Aspects of Natural Language Generation and Prosody

Martin Haase

June 23, 2001

Outline

- Overview of Generation
- Document Planning
- Surface Realization
- The Role of Prosody

Scenarios/Applications

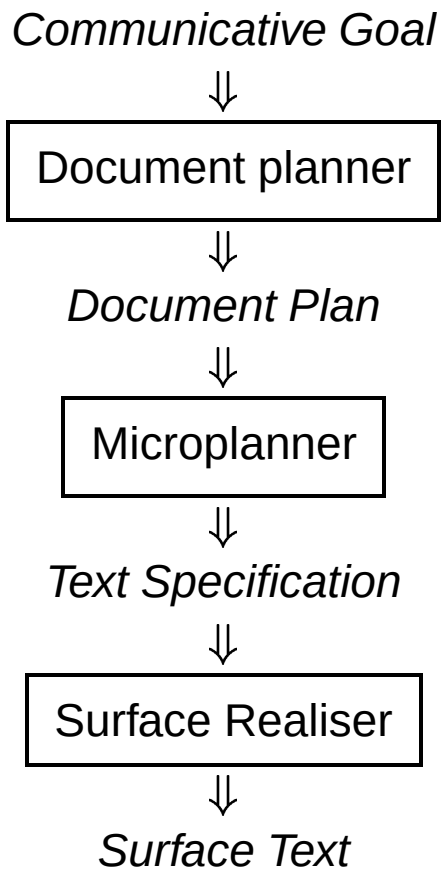
Typical NLG applications

- Natural language interface for databases
- Automatized periodical reports from date
- Expert systems, instructional guides
- Generation component in dialogue systems
- Machine translation
- Multilingual production of documents
- Summary generation in information retrieval systems

Output often confines to written text.

Newer systems: speech output, combined with graphical information (animated character, tables, pictures).

Architecture



Content task	Structure task
Content determination	Document structuring
Lexicalisation, Anaphora	Aggregation
Linguistic Realisation	Structure realisation

(after Reiter and Dale (2000))

Document Planning - Schemas

The TEXT system (McKeown, 1982)

Application: questions about structure of a database on naval vehicles

Query form (replacing a NL request):

1. (definition $< e >$)
2. (information $< e >$)
3. (difference $< e1 >< e2 >$)

Use of *schemas* as template for the response.

Identification Schema
identification (class&attribute/function) [analogy/constituency/attributive]* [particular-illustration/evidence]+ {amplification/analogy/attributive} {particular-illustration/evidence}

Example output:

(definition SHIP)

Schema selected: identification

1) identification
2) evidence
3) attributive
4) particular-illustration

1) A ship is a water-going vehicle that travels on the surface. 2) Its surface-going capabilities are provided by the DB attributes DISPLACEMENT and DRAFT. 3) Other DB attributes of the ship include MAXIMUM_SPEED, PROPULSION, FUEL [...] 4) The DOWNES, for example, has MAXIMUM_SPEED of 29, PROPULSION of STMTURGRD, FUEL of [...]

Choice of a specific schema depends 1) on the type of request and 2) on the information available in the DB on the object.

Document Planning - Rhetorical Structure Theory (RST)

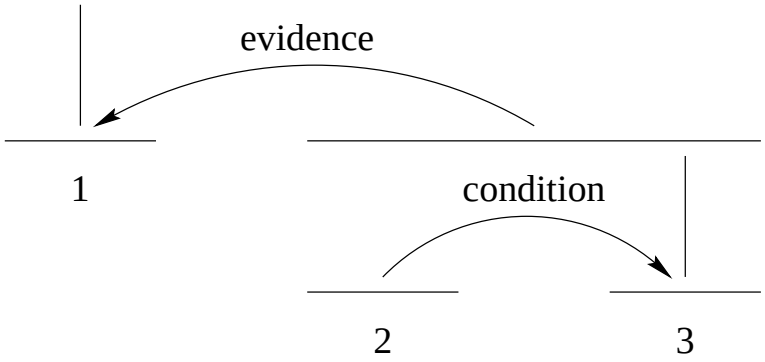
(Mann & Thompson, 1987b, 1987a)

- Initially used as a descriptive tool rather than constructive
- Description of a text by assigning *stucture* to it
- Segmentation into units ($\approx$ clauses, also smaller or larger portions of text)
- Construction of an analysis tree by determination of *rhetorical relations* that hold between units
- A rhetorical relation connects a *nucleus* with one or more *satellites*
- Decribe what writer had in mind how to influence reader's beliefs

RST - example analysis

from (Mann & Thompson, 1987b)

1. The program as published for calendar year 1980 really works.
2. In only a few minutes, I entered all the figures from my 1980 tax return
3. and got a result which agreed with my hand calculations to the penny.



