Informatics 1 Cognitive Science

Lecture 4: Language Acquisition

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Overview

The Past Tense in English

Evidence from Language Acquisition

The Knowledge Acquisition Problem

Preview: Neural Networks

Recap

Human language involves two different kinds of "mental tissue":

- a finite lexicon of words, stored in and retrieved from memory;
- a finite grammar of rules (productive, abstract, combinatorial);
- these two mechanisms produce an infinite set of sentences.

Examples in context-free grammar notation:

- **words:** Det $\rightarrow$ the; N $\rightarrow$ dog
- **rules:** NP $\rightarrow$ Det N; VP $\rightarrow$ V NP

Evidence for Words & Rules

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- look at large amounts of text or speech (corpus data)
- study how humans process language in real time (eye-tracking, brain imaging)
- looks at what sort of errors speakers make
- track language acquisition in children

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The English past tense can be used as a "fruit fly" (exemplar) to study and model language acquisition.

The Past Tense in English

Regular Verbs

- Past tense: just add *-ed* to the end of present tense form.
- Set of regular verbs is open-ended (probably tens of thousands in the mental lexicon of an educated adult).
- New regular verbs enter English every year.

jog $\rightarrow$
walk $\rightarrow$
play $\rightarrow$
kiss $\rightarrow$

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Irregular Verbs

buy $\rightarrow$

hold $\rightarrow$

steal $\rightarrow$

go $\rightarrow$

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buy $\rightarrow$ *buyed
hold $\rightarrow$ *holded
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sing $\rightarrow$ sang
think $\rightarrow$ *thank $\rightarrow$ thought
ring $\rightarrow$ rang
cling $\rightarrow$ *clang $\rightarrow$ clung

Irregular Verbs

buy → *buyed → bought	sing → sang
hold → *holded → held	think → *thank → thought
steal → *stealed → stole	ring → rang
go → *goed → went	cling → *clang → clung

- Some past tense forms don't just add *-ed* to the end of the present tense form.
- Irregular past tense inflection is chaotic and idiosyncratic.
- Irregular verbs are a closed list, of 150–180 members.
- There have been no recent additions (not since *sneak–snuck* arrived during the 19th century).

Linguists use an asterisk (*) to mark things which are not part of the language, or, at least, which make native speakers uncomfortable, or are meaningless.

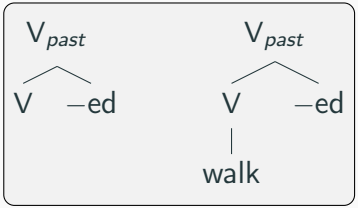
Irregular Verbs

Time for a short quiz on Wooclap!

https://app.wooclap.com/GXLBID

A Simple Theory of Regular and Irregular Verbs

Regular past tense forms are created by a rule.



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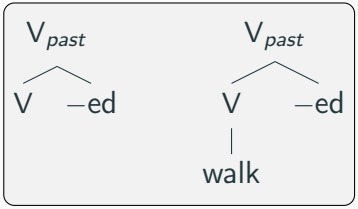

Irregular past tense forms are stored and retrieved as words.

sound: *hold*

meaning:

part of speech: V

sound: *held*

meaning:

part of speech: V_{past}

Blocking

We have two independent mechanisms for past tense formation:

- irregular past tense forms stored as words;
- a productive rule for regular past tense forms;
- Why don't they get in each other's way?
  held vs. *holded, stole vs. *stealed

Blocking

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Simple Answer

If a past tense verb form is stored in memory as a word, the rule is blocked. If no past tense form is stored, then the rule may be applied (e.g., *snarfed, moshed, ricked*).

Evidence from Language Acquisition

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Errors preschool children make in their spontaneous speech:

It was neat – you should have sawn it!
Doggie bat me [bit].
The cheerios got aten by the Marky.
I know how to do that. I truck myself [tricked].
This is the best place I ever sot [sat].

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- Most children make at least some errors of this kind.
- Such errors persist well into their school-age years.
- Children have never heard adults using past tense forms like *swang* or *shuck*. Must be constructing these forms creatively, by *analogy* with verbs they already know.

Overzealous Grammarians

Children don't just overgeneralize from regular past tense forms:

- they overuse the plural suffix *-s* (*mans*, *foots*, *tooths*, *mouses*)
- they overuse the third person sing suffix *-s* (*haves*, *do's*, *be's*)
- they overuse the comparative *-er* and superlative suffixes *-est* (*specialer*, *powerfullest*, *gooder*)
- they overuse the ordinal suffix *-th* on numerals (*oneth*, *twoth*)

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- they overuse the ordinal suffix *-th* on numerals (*oneth*, *twoth*)
- Children find regularity in the oddest places.

> Parent: No booze in the house!
> Child: What's a "boo"?
>
> Child: "It did! It snew!"
> [After being told it was going to snow.]

U-Shaped Learning

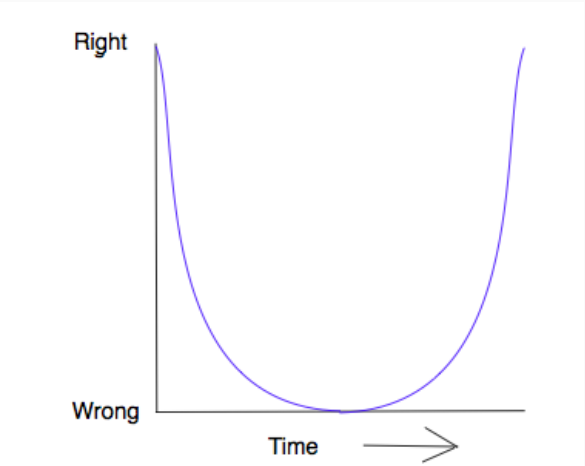
Children's performance gets better as they get older. With inflectional morphology they get worse before getting better. This is what child psychologists call U-shaped development.

