Grammar and Feature Unification

Problems with CF Phrase Structure Grammars

- Difficult to capture **dependencies** between constituents

  - the boy runs
  - the boys run

  - * the boy run
  - * the boys runs

Problems with CF Phrase Structure Grammars

- Difficult to capture **dependencies** between constituents

  – the boy opens the door
  – *?? the boy opens

  – the boy hops
  – *?? the boy hops the table

CF Solution

- exploding the number of rules is one way to provide a solution…

S → NPsing VPsing
S → NPplural VPplural
NP → NPsing
NP → NPplural
NPsing → Detsing Nsing
NPplural → Detplural Nplural

VPsing → Vintsing
VPplural → Vintplural

VPsing → Vtrsing NP
VPplural → Vtrplural NP

grammar

Detsing → {a, this, the}
Detplural → {some, these, the}

Nsing → {boy, girl, …}
Nplural → {boys, girls, …}

Vintsing → {hops, …}
Vintplural → {hop, …}

Vtrsing → {opens, …}
Vtrplural → {open, …}

lexicon

A better solution…

- What we really want to say is that some constituents *share* properties

The boy runs

the ‘Subject’ and the ‘Verb’ **agree** in number

– i.e., they share the same value for their number feature

Phrase structure rules with features

S	→	NP	VP
		+singular	+singular

VP	→	V	(NP)
+singular		+singular	

Phrase structure rules with features

S	→	NP		VP
		+plural		+plural

VP	→	V		(NP)
+plural		+plural		

grammar, phonology, …

Features → Feature structures

Attribute-value matrices (AVMs)

+singular	[number: singular]
+ing-form	[verb: ing-form]
+masc +sing	gender: masc number: sing

Feature structures
Unification

Compatibility

Information

Phrase structure rules with features

S	→	NP	VP
		+singular	+singular

VP	→	V	(NP)
+singular		+singular	

Phrase structure rules with features

S	→	NP	VP
		[number: sing]	[number: sing]

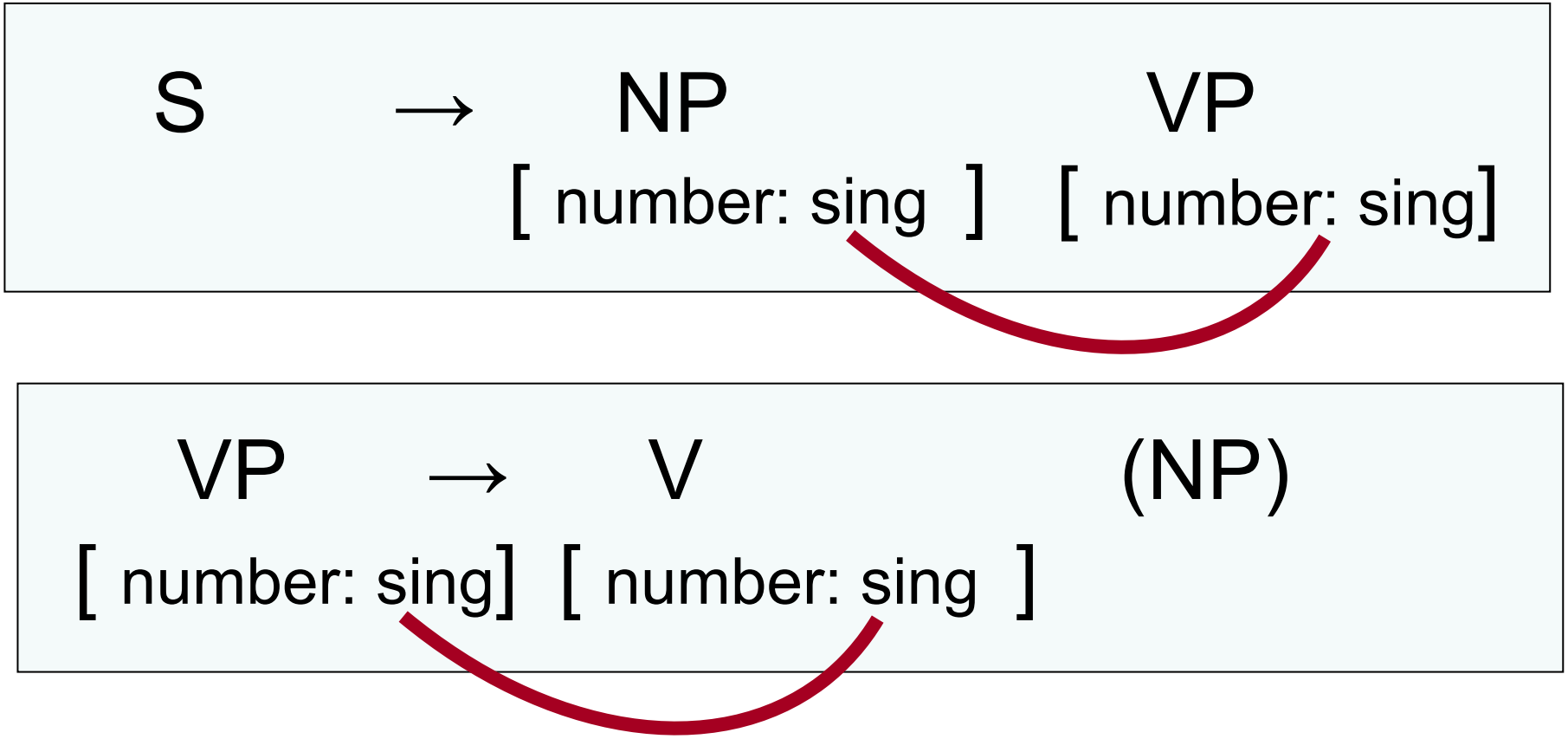
VP	→	V	(NP)
[number: sing]		[number: sing]	

