Testing Universal Grammar in phonological artificial grammar learning

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Overview

- Nasal spreading typology
- Explaining phonological typology
  - Learning biases (including Universal Grammar)
- Testing for biases in artificial grammar learning
- Effects of task
  - Meta-linguistic judgments vs. recall
A common nasal spreading pattern

- Johore Malay (Onn 1976, McCarthy 2009)
  - Nasality spreads rightward from a nasal consonant
  - Spread is blocked by full consonants

- məŋãp  ‘pardon’  (spread not blocked by glottal stop)
- pəŋŋãwãsan  ‘supervision’  (spread past glide /w/, but not /s/)

Blocker hierarchy: *NASPLO >> *NASFRIC >> *NASLIQ >> *NASGLI >> *NASVOW

(Walker 1998)
An unattested pattern

“Sour grapes” (McCarthy 2009)

Nasality spreads rightward from a nasal consonant, but only if there is no blocker at all

mãŋãp (glottal stop is not a blocker: spread to end)

pɔŋawasan (/s/ is a blocker: no spread at all)
Explaining phonological typology

- Two sources of bias (Steriade 2001, Moreton 2008)
- **Analytic bias** (standard generative view)
  - Learning constraints
  - Includes UG, which defines possible grammars
- **Channel bias** (Ohala 1993, Blevins 2004, Hansson 2008)
  - Diachronic phonologization of phonetically systematic “errors” in speech transmission
  - Not represented explicitly within a grammar or UG
UG: Autosegmental phonology

- Traditional **analytic bias** (UG) explanation

- Spread is iterative, blocking is local
UG: Standard Optimality Theory

- Predicts sour grapes pattern (McCarthy 2009)!

<table>
<thead>
<tr>
<th></th>
<th>/mawasa/</th>
<th>*NASFRIC</th>
<th>AGREE-R([nasal])</th>
<th>IDENT([nasal])</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>mawasa</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>mawasa</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>c.</td>
<td>mawasa</td>
<td>*</td>
<td>**</td>
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<td>d.</td>
<td>mawasa</td>
<td>*</td>
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<tr>
<td>d.</td>
<td>mawasa</td>
<td>*</td>
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<td>****</td>
</tr>
<tr>
<td>e.</td>
<td>mawasa</td>
<td>*</td>
<td></td>
<td>*****</td>
</tr>
</tbody>
</table>
UG: Harmonic serialism

- Incremental spread in OT (McCarthy 2009)
  - Candidate outputs only change one thing in input
  - Winning output in one cycle is input to the next
- \texttt{*NASFRIC >> SHARE(nas) >> *NASGLI}
  - Step 1: Input: /mawasa/  Optimal output: /mãwasa/
  - Step 2: Input: /mãwasa/ ...
  - Last step: Input = output: /mãwãsãa/
- Cf. Mailhot & Reiss (2007): serial processing of vowel harmony without OT or autosegments
A channel bias alternative

- Incremental spread happens via channel bias across generations (cf. Boersma & Hamann’s 2008 non-teleological model of diachronic auditory dispersion)

- Schematic example:

  Generation 1: /mawasa/ → [mãwasa] via coarticulation
  Generation 2: /mãwasa/ (nasalization now intentional)
  Eventual stable state: /mãwãsã/ 
  Further nasal coarticulation stopped by articulatory incompatibility of nasality and /s/
Testing for analytic bias

- If the attested pattern is favored by UG, it should be easier to learn than the sour grapes pattern
  - Study phase: Present forms generated by grammar(s)
  - Test phase: Check if grammatical vs. ungrammatical forms are responded to differently
  - Compare accuracy against chance
  - Compare relative accuracy for two different grammars
Controlling linguistic experience

- Participants were native speakers of Taiwan Southern Min (Taiwanese)
- Vowel nasality is phonemic in S. Min
  - Accurate perception was confirmed in a post-test
- Yet in S. Min vowel nasality does not spread across syllables (Chung 1996, Chou 2002)
- Participants were trained either on a local blocking grammar or on a sour grapes grammar
Stimuli: Basic parameters

- Schematic structures
  \[ VC.C_1V.C_2V \quad CV.VC.C_1V \quad CV.CV.VC \]

- Parameters (generating 12,288 forms)
  - Trigger (\( C = /m, n/ \)) vs. non-trigger (\( C = /p, t/ \))
  - Blocker (\( C_1 \) or \( C_2 = /s, k/ \)) vs. non-blocker (\( C_1 \) and \( C_2 = /w, j/ \))
  - Vowels: /a, i, e, u/ and nasalized variants
  - Position of trigger: First, second, third syllable
Stimuli: Construction

- Trigger syllable always VN
  - In S. Min, NV syllables must have nasal vowel, so testing sour grapes pattern would be impossible

- Auditory stimuli
  - Phonotactically legal S. Min syllables produced by naive native speaker
  - All syllables assigned the same level pitch contour
  - Trisyllabic “words” created by concatenation
Stimuli: Grammatical status

