set of alternative beliefs ascribed to the listener, or it is a revision of certain beliefs (in case of contrastive focus), or the focused phrase expresses 'new' information the listener does not know or is not able to infer from his beliefs [Halliday, 1967].[1]

In all three cases the focus domain – the syntactic realization of a focus – contains the so–called focus exponent, i.e. the bearer of the focal accent which we are identifying with the obligatory nucleus accent. The existence of this accent indicates to the listener that one part of the message conveys one of these three functions. In addition to the nucleus accent optional prenucleus accents can exist as well which do not have a discourse function in general.

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[1] This list of apparently diverse functions shows that there are possibly several phenomena which have been labeled as 'focus' within the last 70 years or so. There is an ongoing discussion in the linguistic community whether these three functions can be traced back to one common principle (cf. [Schwarzschild, 1999]).

but a prosodic function which goes back to diverse planning phenomena.

Three examples shall demonstrate the interplay of word order with accent placement. Example (3) is from our speech corpus of retellings of a trick film we analyzed to obtain rules for accent placement. The other examples are variations of (3) showing that different word order and accent placement correspond to different focus domains. For reasons of simplicity we are abstracting from specific pitch accents in this paper. Accent bearers are given in capitals. Furthermore, the examples do not exhibit prenucleus accents. However, our rules for accent placement account for these accents as well. The reason is that prenucleus accents are determinable if the bearer of the nucleus accent is known.

1. *er fällt in die STEINebene runter*
   he falls in the stone plateau down
   'he is falling down to the stone plateau'
2. *in die STEINebene fällt er runter*
3. *er fällt RUNter in die STEINebene*

Semanticians pointed out that the key concept for word order and its consequences for accent placement is contextual boundedness (see, e.g., [Jackendoff, 1972; Rooth, 1992]). However, their method to simulate the different contexts by questions the sentence is able to answer tells us only something about the number of possible foci. For example, sentence (1) is able to answer five possible questions, depending on which constituent provides the answer (the contexts range from *Which specific plateau is he falling down to?* with focus on the compound only to *What's up?*, focusing the whole sentence). Example (2), however, with the locative PP in sentence–initial position but identical accent placement is only able to answer three questions. Hence, (2) is contextually more bounded than (1). Example (3) exhibiting an extraposed unit clearly demonstrates the need for an FBS–related word order. Extrapositions are the linguistic means in German to separate sense units. The extraposition is used to mark two informational units: first, the person is falling down and second that the resulting place is the stone plateau. Since informational units coincide with prosodic phrases, each phrase contains one nucleus accent so that two separate focus domains exist.

From an NLG perspective explaining word order and accent placement by the possibility to answer context questions points to the wrong direction. Neither should we generate isolated sentences nor are we interested in focus ambiguities. Rather we have to determine a certain word order with a twofold purpose: first, it must be able to express a planned focus and second, it should guarantee coherence of the text.

To our knowledge, the problem of how word order and focal domain determination interact has not been adressed in NLG research yet. The SYNPHONICS formulator [Abb *et al.*, 1995] that is able to generate German single sentences with FBSs does not take into account the interplay between word order and accent placement. Instead word order is determined by incremental syntactic construction; situative factors have not been addressed in this system. The SPEAK! system [Teich *et al.*, 1997] also does not account for the interplay of word order with accent placement. However, this system cannot be directly compared with our approach, since the coverage of phonological phenomena is completely different: We are interested in FBSs in monologues, whereas the SPEAK! system primarily accounts for the role of a dialogue history to achieve the assignment of various intonation patterns.

Generally, the realized word order of an utterance is the result of its embedding into the situative context, which finds expression in the use of linear precedence (LP) rules for word order determination during surface realization. The idea is that constituents are ordered with respect to preferential properties expressed by these LP–rules. From an NLG perspective the question is, then, where the information comes from that allows us to make use of these LP–rules? In our approach we derive the information necessary for the use of LP–rules from a discourse model that relates various aspects of a discourse to one another. Since we are generating monologues only the utterances previously produced by the program require consideration.

The generation of monologues with appropriate word order and focus/background structures comprises five major tasks:

1. The information to be conveyed must be selected and linearized by a content planner.
2. During sentence planning:
   (a) foci must be determined, and
   (b) conditions for word order realization must be given.
3. During surface realization:
   (a) the foci must be mapped onto focus domains while the sentences with their respective word order are formulated, and
   (b) the bearers of (pre)nucleus accents within each focus domain must be determined.

