Psych229:
Language Acquisition

Lecture 16
Productivity - Modeling

Yang (2005): Productivity

Rules & Exceptions
Linguistic knowledge is comprised of lots of rules - but there are exceptions, too
Ex: Morphology
kiss-kissed, dance-danced, ..., sing-sang
king-kings, goblin-goblins, ..., child-children, dwarf-dwarves

Chomsky & Halle, 1968: "...existence of exceptions does not prevent the systematic formulation of those regularities that remain"

How does a child extract the regularity that’s there?
Big question: How does a child know what’s systematic/productive?

Yang (2005): Productivity
Built-In learning component that recognizes productivity
Mathematical formulation = Tolerance Principle
Recognizes a productive process (way of defining what is productive from the child’s perspective).

Dealing with noise in the data
If something isn’t productive, can just memorize it - rather than trying to account for it in the grammar

Test case: English past tense morphology
kiss-kissed, dance-danced, ..., sing-sang, go-went, make-made

Need a way to decide which rules are productive
rule 1: “+ed” (kiss-kissed)
rule 2: no change (cut-cut)

The errors kids make with the past tense
Most are over-regularizations
over-regularizations: hold-holded
hold-holded make up 10% of all irregular past tense forms: (Marcus et al. 1992; Yang 2002)

Very rare are over-irregularizations
over-irregularizations: bring-brang
bring-brang (0.2% of irregular past tense forms: Xu & Pinker, 1995)

Cross-linguistically: most errors are over-regularizations or omissions of past tense morphology (Phillips 1995; Guasti 2002)

The point: "Children recognize and generalize productive rules while memorizing the restricted use of unproductive ones"

Yang (2005): Productivity
Some definitions
Default: “when all else fails”
When more specific rules fail to apply, use this rule (which by definition is the most general).

Productive: “predictable” or “generalizable”
A rule automatically applies to a set of lexical items characterized by a certain context. It can extend to novel items that fit this context (though may not always)

A default rule is always productive, but a productive rule can exist without being the default. Neither kind of rule needs to be exception-less.

Yang (2005): Productivity

First: How do kids learn what rules there are in the first place?
Not about just looking at the rule that applies to the majority of the word types
German noun plurals have a default +s that appears in only 7% of the words
Wind-Winde, Kind-Kinder, Frau-Frauen, Daumen-Daumen, Auto-Autos
(Marcus et al., 1995)

Sussman-Yip model of Mohar (2001): About looking at the context where the rule applies
Learning “+ed” rule (default that applies without restrictions)
Yang (2005): Productivity

Then: How do kids learn what rules are productive and what ones only apply to a restricted set (morphological)?

Productivity of a rule depends on knowledge of current items it applies to.

ring-rang...sing-sang...
...bring-brought...sing-stung...

Sussman-Yip (Rubenstein et al. 1970; Forster 1976)

Rule selection: Lexical Search Theory

Restricted set

Not so productive once more items are encountered...

Point: Productivity of rule depends on some kind of cost-benefit analysis, given the items that follow the rule and the items that don’t.

---

Yang (2005): Productivity

Idea: Cost-benefit analysis based on computational complexity

Empirical evidence points to time complexity as a sensible metric: how long does it take to access the right rule? (Morphological processing is oriented towards time efficiency.)

Question: What is the threshold for determining if a rule is productive or not?

We want some way a child could calculate this, some algorithm based on the time it takes to access the correct rule. This is what the Tolerance Principle is supposed to do.

The computational process of morphologically derived words: executed sequentially (Carmazza 1997; Levelt et al. 1999)

1) Word search (look up the word stem in the lexicon; dance)
2) Rule selection (find the right rule to use; dance + ed)
3) Rule application (apply the rule to get the derived form; danced)

Productivity Assessment/Tolerance Principle deals with this part
Tolerance Principle: How many is too many exceptions?

N = number of items that fit the context the rule applies to
M = number of items that are exceptions to the rule

T(M, N) = time it takes to find out if a rule applies to a given word when there are M exceptions and N items that have the rule's context

T(N, N) = time it takes to find out if a rule applies to a given word when all words are stored as exceptions

When it takes longer if exceptions are stored along with a rule (T(M, N)) than it does if all words are stored as exceptions (T(N, N)), don’t bother storing the rule. The rule is not productive.

If T(N, N) < T(M, N), rule is not productive. Don’t store rule. (This happens when M ≈ N/ln N)

Yang (2005): Productivity

Tolerance Principle predictions for child acquisition

By the time the child has a productive rule (like +ed), the child should know a good deal more regular verbs than irregular verbs. This seems to be true (Marcus et al., 1992).

U-shaped development (in some children) - or at least the initial dip:

1) Initially, irregular verbs learned first because they’re frequent.
2) Only a few regular verbs required to posit +ed rule (20-30).
3) At this point, kids may have rules but it may not be productive because they haven’t learned enough regulars. (Too many exceptions) [initial stage]
4) Once they do see enough (M < N/ln N), they use the rule productively. [dip of U-curve]

Tolerance Principle predictions for English plural nouns

English plural nouns: Many regular nouns initially, few irregulars. +s rule (goblin-goblins) becomes productive very quickly. No initial good performance with irregulars. Should never see U-shaped curve in development - only an increase in performance. This seems to be true (Brown 1973, Pallos & Yang 2005)

Tolerance Principle predictions for German plural nouns

German plural nouns: many “irregular” regular rules Ex: +en for feminine nouns (Frau - Frauen)
M = 80 exceptions
Tolerance Principle predicts at least N where N/ln N > 80 to have a productive rule. There must be N > 500 feminine nouns (and 420 that follow the +en rule). There are at least 3600.

Therefore, this rule should be productive (and seems to be): Wiese 1996; Dressier 1996; Wunderlich 1999
Yang (2005): Productivity

Process for forming the plural in German

- **Irregulars**
  - If feminine
  - THEN add -(e)n
  - add -s

  More context-specific rule (feminine)

  Elsewhere condition rule

---

Yang (2005): Productivity

Elsewhere condition in morphology & syntax

- **Context-specific (not default pattern)**
- **Elsewhere (general core grammar)**

- **irregulars**
  - add -d

  Imperative drop

  Obligatory subject

  Dance-danced

  Sing!

  Sing

  Seems like we should sing