Ling 566
Oct 9, 2008
Semantics
Overview

• Some notes on the linguist’s stance
• Which aspects of semantics we’ll tackle
• Our formalization; Semantics Principles
• Building semantics of phrases
• Modification, coordination
• Structural ambiguity
The Linguist's Stance: Building a precise model

• Some of our statements are statements about how the model works:

“[prep] and [AGR 3sing] can’t be combined because AGR is not a feature of the type prep.”

• Some of our statements are statements about how (we think) English or language in general works.

“The determiners a and many only occur with count nouns, the determiner much only occurs with mass nouns, and the determiner the occurs with either.”

• Some are statements about how we code a particular linguistic fact within the model.

“All count nouns are [SPR < [COUNT +]>].”
The Linguist's Stance:
A Vista on the Set of Possible English Sentences

• ... as a background against which linguistic elements (words, phrases) have a distribution

• ... as an arena in which linguistic elements “behave” in certain ways
Semantics: Where's the Beef?

So far, our grammar has no semantic representations. We have, however, been relying on semantic intuitions in our argumentation, and discussing semantic contrasts where they line up (or don't) with syntactic ones.

Examples?

- structural ambiguity
- S/NP parallelism
- count/mass distinction
- complements vs. modifiers
Our Slice of a World of Meanings
Aspects of meaning we won’t account for

• Pragmatics
• Fine-grained lexical semantics:

The meaning of *life* is *life‘*, or, in our case,

\[
\begin{bmatrix}
\text{RELN} & \text{life} \\
\text{INST} & i
\end{bmatrix}
\]
“... the linguistic meaning of *Chris saved Pat* is a proposition that will be true just in case there is an actual situation that involves the saving of someone named Pat by someone named Chris.” (p. 140)
Our Slice of a World of Meanings

What we are accounting for is the compositionality of sentence meaning.

• How the pieces fit together
  ➞ Semantic arguments and indices

• How the meanings of the parts add up to the meaning of the whole.
  ➞ Appending RESTR lists up the tree
Semantics in Constraint-Based Grammar

• Constraints as (generalized) truth conditions
  • proposition: what must be the case for a proposition to be true
  • directive: what must happen for a directive to be fulfilled
  • question: the kind of situation the asker is asking about
  • reference: the kind of entity the speaker is referring to

• Syntax/semantics interface: Constraints on how syntactic arguments are related to semantic ones, and on how semantic information is compiled from different parts of the sentence.
Feature Geometry

**SYN**
- **HEAD** \( pos \)
- **VAL**
  - **SPR** \( list(expression) \)
  - **COMPS** \( list(expression) \)

**SEM**
- **MODE** \{ prop, ques, dir, ref, none \}
- **INDEX** \{ \( i, j, k, \ldots s_1, s_2, \ldots \) \}
- **RESTR** \( list(pred) \)
How the Pieces Fit Together

```
⟨ Dana ,

word

[ HEAD
noun
AGR 3sing ]

[ SPR ⟨ ⟩ ]

[ COMPS ⟨ ⟩ ]

INDEX

i

MODE ref

RESTR

REM

NAME Dana

NAMED i

SEM

⟩
```
How the Pieces Fit Together

\[ \langle \text{slept}, \right| \begin{array}{ll}
\text{word} & \left| \begin{array}{l}
\text{HEAD} & \text{verb} \\
\text{VAL} & \left| \begin{array}{l}
\text{SPR} & \langle \text{NP} j \rangle \\
\text{COMPS} & \langle \rangle \\
\text{INDEX} & s_1 \\
\text{MODE} & \text{prop} \\
\text{RESTR} & \left| \begin{array}{l}
\text{RELN} & \text{sleep} \\
\text{SIT} & s_1 \\
\text{SLEEPER} & j \\
\end{array} \right|, \ldots
\end{array} \right| \right| \end{array} \right| \]
The Pieces Together

S

[SEM [INDEX i]]

[INP]

Dana

[VP

[SYN [VAL [SPR ⟨⟩]]]

SEM

RESTR

[RELN sleep s₁, ...]

SLEEPER i

slept]
To Fill in Semantics for the S-node

We need the Semantics Principles

• The Semantic Inheritance Principle:

In any headed phrase, the mother's MODE and INDEX are identical to those of the head daughter.

• The Semantic Compositionality Principle:
Semantic Inheritance Illustrated
To Fill in Semantics for the S-node

We need the Semantics Principles

• The Semantic Inheritance Principle:
  In any headed phrase, the mother's MODE and INDEX are identical to those of the head daughter.

