Ling 566
Dec 4, 2014
Sign-Based Construction Grammar
Overview

• Chapter 16 framework (same analyses, different underlying system)

• Reading questions

• Untangle this

• General wrap up
Overview of Differences

- Multiple Inheritance
- Signs
- Grammar rules form a hierarchy
- Every tree node has its own phonology
- Many principles become constraints on grammar rules
- The definition of well-formedness is simplified
Multiple Inheritance Hierarchies

literary work

GENRE

verse
epic
Greek-epic
The Odyssey

prose
English-epic
Beowolf

Asian

Greek

English

European

Greek-lyric
Ode to a Nightingale
Lexeme Hierarchy

- **PART-OF-SPEECH**
  - *verb-lxm*
  - *adj-lxm*
  - ...

- **ARG-SELECTION**
  - *si-lxm*
  - *pp-arg-lxm*
  - *sr-lxm*
  - *sc-lxm*
  - *

- *die*
- *rely*
- *continue*
- *try*
- *dead*
- *fond*
- *likely*
- *eager*
Lexeme Abbreviations

• $si$-l$xm$ : strict-intransitive-lexeme
• $pp$-arg-l$xm$ : PP-argument-lexeme
• $sr$-l$xm$ : subject-raising-lexeme
• $sc$-l$xm$ : subject-control-lexeme
• $siv$-l$xm$ : strict-intransitive-verb-lexeme
• $piv$-l$xm$ : PP-intransitive-verb-lexeme
• $srv$-l$xm$ : subject-raising-verb-lexeme
• $scv$-l$xm$ : subject-control-verb-lexeme
• $sia$-l$xm$ : strict-intransitive-adjective-lexeme
• $pia$-l$xm$ : PP-intransitive-adjective-lexeme
• $sra$-l$xm$ : subject-raising-adjective-lexeme
• $sca$-l$xm$ : subject-control-adjective-lexeme
Lexeme Constraints

- $si-lxm: \left[ \text{ARG-ST} \langle X \rangle \right]$
- $pp-arg-lxm: \left[ \text{ARG-ST} \langle X, PP \rangle \right]$
- $sr-lxm: \left[ \text{ARG-ST} \langle 1, [\text{SPR} \langle 1 \rangle] \rangle \right]$
- $sc-lxm: \left[ \text{ARG-ST} \langle NP_i, [\text{SPR} \langle NP_i \rangle] \rangle \right]$
Another Lexeme Constraint

verb-lxm:

\[
\begin{align*}
\text{SYN} & \quad \begin{cases}
\text{HEAD} & \begin{cases}
\text{verb} & - \\
\text{PRED} & - \\
\text{INF} & - \\
\text{AUX} & - \\
\text{POL} & - 
\end{cases} \\
\text{ARG-ST} & \begin{cases}
\text{VAL} & \begin{cases}
\text{SPR} & \langle \rangle \\
\text{COMPS} & \langle \rangle 
\end{cases} \\
\text{SEM} & \begin{cases}
\text{MODE} & \text{prop} 
\end{cases}
\end{cases}
\end{align*}
\]
And Another

\[
\begin{align*}
\text{SYN} & : \begin{bmatrix}
\text{HEAD} & \text{adj} \\
\text{VAL} & \\
\end{bmatrix} \\
\text{VAL} & : \begin{bmatrix}
\text{SPR} & \langle X \rangle \\
\text{MOD} & \langle [\text{HEAD} \text{ noun}] \rangle \\
\end{bmatrix} \\
\text{ARG-ST} & : \begin{bmatrix}
\text{HEAD} & \text{nominal} \\
\text{VAL} & \\
\end{bmatrix} \\
\text{SEM} & : \begin{bmatrix}
\text{MODE} & \text{prop} \\
\end{bmatrix}
\end{align*}
\]
Synsem Types

\[ \text{synsem} \]

\[ \text{expression} \quad \text{lexeme} \]