Phrase structure rules with features

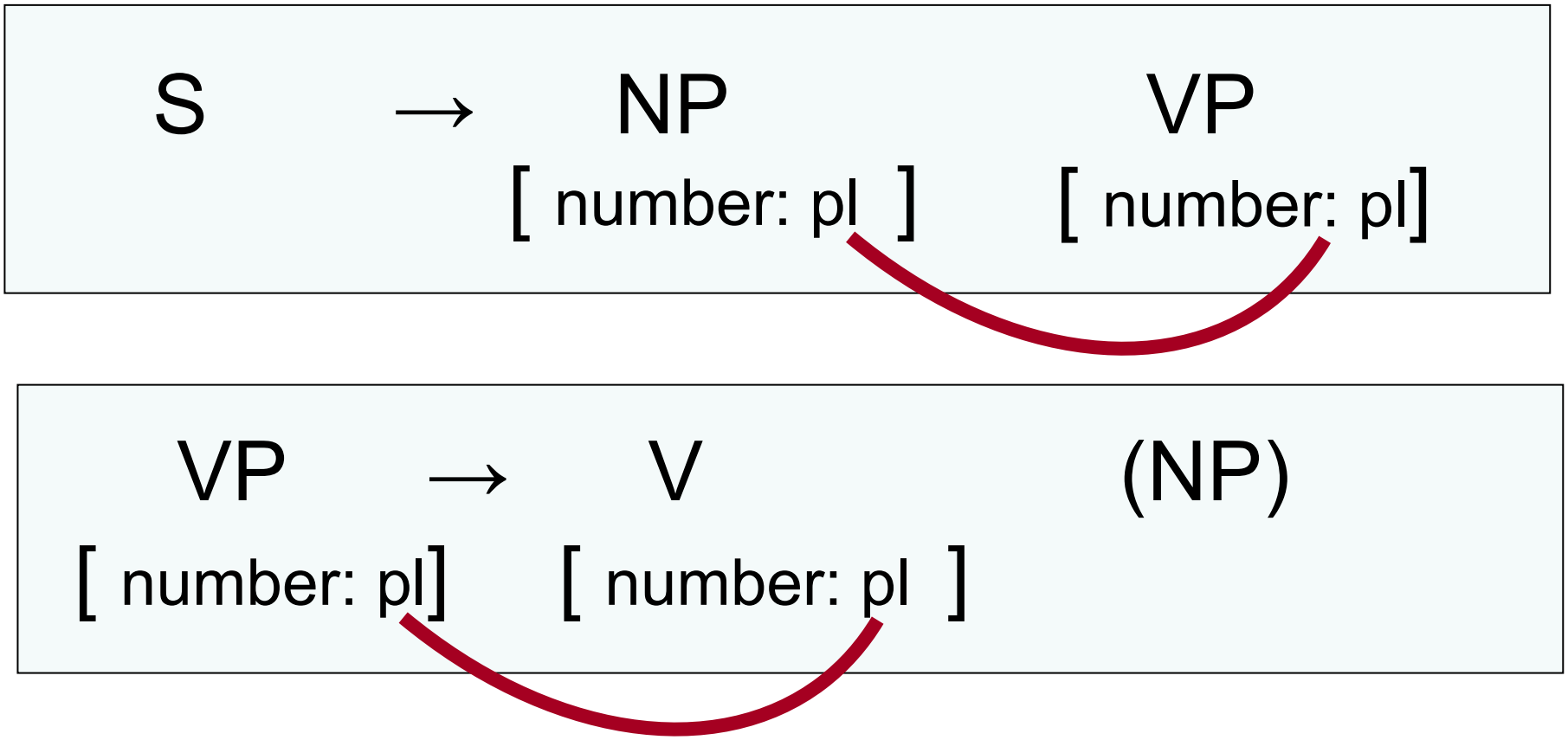
S → NP [number: pl] VP [number: pl]