RST - Relations

Circumstance	Solutionhood	Elaboration	Background
Enablement	Motivation	Evidence	Justify
Volitional Cause	Non-Volitional Cause	Volitional Result	Non-Volitional Result
Antithesis	Concession	Condition	Otherwise
Interpretation	Evaluation	Restatement	Summary
Sequence	Contrast	Purpose	. . .

An example relation definition:

relation name:	EVIDENCE
constraints on N:	R might not believe N to a degree satisfactory to W.
constraints on S:	The reader believes S or will find it credible.
constraints on the N+S combination:	R's comprehending S increases R's Belief of N
the effect:	R's belief of N is increased
locus of the effect:	N

Using RST for Text Generation

- M&T: observation of a 'canonical order' for many RST Relations
- (Mann & Thompson, 1987b) Oracles
- (Hovy, 1991) relation/plans
  - Goal-directed top-down planning of an RST Tree
  - *Growth points* for nucleus and satellite of every relation specify possible expansion of tree
- (Rösner & Stede, 1992) - generation of technical manuals.
  - Use of RST trees for microstructure of the text (relations between small clauses), schemas for macroplanning.
  - Specification of *realization patterns* for each rhetorical relation: e.g. PURPOSE $\rightarrow < N >$ "in order to" $< S >$ "." ...
  - Sentence plans as input to *Penman*.
- (Marcu, 1996): assembly of RS Tree from a DB (unordered clauses and their relations) via constraint satisfaction techniques.

Segmented DRSs (Asher, 1993)

- Extension of DRT - intended for text *analysis*
- Assign structure to a discourse representation
- SDRS - set of DRS's (and recursively SDRS's) plus a set of discourse relations holding between them.
- Fewer relations: *Continuation*(α, β), *Elaboration*(α, β), *Parallel*(α, β), *Contrast*(α, β) *Instance*(α, β), *Support*(α, β), *Explanation*(α, β), *Generalization*(α, β), *Cause*(α, β), *Purpose*(α, β), *Result*(α, β)
- DRP, (Lascarides & Asher, 1993): *Narration*(α, β), *Elaboration*(α, β), *Explanation*(α, β), *Background*(α, β), *Result*(α, β)
- considers clause-internal structure (opp. RST) $\rightarrow$ allows for statements on referent accessibility, temporal structure etc.

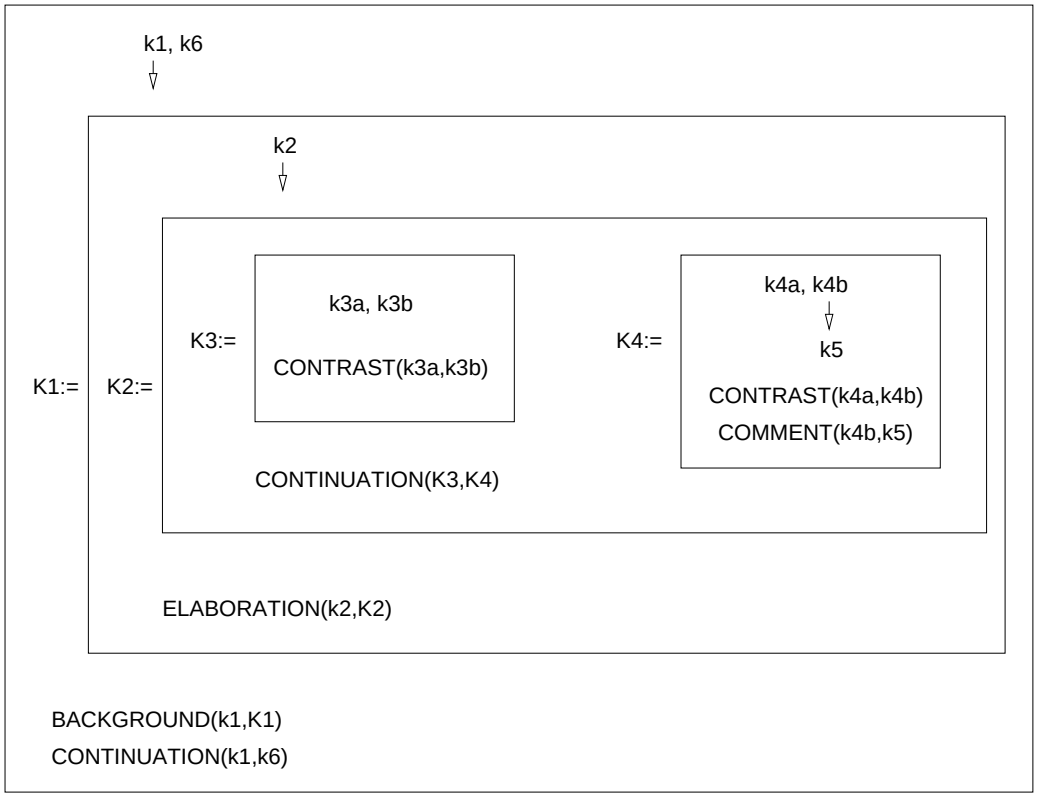
Example: “Das dicke Kind” (M. L. Kaschnitz)

