Psych 215L: Language Acquisition

Lecture 9
Morphology I: Rules vs. Statistics

Words & Rules

Computational Problem: Identifying word *affixes* that signal meaning.
affix examples: prefix *(un-* in *unsolvable), suffix (-ed* in *kissed)*

affix = sound sequence smaller than an entire word that is attached to a word in order to indicate some additional meaning

un- = not, *un- + solvable = unsolvable* = not solvable
"This labyrinth is unsolvable!"

-ed = past tense, *kiss + -ed = kissed* = kiss (past tense)
"Sarah almost kissed Jareth last night in the ballroom."

Words & Rules

Computational Problem: Identifying word *affixes* that signal meaning.

Example: What do you have to change about the verb to signal the past tense in English? (There are both regular and irregular patterns.)

blink~blinked	confide~confided	drink~drank (not drinked)
rub~rubbed	hide~hid (not hided)	think~thought (not thinked)

Words & Rules

Computational Problem: Identifying word *affixes* that signal meaning.
= Identify the rules for altering word forms in order to signal meaning.

Example: What do you have to change about the verb to signal the past tense in English? (There are both regular and irregular patterns.)

blink~blinked (+ed)	confide~confided (+ed)	drink~drank ("ih" --> "ey")
rub~rubbed (+ed)	hide~hid ("aye" --> "ih")	think~thought ("ink" --> "ought")

English Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

holded = hold + ed
Regular +ed rule is applied to verb that actually obeys an irregular rule to form the past tense

(hold ~ held)

This is an example of an overregularization error.

English past tense overregularization tends to happen between the end of the first year and the end of the second year

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English Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

What this means:

In order for children to have over-applied the regular past tense rule for English, they must have already figured out that there *is* a regular past tense rule for English.

Not necessarily so easy: Requires children to abstract across different pronunciations of "+ed" that signal the past tense:

baked	clawed	folded
baked /t/	clawed /d/	folded /ed/

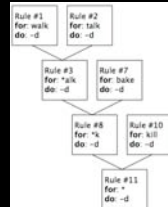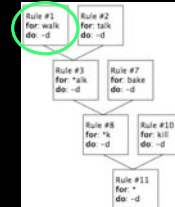## Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

"Ludo walked to Sarah."

Pattern: walk --> walked

This pattern works for "walk".

Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

"Hoggle talked to Sarah."

Pattern: talk --> talked
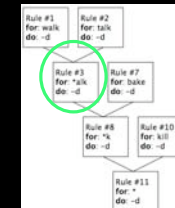
This pattern works for "walk" and "talk".

Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

"walk" and "talk" both end in "-alk".

Abstraction, based on data:

+ed for words ending with -alk

Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

"Didymus baked Sarah a cake."

Pattern: bake --> baked
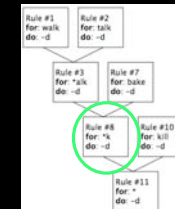
This pattern works for "-alk" words and "bake".

Past Tense Rule

"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

"-alk" words and "bake" both have the "k" sound at the end.

Abstraction, based on data:

+ed for "-k" words

Past Tense Rule
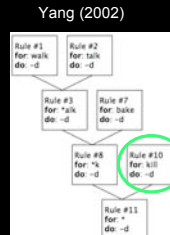
"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

"Hoggle would have gladly killed the mean fairy."

Pattern: kill --> killed

This pattern works for "-k" words and "kill".

Past Tense Rule
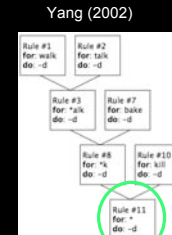
"My teacher holded the baby rabbits and we patted them"

How do they figure out that there's a regular rule that applies to a lot of verbs in English?