Since this paper addresses sentence planning, we are focusing on tasks (2a) and (2b) only. We are leaving aside content planning (task 1) because the linearization problem does not affect FBS determination. The content planner provides the respective propositions that will be extended during sentence

planning by pragmatic information for realizing the FBS. The result of sentence planning functions as input for a competition-based formulator. In order to demonstrate how the formulator is able to realize FBSs by means of grammatical competition, we will also outline the determination of focus domains, word order, and accent bearers in focus domains (tasks 3a and 3b).

## 3 Architecture of FOGS

The five tasks mentioned above are realized in our NLG system FOGS.[2] Currently the system generates brief retellings of a trick film with each sentence having a contextually appropriate word order and focus-relevant prosody with the context provided by the discourse model. Figure (1) shows the architecture of the system. Sentence planning takes into consideration the current state of a discourse model. When constructing the input for the formulator, the discourse model will be continuously updated so that the word order of the currently planned sentence is coherent with the word order of the preceding sentence. Word order relevant information is encoded by discourse relational features of discourse referents.

The HPSG-based formulator realizing the sentences uses weighted LP-rules for word order determination that take into account the discourse-relational features in the semantic input. Bearers of (pre)nucleus accents within focus domains are determined by a focus principle.

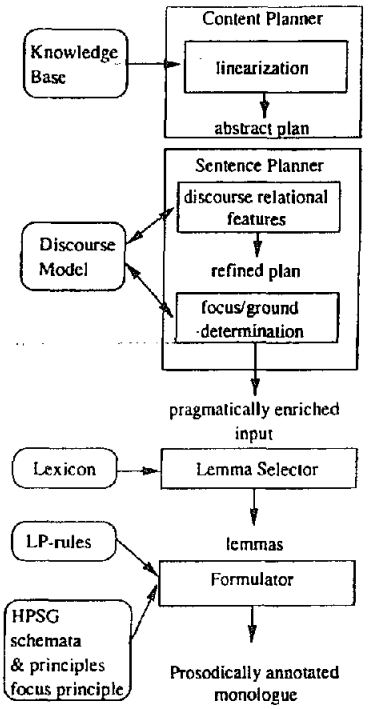


Figure 1: Architecture of FOGS

## 4 Sentence planning in FOGS

The planning operators creating the input for the formulator cause the transition to new states of the discourse model. The initial state of the discourse model is characterized by the lack of any information on the events to be conveyed. Correspondingly in the goal state all events are represented.

Our discourse model is a knowledge store consisting of two major registers. It consists of a Discourse Representation Structure (DRS, cf. [Kamp and Reyle, 1993]) $\langle R, K \rangle$ with sets of mutually known discourse referents $R$ and DRS-conditions $K$, and a set $Ref$ of referential movements assigned to the discourse referents. Referential movements determine how discourse referents are passed on from one sentence to the next one. $R$ is a pair $\langle R_A, R_N \rangle$ consisting of referents of the directly preceding utterance and referents of all other previous utterances. Since referential movements are typically linked with identifiability conditions for discourse referents, the latter can be derived from the former. New referents are declared as being unidentifiable for the listener, while re-established ones should typically be identifiable by a definite description. Maintained referents are usually anaphorically identifiable. Furthermore, alternative sets $Alt$ are determined by sortal restrictions. Discourse referents function as alternatives if they are stored in the discourse model in $R$ and are instances of the same superordinated concept. Analogously, concepts are alternatives if they are stored in the discourse model in $K$ and possess the same directly superordinated concept. During planning the discourse model will be continuously updated. Updating comprises the insertion of new discourse referents into $R_A$, shifting referents from $R_A$ to $R_N$ and, in case of referential re-establishment, shifting referents from $R_N$ to $R_A$. Furthermore, new DRS conditions will be introduced into $K$, and the referential movement conditions are updated, resulting also in new alternative sets and identifiability conditions $Id$.

We use a hierarchical planner [Sacerdoti, 1974]. The content planner provides the abstract plan. Plan refinement during sentence planning consists of the proposition-wise introduction of operators for the discourse relational features and focus/background determination. The result of applying the operators to the single propositions functions as input to the formulator.

[2] Not to be confused with FOG, a system that generates weather forecasts [Goldberg *et al.*, 1994]. FOGS is the acronym for "focus generation system".

