Deep Linguistic Analysis, Interfaces and World Knowledge

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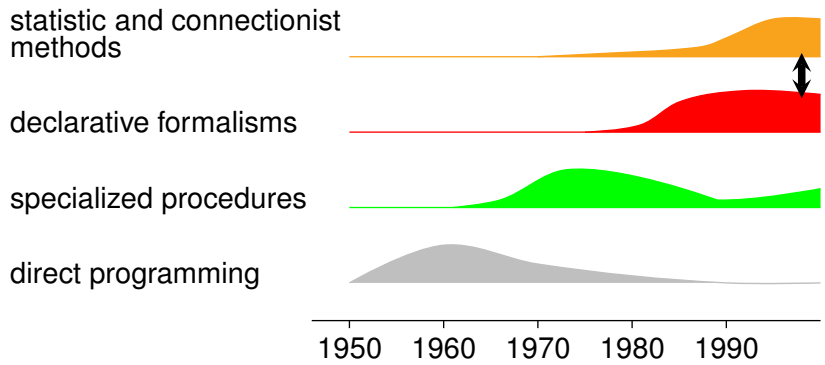
Symposium “The Semantics of Action”, Göttingen, 2013

Different Approaches (Uszkoreit, 2001)



On statistics and deep processing see:
Church, 2011; Kay, 2011; Steedman, 2011, speech: Kaufmann, 2009

Constraint-Based Grammar

- Constraint-based grammars were developed as an alternative to generative grammars.
- Frameworks: GPSG, LFG, HPSG, and CxG
  (with the respective basic assumptions)
- Some of these frameworks started out as generative grammars, but the underlying assumptions changed in the mid of the 90s.
- Example for a constraint on English sentences:

  (1) a. Kim loves Sandy.
  b. * I loves Sandy.

  The subject has to agree with the verb in person and number.
- Constraint-based view: If nothing is said, everything goes.
  See Pullum and Scholz, 2001 for consequences of this view.

The Framework

- the framework: Head-Driven Phrase Structure Grammar (HPSG)
  (Pollard and Sag, 1987, 1994; Müller, 2007).
- Since Sag, 1997 this is compatible with basic insights from Construction Grammar (CxG).
- Since it is a constraint-based grammar nowadays,
  it is not a phrase structure grammar.
- The framework allows for and uses headless constructions
  (Müller, 1999, Chapter 10).
  Since there are headless constructions, it is not always head-driven.
- Recent development Sign-based CxG (Sag, 2007, 2010).
- Embodied CxG (Bergen and Chang, 2005) can be reformulated as a HPSG (see Müller, 2010a, Chapter 9.6.2).
- Minimalist Grammars correspond to the main schemata in HPSG
  (Müller, To appear)

Basic Ingredients: Features and Values

- To describe language we need only three things:
  - features
  - values
  - identities between values
- Values can be simple or complex:

FIRST NAME	*max*
SURNAME	*meier*
BIRTHDAY	*10.10.1985*
FATHER	FIRST NAME *peter* SURNAME *meier* BIRTHDAY *10.05.1960* FATHER ... MOTHER ...
MOTHER	...

Types

- In addition we have types:

FIRST NAME	*max*
SURNAME	*meier*
BIRTHDAY	*10.10.1985*
FATHER	FIRST NAME *peter* SURNAME *meier* BIRTHDAY *10.05.1960* FATHER ... MOTHER ... ***person***
MOTHER	...
person	

- Types define which features belong to a description of certain objects.
- Types are organized in hierarchies → generalizations over all kinds of linguistic objects

Heads and Arguments

- Basic aspects of the sentence structure are determined by the verb.

  (2) a. Peter sleeps.
  b. Peter likes Maria.
  c. Peter talks about the financial crises.

- The verb is called head.
  The non-verbal elements in (2) are arguments of the verb.