from (Mayer, 1997), translation kindly provided by Antje Schweitzer

- **k1** It was the end of January, soon after Christmas holidays, when the fat child came to me.
  - **k2** That winter I had begun to give books to the children of the neighborhood. The children were supposed to get and bring them back on a specific day.
    - **k3**
      - **k3a** Of course I knew most of these children,
      - **k3b** but sometimes there were strangers who didn’t live in our street.
    - **k4**
      - **k4a** And even if the majority of them only stayed as long as the exchange took
      - **k4b** there were some who sat down and started reading right away.
    - **k5** I would sit at my desk working, and the children would sit by the little table at the bookshelf, and their presence made me feel
      pleasant and didn’t disturb me.
- **k6** The fat child came on a Friday or Saturday, in any case not on the day reserved for the handing out of the books.

SDRS Analysis

from (Mayer, 1997)



Microplanning

Sentence planning tasks (Wanner & Hovy, 1996)

- Transform (underspecified) deep semantics into more surface-oriented representations
- Lexical choice of heads for valency determination
- Sentence internal structuring: simple/hypo-/paratactical, theme/rheme/focus
- Realization of discourse relations (discourse marker, N/S ordering)
- Aggregation of parts of sentence(s)
- Realization of referring expressions

Surface Realization - Overview

- Systemic functional grammars (Penman / KPML)
- Feature unification based grammars (LFG, HPSG, DCG,)
- Approaches for incremental generation (TAG, IPF, SYNPHONICS)
- Meaning-Text Theory

Meaning-Text Theory

(Mel'čuk & Žolkovskij, 1970; Mel'čuk, 1981, 1988)

- Abstract, "formal" model of natural language
- Synthesis-oriented or neutral (vs. analysis-oriented)
- Many-to-many correspondence between *meanings* and *texts*
- $M \Leftrightarrow T$: representations and set of rules (Meaning-Text Model)

Division into intermediate representational levels:

SemR⇔DSyntR⇔SSyntR⇔DMorphR⇔SMorphR⇔DPhonR⇔SPhonR

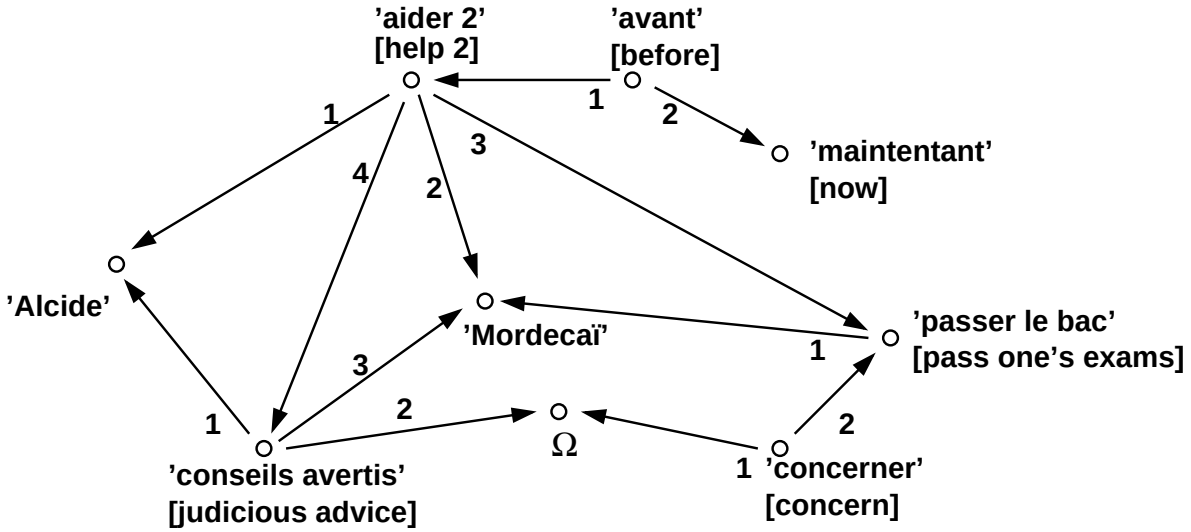
Semantics | Deep-Syntax | Surface-Syntax | Deep-Morphology | Surface-Morphology | Phonemics

