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

mãʔãp ‘pardon’ (spread not blocked by glottal stop)

pəŋãw̃ãsan ‘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

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

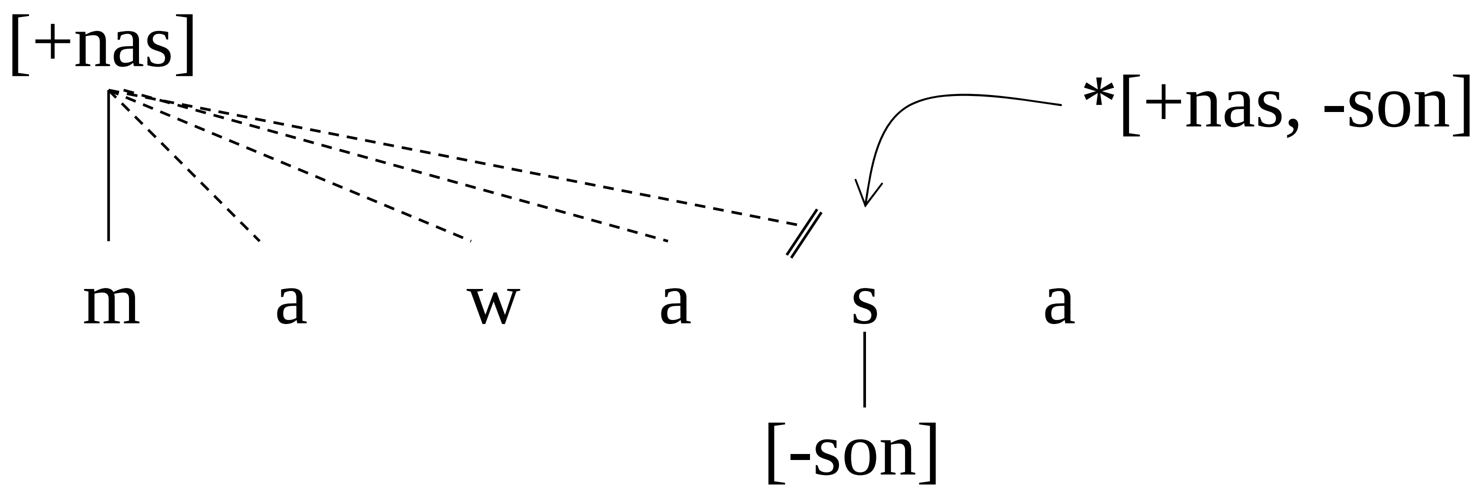
pəŋawasan (/s/ is a blocker: no spread at all)

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)!

/mawasa/	*NasFric	Agree-R([nasal])	Ident([nasal])
a. ☞ mawasa		*	
b. mãwasa		*	*
c. mãw̃asa		*	**
d. ☹ mãw̃ãsa		*	***
d. mãw̃ãs̃a	*	*	****
e. mãw̃ãs̃ã	*		*****

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
- *NASFRIC >> SHARE(nas) >> *NASGLI

  Step 1: Input: /mawasa/ Optimal output: /mãwasa/

  Step 2: Input: /mãwasa/ ...

  Last step: Input = output: /mãw̃ãsa/
- 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: /mãw̃ãsa/

  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
- Use **artificial grammar learning paradigm** (Reber 1989, Wilson 2003, Moreton 2008)
  - 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

  V<u>C</u>.C_1V.C_2V **CV.V<u>C</u>.C_1V** **CV.CV.V<u>C</u>**

- Parameters (generating 12,288 forms)
  - Trigger (**<u>C</u>** = /m, n/) vs. non-trigger (**<u>C</u>** = /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 :	[anw̃ãsa]	(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