Valence Representations

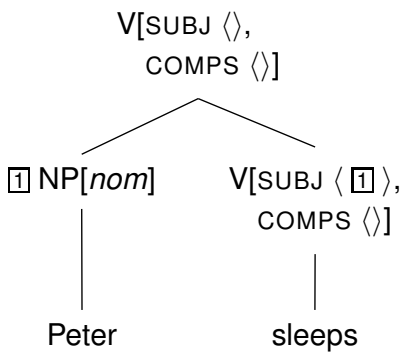
- Descriptions of lexemes contain a list with descriptions of the syntactic and semantic properties of their arguments.

(3)

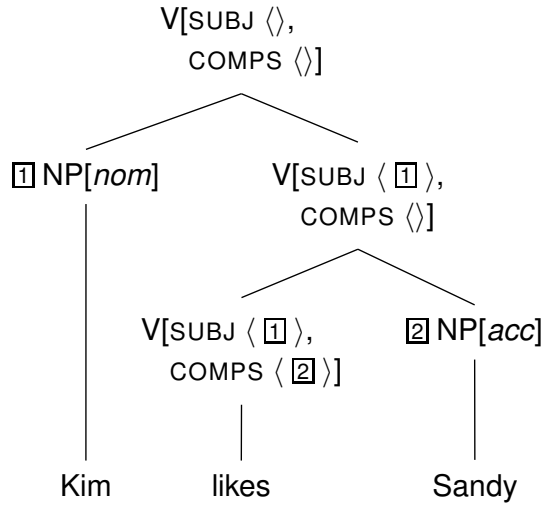
Verb	ARG-ST	SUBJ	COMPS
sleeps	⟨ NP[*nom*] ⟩	⟨ NP[*nom*] ⟩	⟨ ⟩
likes	⟨ NP[*nom*], NP[*acc*] ⟩	⟨ NP[*nom*] ⟩	⟨ NP[*acc*] ⟩
talks	⟨ NP[*nom*], PP[*about*] ⟩	⟨ NP[*nom*] ⟩	⟨ PP[*about*] ⟩

- For English, the ARG-ST list is mapped onto two valence features: SUBJ and COMPS.

An Intransitive Sentence

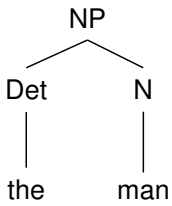


A Transitive Sentence



Constituent Structure

- Remember that I claimed that we need features and values only? So what are these trees?

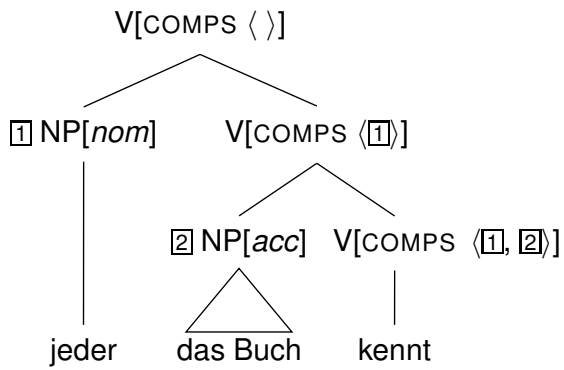


(4)
$$\begin{bmatrix} \text{PHON} & \langle\, \textit{the man} \,\rangle \\ \text{HEAD-DTR} & \begin{bmatrix} \text{PHON} & \langle\, \textit{man} \,\rangle \end{bmatrix} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{PHON} & \langle\, \textit{the} \,\rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

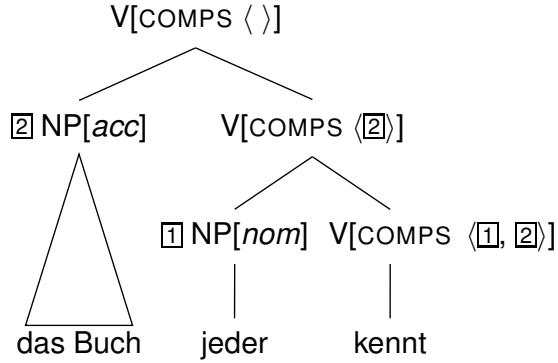
Languages with free(er) constituent order

- languages like German and Persian:
  all arguments (of finite verbs) represented under COMPS.
- An arbitrary element from the list can be combined with the head.