MTT - example

from (Mel'čuk & Polguère, 1987)

> Alcide a aidé Mordecaï à passer son bac par ses conseils avertis.
> [Alcide helped Mordecaï pass his high school leaving exams with his judicious advice.]

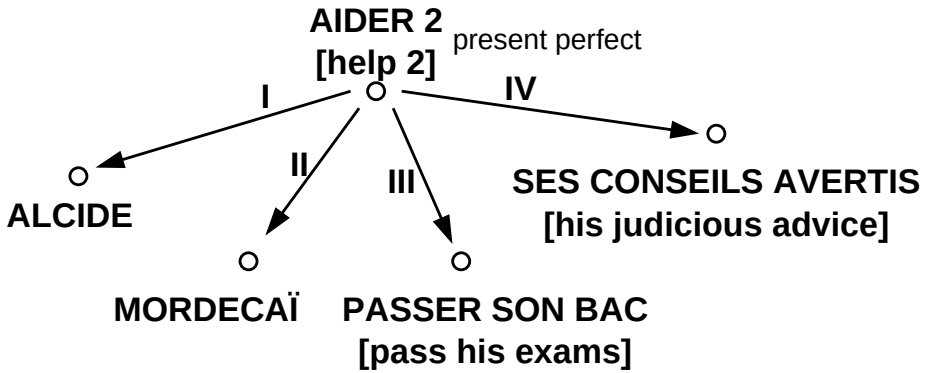
Semantic Representation (SemR):



- semantic net
- nodes: semantemes
- relations: sem. roles
- SemCommS: theme/ rheme
- RhetS: formality, style

Deep Syntactic Representation (DSyntR):

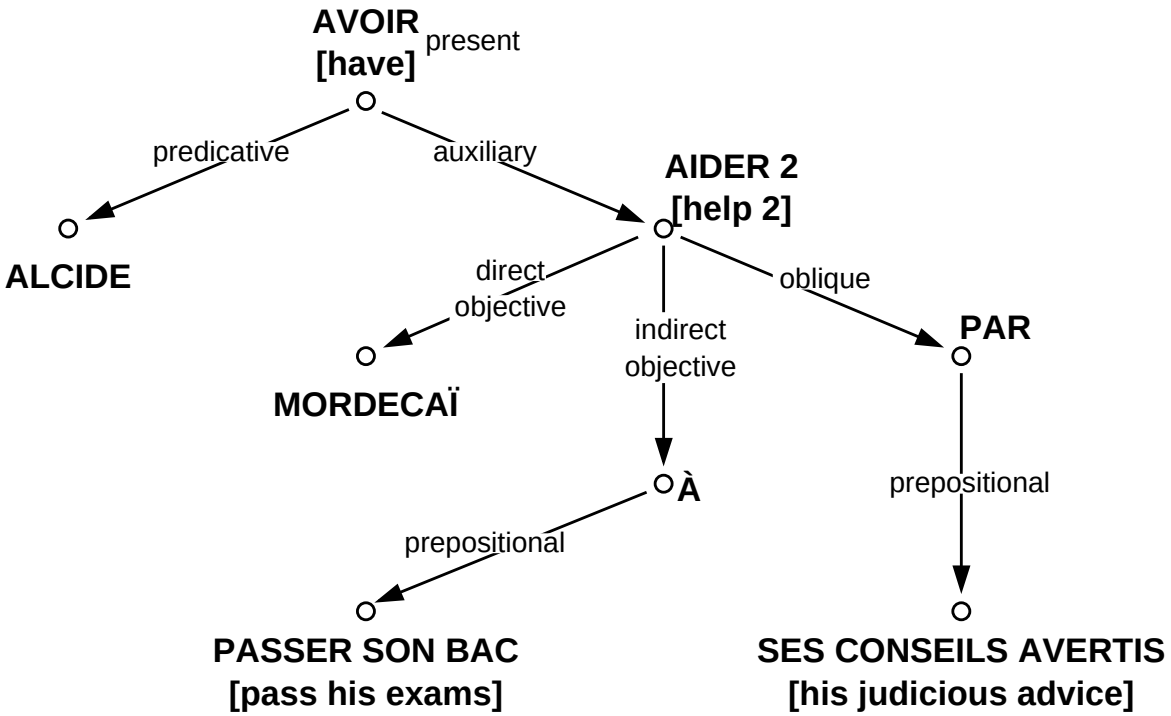
- linearly unordered *dependency* tree
- nodes: “generalized lexemes”, roughly semantically non-empty lexemes
- “language-independend” relations between nodes (I..VI, ATTR, COORD, APPEND)



- DSynt-CommS
- DSynt-AnaphS
- DSynt-ProsS

Surface Syntactic Representation (SSyntR):

- nodes: “actual lexemes”
- language-specific relations



following: DMorphR, SMorphR, DPhonR, SPhonR (linear levels)

The Role of Prosody

- Pitch, intensity, duration
- Factors
  - extra-linguistic: emotions, hurry, . . .
  - discourse/pragmatics: register choice, pause length
  - semantics: contrastive accent, focal scope
  - syntax: neutral sentence accent, sentence mood, final lengthening
  - morphology/phonology: word stress
- Descriptive study vs. integration in a generation system

Influence from Discourse

from (Mayer, 1997)

Results from an SDRS-segmented discourse read by one Speaker

- Correlation of pause length between constituents and their embedding difference
- Choice of registers for intonation phrases depends upon the specific relations
  - Background and Evaluation trigger l-modification before constituent boundary
  - After a recursive embedding sequence (topic reset): l-modification followed by hl-modification
  - h-modification of first phrase in double d-dominated segment (sub-topic)
  - Contrast triggers l-modification of initial phrases

Information structure

(Steedman, 2000)

- *theme*: that part of an utterance which connects it to the rest of the discourse (topic, given) $\rightarrow$ rise-fall-rise tune, L+H* LH%
- *rheme*: what is communicated about the theme (comment/focus, new) $\rightarrow$ rise-fall tune, H*L, H* LL%
- *focus*: information marked by pitch accent within theme or rheme (vs. *background*)

Example with contrastive focus (from Prevost (1996))

Q: I know the AMERICAN amplifier produces MUDDY treble,
Q1: but WHAT does the BRITISH amplifier produce?
A1: (The BRITISH amplifier produces)$_{th}$ (CLEAN treble.)$_{rh}$
L+H* LH% H* LL$
Q2: but WHAT produces CLEAN treble?
A2: (The BRITISH amplifier)$_{rh}$ (produces CLEAN treble.)$_{th}$
H* LL% L+H* LH$

Prosody integration in existing systems

- SPEAK! (Teich, Hagen, Grote, & Bateman, 1997)
  - system in the Penman/KPML tradition, dialogue system for database enquiries
  - uniform realization of intonation as part of grammar
  - assigns complete (meaningful) tone groups to prosodic phrases based on sentence mood, dialogue move type and value, speaker's attitude towards the message etc.
- SYNPHONICS (Abb, Günther, Herweg, Lebeth, Maienborn, & Schopf, 1996; Günther, 1999)
  - Generation component: formulator in style of Levelt's model
  - HPSG-based generation, accepting fragmentary conceptual input
  - Prosodic planning also incremental, building on abstract accent structure specification from focus structure
- FOGS (Endriss & Klabunde, 2000)
  - Sentence planning using DRSs
  - Computation of focus structure based on *referential movements*
  - Integrated planning of word order and prosodic structure

Summary

- Theoretical questions
  - Integration of both discourse relations and information structure in NLG for prosodic planning
  - Exploit internal structure of SDRSs
  - Spoken discourse?
- Practical consideratons
  - Resources for a NLG system
  - Example domain
  - Model ‘world knowledge’
  - A corpus; automatical extraction of representations desirable

*References

Abb, B., Günther, C., Herweg, M., Lebeth, K., Maienborn, C., & Schopf, A. (1996). Incremental grammatical encoding - an outline of the synphonics formulator. In Adorni, G. & Zock, M. (Eds.), *Trends in Natural Language Generation - An Artificial Intelligence Perspective*. Springer. Selected Papers of the 4th European Workshop, EWNLG'93, Pisa.