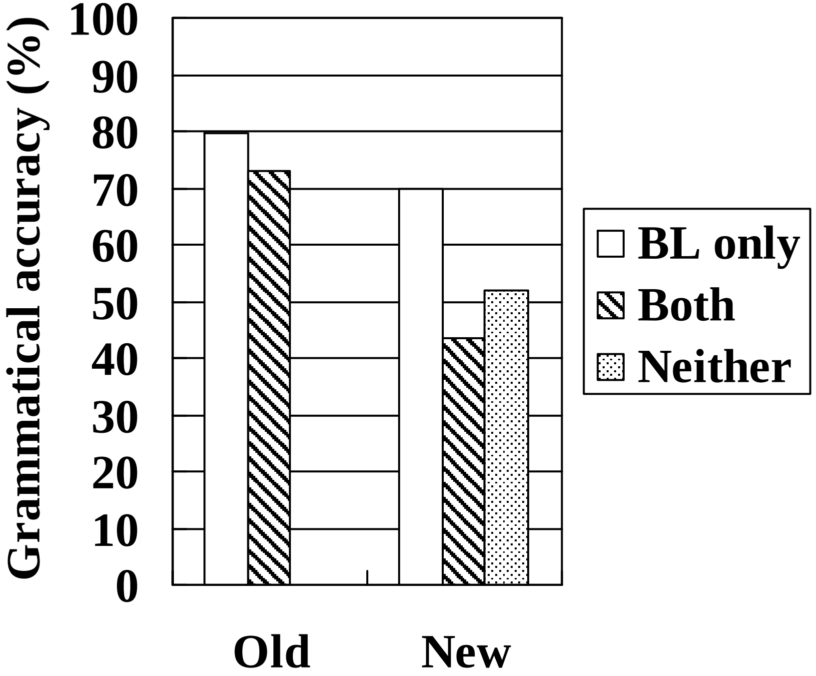
Analysis

- ❖ 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):

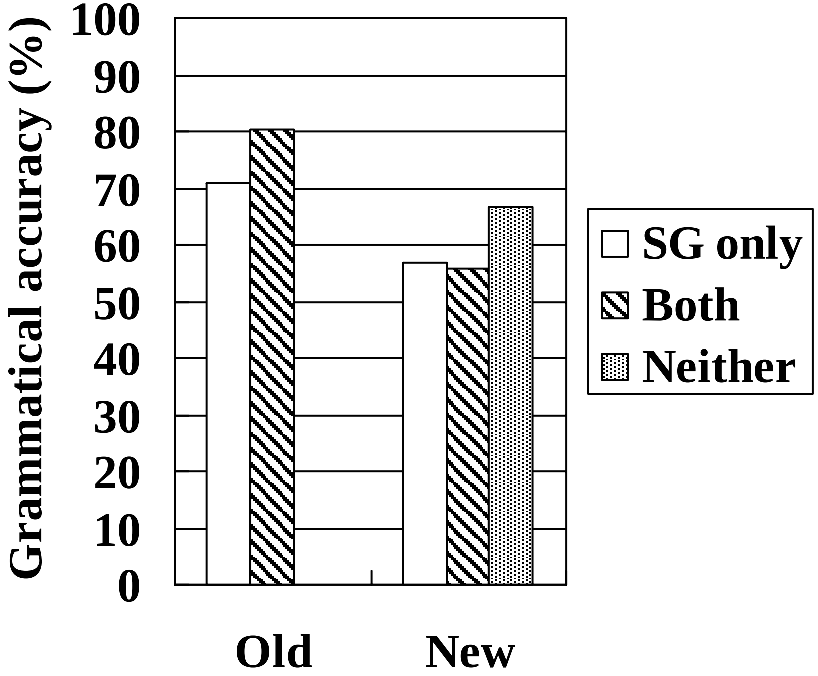
  Grammar × Old × Trigger × Blocker + [–BL] + [–SG] + TriggerPosition (focus below on grammatical items)
- ❖ Mixed-effects logistic regression