(5) [weil] jeder das Buch kennt (SOV)
because everybody.NOM the book.ACC knows
'because everybody knows the book'



(6) [weil] das Buch jeder kennt (OSV)
because the book.ACC everybody.NOM knows



Demo: Valence, Head Features, and Order

Grammar 4:

(7) der Mann die Frau kennt
the man.NOM the woman.ACC knows

Grammar 9:

(8) a. der Mann der Frau das Buch gibt
the man.NOM the woman.DAT the book.ACC gives

b. der Mann das Buch der Frau gibt
the man.NOM the book.ACC the woman.DAT gives

Semantics: Nominal Objects

- The meaning of *dog* is usually represented as:

  (9) λ x *dog'*(x)

- Features and values (Copestake, Flickinger, Pollard and Sag, 2005):

(10)
$$\begin{bmatrix} \text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & 3 \\ \text{NUM} & sg \\ & index \end{bmatrix} \\ \text{RELS} & \left\langle \begin{bmatrix} \text{INST} & \boxed{1} \\ dog & \end{bmatrix} \right\rangle \\ mrs & \end{bmatrix}$$

$\boxed{1}$ is a referential index (person, number(, gender) for pronoun binding).
RELS is a list of restrictions.

Semantics: Verbal Objects

- Menaing of *chase* with an event variable:

  (11) λ y λ x λ e *chase*′(e,x,y)

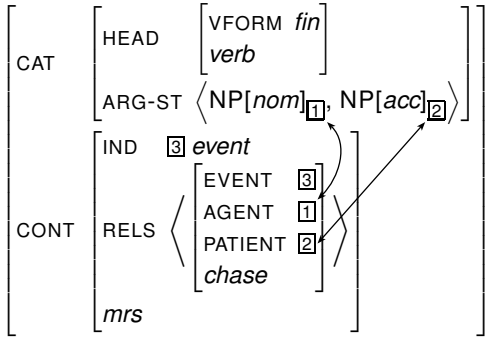
- Features and values:

(12)
$$\begin{bmatrix} \text{IND} & \boxed{1}\ \textit{event} \\ \text{RELS} & \left\langle \begin{bmatrix} \text{EVENT} & \boxed{1} \\ \text{AGENT} & \textit{index} \\ \text{PATIENT} & \textit{index} \\ \textit{chase} \end{bmatrix} \right\rangle \\ \textit{mrs} \end{bmatrix}$$

Linking

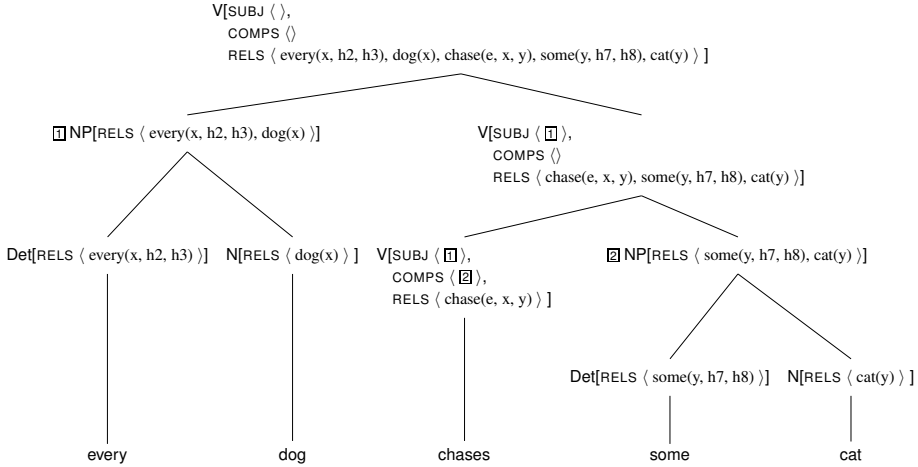
- Linking of valency information and semantic contribution

(13) *chase*:



- referential indices of NPs are identified with the semantic roles.