Yang (2002)

Observation and extraction process

"-k" words and "kill" use this +ed rule.
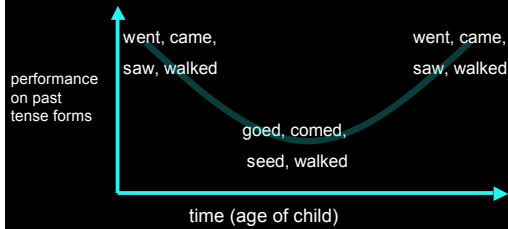
Abstraction, based on data:

+ed for any word

Developmental Trajectory of Past Tense Rule

U-shaped development (often occurs)

performance on past tense forms

went, came, saw, walked

went, came, saw, walked

goed, comed, seed, walked

time (age of child)

Why U-Shaped Performance?

U-Shaped: When children's performance on past tense verbs gets worse before it gets better, instead of always getting better. This happens because they overregularize verbs that actually follow irregular rules. (hold~holded (instead of held))

Why do they overregularize?

Interestingly, it's not that children don't realize that the overregularized forms are wrong.

Child: "You readed some of it too...she readed all the rest."
Parent: "She read the whole thing to you, huh?"
Child: "Nu-uh, you read some."
Parent: "Oh, that's right, yeah. I readed the beginning of it."
Child: "Readed? (*annoyed surprise*) Read! (*pronounced "red"*)
Parent: "Oh, yeah, read."
Child: "Will you stop that, Papa?"

Overregularization

Why do children overregularize?

One idea: Children's memory is weaker than adults' memory is

Producing a past tense form is a process:

   Intended form: VERB + past tense

   Root form of VERB: VERB

   If irregular VERB, past tense:

      IRREGULAR PAST (retrieve from memory)

   If regular VERB, past tense:

      VERB + ed (apply regular rule)

Overregularization

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Producing a past tense form is a process:

   Intended form: walk + past tense

   Root form of VERB: walk

   If irregular VERB, past tense:

      IRREGULAR PAST (retrieve from memory)

   If regular VERB, past tense:

      walk + ed (apply regular rule) = walked

Overregularization

Why do children overregularize?

One idea: Children's memory is weaker than adults' memory is

Producing a past tense form is a process:

    Intended form: go + past tense

    Root form of VERB: go

    If irregular VERB, past tense:

        went (retrieve from memory)

    If regular VERB, past tense:

        VERB + ed (apply regular rule)

Overregularization

Why do children overregularize?

One idea: Children's memory is weaker than adults' memory is

Producing a past tense form is a process:

    Intended form: go + past tense

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But what if children can't retrieve the irregular past form in time to produce it when they speak?

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    Intended form: go + past tense

    Root form of VERB: go

    If irregular VERB, past tense:

        ~~went (retrieve from memory)~~

    If regular VERB, past tense:

        go + ed (apply regular rule) = goed

But what if children can't retrieve the irregular past form in time to produce it when they speak?

They may fall back on the regular verb rule.

Overregularization

Why do children overregularize?

One idea: Children's memory is weaker than adults' memory is

Related idea: The more often children hear a word, the easier it is to retrieve from memory.

Implication: The more often children hear irregular past tense forms like "went", the easier it will become to retrieve those irregular past tense forms even when children already have a regular rule (+ed) they use for many other verbs.

Support for this idea: Children make more errors on words parents don't use as frequently (Marcus et al. 1992).


About Rules

Is it really necessary to have learned rules, or could children (and adults) simply be learning (and using) patterns of association?

    Pattern: hold~held, walk~walked, go~went

This kind of pattern association can be represented in Parallel Distributed Processing (PDP) computational models, sometimes referred to as neural nets. (Rumelhart & McClelland (1986))

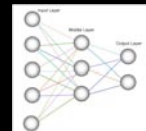Neural nets are very good at learning by analogy, and recognizing similar patterns in the data that is given to them.
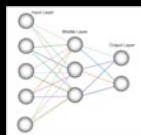
Patterns of Association

If the past tense rule is really just a bunch of associations we have in ours minds between root forms (like "walk") and past tense forms (like "walked"), do we expect the same learning U-shaped behavior we see in children? Remember, that behavior was explained by children over-applying a regular past tense rule.