• The Semantic Compositionality Principle:
  In any well-formed phrase structure, the mother's RESTR value is the sum of the RESTR values of the daughter.
Semantic Compositionality Illustrated

\[
\begin{array}{c}
S \\
\text{SEM} \\
\text{INDEX } s_1 \\
\text{MODE } \text{prop} \\
\text{RESTRICTION} \\
\langle \left[ \text{RELN name} \right], \left[ \text{RELN sleep} \right], \ldots \rangle \\
\end{array}
\]

\[
\begin{array}{c}
\text{NP} \\
\text{SEM} \\
\text{INDEX } i \\
\text{RESTRICTION} \\
\langle \left[ \text{RELN name} \right], \left[ \text{NAMED } i \right] \rangle \\
\end{array}
\]

\[
\begin{array}{c}
\text{VP} \\
\text{SEM} \\
\text{RESTRICTION} \\
\langle \left[ \text{RELN sleep} \right], \left[ \text{SLEEPER } i \right] \rangle \\
\end{array}
\]

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What Identifies Indices?

S

[1]NP

D
the

NOM

[1]cat

VP[SPR 〈1〉]

SPR

〈1〉

RESTR

RELN sleep

SIT

SLEEPER 〈i〉

s

3

slept

PP

on the mat
Summary: Words ...

- contribute predications
- ‘expose’ one index in those predications, for use by words or phrases
- relate syntactic arguments to semantic arguments

\[
\begin{align*}
\langle \text{slept,} \rangle
\end{align*}
\]
Summary: Grammar Rules...

- identify feature structures (including the INDEX value) across daughters

**Head Specifier Rule**

\[
\begin{align*}
\begin{array}{c}
\text{phrase} \\
\text{SYN} \left[ \text{VAL} \left[ \text{SPR} \langle \rangle \right] \right]
\end{array}
\end{align*}
\rightarrow
\begin{array}{c}
\text{H} \\
\text{SYN} \left[ \text{VAL} \left[ \text{SPR} \langle \text{1} \rangle \rangle \right] \right]
\end{array}
\]

**Head Complement Rule**

\[
\begin{align*}
\begin{array}{c}
\text{phrase} \\
\text{SYN} \left[ \text{VAL} \left[ \text{COMPS} \langle \rangle \right] \right]
\end{array}
\end{align*}
\rightarrow
\begin{array}{c}
\text{H} \\
\text{word} \\
\text{SYN} \left[ \text{VAL} \left[ \text{COMPS} \langle \text{1}, \ldots, \text{n} \rangle \rangle \right] \right]
\end{array}
\]

**Head Modifier Rule**

\[
\begin{align*}
\begin{array}{c}
\text{phrase}
\end{array}
\end{align*}
\rightarrow
\begin{array}{c}
\text{H} \langle \text{1} \rangle \\
\text{SYN} \left[ \text{COMPS} \langle \rangle \right] \\
\text{SYN} \left[ \text{VAL} \left[ \text{COMPS} \langle \text{1}, \ldots, \text{n} \rangle \rangle \right] \right]
\end{array}
\]
Summary: Grammar Rules ...

- identify feature structures (including the INDEX value) across daughters
- license trees which are subject to the semantic principles
  - SIP ‘passes up’ MODE and INDEX from head daughter

```plaintext
S
  [INDEX s₁
   MODE prop]
  SEM
  [RELN name
   NAME Dana
   NAMED i]
  [RELN sleep
   SIT s₁
   SLEEPER i], ...

NP
  [INDEX i
   MODE prop]
  SEM
  [RELN name
   NAME Dana
   NAMED i]

VP
  [SYN [VAL [SPR ⟨⟩]]]
  INDEX s₁
  MODE prop
  SEM
  [RELN sleep
   SIT s₁
   SLEEPER i], ...
```
Summary: Grammar Rules ...

- identify feature structures (including the INDEX value) across daughters
- license trees which are subject to the semantic principles
  - SIP ‘passes up’ MODE and INDEX from head daughter
  - SCP: ‘gathers up’ predications (RESTR list) from all daughters

\[
\begin{align*}
S & \quad \text{SEM} \quad \text{INDEX } s_1 \\
& \quad \text{MODE } \text{prop} \\
& \quad \text{RESTR} \quad \langle \text{RELN} \quad \text{name} \rangle, \quad \langle \text{RELN} \quad \text{sleep} \rangle, \ldots \\
& \quad \langle \text{NAME} \quad \text{Dana} \rangle, \quad \langle \text{SIT} \quad s_1 \rangle, \ldots \\
& \quad \langle \text{NAMED} \quad i \rangle, \quad \langle \text{SLEEPER} \quad i \rangle \\
\end{align*}
\]
Other Aspects of Semantics

• Tense, Quantification (only touched on here)
• Modification
• Coordination
• Structural Ambiguity
Evolution of a Phrase Structure Rule

Ch. 2: \[ \text{NOM} \rightarrow \text{NOM PP} \]
\[ \text{VP} \rightarrow \text{VP PP} \]

Ch. 3:
\[
\begin{bmatrix}
\text{phrase} \\
\text{VAL} \\
\text{SPR}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\text{phrase} \\
\text{VAL} \\
\text{SPR}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\text{H} \\
\text{VAL} \\
\text{SPR}
\end{bmatrix}
\]

Ch. 4:
\[
\text{[phrase]} \rightarrow \text{H}\left[\text{VAL} \left[\text{COMPS } \langle \rangle\right]\right] \text{PP}
\]

Ch. 5:
\[
\text{[phrase]} \rightarrow \text{H}[\text{SYN} \left[\text{VAL} \left[\text{COMPS } \langle \rangle\right]\right]] \text{PP}
\]

Ch. 5 (abbreviated):
\[
\text{[phrase]} \rightarrow \text{H}[\text{COMPS } \langle \rangle] \text{PP}
\]
Evolution of Another Phrase Structure Rule

Ch. 2: $X --\to X^+ \text{ CONJ } X$

Ch. 3: $[1] \to [1]^+ \begin{bmatrix} \text{word} \\ \text{HEAD} \text{ conj} \end{bmatrix} [1]$

Ch. 4: $\begin{bmatrix} \text{VAL} [1] \end{bmatrix} \to \begin{bmatrix} \text{VAL} [1] \end{bmatrix}^+ \begin{bmatrix} \text{word} \\ \text{HEAD} \text{ conj} \end{bmatrix} [\text{VAL} [1]]$

Ch. 5: $\begin{bmatrix} \text{SYN} \ [\text{VAL} [0]] \\ \text{SEM} \ [\text{IND} \ s_0] \end{bmatrix} \to$

$\begin{bmatrix} \text{SYN} \ [\text{VAL} [0]] \\ \text{SEM} \ [\text{IND} \ s_1] \end{bmatrix} \ldots \begin{bmatrix} \text{SYN} \ [\text{VAL} [0]] \\ \text{SEM} \ [\text{IND} \ s_{n-1}] \end{bmatrix} \begin{bmatrix} \text{SYN} \ [\text{HEAD} \text{ conj}] \\ \text{SEM} \ [\text{IND} \ s_0] \end{bmatrix} \begin{bmatrix} \text{SEM} \ [\text{RESTR} \langle \text{ARGS} \langle s_1 \ldots s_n \rangle \rangle] \end{bmatrix} \begin{bmatrix} \text{SYN} \ [\text{VAL} [0]] \\ \text{SEM} \ [\text{IND} \ s_n] \end{bmatrix}$

Ch. 5 (abbreviated):

$\begin{bmatrix} \text{VAL} [0] \\ \text{IND} \ s_0 \end{bmatrix} \to \begin{bmatrix} \text{VAL} [0] \\ \text{IND} \ s_1 \end{bmatrix} \ldots \begin{bmatrix} \text{VAL} [0] \\ \text{IND} \ s_{n-1} \end{bmatrix} \begin{bmatrix} \text{HEAD} \text{ conj} \\ \text{IND} \ s_0 \end{bmatrix} \begin{bmatrix} \text{RESTR} \langle \text{ARGS} \langle s_1 \ldots s_n \rangle \rangle \end{bmatrix} \begin{bmatrix} \text{VAL} [0] \\ \text{IND} \ s_n \end{bmatrix}$
Combining Constraints and Coordination

Coordination Rule

\[
\begin{bmatrix}
\text{VAL} & 0 \\
\text{IND} & s_0
\end{bmatrix} \rightarrow \begin{bmatrix}
\text{VAL} & 0 \\
\text{IND} & s_1
\end{bmatrix} ... \begin{bmatrix}
\text{VAL} & 0 \\
\text{IND} & s_{n-1}
\end{bmatrix} \begin{bmatrix}
\text{HEAD} & \text{conj} \\
\text{IND} & s_0 \\
\text{RESTR} & \langle \text{ARGS} \langle s_1 \ldots s_n \rangle \rangle
\end{bmatrix} \begin{bmatrix}
\text{VAL} & 0 \\
\text{IND} & s_n
\end{bmatrix}
\]

Lexical Entry for a Conjunction

\[
\langle \text{and} , \\
\text{SEM} \begin{bmatrix}
\text{SYN} \\
\text{HEAD} & \text{conj} \\
\text{INDEX} & s \\
\text{MODE} & \text{none} \\
\text{RESTR} & \langle \left[ \text{RELN} \langle \text{and} \rangle \right] \rangle \\
\text{SIT} & s
\end{bmatrix} \rangle
\]
Combining Constraints and Coordination

Lexical Entry for \textit{and}

\[
\langle \text{and}, \quad \begin{bmatrix}
\text{SYN} & [\text{HEAD } \textit{conj}] \\
\text{INDEX} & s \\
\text{MODE} & \text{none} \\
\text{RESTR} & \langle [\text{RELN and } SIT] \rangle
\end{bmatrix} \rangle
\]

Coordination Rule

\[
\begin{bmatrix}
\text{VAL } [0] \\
\text{IND } s_0
\end{bmatrix} \rightarrow
\begin{bmatrix}
\text{VAL } [0] \\
\text{IND } s_1 \\
\vdots \\
\text{VAL } [0] \\
\text{IND } s_{n-1}
\end{bmatrix}
\begin{bmatrix}
\text{HEAD } \textit{conj} \\
\text{IND } s_0 \\
\text{RESTR} \langle [\text{ARGS } s_1 \ldots s_n] \rangle
\end{bmatrix}
\begin{bmatrix}
\text{VAL } [0] \\
\text{IND } s_n
\end{bmatrix}
\]

\text{Pat sings and Lee dances}
Structural Ambiguity, Tree I

\[ S \]
\[ IND \ s_0 \]
\[ CONJ \]
\[ IND \ s_0 \]
\[ S \]
\[ IND \ s_1 \]
\[ NP \]
\[ IND s_0 \]
\[ MODE \]
\[ prop \]
\[ RULE \]
\[ RELN \ name \]
\[ NAME \ Pat \]
\[ NAMED k \]
\[ RELN \ name \]
\[ NAME \ Lee \]
\[ NAMED j \]
\[ RELN \ sing \]
\[ SIT s_1 \]
\[ SINGER k \]
\[ RELN \ and \]
\[ SIT s_0 \]
\[ ARGS \ s_1, s_2 \]
\[ RELN \ dance \]
\[ SIT s_2 \]
\[ DANCER j \]
\[ RELN \ frequently \]
\[ ARG s_0 \]
\[ ADV \]
\[ MOD \ ⟨\ IDE⟩ \]
\[ frequently \]
Structural Ambiguity, Tree II

```
S
  |  CONJ
[IND s₁]  and  [IND s₂]
  |  
NP  VP
  |  
Pat  sings

S
  |  
[IND s₂]
  |  
NP  VP
  |  
Lee  dances

[IND s₀]

MODE prop

RESTR

[RELN name]
[RELN sing]
[RELN and]
[RELN frequently]

NAME Pat
NAME Lee
NAMED k
NAMED j
SIT s₁
SIT s₀
SIT s₂
SIT s₂
SITER k
DANCER j
ARGs ⟨s₁, s₂⟩
ARG s₂

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Question About Structural Ambiguity

Why isn’t this a possible semantic representation for the string *Pat sings and Lee dances frequently*?

```
IND s0
MODE prop

RESTR

[RELN name NAME Pat NAMED k], [RELN sing SIT SINGER k], [RELN and SIT s0],
[RELN name NAME Lee NAMED j], [RELN dance SIT s2], [ARGS ⟨s1, s2⟩],
[RELN frequently ARG s1]
```
Semantic Compositionality

\[
\begin{array}{c}
\text{IND} \quad s_0 \\
\text{MODE} \quad \text{prop} \\
\text{RESTR} \\
\begin{array}{c}
\text{RELN name} \\
\text{NAME Pat} \\
\text{NAMED k} \\
\text{RELN name} \\
\text{NAME Lee} \\
\text{NAMED j} \\
\end{array}
\begin{array}{c}
\text{RELN sing} \\
\text{SIT s_1} \\
\text{SINGER k} \\
\text{RELN dance} \\
\text{SIT s_2} \\
\text{DANCER j} \\
\end{array}
\begin{array}{c}
\text{RELN and} \\
\text{SIT s_0} \\
\text{ARGS} \langle s_1, s_2 \rangle \\
\text{RELN frequently} \\
\text{ARG s_2} \\
\end{array}
\end{array}
\]

\[
\begin{array}{c}
\text{IND} \quad s_0 \\
\text{MODE} \quad \text{prop} \\
\text{RESTR} \\
\begin{array}{c}
\text{RELN name} \\
\text{NAME Pat} \\
\text{NAMED k} \\
\text{RELN name} \\
\text{NAME Lee} \\
\text{NAMED j} \\
\end{array}
\begin{array}{c}
\text{RELN sing} \\
\text{SIT s_1} \\
\text{SINGER k} \\
\text{RELN dance} \\
\text{SIT s_2} \\
\text{DANCER j} \\
\end{array}
\begin{array}{c}
\text{RELN and} \\
\text{SIT s_0} \\
\text{ARGS} \langle s_1, s_2 \rangle \\
\text{RELN frequently} \\
\text{ARG s_2} \\
\end{array}
\end{array}
\]
Overview

• Some notes on the linguist’s stance
• Which aspects of semantics we’ll tackle
• Our formalization; Semantics Principles
• Building semantics of phrases
• Modification, coordination
• Structural ambiguity
• Next time: How the grammar works