Composition (Simplified)



Minimal Recursion Semantics: Copestake, Flickinger, Pollard and Sag, 2005

Demo: Scope and Underspecification

Dowty, 1979, Section 5.6 on *again*, Egg (1999) on (14):

(14) a. dass Max wieder alle Fenster öffnete
that Max again all windows opend
'that Max opened all windows again'

b. *again*′(∀(CAUSE(open))); repetitiv

c. *again*′(CAUSE(∀(open))); repetitiv

d. CAUSE(*again*′(∀(open))); restitutiv

Selectional Restrictions

- Ambiguous or not?

  (15) Das Buch liest das Kind.
  the book reads the child

- *read* requires an animate (human?) subject.
- Welformed or not?

  (16) Peter isst einen Stein.
  Peter eats a stone

- We can exclude it, but:

  (17) Peter isst keine Steine, denn Steine kann man nicht essen.

- Ontological constraints may be violated under negation.

World Knowledge and Grammar

- Boas (2003) discusses resultative constructions like (18):

  (18) But most of the dogs were unhappy and would bark themselves hoarse. (BNC)

- Suggests an analysis in which lexical items contain world knowledge to rule out (19):

  (19) * The dog barked the postman hoarse.

- But what about (20)?

  (20) # The dog barked and as a result of this the postman became hoarse.

  For (20) we need the full machinery with inferences and so on anyway (Müller, 2005).

Worldknowledge and Grammar

Event-based frame semantic representation of the prototypical sense of *melt*

GOAL
(Ag)
Pt (p3)

Ag: Entity exerting energy that can lead objects to liquefy
Pt: Object that warms up and/or liquefies as the result of energy being applied to it
p3: SYN: PP
SEM: denoting the end result state (or end location of a path) of a mass that has been liquefied by heat

According to Boas, p3 is provided by world knowledge.

More on World Knowledge

(21) a. Dann erzählt Juliane Lumumba von den Tonbändern im Archiv, die wegen fehlender Klimaanlage in der tropischen Hitze zu einer schwarzen Masse schmolzen.[1]

b. Dann ging mal das Schreibpapier aus oder die bestellte Ladung Kerzen war zu Wachs geschmolzen, ehe sie den Hafen erreicht hatte.[2]

c. Erz wird „direkt“ zu Eisenschwamm reduziert, der dann zu flüssigem Roheisen geschmolzen wird.[3]

[1] Frankfurter Rundschau, 05.08.1997, p. 3.
[2] Frankfurter Rundschau, 028.02.1998, p. 8.
[3] Die Presse, 11.01.1992; Voest will vom Staat acht Milliarden Schilling.

World Knowledge and Melting Points

Why is a sentence like (22) strange?

(22) # Dann erzählt Juliane Lumumba von den Stahlträgern im Archiv, die wegen fehlender Klimaanlage in der tropischen Hitze zu einer schwarzen Masse schmolzen.

Summary and Outlook

- Sketch of a constraint-based theory
- Syntax and semantics are treated in the same structure and are linked
- syntactic and semantic (and other constraints) are unordered
- World knowledge should be separate but linked. Complex inference mechanisms are needed.
- Processing procedures should be separate from linguistic knowledge.
- Currently in Berlin: German, Persian, Chinese, Maltese, Danish, ...
- Grammars use the same "core" → generalizations over properties that are shared by several languages. (Müller, 2013)
- Approach different from general MGG approach:
  We start with the individual languages and search for generalizations.

