We are waiting for

Beyond Context-Free Grammar

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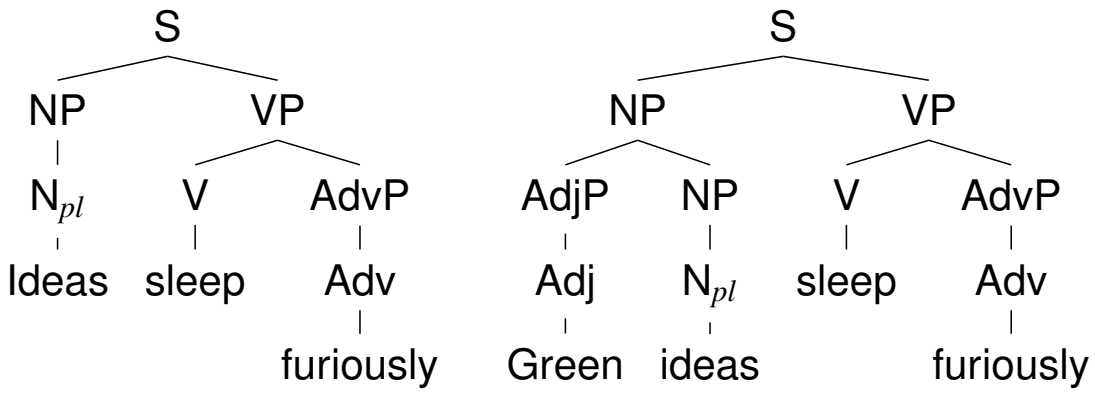
Last lecture

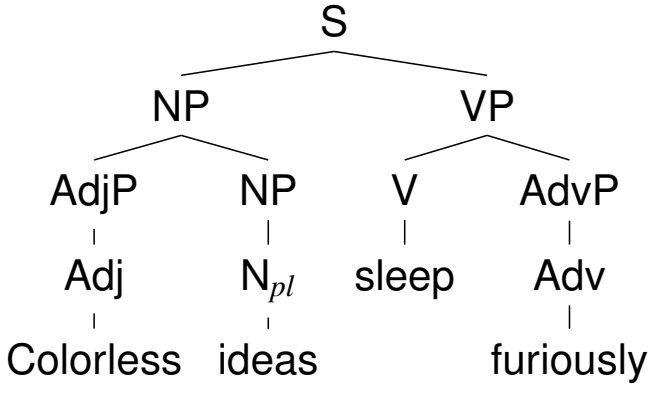
Questions

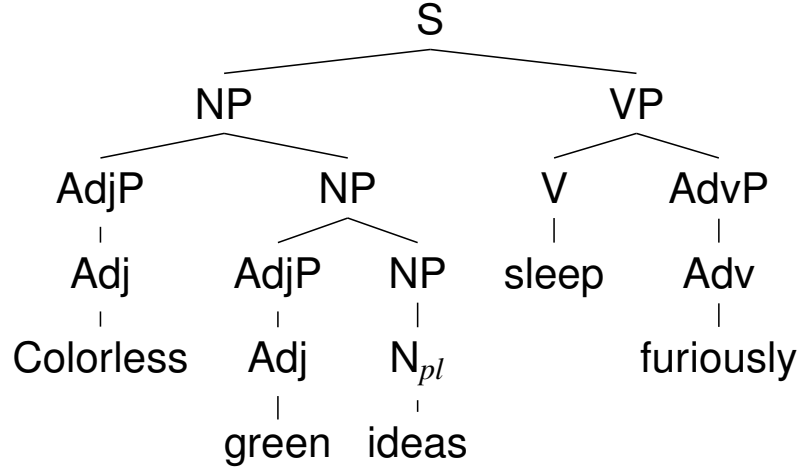
- How meaning is derived from syntax in the mainstream linguistic studies?
- How syntactic analysis is conducted in a real research?
- Why cross-linguistic variation and dialects are important in syntax?

After my lecture

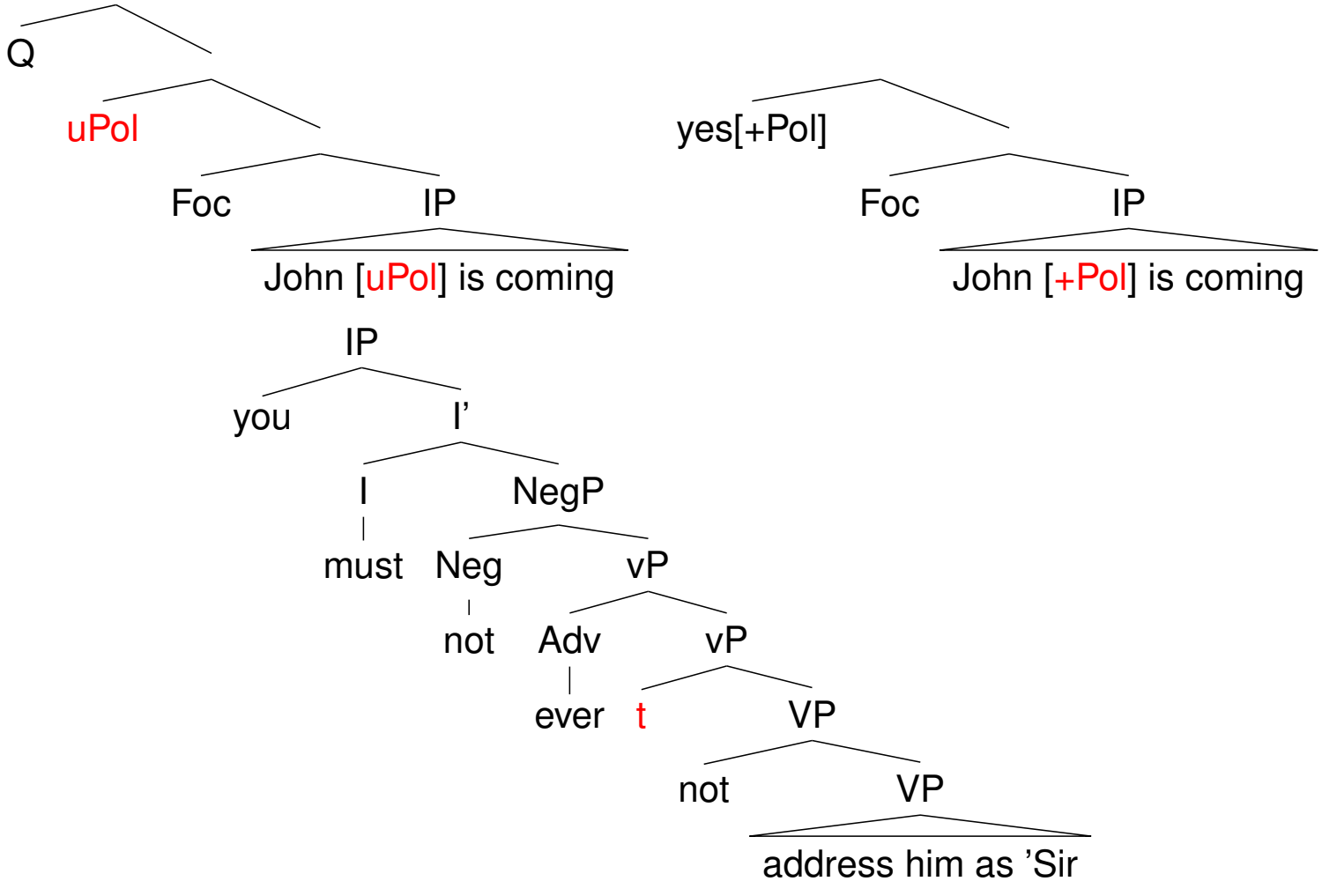
It seems that syntactic trees look like,







