HPSG-Based
Model-Theoretic Dependency Grammar

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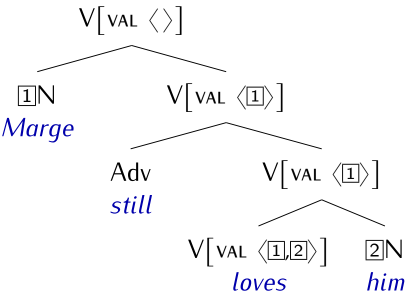
HPSG 2026

Bergen, 3rd August 2026

Dependency Structures

Constituency:



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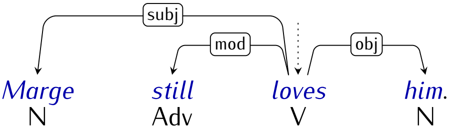

Aim: **Provide an HPSG-based formalization of dependency structures and** (certain kinds of) **dependency grammars**.

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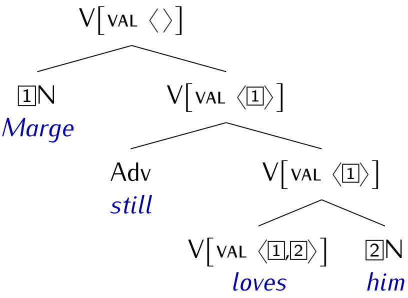

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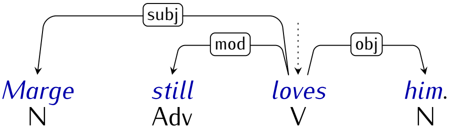

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They also **differ** in the **level of formalization**, e.g.:

- fully formalized: HPSG, LFG, TAG, CG, MG
- partially formalized: TG, MTT, FGD
- not formalized: SSDG, WG

They also differ in their **visibility in general linguistic journals** such as *Language*, *Journal of Linguistics*, *Natural Language and Linguistic Theory*, *Linguistics and Philosophy*, *Glossa*, e.g.:

- dominant: current TG (Minimalist Program with traces of GB)
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Syntactic frameworks 3

Importantly, some are **proof-theoretic** ("generative-enumerative" in Pullum and Scholz 2001, but cf. Pullum 2026):

- CG
- TG, MG
- TAG
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Others are **model-theoretic** ("constraint-based")...

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...or claim to be constraint-based:

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Summary:

degree of formalization

	low	medium	high
Proof-Th		TG, FGD	CG, TAG, MG
Model-Th	WG, SSDG	MTT	HPSG, LFG

Legend:

- **colour** encodes **constituency** vs. **dependency**,
- **font size** encodes **visibility** in contemporary theoretical linguistic publications

Why care?

Dependency Grammars (DGs):

- **a niche** in contemporary theoretical linguistics,
- perhaps because more visible DGs are **not formalized**, and less visible DGs are only **partially formalized** at all,
- so not much of a "(formal) grammar" there,
- but **dominant in NLP** (thanks to machine learning from corpora, both before LLMs and now),
- and **dominant in cognitive science** (e.g., Gibson 2025),
- and perhaps becoming **more visible in theoretical linguistics**, e.g.:
  - *monographs*: Tesnière 2015, Osborne 2019, Mel'čuk 2021,
  - *journal papers*: Osborne and Groß 2017, Osborne and Gerdes 2019, Futrell *et al.* 2020, Hudson *et al.* 2026, Gisborne 2026, Osborne 2026,
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The **basic rules** of the syntactic game:

- utterances have **syntactic structures**,
- **grammars** determine syntactic structures of languages.

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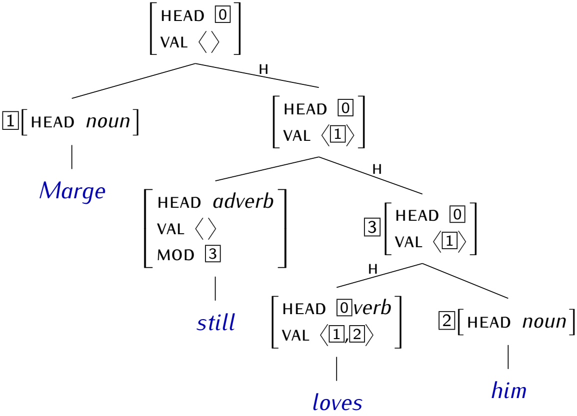