VP [number: pl] → V [number: pl] (NP)

Phrase structure rules with features



Phrase structure rules with features



Generalised Rules

S	→	NP	VP
		[number: **x**]	[number: **x**]

VP	→	V	(NP)
[number: **x**]		[number: **x**]	

Example Grammar

Parameter start symbol is S

Rule {Satz}
S -> NP VP.

Rule {NP-Name}
NP -> Name.

Rule {NP}
NP -> Det N.

PATR-formalism

Rule {VP intransitiv}
VP -> Vi.

Rule {VP transitiv}
VP -> Vt NP.

Rule {VP transitiv mit PP}
VP -> Vt NP PP.

Rule {VP ditransitiv}
VP -> Vt2 NP NP.

Rule {VP mit PP-Objekt}
VP -> Vpo PP.

Rule {einfache PP}
PP -> P NP.

Example Lexicon

```
\w cried
\c Vi

\w saw
\c Vt

\w gave
\c Vt2
```

```
\w girl
\c N

\w student
\c N

\w book
\c N
```

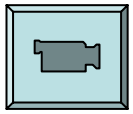
```
\w the
\c Det

\w a
\c Det

\w in
\c P

\w on
\c P
```

PATR-formalism



f03b.grm
f02.lex

Example Lexicon (with features)

```
\w cried
\c Vi

\w saw
\c Vt

\w gave
\c Vt2

\w sings
\c Vi
\f 3sg
```

```
\w girl
\c N
\f sg

\w student
\c N
\f sg

\w book
\c N
\f sg

\w girls
\c N
\f pl

\w students
\c N
\f pl
```

```
\w the
\c Det

\w a
\c Det

\w in
\c P

\w on
\c P
```

Example Lexicon (with features)

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\w the
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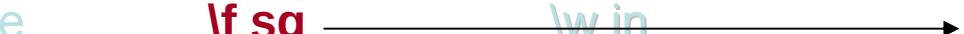
\w a
\c Det

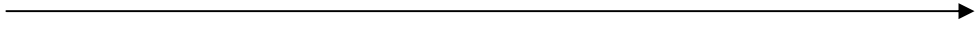
\w in
\c P

\w on
\c P



[num: sg].

Let sg be [num: sg].



[num: sg
pers: 3].

Let 3sg be sg [pers: 3].

Example Lexicon (with features)