Bergen, Benjamin K. and Chang, Nancy. 2005. Embodied Construction Grammar in Simulation-Based Language Understanding. In Jan-Ola Östman and Mirjam Fried (eds.), *Construction Grammars: Cognitive Grounding and Theoretical Extensions*, pages 147–190, Amsterdam/ Philadelphia: John Benjamins Publishing Co.

Bierwisch, Manfred. 1963. *Grammatik des deutschen Verbs*. studia grammatica, No. 2, Berlin: Akademie Verlag.

Boas, Hans Christian. 2003. *A Constructional Approach to Resultatives*. Stanford Monographs in Linguistics, Stanford, CA: CSLI Publications.

Church, Kenneth. 2011. A Pendulum Swung Too Far. *Linguistic Issues in Language Technology* 6(5), special Issue on Interaction of Linguistics and Computational Linguistics. http://elanguage.net/journals/index.php/lilt/issue/view/330, 05.12.2011.

Copestake, Ann, Flickinger, Daniel P., Pollard, Carl J. and Sag, Ivan A. 2005. Minimal Recursion Semantics: an Introduction. *Research on Language and Computation* 4(3), 281–332. http://lingo.stanford.edu/sag/papers/ copestake.pdf, 11.10.2006.

Croft, William. 2001. *Radical Construction Grammar. Syntactic Theory in Typological Perspective*. Oxford University Press.

Davis, Anthony R. 1996. *Lexical Semantics and Linking in the Hierarchical Lexicon*. Ph. D.thesis, Stanford University.

Dowty, David R. 1979. *Word Meaning and Montague Grammar*. Synthese Language Library, No. 7, Dordrecht/ Boston/London: D. Reidel Publishing Company.

Egg, Markus. 1999. Derivation and Resolution of Ambiguities in *wieder*-Sentences. In Paul J. E. Dekker (ed.), *Proceedings of the 12th Amsterdam Colloquium*, pages 109–114.

Gazdar, Gerald, Pullum, Geoffrey K., Carpenter, Bob, Klein, Ewan, Hukari, Thomas E. and Levine, Robert D. 1988. Category Structures. *Computational Linguistics* 14(1), 1–19.

Goldberg, Adele E. 1995. *Constructions. A Construction Grammar Approach to Argument Structure*. Cognitive Theory of Language and Culture, Chicago/London: The University of Chicago Press.

Goldberg, Adele E. 2006. *Constructions at Work. The Nature of Generalization in Language*. Oxford Linguistics, Oxford, New York: Oxford University Press.

Kaplan, Ronald M. 1995. The Formal Architecture of Lexical-Functional Grammar. In Mary Dalrymple, Ronald M. Kaplan, John T. Maxwell III and Annie Zaenen (eds.), *Formal Issues in Lexical-Functional Grammar*, CSLI Lecture Notes, No. 47, pages 7–27, Stanford, CA: CSLI Publications. http://www.sx.ac.uk/linguistics/external/LFG/ www-lfg.stanford.edu/pubs/papers/kaplan/ kaplan-1989-0000.pdf, 09.04.2013.

Kaufmann, Tobias. 2009. *A Rule-based Language Model for Speech Recognition*. Ph. D.thesis, Computer Engineering and Networks Laboratory, ETH Zürich.

Kay, Martin. 2011. Zipf's Law and *L'Arbitraire du Signe*. *Linguistic Issues in Language Technology* 6(8), special Issue on Interaction of Linguistics and Computational Linguistics. http://elanguage.net/journals/index.php/lilt/ issue/view/330, 05.12.2011.

Kay, Paul and Fillmore, Charles J. 1999. Grammatical Constructions and Linguistic Generalizations: the What's X Doing Y? Construction. *Language* 75(1), 1–33.

King, Paul. 1999. Towards Truth in Head-Driven Phrase Structure Grammar. In Valia Kordoni (ed.), *Tübingen Studies in Head-Driven Phrase Structure Grammar*, Arbeitsberichte des SFB 340, No. 132, pages 301–352, Tübingen: Universität Tübingen. http://www.sfs. uni-tuebingen.de/sfb/reports/berichte/132/132abs.html, 12.10.2006.

Müller, Stefan. 1999. *Deutsche Syntax deklarativ. Head-Driven Phrase Structure Grammar für das Deutsche*. Linguistische Arbeiten, No. 394, Tübingen: Max Niemeyer Verlag. http:// hpsg.fu-berlin.de/~stefan/Pub/hpsg.html, 11.06.2013.

Müller, Stefan. 2005. Resultative Constructions: Syntax, World Knowledge, and Collocational Restrictions. Review of Hans C. Boas: A Constructional Approach to Resultatives. *Studies in Language* 29(3), 651–681. http://hpsg.fu-berlin. de/~stefan/Pub/boas2003.html, 11.06.2013.

Müller, Stefan. 2006. Phrasal or Lexical Constructions? *Language* 82(4), 850–883. http://hpsg.fu-berlin.de/~stefan/ Pub/phrasal.html, 11.06.2013.

Müller, Stefan. 2007. *Head-Driven Phrase Structure Grammar: Eine Einführung*. Stauffenburg Einführungen, No. 17, Tübingen: Stauffenburg Verlag, first edition. http://hpsg. fu-berlin.de/~stefan/Pub/hpsg-lehrbuch.html, 11.06.2013.

Müller, Stefan. 2009a. A Head-Driven Phrase Structure Grammar for Maltese. In Bernard Comrie, Ray Fabri, Beth Hume, Manwel Mifsud, Thomas Stolz and Martine Vanhove (eds.), *Introducing Maltese Linguistics. Papers from the 1st International Conference on Maltese Linguistics (Bremen/Germany, 18–20 October, 2007)*, Studies in Language Companion Series, No. 113, pages 83–112, Amsterdam/Philadelphia: John Benjamins Publishing Co. http://hpsg.fu-berlin.de/~stefan/Pub/maltese-sketch.html, 11.06.2013.

Müller, Stefan (ed.). 2009b. *Proceedings of the 16th International Conference on Head-Driven Phrase Structure Grammar, University of Göttingen, Germany*, Stanford, CA, CSLI Publications.

Müller, Stefan. 2010a. *Grammatiktheorie*. Stauffenburg Einführungen, No. 20, Tübingen: Stauffenburg Verlag. http://hpsg.fu-berlin.de/~stefan/Pub/grammatiktheorie.html, 11.06.2013.

Müller, Stefan. 2010b. Persian Complex Predicates and the Limits of Inheritance-Based Analyses. *Journal of Linguistics* 46(3), 601–655. http://hpsg.fu-berlin.de/~stefan/

Pub/persian-cp.html, 11.06.2013.

Müller, Stefan. 2013. The CoreGram Project: Theoretical Linguistics, Theory Development and Verification. Ms. Freie Universität Berlin. http://hpsg.fu-berlin.de/~stefan/Pub/coregram.html, 11.06.2013.

Müller, Stefan. To appear. Unifying Everything: Some Remarks on Simpler Syntax, Construction Grammar, Minimalism and HPSG. *Language* . http://hpsg.fu-berlin.de/~stefan/Pub/unifying-everything.html, 11.06.2013.

Ørsnes, Bjarne. 2009. Preposed Negation in Danish. In Müller (2009b), pages 255–275.

Pollard, Carl J. 1999. Strong Generative Capacity in HPSG. In Gert Webelhuth, Jean-Pierre Koenig and Andreas Kathol (eds.), *Lexical and Constructional Aspects of Linguistic Explanation*, Studies in Constraint-Based Lexicalism, No. 1, pages 281–298, Stanford, CA: CSLI Publications.

Pollard, Carl J. and Sag, Ivan A. 1987. *Information-Based Syntax and Semantics*. CSLI Lecture Notes, No. 13, Stanford, CA: CSLI Publications.