HPSG models 2

Structures may also be represented **fully explicitly**, e.g. (simplifying grammar):

$$
\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{hd-subj-ph}} \\
\text{PHON} & \langle \textit{Marge,still,loves,him} \rangle \\
\text{CAT} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{category}} \\ \text{HEAD} & \boxed{0} \\ \text{VAL} & \langle\rangle \\ \text{MOD} & \textit{none} \end{array}\right] \\
\text{HD-DTR} & \boxed{7}\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{hd-adj-ph}} \\
\text{PHON} & \langle \textit{still,loves,him} \rangle \\
\text{CAT} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{category}} \\ \text{HEAD} & \boxed{0} \\ \text{VAL} & \langle\boxed{1}\rangle \\ \text{MOD} & \textit{none} \end{array}\right] \\
\text{HD-DTR} & \boxed{4}\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{hd-comp-ph}} \\
\text{PHON} & \langle \textit{loves,him} \rangle \\
\text{CAT} & \boxed{5}\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{category}} \\ \text{HEAD} & \boxed{0} \\ \text{VAL} & \langle\boxed{1}\rangle \\ \text{MOD} & \textit{none} \end{array}\right] \\
\text{HD-DTR} & \boxed{3} \\
\text{DTRS} & \left\langle \boxed{3}\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{word}} \\ \text{PHON} & \langle \textit{loves} \rangle \\ \text{CAT} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{category}} \\ \text{HEAD} & \boxed{0}\textit{verb} \\ \text{VAL} & \langle\boxed{1},\boxed{2}\rangle \\ \text{MOD} & \textit{none} \end{array}\right] \end{array}\right], \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{word}} \\ \text{PHON} & \langle \textit{him} \rangle \\ \text{CAT} & \boxed{2}\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{category}} \\ \text{HEAD} & \textit{noun} \\ \text{VAL} & \langle\rangle \\ \text{MOD} & \textit{none} \end{array}\right] \end{array}\right] \right\rangle
\end{array}\right] \\
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\end{array}\right] \\
\text{DTRS} & \left\langle \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{word}} \\ \text{PHON} & \langle \textit{Marge} \rangle \\ \text{CAT} & \boxed{1}\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{category}} \\ \text{HEAD} & \textit{noun} \\ \text{VAL} & \langle\rangle \\ \text{MOD} & \textit{none} \end{array}\right] \end{array}\right], \boxed{7} \right\rangle
\end{array}\right]
$$

HPSG models 3

In model-theoretic frameworks, **such AVMs are representations of** (parts of) **models**:

- sets of objects,
- with properties of objects,
- and relations between objects.

Model for the AVM on the previous slide would be too large to present; a smaller example:

Fully explicit AVM representation: $\begin{bmatrix} \textit{ref} \\ \text{PERS} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEND} & \textit{f} \end{bmatrix}$

Model configuration:

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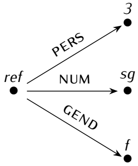
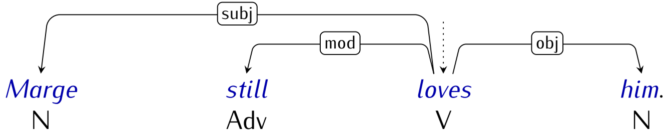
Model configuration: 

Dependency models 1

Again, **structures** may be represented **schematically**, e.g.:



Or **fully explicitly**, e.g.:

$$\boxed{1}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{Marge} \\ \text{CAT} & \textit{noun} \\ \text{REL} & \textit{subj} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \boxed{2} \end{bmatrix} \quad \boxed{2}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{still} \\ \text{CAT} & \textit{adverb} \\ \text{REL} & \textit{mod} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \boxed{3} \end{bmatrix} \quad \boxed{3}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{loves} \\ \text{CAT} & \textit{verb} \\ \text{REL} & \textit{nil} \\ \text{GOV} & \textit{nil} \\ \text{NEXT} & \boxed{4} \end{bmatrix} \quad \boxed{4}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{him} \\ \text{CAT} & \textit{noun} \\ \text{REL} & \textit{obj} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \textit{nil} \end{bmatrix}$$