### 4.1 Discourse-relational features

Extending the propositions by discourse-relational features makes intensive use of the discourse model. Three discourse relational factors influencing word order are realized as plan operators: topic assignment, referential movement, and identifiability of discourse referents by the listener.

**Topic assignment:** Topics establish an aboutness–relation between a familiar discourse referent and the sentential predication. We adopt the conditions for topic assignment proposed in [Klabunde and Jansche, 1998]. Topic candidates must be identifiable discourse referents and they should be as high on a so–called topic acceptance scale as possible. According to such a scale referents that are currently lit up constitute the best topic candidates. In our approach, these are referents from the intersection of $R_A$ and the referents of the current event proposition to be realized. The topic acceptance scale is mirrored in the successive application of operators for topic assignment. For example, if several referents as candidates exist, a discourse referent will be chosen that is marked as anaphorically identifiable and referentially maintained:

```
topicAssignment(Event,Event1):
    PRE: [(R_A ∩ EventRs = Topics),
          E ∈ Topics,
          anaphId(E) ∈ Id,
          refMaintained(E) ∈ Id]
    EFF: [topic(E) ∪ Event = Event1]
    DEL: []
```

The LP–rule referring to topic assignment is `topic < focus`, i.e. topics should precede foci.

**Referential movement:** Referential movement comprises the picking up of discourse referents from previously uttered information and the introduction of new referents, respectively. If referents from the directly preceding utterance are picked up, these referents are maintained. Referents from all other previous utterances are re–established. Referential movement influences word order because maintained referents are usually realized before re–established ones, and re–established ones precede new referents, as indicated by the following LP–rule: `refMaintained < refReEstablished < new`

**Identifiability:** With respect to identifiability of discourse referents, we distinguish between anaphoric identifiability, identifiability by a definite description, and referents that are non–identifiable for the listener. Identifiability influences word order as well because anaphorically identifiable referents are usually realized before definites and those precede non-identifiable referents: `anaphId < definiteId < nonId`.

### 4.2 Focus and background determination

We already pointed out that focusing a semantic representation is based on one of three functions: the selection of beliefs from a set of alternatives, contrasting a belief with a different one, and indicating new information. These three functions have also been verified in our corpus of story tellings. Each of these functions has been treated separately in various systems (see, e.g., [Prevost and Steedman, 1993] for contrastive focus in a concept–to–speech system, [Theune *et al.*, 1997] for new information in a data–to–speech system, and [Blok and Eberle, 1999] for alternative semantics in machine translation), but a single and comprehensive approach has not been proposed yet. However, structure and content of our discourse model allow us to determine FBSs by means of planning operators as well. Different preconditions for the focus determining operator result in the successive check whether one of these three functions is satisfied. First it is checked whether the proposition to be conveyed contains any information that is new for the listener. New information is what is not stored in the DRS $K$ of the discourse model.[3] If these preconditions are not satisfied it is checked whether parts of the proposition belong to alternatives presumed by the listener. Only if these preconditions fail a contrasting focus is realizable. Contrasting focus is realized if some property in $K$ of an activated discourse referent in $R_A$ contradicts a property in the semantic input under consideration, provided the same sortal restriction holds as for the alternatives.

## 5 Surface realization as grammatical competition

The resulting input for grammatical competition is a blend of semantic and pragmatic information. For example, the input for realizing example (1) is as follows:

```
focus:  [fallingDown(e,m), into(e,s), stonePlateau(s),
         definiteId(s), refReEstablishment(s)]
ground: [man(m), anaphId(m), refMaintenance(m),
         topic(m)]
```

The constants `m`, `s`, and `e` are referents for a specific man, stone plateau, and the event of falling down. The values of the features `focus` and `ground` represent the focused part of the proposition and the background, respectively. While the realization of the focus domain is the task of converting the complete focus into one phrase, word order will be determined by LP–rules that pick up the pragmatically motivated literals on topichood, identifiability, and referential movement.

[3] This implies that we are ignoring any inferential capabilities in the current system.