- Four types of items in terms of grammaticality

  +BL+SG conform to both local blocking grammar and sour grapes grammar
  +BL–SG conform only to local blocking grammar
  –BL+SG conform only to sour grapes grammar
  –BL–SG conform to neither grammar
Study phase

Blocking grammar

+BL+SG: [ansawa] (trigger /n/, blocked by /s/)

[atsawa] (nontrigger /t/)

+BL–SG: [anwänasa] (trigger /n/, spread to blocker /s/)

Sour-grapes grammar

+BL+SG: [amtaja] (trigger /m/, spread blocked by /t/)

[aptaja] (nontrigger /p/)

–BL+SG: [amjata] (no spread at all, due to blocker /t/)
Test phase

- For each study grammar, half of the items were grammatical, and the other half ungrammatical
- Ungrammatical test items were the same for both study conditions, violating both grammars
  - Nasal vowel to the right of a blocker: [ankãsã]
  - Nasal spread skipping syllables: [anwawã]
  - Nasal vowels without a trigger: [apwãsa]
Testing for task effects

- The standard task in artificial grammar learning uses meta-linguistic grammaticality judgments.
- Some worry that meta-linguistic tasks may not reflect UG (Wilson 2003).
- Different tasks give different results in artificial grammar learning (Whittlesea & Dorken 1993).
- Thus we also used a recall task, which is also affected by artificial grammar training (Mathews & Cochran 1998, Wilson 2003).
Procedure

- Study phase: 40 randomly selected grammatical items, each repeated once (=80 trials)
- Test phase: 40 study items, 40 new grammatical items, 80 [-BL–SG] items (=160 trials)
- Recall task (20 participants passing post-test):
  - Asked to judge whether test items were old (presented in study phase) or new (not presented before)
- Judgment task (20 participants passing post-test):
  - Asked to judge whether test items were grammatical
Analysis

- Dependent measure
  - Judgment task: Accuracy
  - Recall task: Accuracy, interpreting responses of “old” as responses of “grammatical”
- Compare within each condition against chance
- Compare grammars (along with other variables):
  - Grammar $\times$ Old $\times$ Trigger $\times$ Blocker $+ [\text{–BL}] + [\text{–SG}] +$ TriggerPosition (focus below on grammatical items)
- Mixed-effects logistic regression
Recall task: Overall results

Local blocking condition

- Both grammars significantly better than chance (50%) accuracy

Sour grapes condition

- Sour grapes more accurate than Blocking ($p = .06$)
Recall task: A three-way interaction

- Main effect of Old
  - Grammar × Old ($p = .05$): SG shows less memory influence
  - Old × Trigger ($p < .05$): Trigger effect only in new items
  - Grammar × Old × Trigger ($p = .06$): In Blocking condition, role of triggers harder to generalize to new items
Recall task: Other results

- Blocker did not interact with Grammar
  - Items with blockers more accurate ($p < .05$)
  - Old $\times$ Trigger $\times$ Blocker ($p = .05$)

Summary

- Grammatical status affected (mis)recall
- Sour grapes grammar generalized better than the local blocking grammar to new items, particularly in learning role of trigger
Judgment task: Overall results

Local blocking condition

- Both grammars significantly better than chance (50%) accuracy

Sour grapes condition

- Sour grapes more accurate than Blocking ($p < .01$): a stronger effect than in the recall task
Judgment task: Two interactions

- Main effects of Old and Trigger

- Grammar × Old ($p = .07$): BL shows less memory influence (perhaps a floor effect?)
- Grammar × Trigger ($p = .06$): Trigger effect only in sour grapes condition
Judgment task: Other results

- Blocker did not interact with Grammar
  - No main effect of Blocker ($p < .05$)
  - Trigger $\times$ Blocker ($p < .05$)

- Summary
  - Again sour grapes grammar showed overall better accuracy than local blocking grammar
  - Again key difference related to learning role of trigger, not blocker
Implications for UG hypotheses

- The sour grapes grammar seems to be somewhat easier to learn than the local blocking grammar
  - Vowel nasality is predictive only for sour grapes
    - Sour grapes: [anwãC...], C must be a glide
    - Local blocking: [anwãC...], C is unpredictable

- Thus the typological preference for local blocking grammars doesn’t involve analytic bias
  - The typological pattern may be due to channel bias
  - UG-based explanations may be misguided
Caveats

- These are merely artificial grammars learned by adults in brief laboratory sessions
  - Our experiments on 10-year-old children show similar results, but they may be too old to test UG

- What grammars did they actually learn?
  - Simple strategies may suffice for observed accuracy
  - Yet in a follow-up experiment, one participant described the sour grapes pattern perfectly; nobody could describe the local blocking pattern
Implications for task effects

- The difference across grammars was greater in the judgment task than in the recall task
  - Is a meta-linguistic task more sensitive to competence?
  - Or do artificial tasks better suit the artificiality of the artificial grammars?
- Nevertheless, non-meta-linguistic tasks are also sensitive to briefly learned artificial grammars (see also Mathew and Cochran 1998, Wilson 2003)
Thank you!
References (1/2)

References (2/2)