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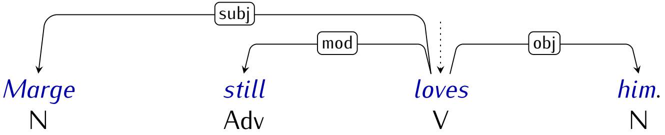

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Dependency models 2

Such **fully explicit** representations...

$$\boxed{1}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{Marge} \\ \text{CAT} & \textit{noun} \\ \text{REL} & \textit{subj} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \boxed{2} \end{bmatrix} \quad \boxed{2}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{still} \\ \text{CAT} & \textit{adverb} \\ \text{REL} & \textit{mod} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \boxed{3} \end{bmatrix} \quad \boxed{3}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{loves} \\ \text{CAT} & \textit{verb} \\ \text{REL} & \textit{nil} \\ \text{GOV} & \textit{nil} \\ \text{NEXT} & \boxed{4} \end{bmatrix} \quad \boxed{4}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{him} \\ \text{CAT} & \textit{noun} \\ \text{REL} & \textit{obj} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \textit{nil} \end{bmatrix}$$

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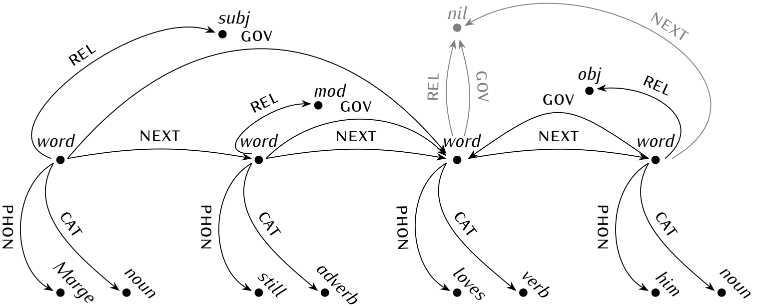

HPSG grammars

A **grammar** is a set of statements constraining possible structures.

Such a **statement** may be given **informally**, e.g.:

- *Headed phrases share morphosyntactic features with their heads.*

Or it can be **fully explicit** but not fully formalized, e.g.:

- $\textit{headed-ph} \Rightarrow \begin{bmatrix} \text{CAT}|\text{HEAD} & \boxed{1} \\ \text{HD-DTR}|\text{CAT}|\text{HEAD} & \boxed{1} \end{bmatrix}$

Or it can be **expressed in a well-defined logical language** (RSRL in HPSG; King 1989, 1994, 1999, Richter 1999, 2004, 2007, 2024), e.g.:

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This corresponds to the following FOL formula without syntactic sugar:

- $\forall x.\,(\textit{obj}(\textsc{rel}(\mathrm{x})) \land \textit{verb}(\textsc{cat}(\textsc{gov}(\mathrm{x})))) \longrightarrow \textit{noun}(\textsc{cat}(\mathrm{x}))$

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- $\forall x. (x \ \text{REL} : \textit{obj} \wedge \text{x GOV CAT} : \textit{verb}) \rightarrow \text{x CAT} : \textit{noun}$

This corresponds to the following FOL formula without syntactic sugar:

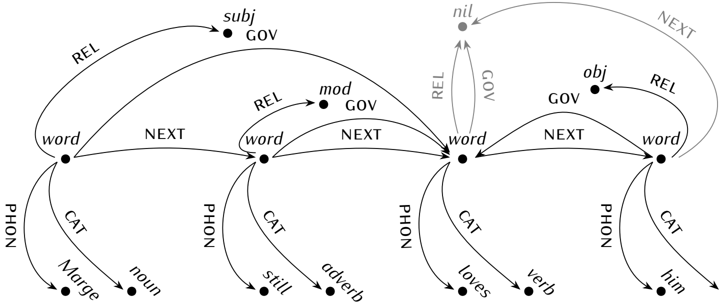
- $\forall x. (\textit{obj}(\text{REL}(x)) \wedge \textit{verb}(\text{CAT}(\text{GOV}(x)))) \rightarrow \textit{noun}(\text{CAT}(x))$

Dependency grammars 2

This statement, repeated in the AVM form...

