Language 5: Empiricism and Nativism

Empiricism: The Lexicon

Impressive animal vocabularies learned through association

Empiricist (Behaviorism & West-Coast Connectionism)

- **Lexicon**: Learned associations between sound and object
- **Grammar**: Learned associations between word transitions

Nativist (Cognitivists)

- **Lexicon**: Learned symbols, learning constrained by domain general mechanisms
- **Grammar**: Innate syntax rules, rule-learning constrained by language-specific mechanisms
Empiricism: The Lexicon
Impressive animal vocabularies learned through association

Kanzi (bonobo) > 200 words
Rico (dog) > 200 words
Nim Chimpsky (Chimpanzee) > 300 words
Rico (sea lion) > 200 words

Empiricism: The Grammar
Word-Chain Device: Learned associations of word transitions

<table>
<thead>
<tr>
<th>Word1</th>
<th>Word2</th>
<th>Word3</th>
<th>Word4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tall</td>
<td>dogs</td>
<td>sleep</td>
<td>continuously</td>
</tr>
<tr>
<td>Fast</td>
<td>wounds</td>
<td>walk</td>
<td>viciously</td>
</tr>
<tr>
<td>Greedy</td>
<td>farmers</td>
<td>yell</td>
<td>openly</td>
</tr>
<tr>
<td>Pretty</td>
<td>foam</td>
<td>kicks</td>
<td>genuinely</td>
</tr>
</tbody>
</table>

- Probability(Tall→dogs) = 0.95
- Probability(sleep→viciously) = 0.001
- Probability("Grammar is a complicated word chain device")= 0.15
- Chain the transitional probabilities to get a sentence

Empiricism: The Grammar

Familiarization Preference Procedure

- Familiarize infants to an auditory stimulus (i.e. play it over and over until baby gets sick of it)
- Test if infants have learned anything about the stimulus (i.e. let the baby control what she hears)

Transitional Probabilities:

- Familiarize 8-mnth-olds to a proto-language for 2 min
tibudopabikudaropigolatupabikutibudo
golatudaropidaropitubadopabikugolatu

- Test
tibudopabiku vs pigolatudaro
     Probability = .8        Probability = .2
     7.5 sec                8.5 sec

- Tamarin Monkeys show this same ability (Hauser et al, 2003)

from Saffran, Aslin, and Newport (1996)
Empiricism: Is Association Enough?

Problems in the Lexicon:

While associations are bi-directional

Reference is only one directional

“Justin”

Problems in the Lexicon:

Associative Learning is slow. Can associations capture 1-trial learning?

“Give me the chromium tray”

Empiricism: Is Association Enough?

Problems in the Grammar:

• Associative Learning is slow
• Consider all of the English sentences under 20 words.
  – e.g. “You have a finite set of rules that help you generate and validate an infinite number of grammatical sentences.” (19 words)
• There are $10^{30}$ such sentences. Even at a rate of memorizing 100 sentences a minute, after 1 billion trillion years, you’ll only learn 1% of it!
  – But, kids acquire language within 5 years! They must not be using associations
Empiricism: Is Association Enough?

Problems in the Grammar:

- Child: My teacher holded the baby rabbits and we patted them.
- Parent: Did you say your teacher held the baby rabbits
- Child: Yes
- Parent: What did you say she did
- Child: She holded the baby rabbits and we patted them.
- Parent: Did you say she held them tightly
- Child: No, she holded them loosely.

Empiricism: Is Association Enough?

Problems in the Grammar:

- An Actual Parent-Child Dialog (sad parenting)
  - Child: Nobody don’t like me.
  - Parent: No, it’s “nobody likes me”.
  - Child: Ya, Nobody don’t like me.
  - Parent: No, it’s “nobody likes me”.
  - Child: Oh, Nobody don’t like me. (growing frustration)
  - Parent: Say, “nobody likes me”.
  - Child: Oh, Nobody don’t likes me.
  - Parents rarely give corrective feedback and when they do it doesn’t work

Empiricism: Is Association Enough?

Problems in the Grammar:

- While animals are aces at learning associations, animals have shown little evidence of learning a grammar (though people keep looking)

  Nim Chomsky:
  “Water-Bird” for egret

  Another Nim utterance:
  “Nim want eat me me eat Nim banana banana banana me banana eat want Nim banana …”

Empiricism: Is Association Enough?

Problems in the Grammar:

“Colorless green ideas sleep furiously”

- Separability of semantics and syntax
  - Probability(“Colorless green ideas sleep furiously”) = 0
  - Grammatical? YES!

Noam Chomsky (1928–)

“Review of verbal behavior” (1959)
Empiricism: Overview

- All knowledge is learned
- All learning is via associations
- Lexicon = word-object associations
- Grammar = word-word associations (transitional probabilities)

Nativism: Cognitivists

- The mind is not just associations
- Two separate systems support language

Lexicon:
Memorized words
(Saussure: the “arbitrary sign”)

Grammar:
Combinatorial grammar
(Humboldt: “the infinite use of finite media”)

“Justin teaches class”

“Colorless green ideas sleep furiously”

Nativism: The Lexicon

- Large number of concepts (> 60,000)
- Rapid computation
  - recognize spoken word: 1/5 second
  - retrieve word for production: 1/4 second
- Disadvantages of words:
  - finite number of concepts
  - everyone must have memorized them
- Symbolic word-object mappings learned through inference not association, learning constrained by domain-general cognition

Nativism: The Grammar

- Content free syntactic rules allow us to combine any noun with any verb
- “Colorless green ideas sleep furiously”
- Rules allow new ideas to be expressed
Nativism: The Grammar

- Grammar is built up from syntactic rules:
  - S → NP VP
  - NP → N
  - NP → adj NP
  - VP → V adv.

--- | --- | --- | ---
Tall | dogs | sleep | continuously
Fast | wounds | talk | viciously
Greedy | farmers | yell | openly
Pretty | foam | kick | genuinely

Learning grammar = Learning the orderly relations among classes of words. No particular rule is innate, rather there are innate parameters that constrain the possible set of rules and the child learns which rules apply in their language.

Nativism: The Grammar

Do young infants spontaneously learn word-order rules prior to knowing a language?

Use familiarization preference procedure

- Familiarize 8-mnth-olds to a proto-language for 2 min

AAB

- Test: new words

AAB vs ABB

Same structure 6 sec vs Novel structure 8 sec

from Marcus, Vijayan, Bandi Rao & Vishton (1999)

Nativism: The Grammar

Word Order Rules: English

- “The boy kicked the ball.”
  - Subj. Verb Dir. Obj.
  - “Kicked the ball the boy.”

This is what animals fail at (e.g. Nim Chimsky) suggesting that syntax might be uniquely human and unique to language.

Word Inflection Rules: Languages of New Zealand (as well as Latin)

- “The ball the boy kicked.”
- “The boy the ball kicked.”
- “Kicked the boy the ball.”

From Paul Bloom

Nativism: The Grammar

At the very beginning of the child making 2-word utterances child obeys the grammatical rules of English.

Child Utterance | Possible Meaning
--- | ---
“Dog big” | “That dog is big”
“Big Dog” | “That is a big dog”
“He big” | “He is big”
“Johnny big” | “Johnny is big”

CHILD NEVER SAYS:

“Big he”
“Big Johnny”

“Big is he”
“Big is Johnny”

Are all legal sentences Each word marked for grammatical role
Language: the structure of meaning

Syntax

Morphology

WORD

MORPHEME

PHONEME

The Plural Rule (children succeed at 2.5 years)

This is a wug.

Now there are two of them. There are two...

Jean Berko (1959)

The Past-tense Rule (children succeed at 3 years)

• “Every day we like to chan.”
• “Yesterday, we ….?"

Pinker (1980)

Nativism: The Grammar

Children Over-regularize irregular verbs
• “My teacher holded the baby rabbits”

Nativism: The Past Tense Rule

• Irregular forms are remembered words:
  
  * bring  ____________________ brought
  * sound: “brɪŋ”  sound: “brʊt”
  * meaning:  meaning:

• Regular forms can be generated by a rule (combinatorial operation):

  V

  walk -ed
Double Dissociation Of Regulars and Irregulars

Marslen-Wilson et al

Proportion of Priming

<table>
<thead>
<tr>
<th></th>
<th>Regular Past Tense</th>
<th>Irregular Past Tense</th>
<th>Semantic Relations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Patient D.E.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Patient J.G.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Patient T.S.</td>
<td></td>
<td></td>
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</table>

Lexicon and Syntax are localized in the human brain

An Agrammatic Aphasic Patient

An Anomic Patient
Design of Human Language

- Lexicon: Words for common entities (>60,000)
  mechanism = memory
- Syntax: Grammatical rules for novel combinations of words
  mechanism = on-line computation