The Processing of Information Structure

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Linguistic Assumptions:

- Current theories of information structure consider the whole sentence as the level at which relational notions such as focus/background and topic/comment are determined.

- From the view point of language processing the sentence level is surely ruled out as a primary processing unit.

- Research in psycholinguistics as well as computational linguistics has shown that incrementality is an essential property of efficient language processing.

This study investigates:

- How a declarative view on information structure taken within theoretical linguistics can be brought into accord with a procedural model of language processing?

- How is information structuring performed under the circumstances of incremental language processing?

The research adopts a cognitive approach to a computational linguistic model of language production that combines results from psycholinguistics research with recent developments in theoretical linguistics concerning the representation of semantic, syntactic, phonological, and phonetic knowledge.

The project investigates the syntactic and prosodic realization of information structure that vary in accordance with conceptual and contextual variations.

The authors argue that certain meaning distinctions triggered by changes in information structure are reflected by prosodic means without any additional support form syntax.

SYNPHONICS

(*Syntactic an Phonological realization of Incrementally Generated Conceptual Structures*)

- The system covers the incremental generation of utterances from paralinguistic conceptualization to the formation of phonological structures, which are in turn interpreted phonetically, yielding an articulatorically specified input to a speech synthesis module.
- The grammar formalism used to encode declarative linguistic knowledge is HPSG.
- Conceptual and linguistic objects are represented formally as typed feature structures in ALE (Attribute Logic Engine, cf. Carpenter 1992).
- The system has three central processing units:
  1. The Conceptualizer
  2. The Formulator
  3. The Articulator

The Conceptual Level

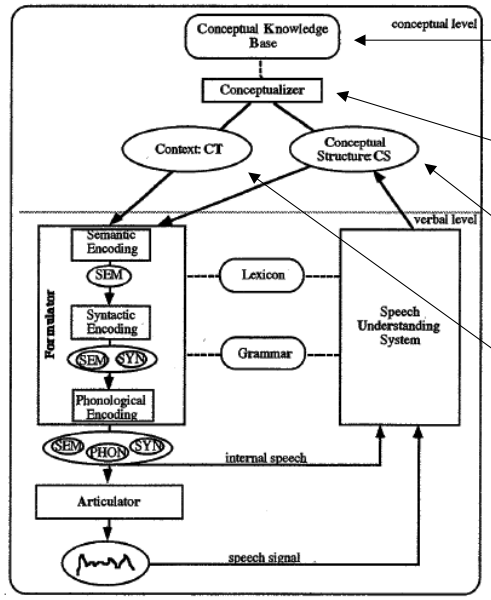


Fig. 2.1. The SYNPHONICS architecture

Facts and rules representing world knowledge (CKB).

It operates on the CKB and creates a conceptual structure (CS), and a contextual structure (CT).

The propositional content of the planned utterance.

Currently relevant parts of the contextual environment.

The Formulator and the Articulator

Input: Extra linguistic structures from CS and CT.
Output: SEM, the semantic structure

SEM is integrated into a complex HPSG sign that is augmented by SYN and PHON

Input: the value for PHON.
Output: an articulatory specified input to the speech synthesis module.

