Informatics 1 Cognitive Science

Lecture 3: Introduction to Language

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Overview

Words

Rules

The Anatomy of Language
Words
What Are Words?

Pairing between a form and a meaning \(\text{(arbitrary and memorized)}\).

<table>
<thead>
<tr>
<th>form:</th>
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- A language community tacitly agrees to use a particular form to convey a particular idea.
- The word \textit{rose} does not smell sweet or have thorns, but we can use it to convey the idea of a rose.
What Are Words?

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- A language community tacitly agrees to use a particular form to convey a particular idea.
- The word *rose* does not smell sweet or have thorns, but we can use it to convey the idea of a rose.
- Onomatopoeia (e.g., *oink*, *crash*) and sound symbolism (e.g., *mellifluous*, *cantankerous*) do exist, but won’t get you far.
Words: The Mental Lexicon

- **Arbitrary sign**: conventional pairing of meaning and sound.
- The mental lexicon is the set of all the words in the language.
- Often assumed to form a hierarchy or a network.
- Speakers of the same language have mutually intelligible lexicon entries.
Example: WordNet Hierarchy

![Diagram showing WordNet hierarchy with examples like Vertebrate, Animal, Fish, Mammal, Mouse, and Artifact with Device and Machine categories.](image)
Amazing facts about how the mental lexicon is acquired and used:

- Between birth and adulthood, children learn about 40,000 unique words and idioms (fit as a fiddle).
- During the second postnatal year, children’s productive vocabulary accelerates dramatically: vocabulary explosion.
- People recognize and produce words extremely quickly: the meaning of a spoken word is accessed by the listener in 0.2 seconds.
- The brain takes 0.25 seconds to name an object, and further 0.25 seconds to program the mouth and tongue to pronounce it.
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Word Learning

Growth curve from the MacArthur-Bates Communicative Development Inventory (MCDI):

http://wordbank.stanford.edu/
Rules
We do not just blurt out isolated words.

Rather we combine them into phrases and sentences.

The meaning of the combination can be inferred from the meanings of the words and the way they are arranged.
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Do these mean the same?

1. The boy saw the girl with the telescope
2. The girl saw the telescope with the boy
3. The boy with the telescope saw the girl
Rules

There must be a code, a set of rules that specifies how words may be arranged into meaningful combinations: the grammar.

```
N       Det       V       NP       VP       S
 rose    a       is       Det      V      NP      NP      VP

a rose   is a     rose
```
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```
N  Det  V  
|    |    |  
rose  a  is

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Time for a short quiz on Wooclap!

https://app.wooclap.com/GDCILA
Rules are **productive**, defined over **kinds** of words rather than **actual** words (we assemble new sentences on the fly).

- Symbols contained in the rules are **abstract** (we can talk about anything we like!)
- The rules are also **combinatorial**: a small inventory of elements can be assembled by rules into immense set of distinct objects.
The Expressive Power of Rules

- Rules are *productive*, defined over *kinds* of words rather than *actual* words (we assemble new sentences on the fly).
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Example:

- Det $\in \{a, \text{any}, \text{one, the}\}$, N $\in$ 10,000 nouns, V $\in$ 4,000 verbs
- NP $\rightarrow$ Det N allows $4 \times 10,000 = 40,000$ NPs
- VP $\rightarrow$ V NP allows $40,000 \times 4,000 = 160,000,000$ VPs
- S $\rightarrow$ NP VP allows $160,000,000 \times 40,000 = 6.4$ trillion Ss
Natural languages exhibit recursion: the rules create an entity that can contain an example of itself. For example, the rule

\[ S \rightarrow NP \quad VP \]  
\[ VP \rightarrow V \quad NP \quad S \]  
\[ NP \rightarrow \text{NP} \]  
\[ V \rightarrow \text{VP} \]  
\[ S \rightarrow \text{NP} \]  
\[ \text{VP} \rightarrow V \quad \text{NP} \quad S \]
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\[ S \rightarrow NP \rightarrow VP \rightarrow V \rightarrow NP \rightarrow S \]
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```
S  →  NP VP
   →  V NP S
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   →  V NP S
```

```
VP  →  V NP S
    →  NP VP
    →  V NP S
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I think I’ll tell you that I just read a news story that recounts that Stephen Brill reported that the press uncritically believed Kenneth Starr’s announcement that Linda Tripp testified to him that Monica Lewinsky told Tripp that Bill Clinton told Vernon Jordan to advise Lewinsky not to testify to Starr that she had had a sexual relationship with Clinton.

How many sentences are there?
The Expressive Power of Rules

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How many sentences are there? Twelve!

Potential infiniteness of the language faculty has been recognized by Galileo, Descartes, von Humboldt. There is no longest sentence!
The Expressive Power of Rules

Time for a short quiz on Wooclap!

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The Anatomy of Language
The Conventional Wisdom: Words plus Rules

- Human language appears to have unlimited expressive power.
- We can be led to think thoughts that have never been thought before, and that never would have occurred to us on our own.
- We need more than just individual words to manage this!
- Words combine to produce meaningful utterances.
- We describe combinations in terms of rules.
- And we’re assuming for the time being that the word/rule duality corresponds to two distinct cognitive mechanisms:
The Anatomy of Language

- Mouth and ears
  - Phonology (rules that define the sound pattern of a language)
  - Lexicon (stored entries for words, including irregulars)
  - Morphology (rules for forming complex words, including regulars)
  - Syntax (rules for forming phrases and sentences)
  - Semantics (meanings expressed through language)
  - Beliefs and desires
Two Kinds of Words

Linguistics: word-as-morphological object, as opposed to phrases and sentences

Psychology: word-as-lexical entry, stretch of sound which has been memorized and cannot be produced by a rule. Pinker calls this a *listeme*

- Some memorized chunks are smaller than a word in first sense.
- Others are larger than a word in the first sense.
- The second sense of word covers things which appear only as parts of words in the first sense.
Pinker’s Listemes

**Suffixes**

-able  \( (cap-able) \)

-ed  \( (wak-ed) \)

-al  \( (refus-al) \)

-ship  \( (fellow-ship) \)

**Prefixes**

-un-  \( (un-finished) \)

-ante-  \( (ante-cedent) \)

-co-  \( (co-pilot) \)

-re-  \( (re-claim) \)
# Pinker’s Listemes

### Suffixes

- *-able*  
  - *cap-able*  
- *-ed*  
  - *wak-ed*  
- *-al*  
  - *refus-al*  
- *-ship*  
  - *fellow-ship*

### Prefixes

- *un-*  
  - *un-finished*  
- *ante-*  
  - *ante-cedent*  
- *co-*  
  - *co-pilot*  
- *re-*  
  - *re-claim*

### Idioms

- *piece of cake*
- *when pigs fly*
- *like two peas in a pod*
- *beat around the bush*
- *see eye to eye*
- *once in a blue moon*
- *the last straw*
- *the best of both worlds*
- *costs an arm and a leg*
- *add insult to injury*
The characteristics of language:

- It consists of words, arbitrary pairings of a sound and meaning.
- Between birth and adulthood, children learn about 40,000 words.
- The ordering of words is governed by a set of rules.
- Rules are combinatorial: they combine words to generate an unlimited number of sentences.
- Cognitively, words correspond to memory, and rules correspond to computation.
- Listemes are stored in memory: words, prefixes and suffixes, idioms.