As already mentioned, the notion of grammatical competition is necessary to account for the interaction of syntactic and phonological constraints on focus/background structures. The idea to use a competition model to explain word order variations in German is not new (cf. [Steinberger, 1994; Uszkoreit, 1987]). The advantage of grammatical competition compared to a non-competitive use of precedence rules (as in standard HPSG) is its flexibility. A competition model allows to take syntactic as well as semantic and pragmatic preferences into consideration, and to determine the acceptability of a sentence with respect to the situative context. The usual approach is to formulate preference rules which have a certain impact on the naturalness of constituent orders. Some of these preference rules are stronger than others. The number of preference rules which are satisfied or violated, in combination with the relative importance of the different factors, is responsible for the varying degree of naturalness of word order variations. Analogously to this idea we use weighted LP-rules as well which are based on the planned discourse-relational features.

Focus domains are realized by means of a focus principle. Applying the focus principle results in the projection of a focus feature to the dominating node. Together with the standard HPSG-principles the focus principle confines the successive application of the head-complement, head-filler, and head-adjunct schemata to two lemmas in order to build up phrases and sentences. The focus principle constrains the placement of prenucleus and nucleus accents in view of the syntactic status of the phrasal signs. It is based on the following empirically validated regularities with respect to the placement of the nucleus and prenucleus accents:

1. in phrases with a head-daughter and adjunct-daughter the focus exponent is in the head-daughter and a prenucleus accent is in the adjunct-daughter.
2. for phrases with a head-daughter and complement-daughter holds:
   (a) if the head daughter is a verbal projection, the focus exponent is in the head-daughter and a prenucleus accent is in the complement-daughter.
   (b) else the accents are in the complement-daughter.

The regularities underlying the nucleus and prenucleus accent placement have been formulated on the basis of an analysis of a story telling corpus. The tellings have been analyzed w.r.t. the position of pitch accents and their indication of possible focus domains. Two results of this analysis shall be mentioned here: First, the analysis showed that the overwhelming number of focus domain determination can be explained by syntax-based projection rules (see, e.g., [Günther, 1999; Ladd, 1996] for some proposals) underlying our focus principle. Second, given the three basic pragmatic functions of FBSs, primarily information that was new to the listener has been accented. Contrastiveness was confined to focal accents on certain closed-class items such as determiners.[4]

While focus domains are realized by a syntactic principle, word order will be realized by means of weighted LP-rules. Since especially the LP-rule `topic < focus` requires information on focused constituents focus determination must be completed before word order will be realized. We introduced the necessary LP-rules in section 4.1.

Based on these LP-rules word order will be determined by means of the operation of domain union proposed in [Reape, 1994]. If the head or the daughter is a verbal projection the domain of the phrase will be received by domain union. Verbal projections are of interest for word order realization because only in this case the LP-rules will be evaluated. Otherwise the domains will be combined according to the directionality feature DIR of the head and a MOD-DIR feature of an adjunct. The former determines the order of head and complement, while the latter is responsible for the order of adjuncts and their modified element. Since in this case no LP-rules have to be evaluated, word order determination is a trivial task.

## 6 Results

The system just described produces brief retellings of one episode of the aforementioned trick film based on a knowledge base representing the single events and a discourse model. Depending on the content of the discourse model word order of the respective sentences and focus assignments differ. We are giving one detailed example showing the different status of the discourse model and its influence on the realization of word order and the FBS. After that some texts FOGS is able to generate are presented.

Let the content of the discourse model be as follows:

$R_{A_0}$ = ∅
$R_{N_0}$ = {s,m,d,...}
$K_0$ = {desertPlateau(d), stonePlateau(s), littleMan(m), fallingDown(e,m), ...}
$Ref_0$ = {refMaintenance(s), refReEstablishment(m),...}
$Alt_0$ = {alt(stonePlateau(s), {desertPlateau(d)}), alt(in(e,s),{on(e,s)})}
$Id_0$ = {definiteId(m), definiteId(s),...}

[4] Note that determiners as bearers of nucleus accents do not constitute a problem for our system. In this case only the identifiability condition belongs to the focus, which will be mapped onto a corresponding lemma.

The content planner determines `fallingDown(e,m)`, `in(e,s)`, `stonePlateau(s)`, `littleMan(m)` as the proposition to be conveyed. The operator for topic assignment marks s as sentence topic because it is the currently best available topic according to the topic acceptance scale. Referential movement is as follows: since s has been declared in the discourse model as being referentially maintained, it will be maintained in the first utterance as well. Discourse referent `m` was re-established and, therefore, will become referentially maintained. Since referent `s` was identifiable by a definite description for the listener and is the topic, it remains identifiable by definite means, resulting in a definite NP. Referent `m` was identifiable by definite means and becomes anaphorically identifiable.

