Ling 566
Oct 16, 2007
How the Grammar Works
Overview

• What we’re trying to do
• The pieces of our grammar
• Two extended examples
• Reflection on what we’ve done, what we still have to do
What We’re Trying To Do

• Objectives
  • Develop a theory of knowledge of language
  • Represent linguistic information explicitly enough to distinguish well-formed from ill-formed expressions
  • Be parsimonious, capturing linguistically significant generalizations.

• Why Formalize?
  • To formulate testable predictions
  • To check for consistency
  • To make it possible to get a computer to do it for us
How We Construct Sentences

• The Components of Our Grammar
  • Grammar rules
  • Lexical entries
  • Principles
  • Type hierarchy (very preliminary, so far)
  • Initial symbol (S, for now)

• We combine constraints from these components.

Q: *What says we have to combine them?*

A: The definition of well-formed structure
An Example

A cat slept.

• Can we build this with our tools?

• Given the constraints our grammar puts on well-formed sentences, is this one?
Lexical Entry for *a*

- Is this a fully specified description?
- What features are unspecified?
- How many word structures can this entry license?
Lexical Entry for *cat*

- Which feature paths are abbreviated?
- Is this a fully specified description?
- What features are unspecified?
- How many word structures can this entry license?
Effect of Principles: the SHAC

\[
\begin{array}{c}
\langle \text{cat}, \text{word} \rangle \\
\langle \text{noun}, \text{head}, \text{d} \rangle \\
\langle \text{spr}, \text{spr}, \text{agr}^2 \rangle \\
\langle \text{comps}, \text{comps} \rangle \\
\langle \text{mod}, \text{mod} \rangle \\
\langle \text{mode}, \text{ref} \rangle \\
\langle \text{index}, k \rangle \\
\langle \text{rest}, \text{rest}, \text{rest}^2 \rangle \\
\end{array}
\]
Description of Word Structures for *cat*

![Diagram of word structures for cat](image-url)
Description of Word Structures for $a$

\[
\begin{align*}
\text{word} & \quad \begin{bmatrix}
\text{det} \\
\text{AGR} \quad 3\text{sing} \\
\text{COUNT} + \\
\end{bmatrix} \\
\text{HEAD} & \quad \begin{bmatrix}
\text{COMPS} \langle \rangle \\
\text{SPR} \langle \rangle \\
\text{MOD} \langle \rangle \\
\end{bmatrix} \\
\text{SYN} & \quad \begin{bmatrix}
\text{none} \\
\text{j} \\
\end{bmatrix} \\
\text{VAL} & \quad \begin{bmatrix}
\langle [\text{RELN}\ a] \rangle \\
\langle [\text{BV}\ j] \rangle \\
\end{bmatrix} \\
\text{SEM} & \quad \begin{bmatrix}
\langle a \rangle \\
\end{bmatrix}
\end{align*}
\]
Building a Phrase
Constraints Contributed by Daughter Subtrees
Constraints Contributed by the Grammar Rule

[phrase
  SYN [ VAL [ SPR ⟨ ⟩]]]

[word
  det
  HEAD
  AGR [ 3sing GEND neut]

  COUNT +
  COMPS ⟨ ⟩

  MOD ⟨ ⟩

  VAL

  MODE none

  INDEX k

  SEM

  RESTR ⟨[RELN a BV k]⟩]

[word
  noun
  HEAD
  AGR [ 3sing GEND neut]

  VAL

  SPR ⟨[COUNT + INDEX k]⟩

  COMPS ⟨ ⟩

  MOD ⟨ ⟩

  SYN

  [VAL

  SPR ⟨ ⟩]

  [MOD ⟨ ⟩]

  RESTR ⟨[RELN a BV k]⟩]

[word
  noun
  HEAD
  AGR [ 3sing GEND neut]

  VAL

  SPR ⟨[COUNT + INDEX k]⟩

  COMPS ⟨ ⟩

  MOD ⟨ ⟩

  SYN

  [VAL

  SPR ⟨ ⟩]

  [MOD ⟨ ⟩]

  RESTR ⟨[RELN a BV k]⟩]

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A Constraint Involving the SHAC

[phrase
  SYN [ VAL [ SPR ⟨ ⟩]]]

[SYN
  HEAD
    AGR
      3sing
      GEND neut
      COUNT +
    COMPS ⟨ ⟩
  SPR ⟨ ⟩
  MOD ⟨ ⟩
  MODE none
  INDEX k
  word]

[SEM
  INDEX k
  word]

[SYN
  HEAD
    AGR
      3sing
      GEND neut
      COUNT +
    SPR ⟨ ⟩
    MOD ⟨ ⟩
  MODE ref
  INDEX k
  word]