\w cried
\c Vi

\w saw
\c Vt

\w gave
\c Vt2

\w sings
\c Vi
\f 3sg

\w girl
\c N
\f sg

\w student
\c N
\f sg

\w book
\c N
\f sg

\w girls
\c N
\f pl

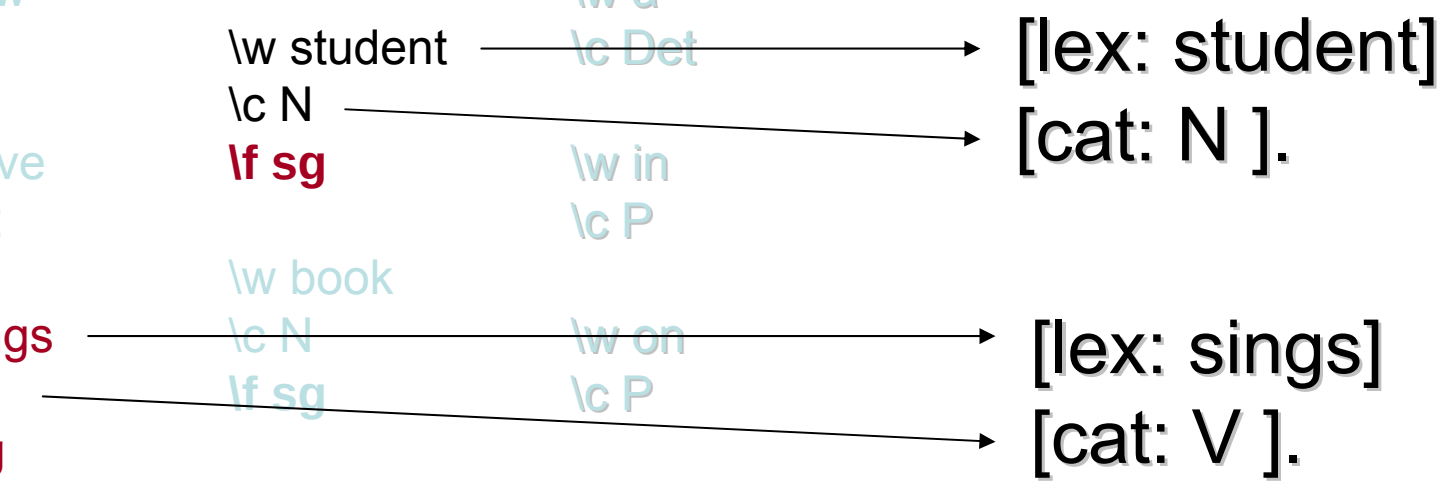
\w students
\c N
\f pl

\w the
\c Det

\w a
\c Det

\w in
\c P

\w on
\c P



Generalised Rules

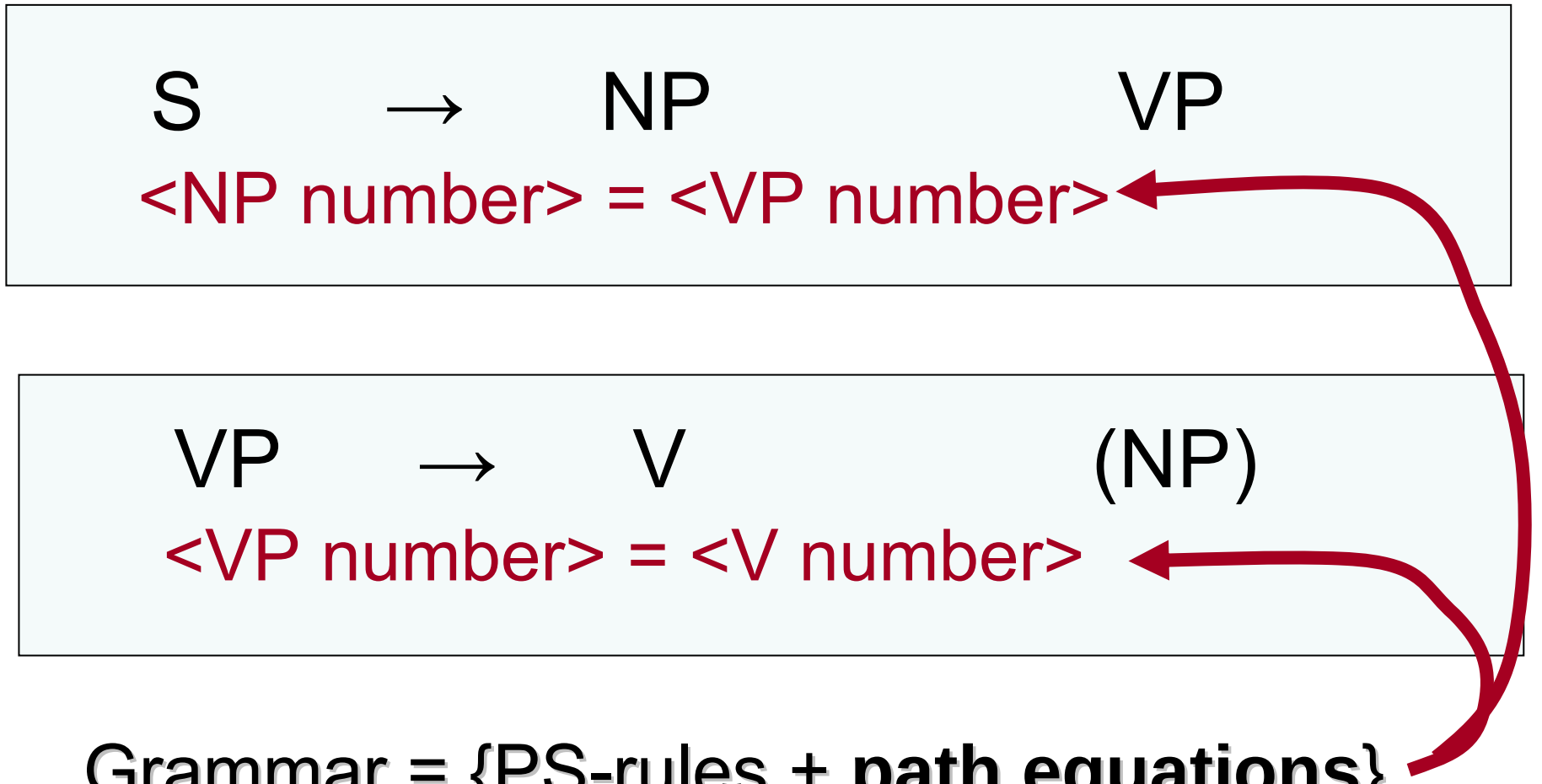
S	→	NP	VP
		[number: **x**]	[number: **x**]

