Psych 215L: Language Acquisition

Lecture 9
Morphology I: Rules vs. Statistics

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 drank)

- rub~rubbed
  - hide~hid
  (not hided)
  - think~thought
  (not thinded)

English Past Tense Rule

“My teacher held the baby rabbits and we patted them”

helded = 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.
Past Tense Rule
“*My teacher held* 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?

Observation and extraction process

Yang (2002)

“*Ludo walked* to Sarah.”

Pattern: walk --> walked

This pattern works for “walk”.

Past Tense Rule
“*My teacher held* 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?

Observation and extraction process

“*Hoggle talked* to Sarah.”

Pattern: talk --> talked

This pattern works for “talk”.

Past Tense Rule
“*Didymus baked* Sarah a cake.”

Pattern: bake --> baked

This pattern works for “-alk” words and “bake”.

Past Tense Rule
“*My teacher held* 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?

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 held* 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?

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?

Observation and extraction process

“Hoggle would have gladly killed the mean fairy.”

Pattern: kill --> killed

This pattern works for “-k” words and “kill”.

Yang (2002)

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?

Observation and extraction process

“-k” words and “kill” use this +ed rule.

Abstraction, based on data:

+ed for any word

Yang (2002)

Developmental Trajectory of Past Tense Rule

U-shaped development (often occurs)

went, came, saw, walked

good, combed, 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”) Payoff: “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

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: 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: \textit{go} + past tense
  - Root form of VERB: \textit{go}
  - If irregular VERB, past tense: \textit{went} (retrieve from memory)
  - If regular VERB, past tense: \textit{VERB} + \textit{ed} (apply regular rule)

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 “\textit{went}”, the easier it will become to retrieve those irregular past tense forms even when children already have a regular rule (+\textit{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: \textit{hold}~\textit{held}, \textit{walk}~\textit{walked}, \textit{go}~\textit{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 our minds between root forms (like “\textit{walk}”) and past tense forms (like “\textit{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: \textit{hold}~\textit{held}, \textit{walk}~\textit{walked}, \textit{go}~\textit{went}

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

If the past tense rule is really just a bunch of associations we have in our 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 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

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

Expectation: went, came, saw, walked

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

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 & 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

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

<table>
<thead>
<tr>
<th>drank (drink)</th>
<th>sank</th>
<th>shrank</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>(more irregular neighbors)</td>
<td>(few irregular neighbors)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

= drink overregularized infrequently

= go overregularized more often

Pattern Associates 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.


(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


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)

Lexicon: Looking up a word in memory
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)

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

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.

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

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?

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?

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.