Stage 1 children produce both regular and irregular past tense forms with very few errors.

Stage 2 after a certain amount of time, the error rate appears to increase significantly; children add regular past tense suffix *-ed* to irregular verb stems even with verbs whose past tense forms they had previously mastered.

Stage 3 the error rate slowly decreases, as the child gets older, until almost no errors are made.

U-Shaped Learning



- U-shaped learning in early childhood cognitive development.
- Child uses *spoke*, then *speaked*, and later again *spoke*.

U-Shaped Learning

Time for a short quiz on Wooclap!

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The Knowledge Acquisition Problem

Where does (linguistic) knowledge come from?

The knowledge acquisition problem:

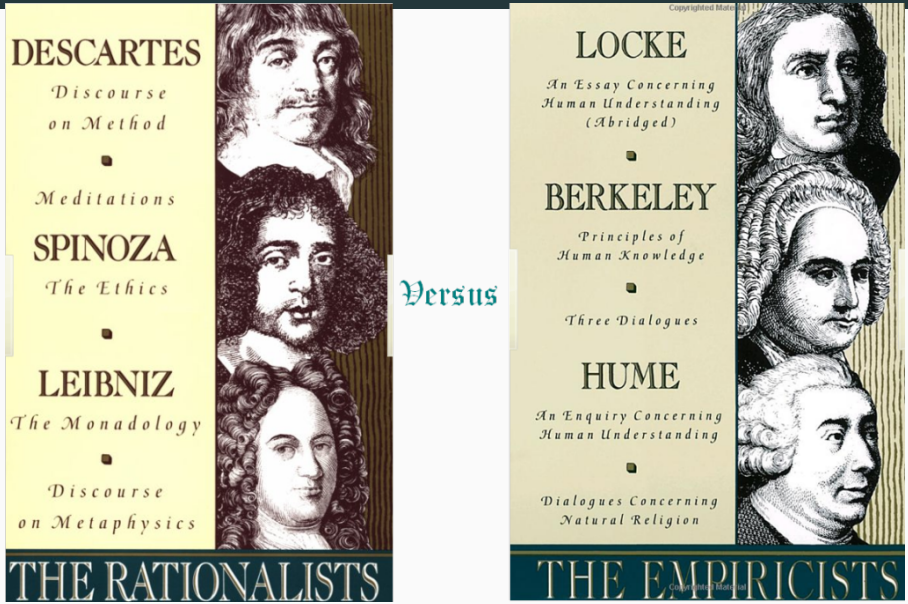
Q_1: How do we acquire knowledge? Clearly, we are not born knowing everything! Else we wouldn't have to go to school!

Q_2: But are we born knowing anything at all?

Q_3: Is the mind completely blank or do we start with some rudimentary understanding of the world?

- These questions are part of the debate about innateness.
- What is the contribution of biology vs. experience to cognitive abilities?
- Innate abilities are genetically determined.
- Alternative: learned through experience and interaction with the environment.
- Biological evolution vs. cultural transmission: see lecture 2.

Rationalism versus Empiricism



Rationalism versus Empiricism

Rationalism

- Intelligence arises from the manipulation of symbols by rules.
- Associated with Leibniz and Descartes, Noam Chomsky.
- The human mind has lots of innate structure (nativism).
- Knowledge comes from logical deduction (i.e., "calculation").

Empiricism

- Intelligence arises from the mind connecting together things that were experienced together or that look alike.
- Associated with John Locke and David Hume.
- More recently with behaviorism (Ivan Pavlov, B.F. Skinner) and even more recently with neural networks.
- The human mind starts out as a "blank slate". Knowledge comes by generalizing from observations.

Evaluating the Knowledge Acquisition Debate

Grasping reflex

Sucking reflex

Step reflex

- Some forms of procedural knowledge are innate.
- Newborn infants come into the world with a variety of different skills; reflexes are important for survival.
- Many innate abilities are domain-specific, i.e., attuned to perform special operations only on a certain type of information.
- *Some* innate knowledge is necessary for learning; the modern debate is about the nature and extent of that knowledge.

Evaluating the Knowledge Acquisition Debate

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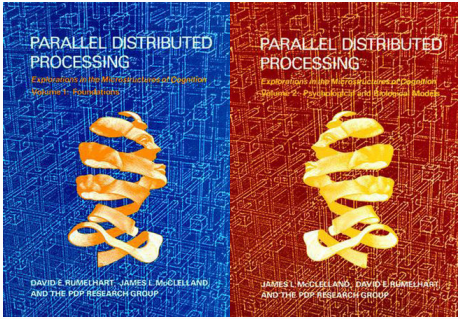
Preview: Neural Networks

Neural Networks

Neural networks (aka deep learning, connectionism) were invented in the 1980s, under the name of Parallel Distributed Processing (PDP):

- **Parallel:** simultaneous, independent, and simple computations.
- **Distributed:** information is represented across processing units.



Neural networks assume that everything is learned from data using a powerful, general learning algorithm: radical empiricism.

Crucially, neural networks impose architectural constraints on theories.

Summary

- English past tense offers a simple, constrained way of analyzing and modeling language acquisition
- children's acquisition is in three stages: produce both regular and irregular forms; overgeneralization errors; errors decrease
- U-shaped curve in terms of accuracy
- wider problem: knowledge acquisition: innate vs. learned, rationalism vs. empiricism
- Neural networks: a framework that provides algorithmic and representational constraints; radical empiricism