Focus and background are determined as follows: first it is checked whether any information in the proposition is new to the listener. Since all literals from the propositional content also exist in $K$, nothing can be focused due to being 'new' information. However, there are two literals in the propositional content with explicitly represented alternatives. Since both literals can be linguistically realized as one constituent (as a PP), only one focus domain and one focus exponent will appear.

The resulting utterance is *in die STEINebene fällt er runter* with the locative PP in clause-initial position and accent on the noun-noun compound. The PP has been fronted because it receives the best evaluation w.r.t. the three discourse-relational features. The compound functions as focus exponent because the whole PP constitutes the focus domain, which is managed by the focus principle.

Taken all effects of the planning operators together, the updated discourse model is as follows:

$R_{A_1}$ = {m,s}
$R_{N_1}$ = {d,...}
$K_1$ = $K_0$
$Ref_1$ = {refReEstablished(s), refMaintenance(m),...}
$Alt_1$ = $Alt_0$
$Id_1$ = {anaphId(m), definiteId(s),...}

The next proposition to be conveyed is `littleMan(m)`, `walkingAround(e1,m)`. The new sentence topic will be m. Anaphoric identifiability and referential maintenance of referent `m` would usually result in keeping these conditions for the linguistic realization so that a pronoun will be generated. However, the topic shift results in a change to identifiability by a definite description for `m` in the following sentence. The event literal is focused because it provides new information, resulting in the VP as focus domain. According to the focus principle, the prefix receives the nucleus accent.[5] The resulting utterance is *Das Männchen läuft umHER* (the little man walks aROUND).

Exemplary brief retellings of the film episode generated by FOGS are given below. Note that the single sentences always express the same respective propositional content. What differs are the word order and/or the position of the nucleus accent. These differences in word order and accent placement are due to the varying content of the discourse model, the different possibilities for focus determination, and the effects of the applicable planning operators for referential movement, topic assignment, and identifiability.

1. *In die Steinebene fällt es runter auf der Suche nach Wasser.*
   *Das Männnchen läuft umHER.*
   *Plötzlich schießen STEINtürme aus der Erde auf.*
   *Die Steintürme erheben das MÄNNchen.*
   A rough translation is:
   *While looking for water it is falling down to the STONE plateau. The little man is running aROUND. Suddenly stone pillars are shooting up from the GROUND. The stone pillars lift up the little MAN.*
2. *Es fällt auf der Suche nach Wasser in die STEINebene runter.*
   *Es läuft umHER.*
   *Plötzlich schießen aus der ERde Steintürme auf.*
   *Die Steintürme erheben das MÄNNchen.*
3. *Es fällt auf der Suche nach Wasser in die STEINebene runter.*
   *Es läuft umHER.*
   *Plötzlich schießen STEINtürme aus der Erde auf.*
   *Die Steintürme erheben das MÄNNchen.*
4. *Es fällt auf der Suche nach WASser in die Steinebene runter.*
   *Es läuft umHER.*
   *Plötzlich schießen STEINtürme aus der Erde auf.*
   *Die Steintürme erheben das MÄNNchen.*

## 7 Summary and outlook

Sentence planning for the realization of focus/background structures in German comprises the determination of discourse relational features for the realization of an appropriate word order and the determination of the focus of the respective propositions. With this information available a competition-based formulator is able to realize the focus domain, word order, and accent bearers within the focus domain.

[5] We adopt an approach to the generation of separable prefix verbs proposed by [Lebeth, 1992] that is based on adjunction and compatible with our focus principle.

While hierarchical planning of discourse relational features for the use of LP-rules during surface realization seems to be a promising approach for word order dependent focus/background determination, additional constraints on word order are required to block overgeneration. The three LP-rules[6] are necessary, but no sufficient means to determine free word order in general. Next to these discourse-related rules there are syntactic and semantic restrictions on word order as well. However, due to their discourse-related nature, the conditions for using our LP-rules can be derived from the discourse model. Syntactic and semantic constraints on word order do not require a discourse model.

To summarize, the combination of hierarchical content planning with grammatical competition in view of a focus principle seems to be a promising approach for focus/background determination.

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[6] `topic < focus: refMaintained < refReEstablished < new: anaphId < definiteId < nonId`