- $\begin{bmatrix} \text{REL} & \textit{obj} \\ \text{GOV} & \text{CAT} \ \textit{verb} \end{bmatrix} \rightarrow \begin{bmatrix} \text{CAT} & \textit{noun} \end{bmatrix}$

...is satisfied by the running model:



MTDG vs. HPSG

How does **MTDG differ from HPSG**?

- **structures of utterances**:
  - HPSG: constituency
  - MTDG: dependency
- **kinds of models**:
  - HPSG: exhaustive models of languages (King 1999, but cf. Przepiórkowski 2021)
  - MTDG: lean models of utterances
- **formal language**:
  - HPSG: specialized Relational Speciate Re-entrant Language (King 1989, Richter 2004)
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...with an additional **special sort** *nil* as a possible value of any attribute.

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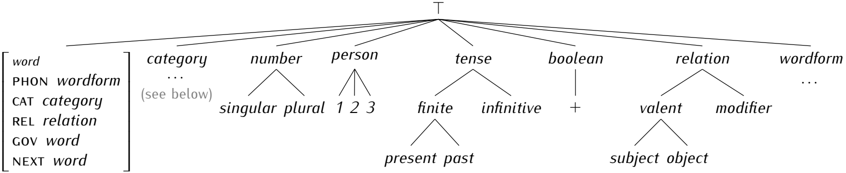
- 

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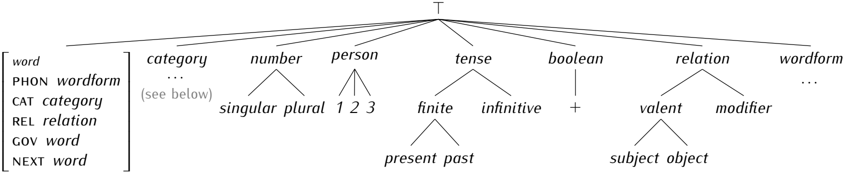
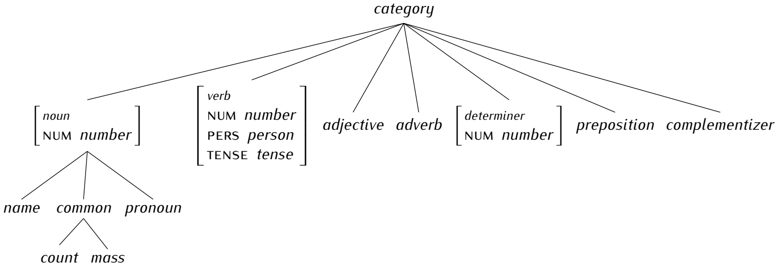
- 

- 

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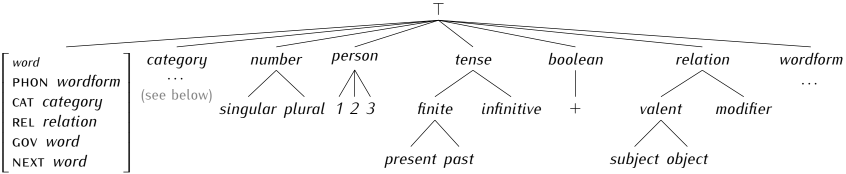
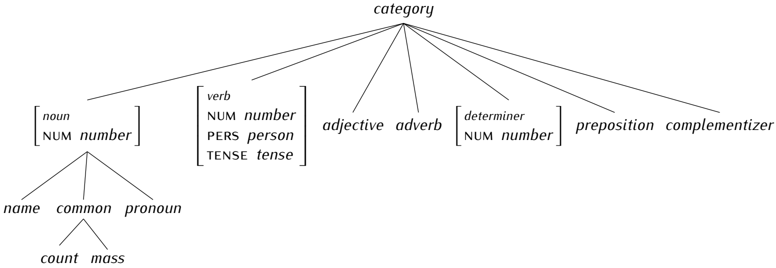
- 

- 

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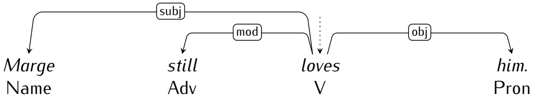
- 

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(Missing attributes are *nil*-valued.)

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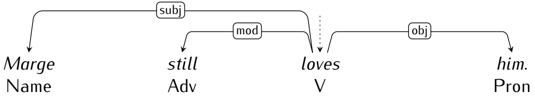
- 

- $\boxed{1}\begin{bmatrix} \textit{word} \\ \text{PHON } \textit{Marge} \\ \text{CAT } \begin{bmatrix}\textit{name}\\ \text{NUM } \textit{sg}\end{bmatrix} \\ \text{REL } \textit{subj} \\ \text{GOV } \boxed{3} \\ \text{NEXT } \boxed{2}\end{bmatrix}$ $\boxed{2}\begin{bmatrix} \textit{word} \\ \text{PHON } \textit{still} \\ \text{CAT } \textit{adverb} \\ \text{REL } \textit{mod} \\ \text{GOV } \boxed{3} \\ \text{NEXT } \boxed{3}\end{bmatrix}$ $\boxed{3}\begin{bmatrix} \textit{word} \\ \text{PHON } \textit{loves} \\ \text{CAT } \begin{bmatrix}\textit{verb}\\ \text{NUM } \textit{sg} \\ \text{PERS } \textit{3} \\ \text{TENSE } \textit{pres}\end{bmatrix} \\ \text{NEXT } \boxed{4}\end{bmatrix}$ $\boxed{4}\begin{bmatrix} \textit{word} \\ \text{PHON } \textit{him} \\ \text{CAT } \begin{bmatrix}\textit{pronoun}\\ \text{NUM } \textit{sg}\end{bmatrix} \\ \text{REL } \textit{obj} \\ \text{GOV } \boxed{3}\end{bmatrix}$

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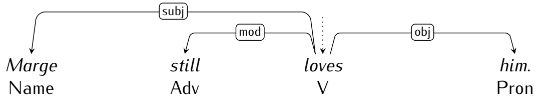
- 

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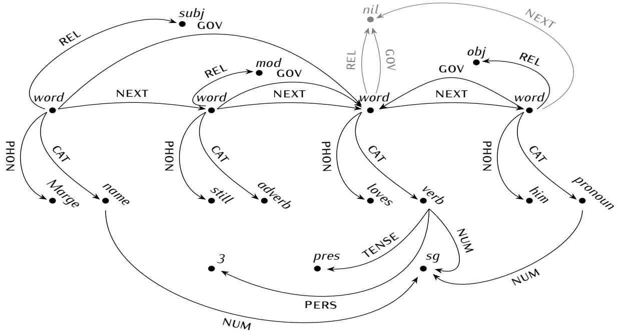
- 

Word order 1

Total Word Order Axiom:

- 'For any two distinct words, one precedes the other.'
- $\forall x.\forall y.\,(x : \mathit{word} \wedge y : \mathit{word} \wedge x \neq y) \rightarrow (\mathtt{precede}(x, y) \veebar \mathtt{precede}(y, x))$

where:

- $p \veebar q \overset{df}{\equiv} p \leftrightarrow \neg q$ (exclusive or, XOR)
- relation precede:
  - 'x precedes y iff both are words and either x immediately precedes y, or it immediately precedes some z that precedes y.'
  - $\forall x.\forall y.\,\mathtt{precede}(x, y) \leftrightarrow (x : \mathit{word} \wedge y : \mathit{word} \wedge (x \text{ NEXT} = y \vee \exists z.\, x \text{ NEXT} = z \wedge \mathtt{precede}(z, y)))$

This and tree axioms ensure all words are part of the ordered dependency tree.

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Word order 2

Linearization of Subjects (ignoring auxiliary inversion, etc.):

- ‘Subjects precede their governors.’
- $\begin{bmatrix}\textsc{rel} & \textit{subj}\\ \textsc{gov} & \boxed{1}\end{bmatrix} < \boxed{1}$
- $\forall x.\forall y.\,(x\ \textsc{rel} : \textit{subj} \wedge x\ \textsc{gov} = y) \rightarrow \texttt{precede}(x, y)$

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Assumes more detailed *relation* hierarchy (cf. Hudson 2024: 1546, 1565):

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  - *valent*
    - *subject*
    - *complement*
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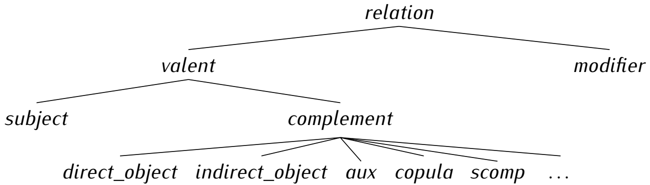
- 

Valency 1

Lexical entries (parts of the Word Principle; Höhle 1994, Richter 2024: 101), e.g.:

- $$\mathrm{LE}_{loves} \overset{df}{\equiv} \begin{bmatrix} \textsc{phon} & \textit{loves} \\ \textsc{cat} & \begin{bmatrix} \textit{verb} & \\ \textsc{num} & \textit{sg} \\ \textsc{pers} & \textit{3} \\ \textsc{tense} & \textit{pres} \end{bmatrix} \\ \textsc{val} & \left\langle \begin{bmatrix} \textsc{cat} & \textit{noun} \\ \textsc{rel} & \textit{subj} \end{bmatrix}, \begin{bmatrix} \textsc{cat} & \textit{noun} \\ \textsc{rel} & \textit{obj} \end{bmatrix} \right\rangle \end{bmatrix}$$

With obvious **extensions of the signature**:

- $$\begin{bmatrix} \textit{word} & \\ \textsc{phon} & \textit{wordform} \\ \textsc{cat} & \textit{category} \\ \textsc{val} & \textit{list}(\textit{word}) \\ \textsc{rel} & \textit{relation} \\ \textsc{gov} & \textit{word} \\ \textsc{next} & \textit{word} \end{bmatrix}$$

- $$\begin{array}{ccc} & \textit{list} & \\ \textit{elist} & & \begin{bmatrix} \textit{nelist} & \\ \textsc{first} & \top \\ \textsc{rest} & \textit{list} \end{bmatrix} \end{array}$$

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- $$\mathrm{LE}_{\mathit{loves}} \overset{df}{\equiv} \begin{bmatrix} \text{PHON} & \mathit{loves} \\ \text{CAT} & \begin{bmatrix} \mathit{verb} & \\ \text{NUM} & \mathit{sg} \\ \text{PERS} & \mathit{3} \\ \text{TENSE} & \mathit{pres} \end{bmatrix} \\ \text{VAL} & \left\langle \begin{bmatrix} \text{CAT} & \mathit{noun} \\ \text{REL} & \mathit{subj} \end{bmatrix}, \begin{bmatrix} \text{CAT} & \mathit{noun} \\ \text{REL} & \mathit{obj} \end{bmatrix} \right\rangle \end{bmatrix}$$

With obvious **extensions of the signature**:

- $$\begin{bmatrix} \mathit{word} & \\ \text{PHON} & \mathit{wordform} \\ \text{CAT} & \mathit{category} \\ \text{VAL} & \mathit{list}(\mathit{word}) \\ \text{REL} & \mathit{relation} \\ \text{GOV} & \mathit{word} \\ \text{NEXT} & \mathit{word} \end{bmatrix}$$

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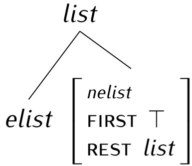
- 

Valency 2

Valency and governor (with `member` defined as usual):

- ‘For any word, every member of this word’s valency list has this word as its governor.’
- $\boxed{1}\left[\textsc{val}\ \boxed{2}\right] \rightarrow \boxed{2}\left\langle \left[\textsc{gov}\ \boxed{1}\right], \ldots, \left[\textsc{gov}\ \boxed{1}\right] \right\rangle$
- $\forall x.\forall y.\mathtt{member}(y, x\ \textsc{val}) \rightarrow y\ \textsc{gov} = x$

Then:

-

- $\boxed{1}\begin{bmatrix} \textit{word} & \\ \textsc{phon} & \textit{Marge} \\ \textsc{cat} & \begin{bmatrix} \textit{name} & \\ \textsc{num} & \textit{sg} \end{bmatrix} \\ \textsc{rel} & \textit{subj} \\ \textsc{gov} & \boxed{3} \\ \textsc{next} & \boxed{2} \end{bmatrix}$ $\boxed{2}\begin{bmatrix} \textit{word} & \\ \textsc{phon} & \textit{still} \\ \textsc{cat} & \textit{adverb} \\ \textsc{rel} & \textit{mod} \\ \textsc{gov} & \boxed{3} \\ \textsc{next} & \boxed{3} \end{bmatrix}$ $\boxed{3}\begin{bmatrix} \textit{word} & \\ \textsc{phon} & \textit{loves} \\ \textsc{cat} & \begin{bmatrix} \textit{lverb} & \\ \textsc{num} & \textit{sg} \\ \textsc{pers} & \textit{3} \\ \textsc{tense} & \textit{pres} \end{bmatrix} \\ \textsc{val} & \left\langle \boxed{1}, \boxed{4} \right\rangle \\ \textsc{next} & \boxed{4} \end{bmatrix}$ $\boxed{4}\begin{bmatrix} \textit{word} & \\ \textsc{phon} & \textit{him} \\ \textsc{cat} & \begin{bmatrix} \textit{pronoun} & \\ \textsc{num} & \textit{sg} \end{bmatrix} \\ \textsc{rel} & \textit{obj} \\ \textsc{gov} & \boxed{3} \end{bmatrix}$

No further “Valency Principle” is needed.

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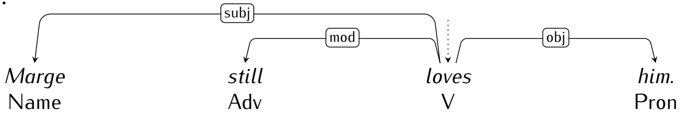
- 

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Then:

- subj, mod, obj

Marge	*still*	*loves*	*him.*
Name	Adv	V	Pron

- $\boxed{1}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{Marge} \\ \text{CAT} & \begin{bmatrix} \textit{name} & \\ \text{NUM} & \textit{sg} \end{bmatrix} \\ \text{REL} & \textit{subj} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \boxed{2} \end{bmatrix}$ $\boxed{2}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{still} \\ \text{CAT} & \textit{adverb} \\ \text{REL} & \textit{mod} \\ \text{GOV} & \boxed{3} \\ \text{NEXT} & \boxed{3} \end{bmatrix}$ $\boxed{3}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{loves} \\ \text{CAT} & \begin{bmatrix} \textit{lverb} & \\ \text{NUM} & \textit{sg} \\ \text{PERS} & \textit{3} \\ \text{TENSE} & \textit{pres} \end{bmatrix} \\ \text{VAL} & \langle\boxed{1}, \boxed{4}\rangle \\ \text{NEXT} & \boxed{4} \end{bmatrix}$ $\boxed{4}\begin{bmatrix} \textit{word} & \\ \text{PHON} & \textit{him} \\ \text{CAT} & \begin{bmatrix} \textit{pronoun} & \\ \text{NUM} & \textit{sg} \end{bmatrix} \\ \text{REL} & \textit{obj} \\ \text{GOV} & \boxed{3} \end{bmatrix}$

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Instead of conclusion

This was just a teaser, see the **full paper** (available on request) for:

- some **basic linguistic analyses** (mainly formalizing Gibson 2025) and
- **gory formal details**.

Why is this **relevant for HPSG**?

- MTDG to some extent based on HPSG
- A way to increase the visibility of HPSG?
- A way to promote model-theoretic linguistics in general?

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Thank you for your attention!

Futrell, R., Levy, R. P., and Gibson, E. (2020). Dependency locality as an explanatory principle for word order. *Language*, **96**(2), 371–412.

Gibson, E. (2025). *Syntax: A Cognitive Approach*. MIT Press, Cambridge, MA.

Gisborne, N. (2026). Mutual dependency, English *wh*-clauses and Word Grammar. *Journal of Linguistics*, pp. 1–30.

Haug, D. (2023). LFG and Dependency Grammar. In M. Dalrymple, ed., *Handbook of Lexical Functional Grammar*, pp. 1829–1859. Language Science Press, Berlin.

Hudson, R. (2024). HPSG and Dependency Grammar. In Müller *et al.* (2024), pp. 1531–1580.