[SEM
  INDEX k
  word]
Effects of the Valence Principle

```
phrase
  SYN
  VAL
    COMPS 3
    MOD 4

word
  det
  AGR 2
  COUNT +
  COMPS ⟨ ⟩
  MOD 〈 ⟩

word
  noun
  AGR 2
  3sing
  GEND neut
  SPR ⟨ 7 ⟩
  COMPS 3 ⟨ ⟩
  MOD 4 ⟨ ⟩

word
  MODE ref
  INDEX k
  RESTR ⟨ RELN cat INST k ⟩
```
Effects of the Head Feature Principle

```
[phrase
  [SYN
    [VAL
      [COMPS 3]
      [MOD 4]
      [SPR ⟨⟩]]
    [HEAD 6]]
  [det [AGR 2 COUNT +]
    [COMPS ⟨⟩]
    [SPR ⟨⟩]
    [MOD ⟨⟩]]
  [word
    [word
      [noun
        [AGR 2 3sing GEND neut]]
      [HEAD 6]
      [MODE ref]
      [INDEX k]
      [RESTR ⟨RELN cat INSTANCE k⟩]]
      [word
        [word
          [noun
            [AGR 2 3sing GEND neut]]
          [HEAD 6]
          [MODE ref]
          [INDEX k]
          [RESTR ⟨RELN cat INSTANCE k⟩]]
      
```
Effects of the Semantic Inheritance Principle
Effects of the Semantic Compositionality Principle

[Diagram]

- **phrase**
  - **SYN**
    - **HEAD**: 6
    - **VAL**: [SPR ⟨ ⟩]
    - **COMPS**: [3]
    - **MOD**: [4]
  - **SEM**
    - **MODE**: 8
    - **INDEX**: k
    - **RESTR**: [A ⊕ B]

- **word**
  - **SYN**
    - **HEAD**: [det AGR 2]
    - **COUNT**: +
    - **VAL**: [COMPS ⟨ ⟩]
    - **SPR**: [⟨ ⟩]
    - **MOD**: [⟨ ⟩]
  - **SEM**
    - **MODE**: none
    - **INDEX**: k
    - **RESTR**: [RELN a BV k]

- **word**
  - **SYN**
    - **HEAD**: 6
    - **AGR**: 2
    - **3sing**: GEND neut
  - **SEM**
    - **MODE**: 8
    - **INDEX**: k
    - **RESTR**: [RELN cat INSTANCE k]
Is the Mother Node Now Completely Specified?

[Diagram of tree structures with labels and symbols, including 'phrase', 'SYN', 'VAL', 'COMPS', 'MOD', 'MODE', 'INDEX', 'RESTR', 'SEM', 'word', 'det', 'AGR 2', 'COUNT +', 'COMPS ⟨ ⟩', 'SPR ⟨ ⟩', 'SPR ⟨ ⟩', 'SPR ⟨ ⟩', 'MOD ⟨ ⟩', 'MODE none', 'INDEX k', 'RESTR A', 'RELN a BV k', 'noun', 'AGR 2', '3sing', 'GEND neut', 'HEAD 6', 'VAL', 'SPR ⟨ ⟩', 'COMPS 3', 'MOD 4', 'MODE 8 ref', 'INDEX k', 'RESTR B', 'RELN cat INSTANCE k', 'word', 'word']
Lexical Entry for **slept**

<table>
<thead>
<tr>
<th>word</th>
<th>syntactic category</th>
<th>semantic interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>slept,</strong></td>
<td>HEAD verb</td>
<td>( \text{NP}_m )</td>
</tr>
<tr>
<td></td>
<td>SPR</td>
<td>( \text{AGR}^{9} )</td>
</tr>
<tr>
<td></td>
<td>COMPS</td>
<td>( \text{CASE}^{\text{nom}} )</td>
</tr>
<tr>
<td></td>
<td>MOD</td>
<td>( )</td>
</tr>
<tr>
<td>INDEX</td>
<td>( s_1 )</td>
<td></td>
</tr>
<tr>
<td>Mode</td>
<td>prop</td>
<td></td>
</tr>
<tr>
<td><strong>slept,</strong></td>
<td>RELN sleep</td>
<td>( [s_1], \ldots )</td>
</tr>
<tr>
<td>PROTO</td>
<td>SIT ( s_1 )</td>
<td></td>
</tr>
<tr>
<td>SLEEPER</td>
<td>( m )</td>
<td></td>
</tr>
</tbody>
</table>
Another Head-Specifier Phrase

Key

- HSR
- SHAC
- Val Prin
- HFP
- SIP
- SCP

Phrase Structure:

```
phrase
  - HEAD 11
  - SYN
    - SPR ⟨ ⟩
    - VAL
      - COMPS 12
      - MOD 13
    - SEM
      - MODE 10 prop
      - INDEX s1
      - RESTR A ⊕ B ⊕ C
```