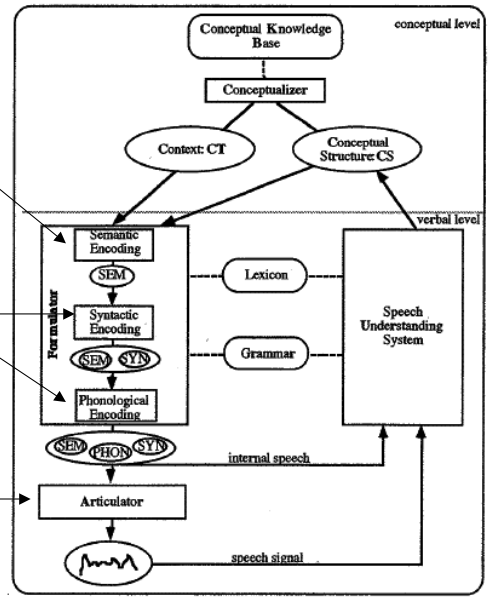


Fig. 2.1. The SYNPHONICS architecture

Encoding Information Structure

- The computation of information structure in terms of focus/background structure takes place at the interface between language independent and language specific processing units.
- In SYNPHONICS it takes place at the **semantic encoding**.
- Two subtasks are carried out to establish the focus/background structure.
  1. The information status of the increment (element) that is currently being processed is determined.
  2. The information on how the focus/background structure of the increment fits into the focus/background structure of the whole utterance.

To determine the information status of the increment it is necessary to compare the information available at CT with the propositional content of the planned utterance (CS).

Encoding Information Structure

The context representation can be seen as expressing the informational demand that the speaker wants to fulfill with the utterance. This demand originates from previous discourse through a question or any other contextual influences.

CT **CS**

The propositional content of the planned utterance. All increments that will appear in the utterance to be generated are listed here.

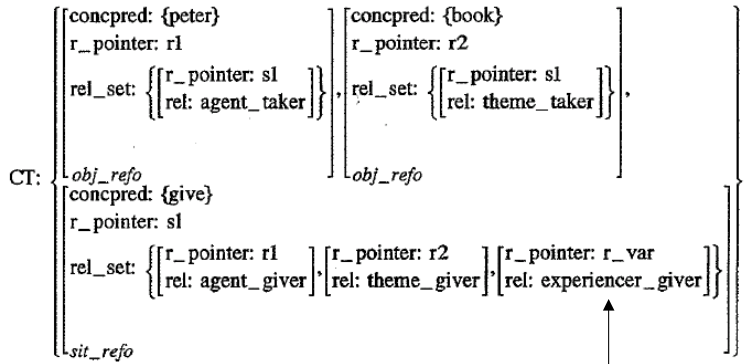
Semantic Encoding

A linguistic representation of the semantic structure from the extra linguistic elements in CT and CS.

Context Representation (1)
(CT)

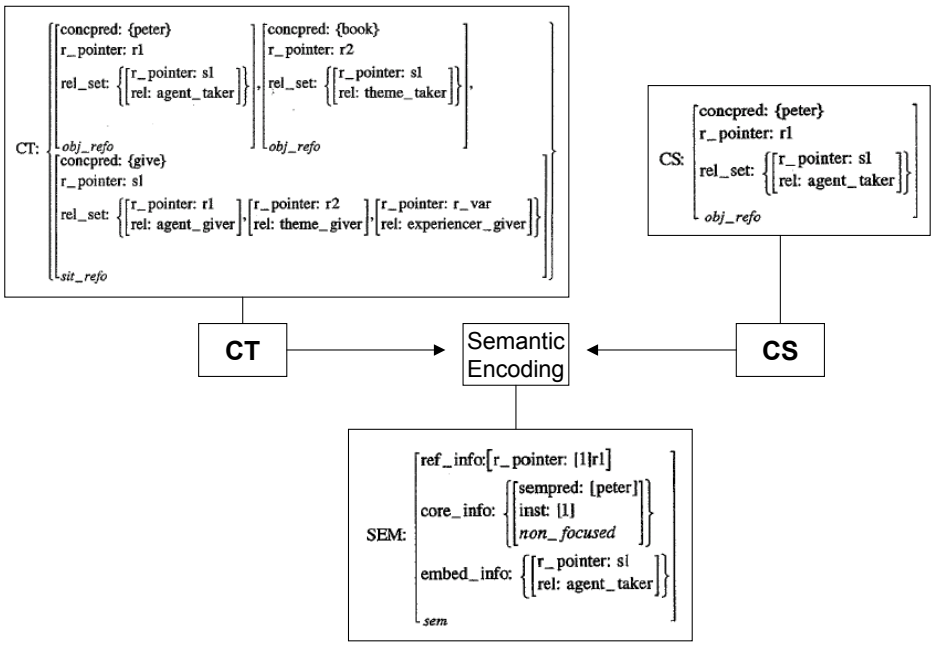
Contextual trigger (question):

A: To whom did Peter give the book ?