    Pattern: hold~held, walk~walked, go~went

Rumelhart & McClelland (1986) found that a neural net could produce U-shaped behavior…
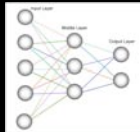
Patterns of Association

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Pattern: hold~held, walk~walked, go~went

Rumelhart & McClelland (1986) found that a neural net could produce U-shaped behavior…

…but only if it was given input data in a certain way. Specifically, it was first given very frequent irregular verbs (go~went, come~came, be~was) and then given less frequent regular verbs (walk~walked, kiss~kissed).
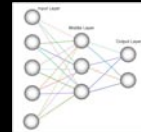
Patterns of Association & U-Shaped Behavior

Implication: Pattern associator models like neural nets, which do not use rules, can produce U-shaped learning behavior.

Caveat: To do that, the model must receive different proportions of irregular verbs in its input at different points in time (high proportion initially, lower proportion later on).
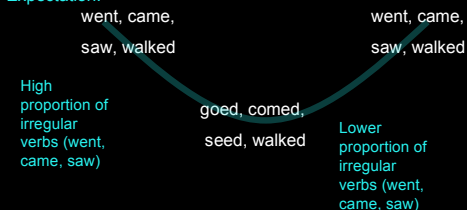
Pattern: hold~held, walk~walked, go~went

Patterns of Association & U-Shaped Behavior

Empirical question: Does the proportion of irregular and regular verbs in a child's input change over time?

Expectation:

went, came, saw, walked

went, came, saw, walked

goed, comed, seed, walked

High proportion of irregular verbs (went, came, saw)

Lower proportion of irregular verbs (went, came, saw)

Patterns of Association & U-Shaped Behavior

Empirical question: Does the proportion of irregular and regular verbs in a child's input change over time?

Reality: The proportion of irregular verbs in the child's input does not seem to change over time, or does not change at the right time to produce the U-shaped behavior at the right time in a neural net. For example, between 2 and 5 years old, children hear regular verbs as 30% of their input. (Pinker 1995)

…though see Maslen et al. (2004) for a case study that does show a change in proportion that correlates with overregularization behavior

Implication: Pattern association alone is insufficient to account for children's learning behavior for the English past tense (in particular, the U-shaped learning curve). Children must be learning rules which take advantage of the regularity in the past tense verb forms, not just patterns of associations between verbs and their past tense forms.

More on Pattern Association Learning

Another prediction if learning proceeds by analogy (pattern association): similar patterns should reinforce each other….and reinforce overregularization errors

holded ~ folded ~ scolded ~ …

drinked ~ blinked

(many regular neighbors)

(few regular neighbors)

= hold overregularized a lot

= drink overregularized infrequently

Reality (Pinker 1995): There is no correlation between how often children overregularize a particular verb (like "hold") and how many regular neighbors (like "fold", "scold", etc.) it has.

Implication: More than just analogy is responsible for children's behavior.

More on Pattern Association Learning

However…what about the irregular verbs (like "drink" and "tell")? Would analogy work there to explain children's behavior?

Irregulars fall into families of rhyming forms ("neighborhoods"):

drink~drank, sink~sank

tell~told, sell~sold, …

keep~kept, sleep~slept, weep~wept, …

…

More on Pattern Association Learning

However…what about the irregular verbs (like "drink" and "tell")? Would analogy work there to explain children's behavior?

Pinker (1995): There *is* a relation between how often a verb is overregularized and the number of rhyming neighbors. Specifically, the more rhyming irregular neighbors a word has, the less that verb will be overregularized

 sink   shrink   show   mow

drank (drink)~ sank ~ shrank ~ …   went (go)~showed~mowed~…

 (more irregular neighbors)   (few irregular neighbors)

 = drink overregularized   = go overregularized more often

  infrequently

More on Pattern Association Learning

However…what about the irregular verbs (like "drink" and "tell")? Would analogy work there to explain children's behavior?

Pinker (1995) Idea: Pattern association may be taking place for the irregular verbs. Under this view, irregular verb past tense forms are simply memorized. The more rhyming verb forms there are for a word (like "drink" (sink~sank, shrink~shrank)), the easier it will be to retrieve that verb's irregular past tense form…and the less the child will end up relying on the regular rule.

Pattern Associators on Novel Input

Pinker & Ullman (2002): Pattern associators also produce odd output for novel forms (*mail-membled*), which is not what people do with novel forms.