Word Structure:

```
word
  - HEAD 11
    - verb
      - AGR 9
  - SYN
    - SPR ⟨ ⟩
    - VAL
      - COMPS 12 ⟨ ⟩
      - MOD 13 ⟨ ⟩
    - SEM
      - MODE 10 prop
      - INDEX s1
      - RESTR C ⊕ RELN sleep
      - SIT s1 ⊕ SLEEPER k
```

Diagram:

- The diagram illustrates the syntactic and semantic structure of a sentence, focusing on head-specifier phrases.
- Each part of the structure is color-coded with the key on the right.
- The diagram uses arrows and boxes to represent the relationships between different parts of the sentence.
- The key on the right provides a legend for the colors used in the diagram.
Is this description fully specified?
Does the top node satisfy the initial symbol?
Initial Symbol (Ch 6 version)

\[
\left[ \begin{array}{c}
\text{SYN} \\
\text{VAL}
\end{array} \right]
\left[ \begin{array}{c}
\text{HEAD} \\
\verb
\text{SPR} \langle \rangle \\
\text{COMPS} \langle \rangle 
\end{array} \right]
\]
RESTR of the S node

\[
\langle \begin{bmatrix} \text{RELN} & a \end{bmatrix}, \begin{bmatrix} \text{RELN} & \text{cat} \end{bmatrix}, \begin{bmatrix} \text{RELN} & \text{sleep} \\ \text{SIT} & s_1 \\ \text{SLEEPER} & k \end{bmatrix}, \ldots \rangle
\]
Another Example

S

NP

the
photos

D NOM PP NP

of

the suspect

VP

disappeared

ADV

yesterday

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Head Features from Lexical Entries

```
S

NP          VP
  [HEADdet]  NOM          [HEADverb] [HEADadverb]
     the       photos       PP  disappeared  yesterday
     [HEADnoun]     [HEADprep]        NP
       of       [HEADdet]  [HEADnoun]
         of       the  suspect
```
Head Features from Lexical Entries, plus HFP

- [HEAD_1] [det] "the"
- [HEAD_1] [noun] "photos"
- [HEAD_2] [prep] "of"
- [HEAD_3] [det] "the"
- [HEAD_3] [noun] "suspect"
- [HEAD_4] [verb] "disappeared"
- [HEAD_adverb] "yesterday"
Valence Features: Lexicon, Rules, and the Valence Principle

Key

Lexicon

Val.

Rules

the

photos

of

disappeared

yesterday

of

the

suspect

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Required Identities: Grammar Rules

S

[1] NP

[2] D

the

N

[COMPS [3]]

photos

[3] PP

disappeared

[6] V

yesterday

[SPR [2]]

[4] NP

of

[5] D

the

[SPR [5]]

suspect

[COMPS [4]]
Two Semantic Features: the Lexicon & SIP

```
the

MODE prop
INDEX s3

MODE ref
INDEX j

the

MODE ref
INDEX j

photos

MODE ref
INDEX j

of

MODE ref
INDEX k

MODE none
INDEX s4

disappeared

yesterday

MODE prop
INDEX s3

MODE ref
INDEX j

the

MODE ref
INDEX k

suspect

```

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RESTR Values and the SCP

A ⊕ B ⊕ C ⊕ D ⊕ E ⊕ F ⊕ G

A ⊕ B ⊕ C ⊕ D ⊕ E

A ⊕ B ⊕ C ⊕ D

A

⟨[
RELN the
BV j
]⟩

the

B ⊕ C ⊕ D ⊕ E

B

⟨[
RELN photo
INST j
CONTENT k
]⟩

photos

[ C ⊕ D ⊕ E ]

of

C

D ⊕ E

disappeared

D ⊕ E

disappeared

E

⟨[
RELN yest.
ARG s3
]⟩
yesterday

E

⟨[
RELN suscep
INST k
]⟩
suspect

G

G
An Ungrammatical Example

What’s wrong with this sentence?
An Ungrammatical Example

What's wrong with this sentence?

So what?
An Ungrammatical Example

The Valence Principle

*\(S\)

[CASE acc]

them

[SPR \(\langle 1 \rangle \)]

sent

us

D

N

a

letter
An Ungrammatical Example

Head Specifier Rule

*S

→ contradiction

them

sent

us

a

letter
Exercise in Critical Thinking

• Our grammar has come a long way since Ch 2, as we've added ways of representing different kinds of information:
  • generalizations across categories
  • semantics
  • particular linguistic phenomena: valence, agreement, modification

• What else might we add? What facts about language are as yet unrepresented in our model?
Overview

• What we’re trying to do
• The pieces of our grammar
• Two extended examples
• Reflection on what we’ve done, what we still have to do
• Next time: Review