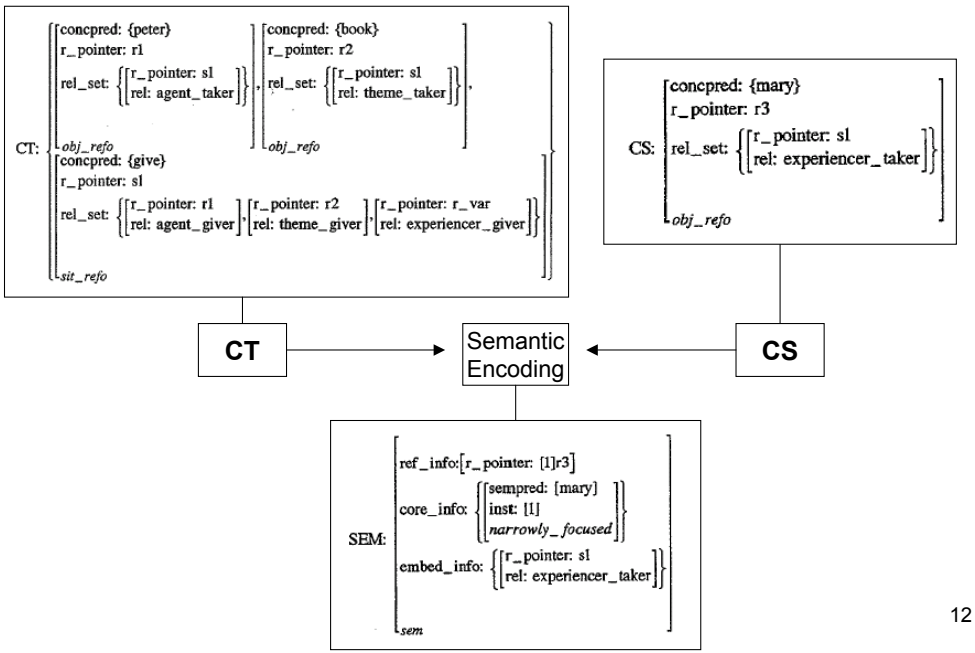


Missing element

Generating Focus/Background Structure
(Non-focused increment)



Generating Focus/Background Structure
(Narrow Focus)



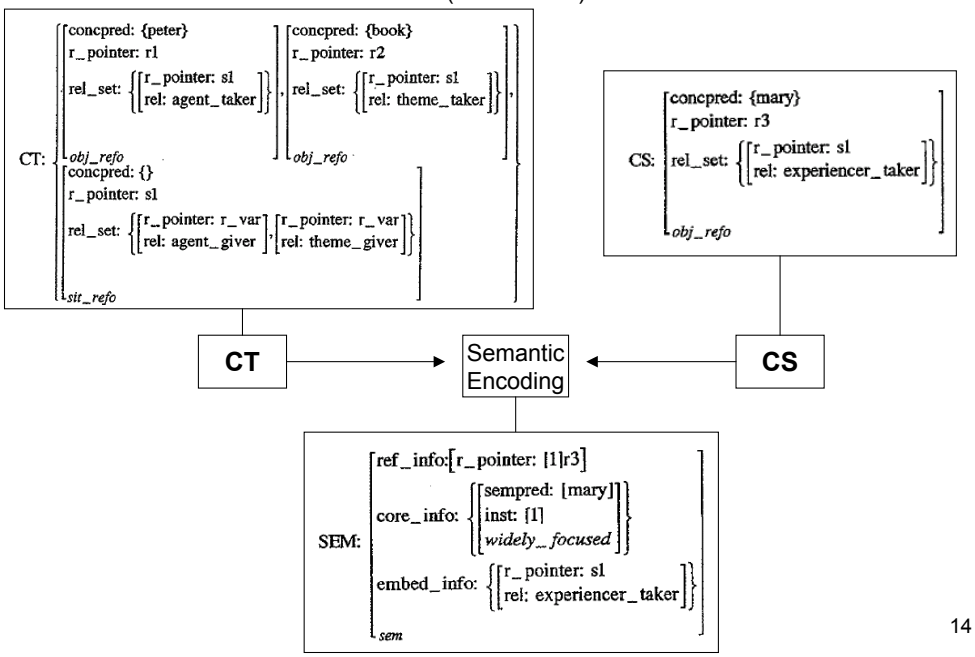
Context Representation (2)
(CT)