VP	→	V	(NP)
[number: **x**]		[number: **x**]	

Feature Representation

- Syntactic tree becomes a more complex structure
- Each node in the tree is in fact a bundle of features
- Particular rules (specified in the grammar) specify what conditions hold on the feature structures
- Usually: local – i.e., conditions hold over a dominating node and its children

Generalised Rules (PATR formalism)



Feature Geometries

- Much of modern linguistics is now to do with bundles of features
- and how these are distributed around syntactic structures

- Some special kinds of features flow along the `backbone' provided by the tree structures: **head features**

Head features are usually ‘passed up’ to the dominating node

S → NP VP

<NP head num> = <VP head num>
<NP head pers> = <VP head pers>

Head features are usually ‘passed up’ to the dominating node

Rule {VP intransitiv}

VP ⟶ V:

<VP head> = <V>

<V subcat> = i.

\w sings
\c Vi
\f 3sg

⟶

[lex: sings]
[cat: V].

Let V be [cat: V].
Let Vi be V [subcat: i].

[cat: V
 subcat: i]

exercise with the example grammar…

what structure (both tree structure and feature structure) does the grammar produce for:

“the boys sing”

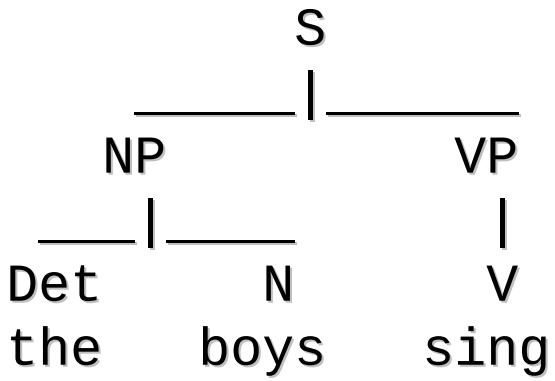
and what would it do for

“the boy sing”

Feature-based Parsing:

“the boys sing”

1:




```
S:
[ cat:   S
  subj:    [ cat:   NP
             spec:    [ cat:   Det
                        lex:   the
                        num:   pl ]
             head:    [ cat:   N
                        lex:   boys
                        num:   pl
                        pers:  3 ] ]
  pred:    [ cat:   VP
             head:    [ cat:   V
                        subcat:i
                        lex:   sing
                        num:   pl
                        pers:  3 ] ] ]

1 parse found
```

Final move…

- *All* information is moved into the feature structure – even the tree structure…
  - HPSG
    (Head-driven Phrase Structure Grammar)