Hudson, R., Gisborne, N., Clark, T. H., Eppler, E. D., Hollmann, W., Rosta, A., and Trousdale, G. (2026). The syntactic constraint on English auxiliary contraction. *Journal of Linguistics*, **62**(2), 357–388.

Höhle, T. N. (1994). Spurenlose extraction. Unpubl. ms., University of Tübingen, reprinted in Müller *et al.* 2019.

King, P. J. (1989). *A Logical Formalism for Head-driven Phrase Structure Grammar*. Ph.D. dissertation, University of Manchester.

King, P. J. (1994). An expanded logical formalism for Head-driven Phrase Structure Grammar. Arbeitspapiere des Sonderforschungsbereichs 340 Bericht Nr. 59, Seminar für Sprachwissenschaft, Universität Tübingen.

King, P. J. (1999). Towards truth in HPSG. In Kordoni (1999), pp. 301–352.

Kordoni, V., ed. (1999). *Tübingen Studies in Head-Driven Phrase Structure Grammar*. Universität Tübingen, Tübingen.

Mel'čuk, I. (2021). *Ten Studies in Dependency Syntax*. De Gruyter Mouton, Berlin / Boston.

Müller, S., Reis, M., and Richter, F., eds. (2019). *Beiträge zur deutschen Grammatik: Gesammelte Schriften von Tilman N. Höhle*. Language Science Press, Berlin.

Müller, S., Abeillé, A., Borsley, R. D., and Koenig, J.-P., eds. (2024). *Head-Driven Phrase Structure Grammar: The Handbook*. Language Science Press, Berlin, 2nd edition.

Osborne, T. (2014). Dependency Grammar. In A. Carnie, Y. Sato, and D. Siddiqi, eds., *The Routledge Handbook of Syntax*, pp. 604–626. Routledge, London.

Osborne, T. (2019). *A Dependency Grammar of English: An Introduction and beyond*. John Benjamins, Amsterdam / Philadelphia.

Osborne, T. (2026). Syntactic predicates. *Journal of Linguistics*, **62**(2), 389–423.

Osborne, T. (2027). Dependency Grammar. In A. Carnie, Y. Sato, and D. Siddiqi, eds., *The Routledge Handbook of Syntax*. Routledge, London, 2nd edition. Forthcoming.

Osborne, T. and Gerdes, K. (2019). The status of function words in dependency grammar: A critique of Universal Dependencies (UD). *Glossa: A Journal of General Linguistics*, **4**.

Osborne, T. and Groß, T. (2017). Left node blocking. *Journal of Linguistics*, **53**(3), 641–688.

Przepiórkowski, A. (2021). Three improvements to the HPSG model theory. In S. Müller and N. Melnik, eds., *Proceedings of the HPSG 2021 Conference*, pp. 165–185. Frankfurt/Main University Library.

Pullum, G. K. (2026). Rules of grammar. In G. Dupre, R. M. Nefdt, , and K. H. Stanton, eds., *Oxford Handbook of Philosophy of Linguistics*. Oxford University Press, Oxford. Forthcoming.

Pullum, G. K. and Scholz, B. C. (2001). On the distinction between model-theoretic and generative-enumerative syntactic frameworks. In P. de Groote, G. Morrill, and C. Retoré, eds., *Logical Aspects of Computational Linguistics: 4th International Conference*, pp. 17–43. Springer-Verlag, Berlin.

Richter, F. (1999). RSRL for HPSG. In Kordoni (1999), pp. 74–115.

Richter, F. (2004). *A Mathematical Formalism for Linguistic Theories with an Application in Head-Driven Phrase Structure Grammar*. Ph.D. dissertation (defended in 2000), Universität Tübingen.

Richter, F. (2007). Closer to the truth: A new model theory for HPSG. In J. Rogers and S. Kepser, eds., *Model-Theoretic Syntax at 10*, pp. 99–108. European Summer School on Logic, Language and Information (ESSLLI 2007).

Richter, F. (2024). Formal background. In Müller *et al.* (2024), pp. 93–131.

Tesnière, L. (2015). *Elements of Structural Syntax*. John Benjamins, Amsterdam.