\[ \text{phrase} \quad \text{word} \]
Give ARG-ST a Unique Home

synsem

expression

phrase

word

lexeme

lex-sign
Words and Phrases as Saussurean Signs

\[
\begin{align*}
\text{word} = & \begin{cases}
\text{PHON} & \langle \text{Kim} \rangle \\
\text{SEM} & \begin{cases}
\text{MODE} & \text{ref} \\
\text{INDEX} & i \\
\text{RESTR} & \begin{cases}
\text{RELN} & \text{name} \\
\text{SIT} & s \\
\text{NAME} & \text{Kim} \\
\text{NAMED} & i \\
\end{cases}
\end{cases}
\end{cases}
\end{align*}
\]
Phrases as Signs

\[
\begin{align*}
\text{phrase} & \quad \langle \text{Kim, walks} \rangle \\
\text{PHON} & \quad \langle \text{Kim, walks} \rangle \\
\text{HEAD} & \quad \left[ \begin{array}{c} \text{verb} \\
\text{FORM} & \text{fin} \end{array} \right] \\
\text{SYN} & \quad \left[ \begin{array}{c} \text{HEAD} \\
\text{FORM} & \text{fin} \end{array} \right] \\
\text{SPR} & \quad \langle \rangle \\
\text{COMPS} & \quad \langle \rangle \\
\text{MODE} & \quad \text{prop} \\
\text{INDEX} & \quad s \\
\text{SEM} & \quad \left[ \begin{array}{c} \text{RELN} & \text{name} \\
\text{NAME} & \text{Kim} \end{array} \right], \left[ \begin{array}{c} \text{RELN} & \text{walk} \\
\text{SIT} & s \end{array} \right], \ldots \\
\text{RESTR} & \quad \left[ \begin{array}{c} \text{RELN} & \text{name} \\
\text{NAME} & \text{Kim} \end{array} \right], \left[ \begin{array}{c} \text{RELN} & \text{walk} \\
\text{SIT} & s \end{array} \right], \ldots \\
\end{align*}
\]
# Types and Constraints

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FEATURES/VALUE TYPES</th>
<th>IST</th>
</tr>
</thead>
</table>
| sign          | \[
|               | PHON \ list(form)               | feat-struc  |
|               | SYN \ syn-cat                   |              |
|               | SEM \ sem-cat                   |              |
| expression    |                                         | sign         |
| lex-sign      | \[ARG-ST \ list(expression)]      | sign         |
| phrase        |                                         | expression   |
| word          |                                         | expression & lex-sign |
| lexeme        |                                         | lex-sign     |
## Constructions: Some Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$cx$</td>
<td>construction</td>
</tr>
<tr>
<td>$l-cx$</td>
<td>lexical-construction</td>
</tr>
<tr>
<td>$d-cx$</td>
<td>derivational-construction</td>
</tr>
<tr>
<td>$i-cx$</td>
<td>inflectional-construction</td>
</tr>
<tr>
<td>$pi-cx$</td>
<td>postinflectional-construction</td>
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<tr>
<td>$p-cx$</td>
<td>phrasal-construction</td>
</tr>
<tr>
<td>$non-hd-cx$</td>
<td>non-headed-construction</td>
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<tr>
<td>$hd-cx$</td>
<td>headed-construction</td>
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<td>$coord-cx$</td>
<td>coordinate-construction</td>
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<tr>
<td>$imp-cx$</td>
<td>imperative-construction</td>
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<td>$hd-fill-cx$</td>
<td>head-filler-construction</td>
</tr>
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<td>$hd-comp-cx$</td>
<td>head-complement-construction</td>
</tr>
<tr>
<td>$hd-spr-cx$</td>
<td>head-specifier-construction</td>
</tr>
<tr>
<td>$hd-mod-cx$</td>
<td>head-modifier-construction</td>
</tr>
</tbody>
</table>
The World of Constructions
# Properties of Constructions

