Evaluation Measure in Language Acquisition

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LING50
MIT
From LSLT to Aspects: A Psychological Turn
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• **LSLT**
  
  • “any simplification along these lines is immediately reflected in the length of the grammar” (§26: MDL)
  
  • “defined the best analysis as the one that minimizes information per word in the generated language of grammatical discourses” (§35.4: entropy)
  
• 23.771 Mathematical Backgrounds for Communication (Hall/Partee)
From LSLT to Aspects: A Psychological Turn

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- **Aspects**
  - “… theories require supplementation by an evaluation measure if language acquisition is to be accounted for … such a measure is not given a priori, in some manner. Rather, any proposal concerning such a measure is an empirical hypothesis about the nature of language” (p37)
Three Psychological Conditions
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• Formal sufficiency: Does the evaluation measure choose the “correct” grammar?
  • Distributional methods: Harris (1951), Fowler (1952), Holt (1953)
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- Ecological validity: Does the evaluation measure operate under reasonable assumptions about the learning data and mechanisms?
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  • Distributional methods: Harris (1951), Fowler (1952), Holt (1953)

• Ecological validity: Does the evaluation measure operate under reasonable assumptions about the learning data and mechanisms?

• Developmental compatibility: Does the evaluation measure employed by the learner produce similar developmental patterns in language acquisition?
MDL: An Evaluation Measure

$$\text{DL}(D, G) = |G| + \log \frac{1}{p(D|G)}$$
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- The composition of data
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• A method for hypothesis **selection** rather than hypothesis **proposing**
  - Three conditions for choosing alternative methods, e.g., reinforcement learning, Fourier transform

• The composition of data

• Subset Principle (Berwick 1985): the first Evaluation Measure to influence empirical work in language acquisition
Evaluation Measuring Parameters
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• CUNY CoLAG Parameter Domain (Sakas & J.D.Fodor *in press*): 13 parameters, 3072 grammars, 48086 distinct degree-0 sentences

  • Most parameters are favorable for the learner and can be set independently (thus “scattered” well)
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- Evidence for parameters in language acquisition
MDL in Action
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Stem
fly
bring
blow
think
catch
draw
walk
(Regulars)

Past tense
flew
brought
blew
thought
caught
drew
walked
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Add -d
MDL in Action
MDL in Action
MDL in Action

Stem

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bring
blow
think
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draw

Past tense

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Add –t & Rime → /a/

Add –Ø & Rime → /u/

Add –d (Regulars)
MDL in Action

“... the acceptance of these Laws (Grimm’s and Verner’s) as historical fact is based wholly on considerations of simplicity”
Halle (1961: On the role of simplicity in linguistic descriptions)
Evidence from Children

- Largest past tense analysis to date (Gorman & Yang 2011)
- Free-rider effect: verbs belonging to larger rules learned better
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<th>Kendall $\tau$</th>
<th>G-K $\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Abstract rules" /></td>
<td>0.276</td>
<td>0.191</td>
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Frequency dissociation

\(<\text{avg. rule freq.}\) >\text{avg. verb freq.} >\text{avg. rule freq.} <\text{avg. verb freq.}\)

two-tailed Mann-Whitney $W=156.5$, $p=0.019$
Yesterday he _____
Yesterday he ______

This is a man who knows how to GLING.
He is GLINGING. He did the same thing yesterday. What did he do yesterday?
Yesterday he ________.
Yesterday he _____

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  - Only one out of 86 children produced *bing-bang, gling-glang*
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- Children’s Evaluation Measure produces a binary outcome: productive or lexical
- Probability spreading insufficient

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Exceptions in Evaluation Measure
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“core”, “basic word order”, “default case”, “unmarked form”
vs.
“periphery”, “lexical listing”, “exceptional marking”, “diacritics”
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“periphery”, “lexical listing”, “exceptional marking”, “diacritics”

- SPE: “Clearly, we must design our linguistic theory in such a way that the existence of exceptions does not prevent the systematic formulation of those regularities that remain ... Finally, an overriding consideration is that the evaluation measure must be designed in such a way that the wider and more varied the class of exceptions to a rule, the less highly valued is the grammar” (p172)
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• SPE: “Clearly, we must design our linguistic theory in such a way that the existence of exceptions does not prevent the systematic formulation of those regularities that remain ... Finally, an overriding consideration is that the evaluation measure must be designed in such a way that the wider and more varied the class of exceptions to a rule, the less highly valued is the grammar” (p172)

• But majority doesn’t rule: 90% of English words in speech are stress initial (Cutler & Carter 1987); Legate & Yang poster
Measuring Rules
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- Optimization again: instead of space, it’s time
Measuring Rules

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• Exceptions = Real time processing slowdown
  • “kicked the bucket” faster than “lifted the bucket” by 51ms (Swinney & Cutler 1979)
  • Production: German irregular past participle (-n) faster than regular (-t) by 38ms (Clahsen & Fleischhauer 2011)
  • Lexical decision: English irregular verbs faster than regulars by 19ms (English Lexicon Project; Lignos 2011)
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$$\frac{N}{\ln N}$$
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- If English has 150 irregular verbs, we need 900 regulars to have a productive -ed rule: \( \frac{1050}{\ln(1050)} = 150 \)
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• Children start over-regularization when they reach the tipping point

• $N$ (e.g., vocabulary size) and the number of exceptions may vary from speaker to speaker, accounting for certain individual patterns in language acquisition and sociolinguistic variation
A Birth-er Problem
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• The suffix -er is productive and segmented in real time even for *broth-er* (Rastle, Davis & New 2004) resulting in slowdown (Lignos 2011)
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- While some -er’s are real (hunt-hunter), some are not (corn-corner, cent-center, sock-soccer): children need to learn -er despite exceptions
A Birth-er Problem

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• English Lexicon Project (Balota et al. 2007)
  • hunt-hunter type: 94, cent-center type: 18
  • The suffix -er is productive: $18 < \frac{112}{\ln(112)} = 24$
A Birth-er Problem

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• The suffix -th fails to reach productivity: warmth, width, depth etc. overwhelmed by tooth, booth, filth, forth, ...
stride-strode-???

\[ \frac{N}{\ln N} \]
Mere majority is not sufficient; filibuster proof majority required
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• [\textit{lexical insertion}] (Halle 1972, esp. fn1)
  • gaps only arise in unproductive corners of morphology
Mere majority is not sufficient; filibuster proof majority required

[-lexical insertion] (Halle 1972, esp. fn1)
  - gaps only arise in unproductive corners of morphology

102 out of 161 irregular verbs (36%) show preterite and past participle syncretism
  - Tolerance Principle only allows $1/\ln(161)=20\%$ exceptions
  - *forwent, *sightsaw, *stridden
Evaluation Metrics
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- What not to do: Computer chess
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- Resource bounded optimization
Evaluation Metrics

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- Resource bounded optimization
- Convergence of methods and disciplines
Evaluation Metrics

• What not to do: Computer chess
• Resource bounded optimization
• Convergence of methods and disciplines
• Simple theories are usually right ones
Thank you, to my teachers

- Bob Berwick
- Noam Chomsky
- Morris Halle