Contextual trigger (question):

A: What has Peter done with the book ?

CT: { [concpred: {peter}; r_pointer: r1; rel_set: {[r_pointer: s1; rel: agent_taker]}; obj_refo], [concpred: {book}; r_pointer: r2; rel_set: {[r_pointer: s1; rel: theme_taker]}; obj_refo], [concpred: {}; r_pointer: s1; rel_set: {[r_pointer: r_var; rel: agent_giver], [r_pointer: r_var; rel: theme_giver]}; sit_refo] }

Generating Focus/Background Structure
(Wide Focus)



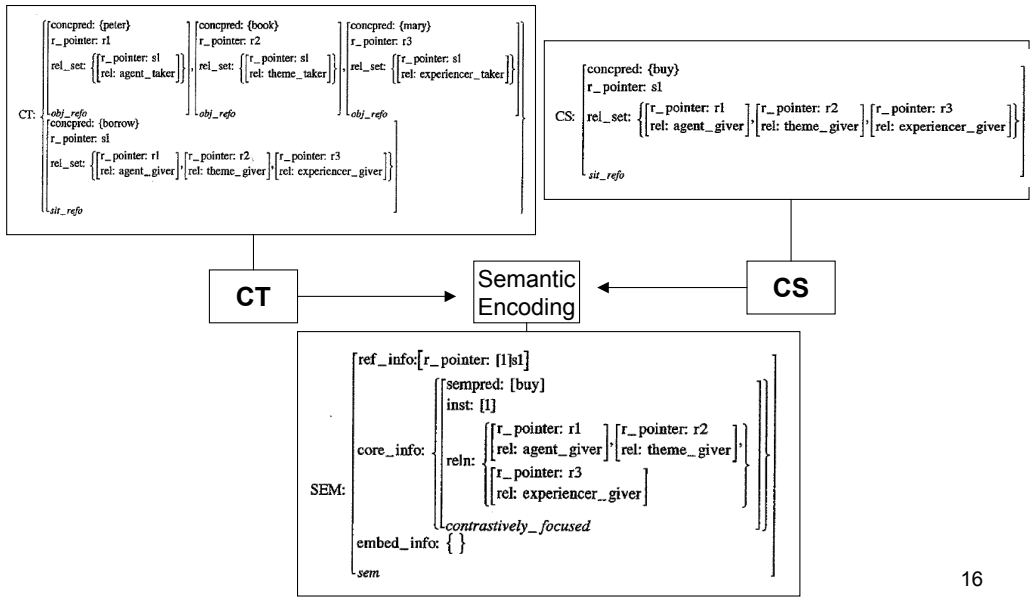
Context Representation (3)
(CT)

Contextual trigger (contrastive information):

A: Peter borrowed the book from Mary. (≠ bought)

CT: { [concpred: {peter}; r_pointer: r1; rel_set: {[r_pointer: s1; rel: agent_taker]}; obj_refo], [concpred: {book}; r_pointer: r2; rel_set: {[r_pointer: s1; rel: theme_taker]}; obj_refo], [concpred: {mary}; r_pointer: r3; rel_set: {[r_pointer: s1; rel: experiencer_taker]}; obj_refo], [concpred: {borrow}; r_pointer: s1; rel_set: {[r_pointer: r1; rel: agent_giver], [r_pointer: r2; rel: theme_giver], [r_pointer: r3; rel: experiencer_giver]}; sit_refo] }

Generating Focus/Background Structure
(Contrastive Focus)



Incremental Realization of Information Structure

• It is not possible to map semantic focus features directly onto phonetic parameters.