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FEATURES/VALUE TYPES</th>
<th>IST</th>
</tr>
</thead>
</table>
| $cx$  | \[
| MOTHER  | sign               |
| DTRS      | list(sign)          |
| feat-struc |
| $l-cx$ | \[
| MOTHER  | lex-sign            |
| DTRS      | ⟨ lex-sign ⟩        |
| cx        |
| $p-cx$  | \[
| MOTHER  | phrase              |
| DTRS      | list(expression)    |
| cx        |
Well-Formed Tree Structure

Φ is a Well-Formed Structure according to a grammar G if and only if

1. there is some construction C in G, such that
2. there is a feature structure I that is an instantiation of C, such that Φ is the value of the MOTHER feature of I.
A Well-Formed Feature Structure

The grammar licenses a feature structure of type phrase whose PHON value is \(<\text{ate}, \text{a}, \text{pizza}>\) because there is a feature structure instantiating the head-complement construction that has that feature structure as its MOTHER value. This phrasal construct satisfies the following description:
Another Well-Formed Feature Structure

```
lexeme

PHON  ⟨ driver ⟩

SYN

   HEAD  [ noun
         AGR [PER 3rd]
   ]

   VAL  [ SPR  ⟨ DP ⟩
        COMPS ⟨ ⟩
        MOD ⟨ ⟩
   ]

   GAP ⟨ ⟩

   MODE ref

   INDEX i

SEM

   RESTR  ⟨ [ RELN drive ] ⟩
        [ SIT s
        DRIVER i ]
```
Two Constraints

Root Constraint:

\[
\begin{bmatrix}
\text{SYN} & [\text{verb}] \\
\text{HEAD} & [\text{FORM fin}] \\
\text{VAL} & [\text{COMPS} \langle \rangle] \\
\text{GAP} & \langle \langle \rangle \rangle
\end{bmatrix}
\]

Principle of Order:

\[
\begin{bmatrix}
\text{MOTHER} & [\text{PHON A1} \oplus \ldots \oplus \text{An}] \\
\text{DTRS} & \langle [\text{PHON A1}] , \ldots , [\text{PHON An}] \rangle
\end{bmatrix}
\]
Semantic Compositional Principle

\[
\begin{align*}
  cx : & \begin{cases}
    \text{MOTHER} & \langle \text{SEM [RESTR } A_1 \oplus \ldots \oplus A_n \rangle \\
    \text{DTRS} & \langle \text{SEM [RESTR } A_1 \rangle, \ldots, \text{SEM [RESTR } A_n \rangle \rangle \\
  \end{cases} \\
  \text{CX-SEM} & : A_0
\end{align*}
\]

Alternative Version:

\[
\begin{align*}
  cx : & \begin{cases}
    \text{MOTHER} & \langle \text{SEM [RESTR } A_0 \oplus A_1 \oplus \ldots \oplus A_n \rangle \\
    \text{DTRS} & \langle \text{SEM [RESTR } A_1 \rangle, \ldots, \text{SEM [RESTR } A_n \rangle \rangle \\
  \end{cases} \\
  \text{CX-SEM} & : A_0
\end{align*}
\]
Head Feature Principle:

\[
hd-cx : \begin{bmatrix}
\text{MOTHER} & [\text{SYN} \ [\text{HEAD} \ [1]] ] \\
\text{HD-DTR} & [\text{SYN} \ [\text{HEAD} \ [1]] ] \\
\end{bmatrix}
\]
Two More Principles

Semantic Inheritance Principle:

\[ \text{hd-cx} : \begin{bmatrix}
\text{MOTHER} \\
\text{HD-DTR}
\end{bmatrix} \begin{bmatrix}
\text{SEM} \\
\text{SEM}
\end{bmatrix} \begin{bmatrix}
\text{MODE} \\
\text{INDEX}
\end{bmatrix} \]