But last lecture



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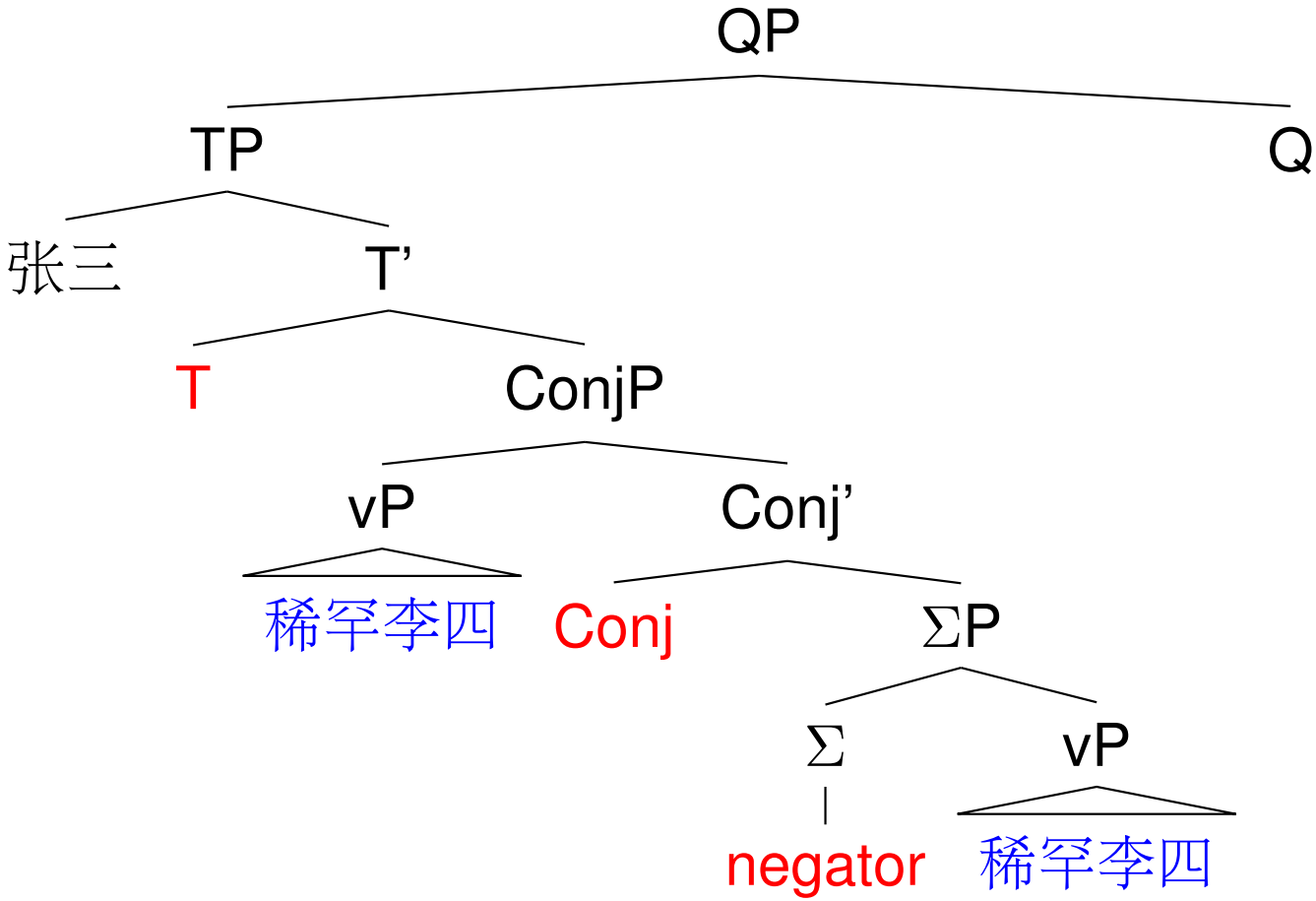
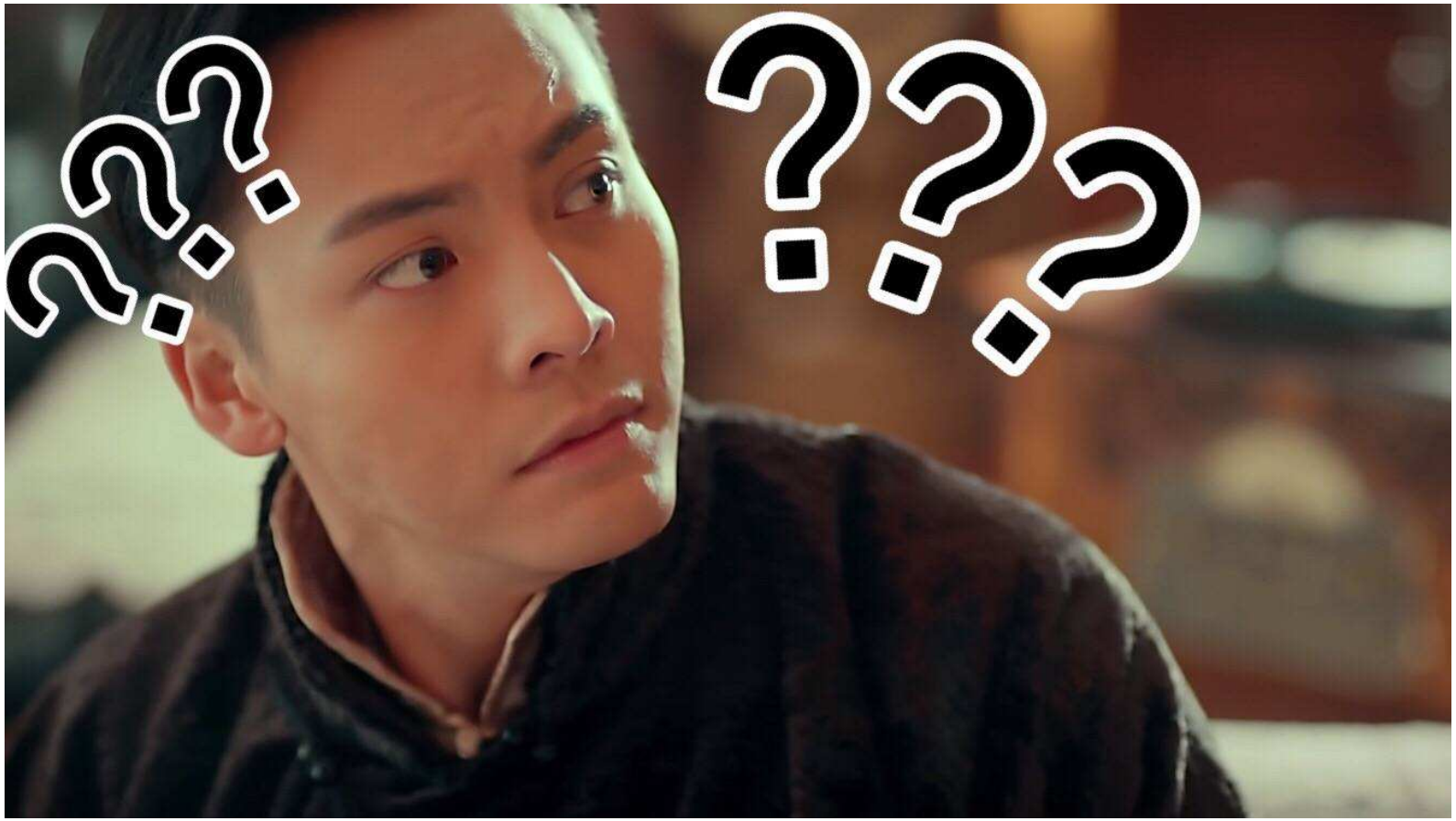