Pollard, Carl J. and Sag, Ivan A. 1994. *Head-Driven Phrase Structure Grammar*. Studies in Contemporary Linguistics, Chicago, IL/London: The University of Chicago Press.

Pullum, Geoffrey K. and Scholz, Barbara C. 2001. On the Distinction between Generative-Enumerative and Model-Theoretic Syntactic Frameworks. In Philippe de Groote, Glyn Morrill and Christian Retor (eds.), *Logical Aspects of Computational Linguistics: 4th International Conference*, Lecture Notes in Computer Science, No. 2099, pages 17–43, Berlin/Heidelberg/New York, NY: Springer Verlag.

Richter, Frank and Sailer, Manfred. 2009. Phraseological Clauses as Constructions in HPSG. In Müller (2009b), pages 297–317.

Rogers, James. 1997. "Grammarless" Phrase Structure Grammar. *Linguistics and Philosophy* 20, 721–746.

Sag, Ivan A. 1997. English Relative Clause Constructions. *Journal of Linguistics* 33(2), 431–484. http://lingo.stanford.edu/sag/papers/rel-pap.pdf, 30.05.2004.

Sag, Ivan A. 2007. Remarks on Locality. In Stefan Müller (ed.), *Proceedings of the 14th International Conference on Head-Driven Phrase Structure Grammar*, pages 394–414, Stanford, CA: CSLI Publications. http://cslipublications.stanford.edu/HPSG/8/, 29.07.2007.

Sag, Ivan A. 2010. English Filler-Gap Constructions. *Language* 86(3), 486–545. http://lingo.stanford.edu/sag/papers/xcons.pdf, 08.07.2009.

Steedman, Mark J. 2011. Romantics and Revolutionaries. *Linguistic Issues in Language Technology* 6(11), special Issue on Interaction of Linguistics and Computational Linguistics. http://elanguage.net/journals/index.php/lilt/issue/view/330, 05.12.2011.

Steels, Luc (ed.). 2011. *Design Patterns in Fluid Construction Grammar*. Constructional Approaches to Language, No. 11, Amsterdam/Philadelphia: John Benjamins Publishing Co.

Steels, Luc (ed.). 2012. *Computational Issues in Fluid Construction Grammar*. Lecture Notes in Computer Science, No. 7249, Berlin/Heidelberg/New York, NY: Springer Verlag.

Steels, Luc and Beule, Joachim De. 2006. A (very) Brief Introduction to Fluid Construction Grammar. Paper presented at the Third International Workshop on Scalable Natural Language Understanding (ScaNaLU 2006) June 8, 2006, following HLT/NAACL, New York City. http://arti.vub.ac.be/~joachim/acl-ny-06-3.pdf, 03.02.2008.

Tanenhaus, Michael K., Spivey-Knowlton, Michael J., Eberhard, Kathleen M. and Sedivy, Julie C. 1995. Integration of Visual and Linguistic Information in Spoken Language Comprehension. *Science* 268(5217), 1632–1634. http://www.bcs.rochester.edu/people/mtan/publications/1995Tanenhaus_Sci.pdf, 07.10.2008.

Tanenhaus, Michael K., Spivey-Knowlton, Michael J., Eberhard, Kathleen M. and Sedivy, Julie C. 1996. Using Eye Movements to Study Spoken Language Comprehension: Evidence for Visually Mediated Incremental Interpretation. In Toshio Inui and James L. McClelland (eds.), *Information Integration in Perception and Communication*, Attention and Performance, No. XVI, pages 457–478, Cambridge, MA: MIT Press.

Wechsler, Stephen Mark. 1991. *Argument Structure and Linking*. Ph. D.thesis, Stanford University.

Wunderlich, Dieter. 1992. CAUSE and the Structure of Verbs. Arbeiten des SFB 282 36, Heinrich Heine Uni/BUGH, Düsseldorf/Wuppertal.