Valence Principle:

\[ \text{hd-cx} : \begin{bmatrix}
\text{MOTHER} \\
\text{HD-DTR}
\end{bmatrix} \begin{bmatrix}
\text{SYN} [\text{VAL} / 1]
\end{bmatrix} \]
The GAP Principle

\[ \text{hd-cx:} \]
\[
\left[ \begin{array}{l}
\text{MOTHER} & \text{[SYN \ [GAP ( A1 \oplus \ldots \oplus \ A_n \oplus \ A_0 ) \ominus \ A_0 ]]} \\
\text{HD-DTR} & \text{[SYN \ [STOP-GAP A_0 ]]} \\
\text{DTRS} & \langle \text{[SYN \ [GAP A_1 ]}, \ldots, \text{[SYN \ [GAP A_n ]]} \rangle \\
\end{array} \right]
\]
The Head-Complement Construction

$$hd-comp-cx: \begin{bmatrix}
\text{MOTHER} & [\text{SYN} [\text{VAL} [\text{COMPS } \langle \rangle ] ] ] \\
\text{HD-DTR} & [\text{word} \\
\text{SYN} & [\text{VAL} [\text{COMPS } \boxed{A} ] ] ] \\
\text{DTRS} & [\langle 0 \rangle \oplus \boxed{A} \text{ anelist}]
\end{bmatrix}$$

And with inherited constraints....
An Instance of the HCC

\[
\begin{array}{c}
hd\text{-}comp\text{-}cx \\
MOTHER \\
HD\text{-}DTR \\
DTRS
\end{array}
\]

\[
\begin{array}{c}
\begin{array}{ll}
\text{phrase} & \\
\text{PHON} \langle \text{talked, to, Kim} \rangle & \\
\text{HEAD} & \text{verb} \\
\text{SYN} & \\
\text{VAL} & \text{SPR} \langle A \langle \text{NP} \rangle \rangle \\
\text{COMPS} & \langle \rangle \\
\text{SEM} & \text{[ ... ]}
\end{array} \\
\begin{array}{ll}
\text{word} & \\
\text{PHON} \langle \text{talked} \rangle & \\
\text{HEAD} & \text{verb} \\
\text{SYN} & \\
\text{VAL} & \text{SPR} \langle A \rangle \\
\text{COMPS} & \langle 1 \rangle \\
\text{SEM} & \text{[ ... ]}
\end{array} \\
\begin{array}{ll}
\text{phrase} & \\
\text{PHON} \langle \text{to, Kim} \rangle & \\
\text{HEAD} & \text{prep} \\
\text{SYN} & \\
\text{VAL} & \text{SPR} \langle \rangle \\
\text{COMPS} & \langle \rangle \\
\text{SEM} & \text{[ ... ]}
\end{array}
\end{array}
\]
Two More Constructions

\(hd-spr-cx:\)

\[
\begin{bmatrix}
\text{MOTHER} & \begin{bmatrix}
\text{SYN} & \begin{bmatrix}
\text{SPR} & \langle \rangle \\
\text{HD-DTR} & 0
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\text{HD-DTR} & \begin{bmatrix}
\text{SYN} & \begin{bmatrix}
\text{SPR} & \langle 1 \rangle \\
\text{COMPS} & \langle \rangle \\
\text{STOP-GAP} & \langle \rangle 
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\text{DTRS} & \langle 1, 0 \rangle
\end{bmatrix}
\]

\(hd-mod-cx:\)

\[
\begin{bmatrix}
\text{HD-DTR} & \begin{bmatrix}
\text{SYN} & \begin{bmatrix}
\text{VAL} & \begin{bmatrix}
\text{COMPS} & \langle \rangle \\
\text{STOP-GAP} & \langle \rangle 
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\text{DTRS} & \langle 1, \begin{bmatrix}
\text{SYN} & \begin{bmatrix}
\text{VAL} & \begin{bmatrix}
\text{COMPS} & \langle \rangle \\
\text{MOD} & \langle 1 \rangle 
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}\rangle
\]
A Tree

\[
\begin{array}{l}
\text{PHON } \langle \text{Kim, loves, Sandy} \rangle \\
\text{SYN } S \\
\text{SEM } [\text{RESTR } A \oplus B \oplus C]
\end{array}
\]
The Head-Filler Construction

\[ hd-fill-cx : \]

\[
\begin{align*}
\text{HD-DTR} \quad &\quad 0 \quad \text{SYN} \\
\text{VAL} \quad &\quad \text{HEAD} \\
\text{GAP} \quad &\quad \text{STOP-GAP} \\
\text{DTRS} \quad &\quad \langle 1 \rangle \text{[GAP } \langle \rangle \rangle \text{, } 0 \rangle
\end{align*}
\]

\[
\begin{array}{c}
\text{verb} \\
\text{FORM fin} \\
\text{SPR } \langle \rangle \\
\text{COMPS } \langle \rangle \\
\end{array}
\]
The Imperative Construction

```
imp-cx:

MOTHER

SYN

HEAD verb

VAL

[SPR ⟨⟩]

GAP

Α

SEM

MODE dir

INDEX s

SEM [INDEX s]

DTRS

SYN

HEAD

verb

[INF − FORM base]

VAL

[SPR ⟨NP[PER 2nd] ⟩]

GAP

Α

COMPS ⟨⟩

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OTOR

SYN

HEAD

verb

[INF − FORM base]

VAL

[SPR ⟨NP[PER 2nd] ⟩]

GAP

Α

COMPS ⟨⟩

SEM [INDEX s ]

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Coordination Construction

\[
\text{MOTHER} \begin{bmatrix}
\text{SYN} & \text{HEAD} & \text{FORM} \ [1] \\
\text{VAL} & 2 \\
\text{GAP} & A \\
\text{SEM} & \text{IND} & s_0
\end{bmatrix}
\]

\[
\text{DTRS} \langle \begin{bmatrix}
\text{SYN} & \text{HEAD} & \text{FORM} \ [1] \\
\text{VAL} & 2 \\
\text{GAP} & A \\
\text{SEM} & \text{IND} & s_1
\end{bmatrix} , \\
\text{HEAD conj} \\
\text{IND} & s_0 \\
\text{RESTR} \langle \text{ARGS} \langle s_1 \ldots s_n \rangle \rangle
\rangle \text{,}
\]

\[
\langle \begin{bmatrix}
\text{SYN} & \text{HEAD} & \text{FORM} \ [1] \\
\text{VAL} & 2 \\
\text{GAP} & A \\
\text{SEM} & \text{IND} & s_{n-1}
\end{bmatrix} \\
\text{HEAD conj} \\
\text{IND} & s_0 \\
\text{RESTR} \langle \text{ARGS} \langle s_1 \ldots s_n \rangle \rangle \rangle
\]

\[
\langle \begin{bmatrix}
\text{SYN} & \text{HEAD} & \text{FORM} \ [1] \\
\text{VAL} & 2 \\
\text{GAP} & A \\
\text{SEM} & \text{IND} & s_n
\end{bmatrix} \rangle
\]

\[\ldots\]

\[
\langle \begin{bmatrix}
\text{SYN} & \text{HEAD} & \text{FORM} \ [1] \\
\text{VAL} & 2 \\
\text{GAP} & A \\
\text{SEM} & \text{IND} & s_{n-1}
\end{bmatrix} \rangle
\]

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MOTHER
SYN
PHON \langle \text{Kim, sleeps, and, Pat, works} \rangle
[HEAD \verb]
VAL
[SPR \langle \rangle]
[COMPS \langle \rangle]
SEM [ ... ]

DTRS \langle
SYN
PHON \langle \text{Kim, sleeps} \rangle
[HEAD \verb]
VAL
[SPR \langle \rangle]
[COMPS \langle \rangle]
SEM [ ... ]

PHON \langle \text{and} \rangle
[PHON \langle \text{Pat, works} \rangle
[HEAD \verb]
VAL
[SPR \langle \rangle]
[COMPS \langle \rangle]
SEM [ ... ]

SYN
[HEAD \text{conj}]
SEM [ ... ]

⟩
## Some More Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>imp-cl</td>
<td>imperative-clause</td>
</tr>
<tr>
<td>decl-cl</td>
<td>declarative-clause</td>
</tr>
<tr>
<td>simp-decl-cl</td>
<td>simple-declarative-clause</td>
</tr>
<tr>
<td>top-cl</td>
<td>topicalized-clause</td>
</tr>
<tr>
<td>wh-rel-cl</td>
<td>wh-relative-clause</td>
</tr>
<tr>
<td>wh-int-cl</td>
<td>wh-interrogative-clause</td>
</tr>
<tr>
<td>core-cl</td>
<td>core-clause</td>
</tr>
</tbody>
</table>
A Construction Hierarchy

construction

CLAUSALITY

clause

non-clause

core-cl

rel-cl

decl-cl

int-cl

imp-cl

simp-decl-cl

top-cl

wh-rel-cl

wh-int-cl

Go in!

Kim left

Lee, we like

which Bo saw

Who do we see?

HEADEDNESS

non-hd-cx

hd-fill-cx

hd-spr-cx

hd-cx
Locality

• Like CFG rules, constructions involve only mothers and daughters.
• A lexical head can place constraints on its sisters or on an appropriate maternal dependent.
• Unbounded dependencies are localized.

  Sandy is hard ((for us) to continue) to please___
  Getting it done is hard for us to imagine them considering___

• Our principles provide a theory of what information (reflected in terms of HEAD, VAL, GAP, etc.) is passed up within the domain projected by a lexical head (including subjects and modifiers) and hence a theory of what information is locally accessible at any given point in a tree.
Reading Questions

• Why wait until Ch 16 to do this?
• Is Ch 16 the final version of the grammar, or is Appendix A?
• Which one do the implemented grammars look like?
• Other kinds of computational syntax?
• What is a sign and why are words and phrases both signs?
Reading Questions

• Why is PHON list-valued? Why are the PHON values of phrases lists of words?

• How does PHON relate to the morphological functions in lexical rules?

• Why are the things on those lists orthographic rather than phonetic (or both)?

• What is the value of having PHON on phrases? Isn't that redundant to what's in the yield of the tree?
Reading Questions

• Are there still trees in this version of the theory?

• What's the gain of making everything feature structures?

• What are examples of semantically contentful constructions?

• Doesn't a multiple inheritance hierarchy lead to more types? How is that more convenient?
Untangle This

• What phenomena are illustrated by this sentence?

• What rules or interesting lexical types are involved in our analysis of it?

• What tree structure does our grammar assign?
Complicated example #5

That Sandy could laugh so hard, Kim did not realize.

*That Sandy could laugh so hard, Kim realized not.

*Sandy could laugh so hard, Kim did not realize.

*That Sandy could laugh so hard, Kim did not realize it.
That Sandy could laugh

Kim did not realize
Complicated example #6

*Kim continues to be likely to be easy to talk to.

*Kim continue to be likely to be easy to talk to.

*Kim continues to be likely to is easy to talk to.

*Kim continues to Kim be likely to be easy to talk to.
Kim continues to be likely to be easy to talk to.
Complicated example #7

That cake, Kim thought would be easy to eat.

*That cake, Kim thought would be easy to eat pie.

*That cake, Kim thought would be easy to eaten.

*Cupcake, Kim thought would be easy to eat.

*That cake, Kim thought that would be easy to eat.
That cake Kim thought would be easy to eat.
Course overview

• Survey of some phenomena central to syntactic theory

• Introduction to the HPSG framework

• Process over product: How to build a grammar fragment

• Value of precise formulation (and of getting a computer to do the tedious part for you!)
Reflection

• What was the most surprising thing in this class?
• What do you think is most likely wrong?
• What do you think is the coolest result?
• What do you think you’re most likely to remember?
• How do you think this course will influence your work as a computational linguist?
Overview

• Chapter 16 framework (same analyses, different underlying system)

• Reading questions

• Untangle this

• General wrap up