What?



What?

The generative revolution

Chomsky (*Syntactic Structures*)

> *By pushing a precise but inadequate formulation to an unacceptable conclusion, we can often expose the exact source of this inadequacy and, consequently, gain a deeper understanding of the linguistic data. [...] Obscure and intuition-bound notions can neither lead to absurd conclusions nor provide new and correct ones, [...]*

说好的 precise 呢?

Today

More expressive grammar formalisms

- Multiple Context-Free Grammar, Tree-Adjoining Grammar
- Lexical-Functional Grammar, Head-driven Phrase Structure Grammar, Combinatory Categorial Grammar
- Minimalist Grammar

Outline

1. Typed feature structure
2. Phrase-structure rules with features
3. Rethink a tree
4. Go Back to Last Lecture's Example
5. Generative-enumerative vs. Model-theoretic approaches

Motivation

Weakness of CFG

CFG treats each grammatical category symbol as atomic without internal structure.

- ⇒ Two categories are either identical or different.
- ⇒ There is no mechanism for saying that two categories are alike in some ways, but different in others.

Cross-cutting grammatical properties

	3rd singular subject	plural subject
direct object NP	*denies*	*deny*
No direct object NP	*disappears*	*disappear*

Using features

Observation

Words and phrases in natural languages typically behave alike in certain respects, but not others.

Key idea: Using features

- The elements associated to linguistic expressions, such as words, can be broken down.
- Complex categories can be decomposed to features that are the atomic units.
- Linguistic feature: a property-like element that indicates the grammatical behavior of syntactic constituents.
  - The VP has the feature value *past tense*.
  - The verb is a *past tense* verb.
  - The noun has a case feature *accusative*.

Linguistic features

Example

Feature	Example	Value
person	I go, you go, he goes	1st, 2nd, 3rd
number	he dances, they dance	singular, plural
case	he brings Bob, Bob brings him	nominative accusative
tense	go, went, gone	past, present, future
modality	may, can,	conditional, subjunctive

A nice summary of linguistic features

http://www.grammaticalfeatures.net

Feature structure

Description

Use a feature structure to specify of grammatical information.

- A feature structure is a specification of a set of *features*, each of which is paired with a particular *value*.
- A feature structure can be represented by an AVM.

$$\begin{bmatrix} \text{FEATURE}_1 & \text{VALUE}_1 \\ \text{FEATURE}_2 & \text{VALUE}_2 \\ \ldots & \\ \text{FEATURE}_n & \text{VALUE}_n \end{bmatrix}$$

Example: *dog*

$$\begin{bmatrix} \text{FORM} & \text{dog} \\ \text{NUMBER} & \text{singular} \\ \text{ANIMACY} & \text{animate} \end{bmatrix}$$

More on feature values

Atomic value

An unstructured value, one with only one part

$$\begin{bmatrix} \text{TENSE} & \text{past} \\ \text{PERSON} & 2 \end{bmatrix}$$

Complex value

A structured value, itself a feature structure

$$\begin{bmatrix} \text{TENSE} & \text{past} \\ \text{AGREEMENT} & \begin{bmatrix} \text{PERSON} & 2 \\ \text{NUMBER} & \text{singular} \end{bmatrix} \end{bmatrix}$$

Typed feature structure

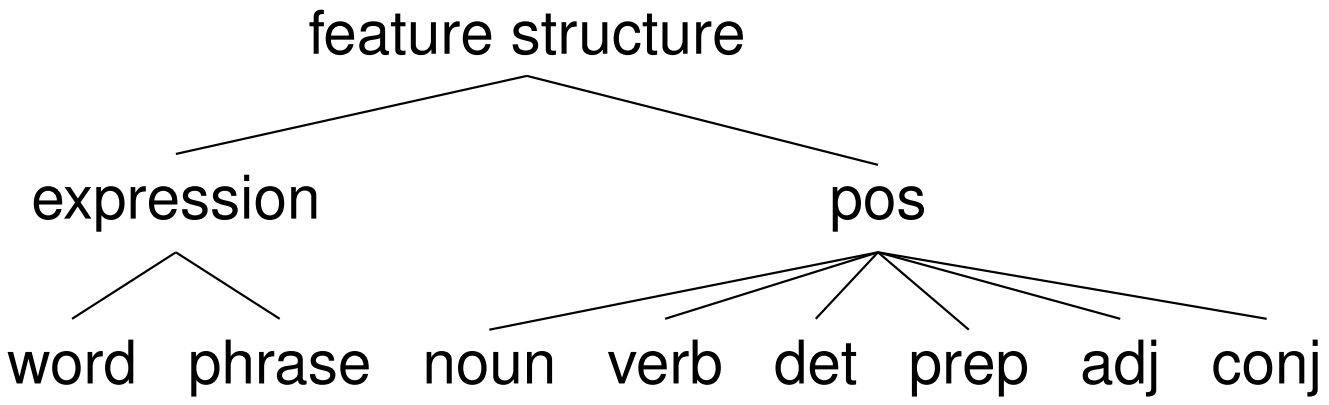
- Entities belonging to a particular type have their own special properties.

$\Rightarrow$ Each type of entity has its own constellation of features

  - Some features are declared appropriate for entities of the indicated type
  - Other features are sanctioned by one of the supertypes

- Type has subtype and supertype $\Rightarrow$ Hierarchical organization

Example



Example: Outside linguistic world

TYPE	FEATURES/VALUES	IMMEDIATE ST
entity	[NAME string; TEL number]	
individual	[BIRTHDAY date]	entity
organization	[FOUNDERS list(individual)]	entity
university	[PRESIDENT individual]	organization
department	[CHAIR individual]	organization

[NAME Weiwei Sun; TEL 18****5]

[NAME ICST.PKU; TEL 010-82529922]

Example: Outside linguistic world

TYPE	FEATURES/VALUES	IMMEDIATE ST
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$$\begin{bmatrix} \textit{entity} & \\ \text{NAME} & \text{Weiwei Sun} \\ \text{TEL} & \text{18****5} \end{bmatrix} \qquad \begin{bmatrix} \textit{entity} & \\ \text{NAME} & \text{ICST.PKU} \\ \text{TEL} & \text{010-82529922} \end{bmatrix}$$

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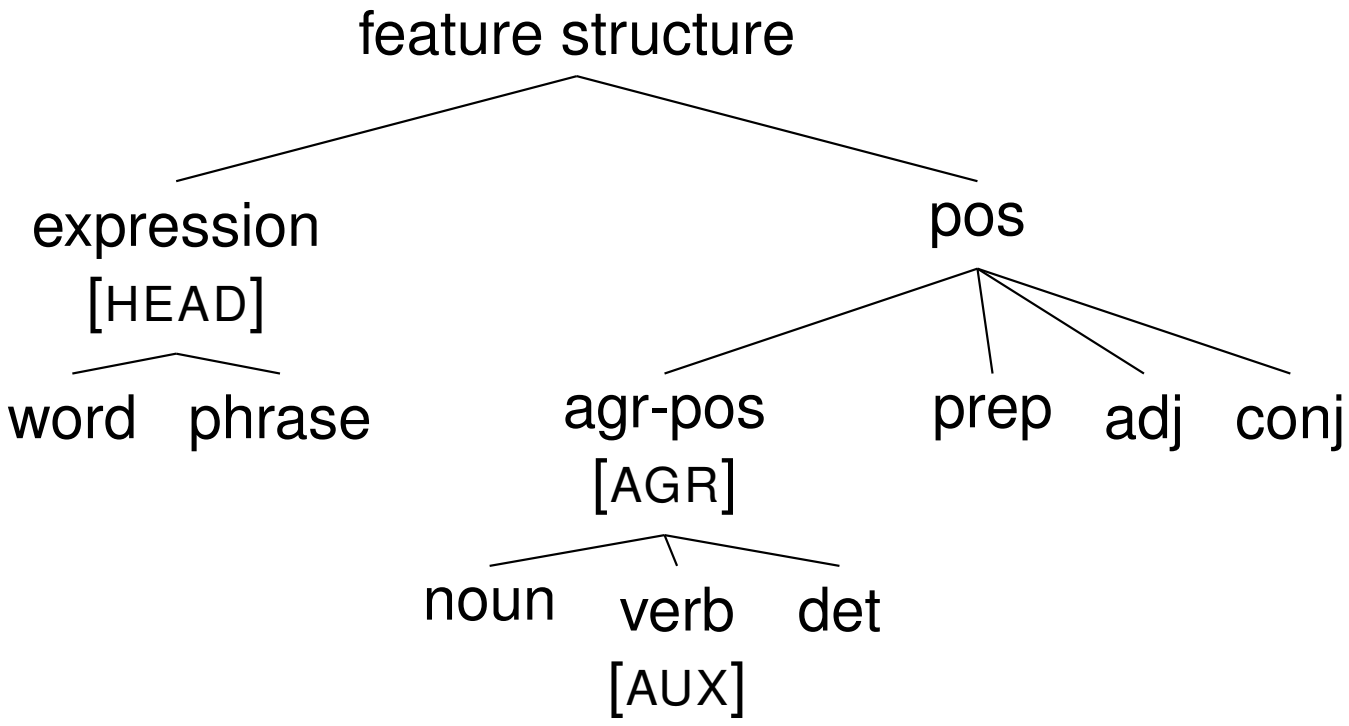
department	[CHAIR individual]	organization

individual	
NAME	Weiwei Sun
BIRTHDAY	**-**-198*
TEL	18****5

department	
NAME	ICST.PKU
FOUNDER	⟨XUAN WANG⟩
CHAIR	Zongming Guo
TEL	010-82529922

Linguistic features

Part-of-speech



V:

$$\begin{bmatrix} word & \\ \text{HEAD} & \text{verb} \end{bmatrix}$$

N:

$$\begin{bmatrix} word & \\ \text{HEAD} & \text{noun} \end{bmatrix}$$

NP:

$$\begin{bmatrix} phrase & \\ \text{HEAD} & \text{noun} \end{bmatrix}$$

Linguistic features

Valence

Feature: VAL — Value of VAL: *val-cat*

Feature of *val-cat*: COMPS — Value of COMPS: *itr*, *str*, *dtr*

Feature of *val-cat*: SPR — Value of SPR: $+/-$

Abbreviations

IV:

$$\begin{bmatrix} word \\ \text{HEAD} \quad \text{verb} \\ \text{VAL} \quad \begin{bmatrix} val\text{-}cat \\ \text{COMPS} \quad \text{itr} \end{bmatrix} \end{bmatrix}$$

TV:

$$\begin{bmatrix} word \\ \text{HEAD} \quad \text{verb} \\ \text{VAL} \quad \begin{bmatrix} val\text{-}cat \\ \text{COMPS} \quad \text{str} \end{bmatrix} \end{bmatrix}$$

DTV:

...

Linguistic features

(1) a. We created a monster.

b. our creation of a monster

Example

NP

$$\begin{bmatrix} \textit{phrase} & \\ \text{HEAD} & \text{noun} \\ \text{VAL} & \begin{bmatrix} \textit{val-cat} & \\ \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix}$$

NOM

$$\begin{bmatrix} \textit{phrase} & \\ \text{HEAD} & \text{noun} \\ \text{VAL} & \begin{bmatrix} \textit{val-cat} & \\ \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

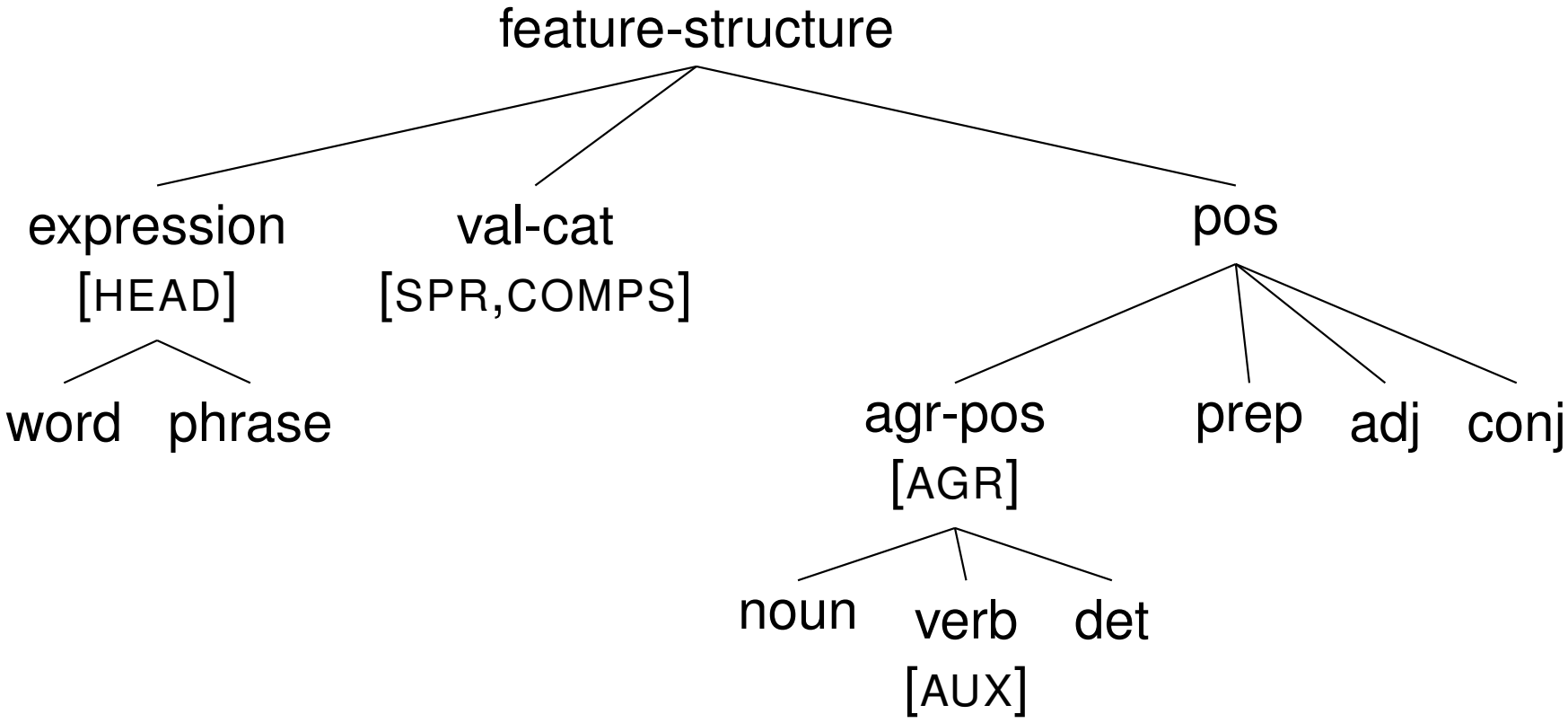
S

$$\begin{bmatrix} \textit{phrase} & \\ \text{HEAD} & \text{verb} \\ \text{VAL} & \begin{bmatrix} \textit{val-cat} & \\ \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix}$$

VP

$$\begin{bmatrix} \textit{phrase} & \\ \text{HEAD} & \text{verb} \\ \text{VAL} & \begin{bmatrix} \textit{val-cat} & \\ \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

Mini type hierarchy



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Reformulating the grammar rules

VP$\rightarrow$V NP*

$$\begin{bmatrix} phrase \\ \text{HEAD} \quad \boxed{1}\ \text{verb} \\ \text{VAL} \quad \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} word \\ \text{HEAD} \quad \boxed{1} \\ \text{VAL} \quad \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} phrase \\ \text{HEAD} \quad \boxed{1}\ \text{verb} \\ \text{VAL} \quad \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} word \\ \text{HEAD} \quad \boxed{1} \\ \text{VAL} \quad \begin{bmatrix} \text{COMPS} & \text{str} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \text{NP}$$

$$\begin{bmatrix} phrase \\ \text{HEAD} \quad \boxed{1}\ \text{verb} \\ \text{VAL} \quad \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} word \\ \text{HEAD} \quad \boxed{1} \\ \text{VAL} \quad \begin{bmatrix} \text{COMPS} & \text{dtr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \text{NP NP}$$

Reformulating the grammar rules

- S $\rightarrow$ NP VP
- NP $\rightarrow$ (D) NOM

$$\begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1}\ \text{verb} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix} \rightarrow \text{NP} \begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1}\ \text{noun} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} word \\ \text{HEAD} & \text{det} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix} \begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

NP→(D) NOM

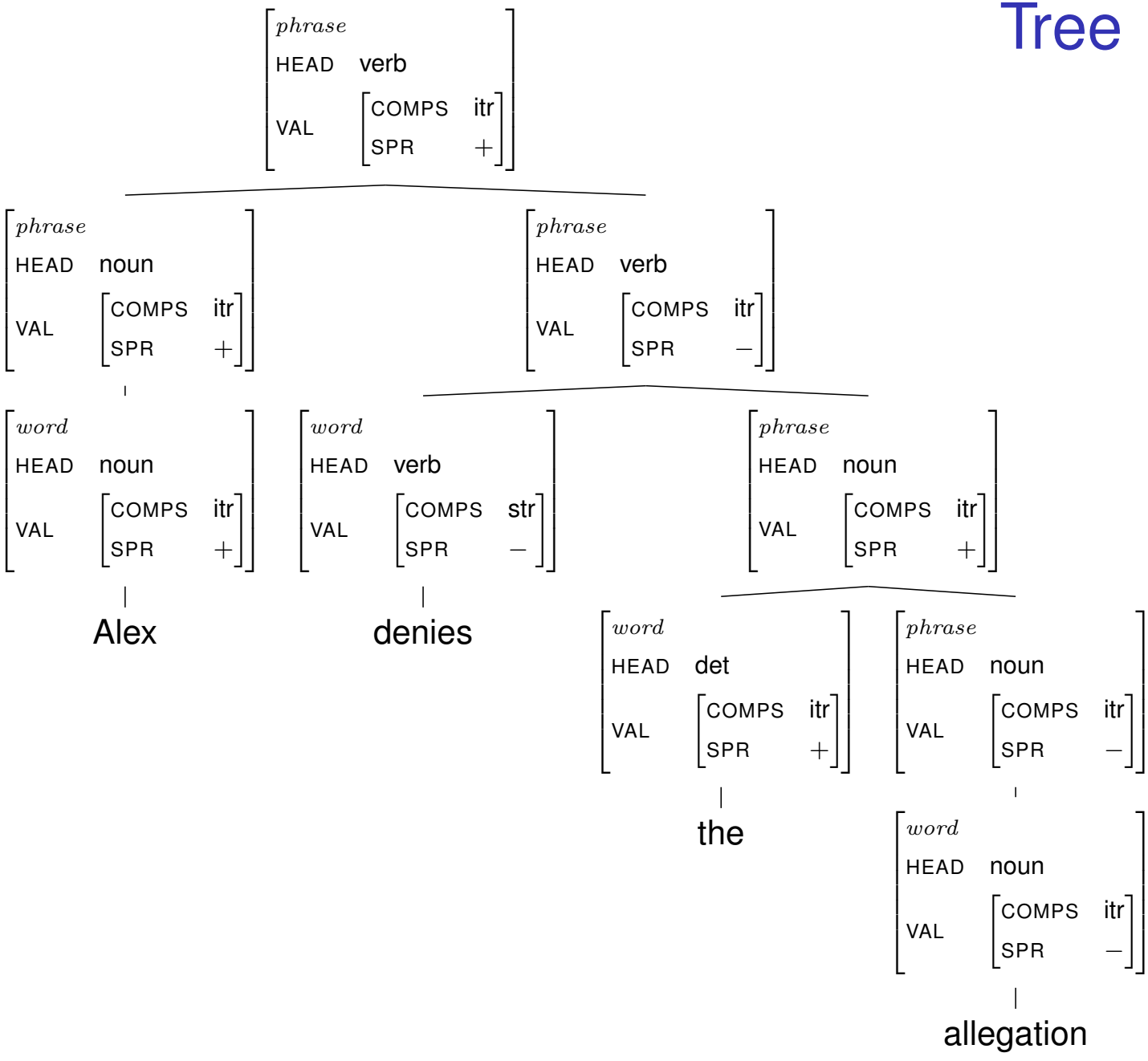
$$\begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1}\ \text{noun} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} word \\ \text{HEAD} & \text{det} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix} \begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1}\ \text{noun} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} phrase \\ \text{HEAD} & \boxed{1} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & + \end{bmatrix} \end{bmatrix}$$

Common and proper nouns

$$\left\langle \text{cat}, \begin{bmatrix} word \\ \text{HEAD} & \text{noun} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & - \end{bmatrix} \end{bmatrix} \right\rangle \left\langle \text{David}, \begin{bmatrix} word \\ \text{HEAD} & \text{noun} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & + \end{bmatrix} \end{bmatrix} \right\rangle$$

Tree


phrase
HEAD verb
VAL COMPS itr
SPR +
phrase
HEAD noun
VAL COMPS itr
SPR +
phrase
HEAD verb
VAL COMPS itr
SPR −
word
HEAD noun
VAL COMPS itr
SPR +
word
HEAD verb
VAL COMPS str
SPR −
phrase
HEAD noun
VAL COMPS itr
SPR +
Alex
denies
word
HEAD det
VAL COMPS itr
SPR +
phrase
HEAD noun
VAL COMPS itr
SPR −
the
word
HEAD noun
VAL COMPS itr
SPR −
allegation

Generalizing grammar rules

PP attachment

- VP $\rightarrow$ VP PP
- NOM $\rightarrow$ NOM PP

Combining them

$$\begin{bmatrix} phrase \\ \text{HEAD} \quad \boxed{1} \\ \text{VAL} \quad \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} phrase \\ \text{HEAD} \quad \boxed{1} \\ \text{VAL} \quad \begin{bmatrix} \text{SPR} & - \end{bmatrix} \end{bmatrix} \text{ PP}$$

Generalization

Only one *rule* is needed.

Agreement

Two features

$$agr\text{-}cat\begin{bmatrix}\text{PER} & \text{3rd}\\ \text{NUM} & \text{sg}\end{bmatrix}$$

Lexical entry & Grammar rule

$$\left\langle \text{David},\ word\begin{bmatrix}\text{HEAD} & noun\begin{bmatrix}\text{AGR} & agr\text{-}cat\begin{bmatrix}\text{PER} & \text{3rd}\\ \text{NUM} & \text{sg}\end{bmatrix}\end{bmatrix}\\ \text{VAL} & \begin{bmatrix}\text{SPR} & +\end{bmatrix}\end{bmatrix}\right\rangle$$

$$\begin{bmatrix}phrase\\ \text{HEAD} & \boxed{1}\ \text{verb}\\ \text{VAL} & \begin{bmatrix}\text{COMPS} & \text{itr}\\ \text{SPR} & +\end{bmatrix}\end{bmatrix} \rightarrow \begin{bmatrix}phrase\\ \text{HEAD} & \begin{bmatrix}\text{AGR} & \boxed{2}\end{bmatrix}\end{bmatrix}\begin{bmatrix}phrase\\ \text{HEAD} & \boxed{1}\begin{bmatrix}\text{AGR} & \boxed{2}\end{bmatrix}\\ \text{VAL} & \begin{bmatrix}\text{SPR} & -\end{bmatrix}\end{bmatrix}$$

Head feature principle

Head Feature Principle (HFP)

In any headed phrase, the HEAD value of the mother and the HEAD value of the head daughter must be identical.

$$\begin{bmatrix} phrase \\ \text{VAL} \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} word \\ \text{VAL} \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} phrase \\ \text{VAL} \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} word \\ \text{VAL} \begin{bmatrix} \text{COMPS} & \text{str} \\ \text{SPR} & - \end{bmatrix} \end{bmatrix} \text{NP}$$

$$\begin{bmatrix} phrase \\ \text{VAL} \begin{bmatrix} \text{COMPS} & \text{itr} \\ \text{SPR} & + \end{bmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} phrase \\ \text{HEAD} \begin{bmatrix} \text{AGR} & \boxed{2} \end{bmatrix} \end{bmatrix} \begin{bmatrix} phrase \\ \text{HEAD} \begin{bmatrix} \text{AGR} & \boxed{2} \end{bmatrix} \\ \text{VAL} \begin{bmatrix} \text{SPR} & - \end{bmatrix} \end{bmatrix}$$

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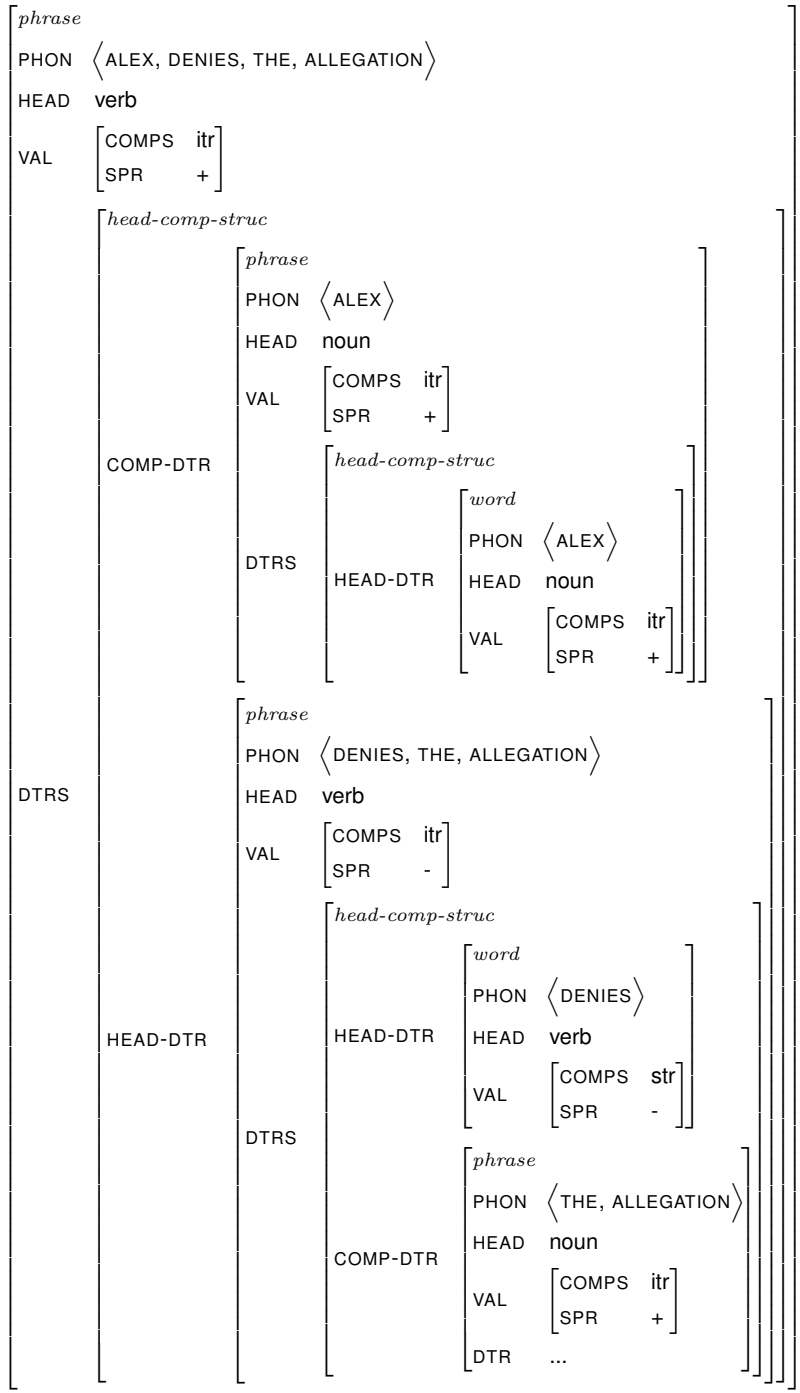
phrase
PHON ⟨ALEX, DENIES, THE, ALLEGATION⟩
HEAD verb
VAL COMPS itr
SPR +
head-comp-struc
COMP-DTR
phrase
PHON ⟨ALEX⟩
HEAD noun
VAL COMPS itr
SPR +
DTRS
head-comp-struc
HEAD-DTR
word
PHON ⟨ALEX⟩
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HEAD verb
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VAL COMPS str
SPR -
DTRS
COMP-DTR
phrase
PHON ⟨THE, ALLEGATION⟩
HEAD noun
VAL COMPS itr
SPR +
DTR ...

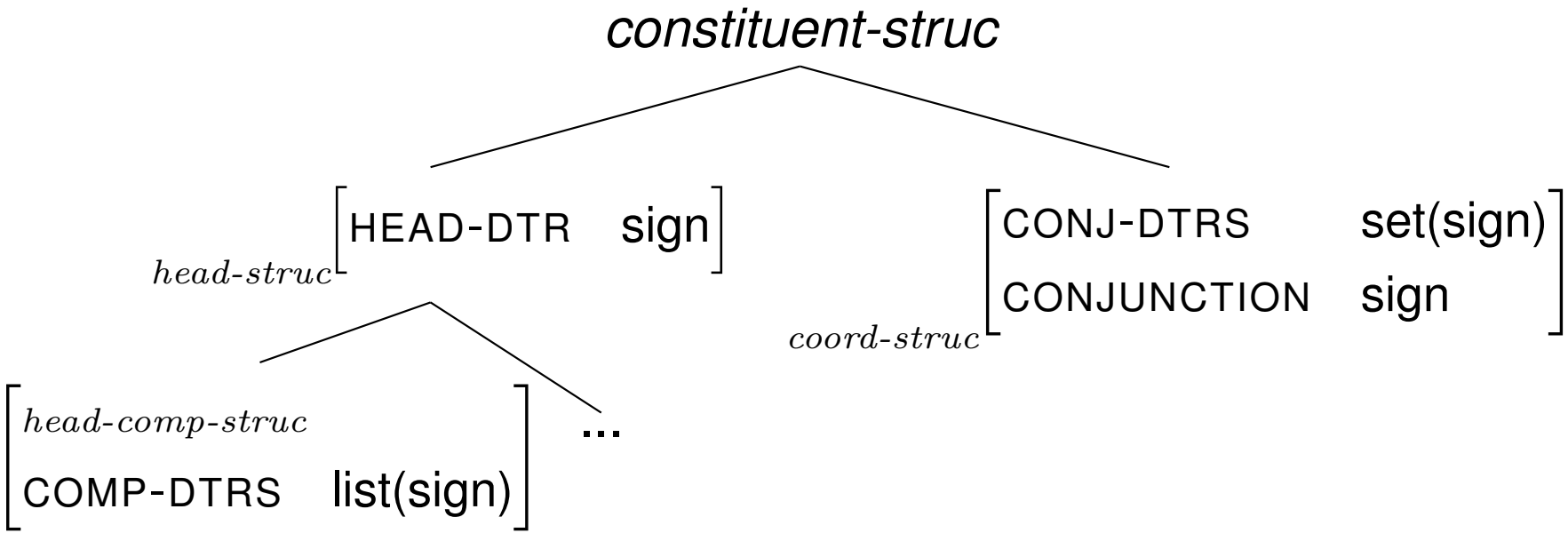
Types of phrases

Phrase structure can be represented by the various daughters attributes of phrasal signs.

- Each phrase has a DTRS attribute which has a *constituent-structure* value
- This DTRS value corresponds to what we view in a tree as daughters
- By distinguishing different kinds of *constituent-structures*, we can define different kinds of constructions in a language

Trees are used as a convenient graphic representation.

Types of phrases



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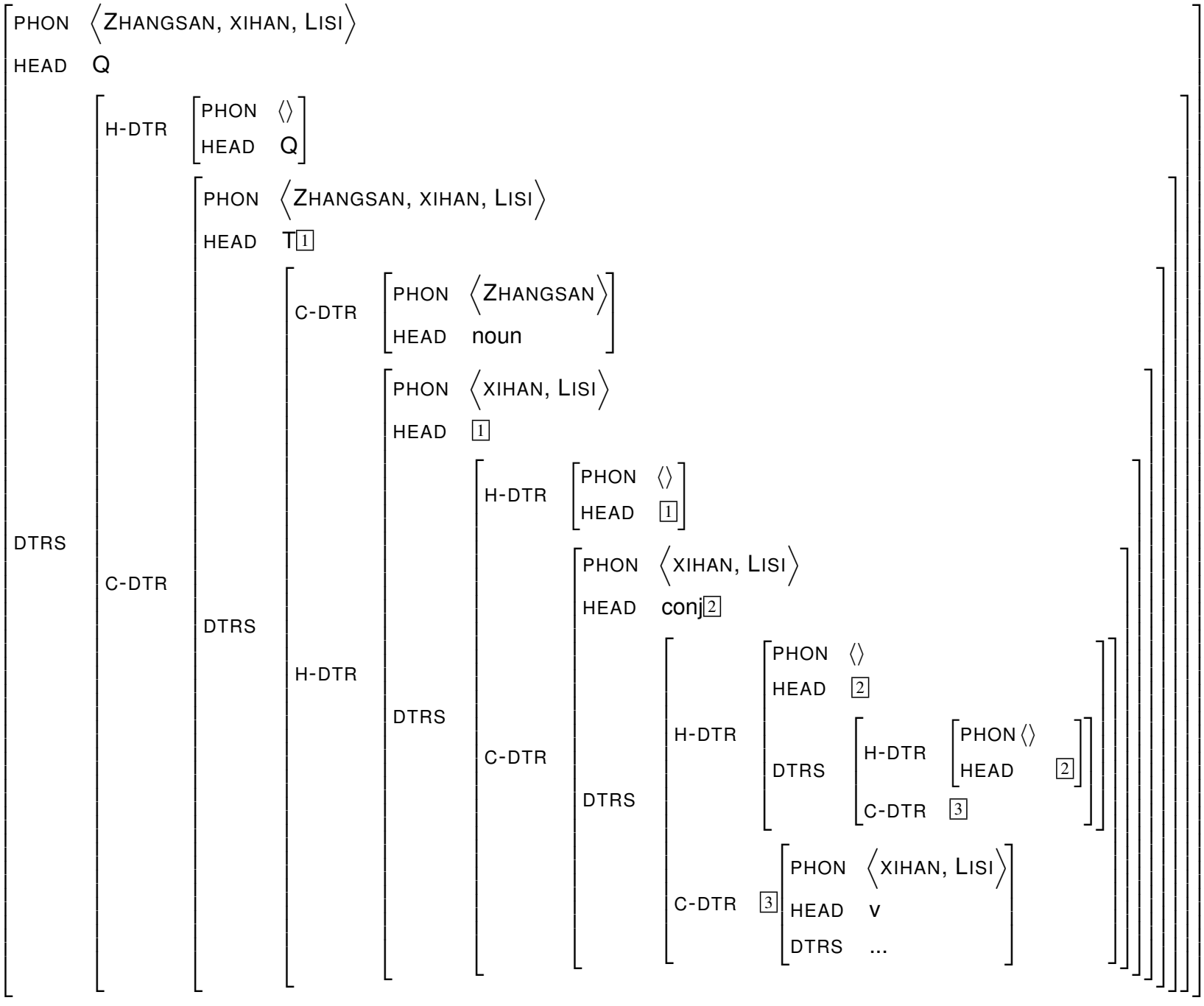
PHON ⟨ZHANGSAN, XIHAN, LISI⟩
HEAD Q
DTRS
H-DTR
PHON ⟨⟩
HEAD Q
C-DTR
PHON ⟨ZHANGSAN, XIHAN, LISI⟩
HEAD T1
DTRS
C-DTR
PHON ⟨ZHANGSAN⟩
HEAD noun
H-DTR
PHON ⟨XIHAN, LISI⟩
HEAD 1
DTRS
H-DTR
PHON ⟨⟩
HEAD 1
C-DTR
PHON ⟨XIHAN, LISI⟩
HEAD conj2
DTRS
H-DTR
PHON ⟨⟩
HEAD 2
DTRS
H-DTR
PHON ⟨⟩
HEAD 2
C-DTR 3
C-DTR 3
PHON ⟨XIHAN, LISI⟩
HEAD v
DTRS ...

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A non-derivational approach

A CFG rule: $S \rightarrow NPVP$

Top-down An S phrase consists of an NP and a VP

Bottom-up An NP and a VP make up an S

Constraint-based approach with feature structures

- A structure is well-formed iff it satisfies all relevant constraints.
- Constraints are not violable
  - lexical entries
  - phrase-structure rules (as definitions of phrase types)
  - principles

Where is the derivation?

Representational or Derivational

Two categories of grammars

- Derivationally oriented grammars
- Representationally oriented grammar

Derivationally oriented grammar

A grammar generally include a set of structural atoms (the basis) of the derivation.
The derivational procedure constructs syntactic structures using operations of two types.

1. **Structural composition**: Either previously constructed syntactic representations or elements of the basis are combined to form larger representations.
   - $\Rightarrow$ Fundamental: Such operations provide a way to generate the requisite infinity of possible structures.
2. **Transformations**: Modify an individual syntactic representation in some specified fashion.

Representational or Derivational

Two categories of grammars

- Derivationally oriented grammars
- Representationally oriented grammar

Representationally oriented grammar

A grammar determines the set of linguistic expressions using a system of well-formedness constraints.

- Each constraint provides an evaluation of some part of the linguistic expression. The well-formedness of the entire linguistic expression is determined by combining together the evaluations of the individual constraints.
- Representationally oriented grammars
  - **don't specify how to find well-formed linguistic expressions**,
  - but only **what properties well-formed expressions must have**.

Reading

- §3, *Syntactic Theory: A Formal Introduction*
- §2.3, *Aspects of the Theory of Syntax*
* Introduction, *Head-driven Phrase Structure Grammar*