• An abstract prosodic rule inventory is required. It interprets focus-type information into an abstract prosodic feature representation in terms of accent pattern and accent tones. These abstract features are converted into concrete tonal, durational and intensity parameters afterwards.

• The accent placement and the corresponding tone contour on focused constituents depends on the assigned focus-type information and the argument/modifier status of the verb adjacent constituent.

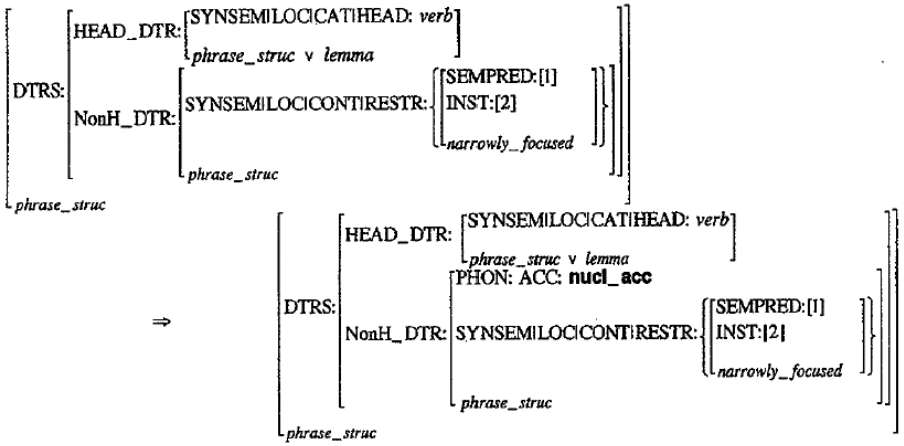
•See pages 31, 32, and 34 for examples of intonation contour.

Prosodic realization of different focus-type information for German

Semantic Focus Type	Accent Type	Pitch Accent
narrow focus	nuclear accent	accent tone: L+H* phrasal tone: L-
wide focus	prenuclear accent	accent tone: L+H*
	nuclear accent (assigned either to the verb-adjacent argument or to the verb itself)	accent tone: L+H* phrasal tone: L-
contrastive focus	contrastive accent	accent tone: L*+H phrasal tone: L-

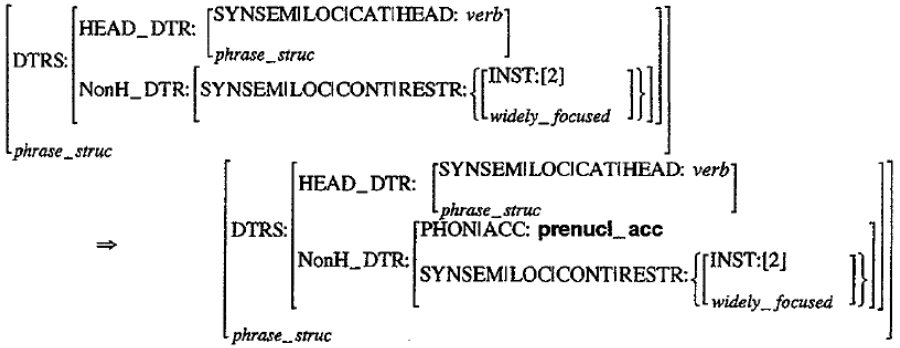
From semantics/syntax information to prosodic realization (from semantic focus to accent type)

Narrow focus accent rule:



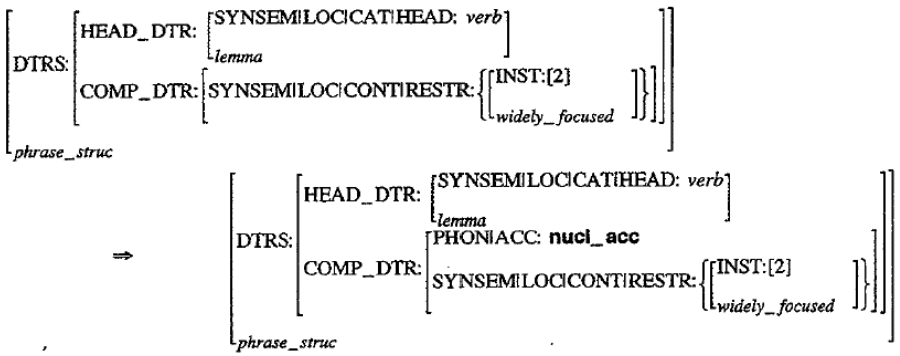
From semantics/syntax information to prosodic realization (from semantic focus to accent type)

Wide focus accent rule (for non-verb-adjacent constituents):



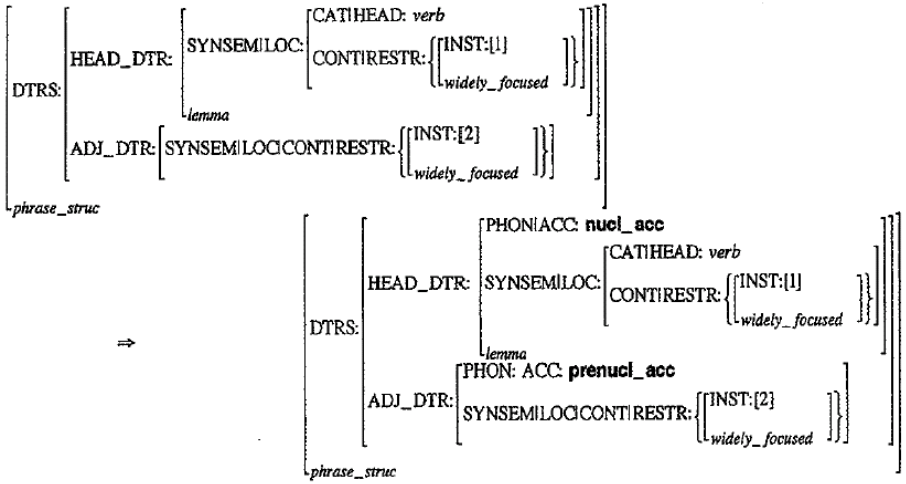
From semantics/syntax information to prosodic realization
(from semantic focus to accent type)

Wide focus accent rule (for verb-adjacent constituents):



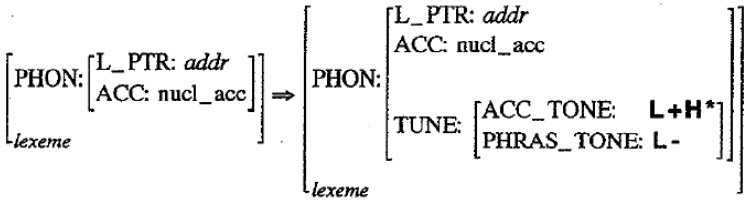
From semantics/syntax information to prosodic realization
(from semantic focus to accent type)

Wide focus accent rule (for verb-adjacent adjuncts):

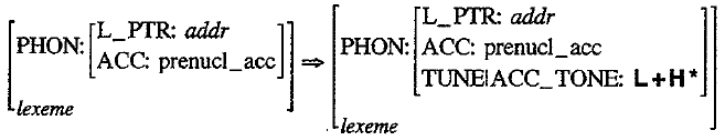


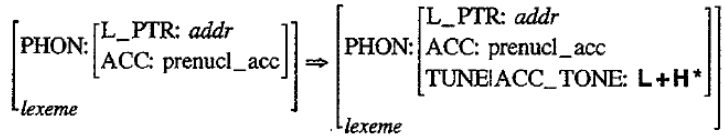
From semantics/syntax information to prosodic realization
(from accent type to pitch accent)

Nuclear accent realization rule:



Pre-nuclear accent realization rule:



From semantics/syntax information to prosodic realization
(from accent type to pitch accent)

Contrastive accent realization rule: