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
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

\[
\begin{align*}
\text{SYN} & \quad \begin{bmatrix}
\text{HEAD} & pos \\
\text{VAL} & \begin{bmatrix}
\text{SPR} & \text{list(expression)} \\
\text{COMPS} & \text{list(expression)}
\end{bmatrix}
\end{bmatrix} \\
\text{SEM} & \quad \begin{bmatrix}
\text{MODE} & \{\text{prop}, \text{ques}, \text{dir}, \text{ref}, \text{none}\} \\
\text{INDEX} & \{i, j, k, \ldots s_1, s_2, \ldots\} \\
\text{RESTR} & \text{list(pred)}
\end{bmatrix}
\end{align*}
\]
How the Pieces Fit Together

\[
\left< \text{Dana} , \right>
\]

\[
\begin{array}{c}
\text{word} \\
\text{SYN} \\
\text{VAL} \\
\text{SEM} \\
\end{array}
\]

\[
\begin{array}{c}
\text{HEAD} \\
\text{AGR} \quad 3\text{sing} \\
\text{SPR} \quad \langle \rangle \\
\text{COMPS} \quad \langle \rangle \\
\text{INDEX} \\
\text{MODE} \\
\text{RESTR} \\
\text{RELN} \quad \text{name} \\
\text{NAME} \quad \text{Dana} \\
\end{array}
\]

\[
\begin{array}{c}
\text{MODE} \\
\text{ref} \\
\text{i} \\
\end{array}
\]

\[
\begin{array}{c}
\text{INDEX} \\
\text{i} \\
\end{array}
\]
How the Pieces Fit Together

\[
\langle \text{slept,} \rangle
\]

\[
\begin{array}{c}
\text{word} \\
\text{SYN} \\
\text{VAL} \\
\text{SEM}
\end{array}
\]

\[
\begin{align*}
\text{HEAD} & : \text{verb} \\
\text{SPR} & : \langle \text{NP} j \rangle \\
\text{COMPS} & : \langle \rangle \\
\text{INDEX} & : s_1 \\
\text{MODE} & : \text{prop} \\
\text{RESTR} & : \langle \text{RELN sleep} s_1 \rangle, \ldots
\end{align*}
\]
The Pieces Together

S

[SEM [INDEX i]]

[SEM [RESTR [RELN sleep s1], ...]]

[SYN [VAL [SPR ⟨⟩]]]

[INP]

Dana

slept
A More Detailed View of the Same Tree

S

[SEM

[INDEX

MODE

RESTR

]]

[INDEX

i

SEM

RESTR

]]

1NP

[RELN name

NAME Dana

NAMED i

]]

VP

[SYN [ VAL [ SPR ⟨ 1 ⟩ ]] ]

[RELN sleep

SIT s1

SLEEPER i

]]
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

S

[INDEX \(s_1\)]

[MODE prop]

[SEM]

[RESTR]

\[
\left\langle \begin{array}{c}
\text{RELN name} \\
\text{Name Dana} \\
\text{NAMED } i
\end{array} \right\rangle,
\left\langle \begin{array}{c}
\text{RELN sleep} \\
\text{SIT } s_1 \\
\text{SLEEPER } i
\end{array} \right\rangle,
\ldots
\]

[INP]

[SEM]

[RESTR]

\[
\left\langle \begin{array}{c}
\text{RELN name} \\
\text{Name Dana} \\
\text{NAMED } i
\end{array} \right\rangle
\]

[VP]

[SEM]

[RESTR]

\[
\left\langle \begin{array}{c}
\text{RELN sleep} \\
\text{SIT } s_1 \\
\text{SLEEPER } i
\end{array} \right\rangle,
\ldots
\]

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What Identifies Indices?

[Diagram of a tree structure representing a sentence: S -> [1]NP_i -> D the, NOM_i cat -> [SPR 1] -> [RESTR] -> [RELN sleep SIT s3 SLEEPER_i slept] -> VP[SPR 1] -> [PP] on the mat]
Summary: Words ...

- contribute predcations
- ‘expose’ one index in those predications, for use by words or phrases
- relate syntactic arguments to semantic arguments
Summary: Grammar Rules ...

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

Head Specifier Rule

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

Head Complement Rule

\[
\begin{align*}
&\left[ \text{phrase} \right] \\
&\quad \left[ \text{SYN} [\text{VAL} [\text{COMPS } \langle \rangle]] \right] \\
&\quad \rightarrow \quad \text{H} \left[ \text{SYN} [\text{VAL} [\text{COMPS } \langle \rangle]] \right]
\end{align*}
\]

Head Modifier Rule

\[
\begin{align*}
&\left[ \text{phrase} \right] \\
&\quad \rightarrow \quad \text{H} \left[ \text{SYN} [\text{COMPS } \langle \rangle]] \right] \times \text{H} \left[ \text{SYN} [\text{VAL} [\text{COMPS } \langle \rangle]] \right]
\end{align*}
\]
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

```
S

[ INDEX s₁
   MODE prop

   SEM
   RESTR
     RELN name ]
     NAME Dana
     NAMED i
   [ RELN sleep
     SIT s₁
     SLEEPER i ]
   ...
```

```
NP

[ INDEX i

   SEM
   RESTR
     RELN name ]
     NAME Dana
     NAMED i
```

```
VP

[ INDEX s₁
   MODE prop

   SEM
   RESTR
     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

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

```
NP
  [ INDEX i
    RELN name
    NAME Dana
    NAMED i
  ]
  SEM
  RESTR
```

```
VP
  [ SYN [ VAL [ SPR ⟨ ⟩ ] ]
    INDEX s₁
    MODE prop
   ]
  SEM
  RESTR
  [ RELN sleep
     SIT s₁
     SLEEPER i
   ]
```
Reading Questions

• What's with the overly specific semantic role labels (LOVER, LOVED, etc)? Why not go with something more general, like AGENT, PATIENT, …

• Thing #68

• Is there an unlimited set of possible RESTR values?

• Does the RELN represent the individual or situational value of the INDEX?
Reading Questions

• Are our semantic representations really semantics? They look syntactic.

• Are constraints really an encoding of semantics?
Reading Questions

• Does MOD get cancelled as you move up the tree? Does it get "fuller"?

• Does the current HMR only allow modifiers to the right of the head? How could we handle modifiers to the left?

• Why do we stipulate that mother's INDEX and MODE must be the same with HEAD daughter?
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: 
\[
\begin{bmatrix}
\text{phrase} \\
\text{VAL} \\
\text{SPR}
\end{bmatrix}
\begin{bmatrix}
\text{COMPS} \\
\text{itr}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\text{phrase} \\
\text{VAL} \\
\text{SPR}
\end{bmatrix}
\begin{bmatrix}
- 
\end{bmatrix}
\]

Ch. 4: 
\[
\begin{bmatrix}
\text{phrase}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\text{VAL} \\
\text{COMPS} \\
\end{bmatrix}
\begin{bmatrix}
- 
\end{bmatrix}
\]

Ch. 5: 
\[
\begin{bmatrix}
\text{phrase}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\text{SYN} \\
\text{VAL} \\
\text{COMPS}
\end{bmatrix}
\begin{bmatrix}
\text{MOD}
\end{bmatrix}
\begin{bmatrix}
- 
\end{bmatrix}
\begin{bmatrix}
\text{1}
\end{bmatrix}
\]

Ch. 5 (abbreviated): 
\[
\begin{bmatrix}
\text{phrase}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\text{COMPS}
\end{bmatrix}
\begin{bmatrix}
\text{MOD}
\end{bmatrix}
\begin{bmatrix}
\text{1}
\end{bmatrix}
\]
Evolution of Another Phrase Structure Rule

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

Ch. 3: $[1] \rightarrow [1]^{+} \left[ \begin{array}{c} \text{word} \\ \text{HEAD conj} \end{array} \right] [1]$

Ch. 4: $\left[ \begin{array}{c} \text{VAL} [1] \\ \text{HEAD conj} \end{array} \right] \rightarrow \left[ \begin{array}{c} \text{VAL} [1] \\ \text{HEAD conj} \end{array} \right] [\text{VAL} [1]]$

Ch. 5: $\left[ \begin{array}{c} \text{SYN [VAL 0]} \\ \text{SEM [IND } s_{0}] \end{array} \right] \rightarrow \left[ \begin{array}{c} \text{SYN [VAL 0]} \\ \text{SEM [IND } s_{1}] \end{array} \right] \ldots \left[ \begin{array}{c} \text{SYN [VAL 0]} \\ \text{SEM [IND } s_{n-1}] \end{array} \right]$

Ch. 5 (abbreviated):

$\left[ \begin{array}{c} \text{VAL } 0 \\ \text{IND } s_{0} \end{array} \right] \rightarrow \left[ \begin{array}{c} \text{VAL } 0 \\ \text{IND } s_{1} \end{array} \right] \ldots \left[ \begin{array}{c} \text{VAL } 0 \\ \text{IND } s_{n-1} \end{array} \right] \left[ \begin{array}{c} \text{HEAD conj} \\ \text{IND } s_{0} \end{array} \right] \left[ \begin{array}{c} \text{RESTR } \langle [\text{ARGS } s_{1} \ldots s_{n}] \rangle \end{array} \right] \left[ \begin{array}{c} \text{VAL } 0 \\ \text{IND } s_{n} \end{array} \right]$
Combining Constraints and Coordination

Coordination Rule

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

Lexical Entry for a Conjunction

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

\[
\text{SEM} \begin{bmatrix}
\text{and} \\
\text{SIT} & s
\end{bmatrix}
\]

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Combining Constraints and Coordination

Lexical Entry for *and*

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

Coordination Rule

\[
\begin{bmatrix}
\text{VAL} & \text{IND} & s_0 \\
\text{VAL} & \text{IND} & s_1 \\
\vdots \\
\text{VAL} & \text{IND} & s_{n-1}
\end{bmatrix} 
\rightarrow 
\begin{bmatrix}
\text{VAL} & \text{IND} & s_0 \\
\text{VAL} & \text{IND} & s_1 \\
\vdots \\
\text{VAL} & \text{IND} & s_{n-1}
\end{bmatrix}
\text{RESTR} \left\{ \text{ARGS} \left[ s_0, s_1, \ldots, s_n \right] \right\}
\]

Patterns

Pat sings

\[
\begin{bmatrix}
\text{HEAD} & \text{conj} \\
\text{IND} & s_0 \\
\text{RESTR} & \text{RELN} & \text{SIT} & \langle \text{and} \rangle & \langle \text{SIT} \rangle
\end{bmatrix}
\]

Lee dances
Structural Ambiguity, Tree II

S
  [IND s₀]
  S
  [IND s₁]
  CONJ
  [IND s₂]
  S
  NP
  [IND s₁] NP
  [IND s₀] VP
  Pat
  sings
  and
  S
  NP
  [IND s₂] NP
  Lee
  dances
  ADV
  [MOD ⟨frequently⟩]
Question About Structural Ambiguity

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

\[
\begin{align*}
\text{IND} & \quad s_0 \\
\text{MODE} & \quad \text{prop} \\
\text{RESTR} & \quad \begin{cases}
\text{RELN name} & \text{NAME Pat} \\
\text{NAMED} & k
\end{cases}, &
\begin{cases}
\text{RELN sing} & \text{SIT s}_1 \\
\text{SINGER} & k
\end{cases}, &
\begin{cases}
\text{RELN and} & \text{SIT } s_0 \\
\text{ARGS} & \langle s_1, s_2 \rangle
\end{cases}, \\
\text{RELN name} & \text{NAME Lee}, &
\begin{cases}
\text{RELN dance} & \text{SIT } s_2 \\
\text{DANCER} & j
\end{cases}, &
\begin{cases}
\text{RELN frequently} & \text{ARG } s_0
\end{cases}
\end{align*}
\]
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