Asher, N. (1993). *Reference to Abstract Objects in Discourse*. Kluwer Academic Publishers.

Endriss, C. & Klabunde, R. (2000). Planning word-order dependend focus assignment. In *Proc. 1st Int. Conf. on Natural Language Generation (INLG'2000), Mizpe Ramon, Israel*.

Günther, C. (1999). *Prosodie und Sprachproduktion*. No. 401 in Linguistische Arbeiten. Niemeyer, Tübingen.

Hovy, E. H. (1991). Approaches to the planning of coherent text. In Paris, C. L., Swartout, W. R., & Mann, W. C. (Eds.), *Natural Language Generation in Artificial Intelligence and Computational Linguistics*. Kluwer Academic Publishers. 4th Int. Workshop on NLG, sel. papers.

Lascarides, A. & Asher, N. (1993). Temporal interpretation, discourse relations and commonsense entailment. *Linguistics and Philosophy*, *16*, 437–493.

Mann, W. C. & Thompson, S. A. (1987a). Rhetorical structure theory: a theory of text organziation. Tech. rep. RS-87-190, Information Sciences Institute, Univ. Southern Calif.

Mann, W. C. & Thompson, S. A. (1987b). Rhetorical structure theory: description ans construction of text structures. In Kempen, G. (Ed.), *Natural Language Generation: New Results in Artificial Intelligence, Psychology and Linguistics*. Martinus Nijhoff Publishers, Dordrecht.

Marcu, D. (1996). Building up rhetorical structure trees. In *Proc. of 13th Nat. Conf. on Artificial Intelligence (AAAI-96)*, pp. 1069–1074.

Mayer, J. (1997). *Intonation und Bedeutung*. Dissertation, Universität Stuttgart, Institut für Maschinelle Sprachverarbeitung.

McKeown, K. R. (1982). The text sytem for natural language generation: an overview. In *Proc. 20th Ann. Meeting of the Ass. of Comp. Ling., Toronto*.

Mel'čuk, I. A. (1981). 'meaning-text' models: a recent trend in soviet linguistics. *Annual Review of Anthropology*, *10*, 27–62.

Mel'čuk, I. A. (1988). *Dependency Syntax: Theory and Practice*. State University of New York Press, Albany, NY.

Mel'čuk, I. A. & Polguère, A. (1987). A formal lexicon in the meaning-text theory (or how to do lexica with words). *Computational Linguistics*, *13*(3-4), 261–275.

Mel'čuk, I. A. & Žolkovskij, A. K. (1970). Towards a functioning 'meaning-text' model of language. *Linguistics*, *57*, 10–47.

Prevost, S. (1996). An information structural approach for spoken language generation. In *Proc. 34th Ann. Meeting of the ACL, Santa Cruz*, pp. 294–301.

Reiter, E. & Dale, R. (2000). *Building Natural Language Generation Systems*. Studies in Natural Language Processing. Cambridge University Press.

Rösner, D. & Stede, M. (1992). Customizing rst for the automatic production of technical manuals. In Dale, R., Hovy, E., Rösner, D., & Stock, O. (Eds.), *Aspects of Automated Natural Language Generation*, Lecture Notes in Artificial Intelligence. Springer. Papers from 6th Int. Workshop on NLG.

Steedman, M. (2000). Information structure and the syntax-phonology-interface. *Linguistic Inquiry*, *31*(4), 649–689.

Teich, E., Hagen, E., Grote, B., & Bateman, J. (1997). From communicative context

to speech: integrating dialogue processing, speech production and natural language generation. *Speech Communication*, *21*, 73–99.

Wanner, L. & Hovy, E. (1996). The healthdoc sentence planner. In *Proc. 8th International Workshop on Natural Language Generation, Brighton*.