PDP models that don't exhibit this weird behavior have a built-in dedicated component for the +ed connection (built-in rule), which is also somewhat strange from a psychological standpoint

Pinker & Ullman 2002:
The Great Past Tense Debate

Why the fuss over the English past tense? Good testbed containing both rule-like regularization and exception-like irregularization.

Pinker & Ullman (2002): Words-And-Rules Theory

(Rules) Regulars: generated by rule-like process of +ed (symbolic manipulation)

 ~GRAMMAR

(Words) Irregulars: stored separately in associative memory and retrieved

 ~LEXICON

Words and Rules

Idea (Pinker (1995), Pinker & Ullman (2002))

Producing a past tense form is a process:
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Lexicon:
Looking up a word in memory

Words and Rules

Idea (Pinker (1995), Pinker & Ullman (2002))

Producing a past tense form is a process:

    Intended form: VERB + past tense

    Root form of VERB: VERB

    If irregular VERB, past tense:

        IRREGULAR PAST (retrieve from memory)

    If regular VERB, past tense: **Grammar:**

        VERB + ed (apply regular rule) **Apply a rule**

Pinker & Ullman are interested in a system of productive, combinatorial operations that assemble smaller pieces into larger pieces

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Words and Rules

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Note: This division into words and rules is a departure from older generative phonology theories (Chomsky & Halle 1968) that suppose there are rules for everything, even for irregulars. This all-rules approach is the one used in Yang (2002), though.

Words and Rules

Idea (Pinker (1995), Pinker & Ullman (2002))

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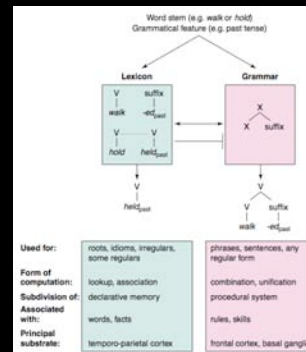   If irregular VERB, past tense:

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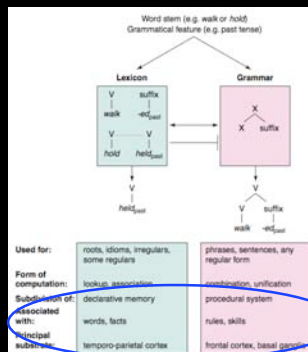
    If regular VERB, past tense:

        VERB + ed (apply regular rule)

The "Blocking Principle" when trying to retrieve an irregular form: if there's a (memory) failure and the correct irregular form is blocked, the regular form is the fall-back.

Words and Rules: Lexicon vs. Grammar

Words and Rules: Lexicon vs. Grammar

Neurological division of words and rules

Where does the default rule come from?

Not just about the most frequent form

  - children regularize before onslaught of regular verbs

  - German default plural 's' is only used in 7% of cases (Researchers name it the default because it's used for unusual nouns, is the default error in childhood, etc.)

How do children decide the mappings?

Not just about the sound pattern: some irregulars are regularized when used in certain contexts

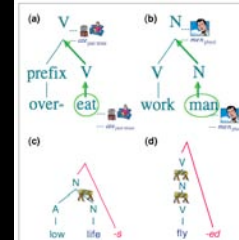"Orcs ringed the city." "I steeled myself for battle"

ring~rang   steal~stole

How do children decide the mappings?

Not just about the sound pattern: may depend on the word's meaning (pluralization examples)

Ex: Low-life is not a type of life (exocentric), pl: low-lifes
        workman is a type of man (endocentric), pl: workmen

What does this mean for pattern associators?

Patterns associators tend to operate only on sounds (mapping from one set of sounds to another). But what if they had a semantic component so they could tell if the meaning was altered? Would this be enough to produce the right kind of mapping behavior?

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Pinker & Ullman's (2002) response:

Problem: exocentric isn't the same as semantically different - it's a particular kind of semantically different.

If pattern associator has component that notices exocentric for noun-like verbs "ring" (to ring, a ring), this is like implementing morphological knowledge already. Also requires lots of training of exocentric verbs with regular past tense, which is data children don't normally get.