Recall task: Overall results

Local blocking condition

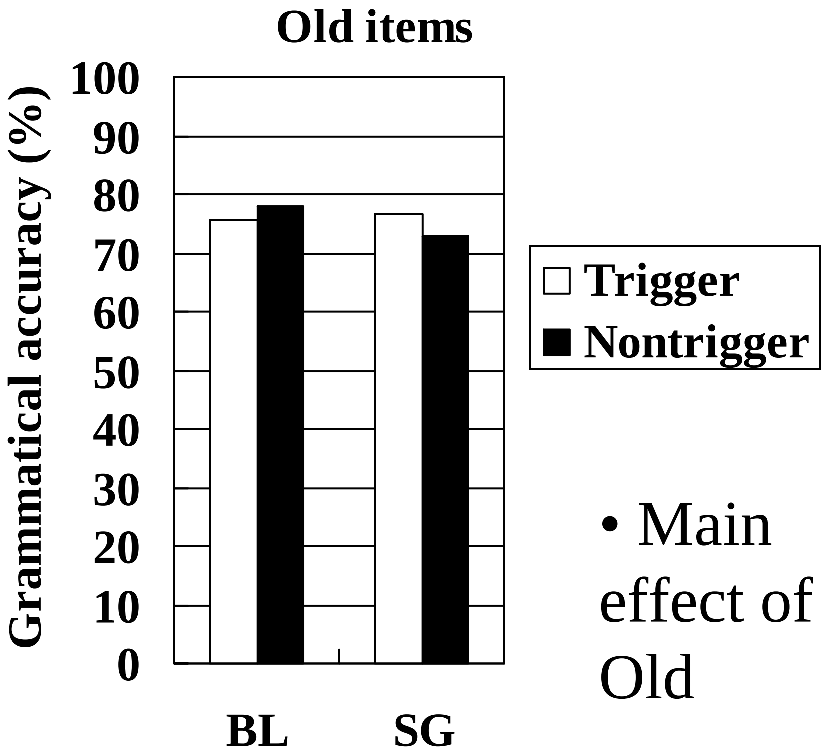


Sour grapes condition

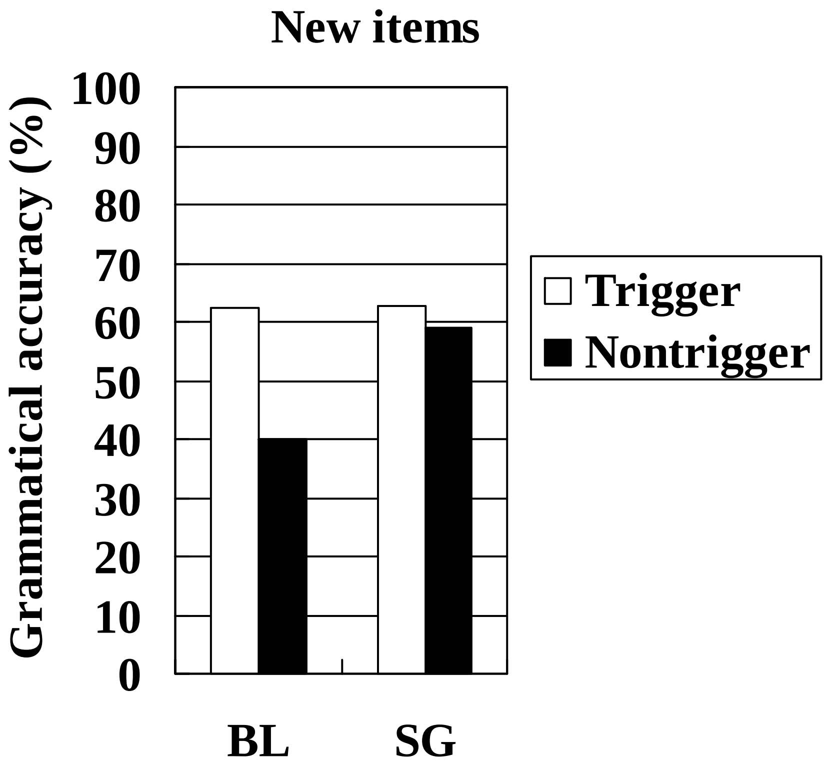


- Both grammars significantly better than chance (50%) accuracy
- Sour grapes more accurate than Blocking (p = .06)

Recall task: A three-way interaction



- Main effect of Old

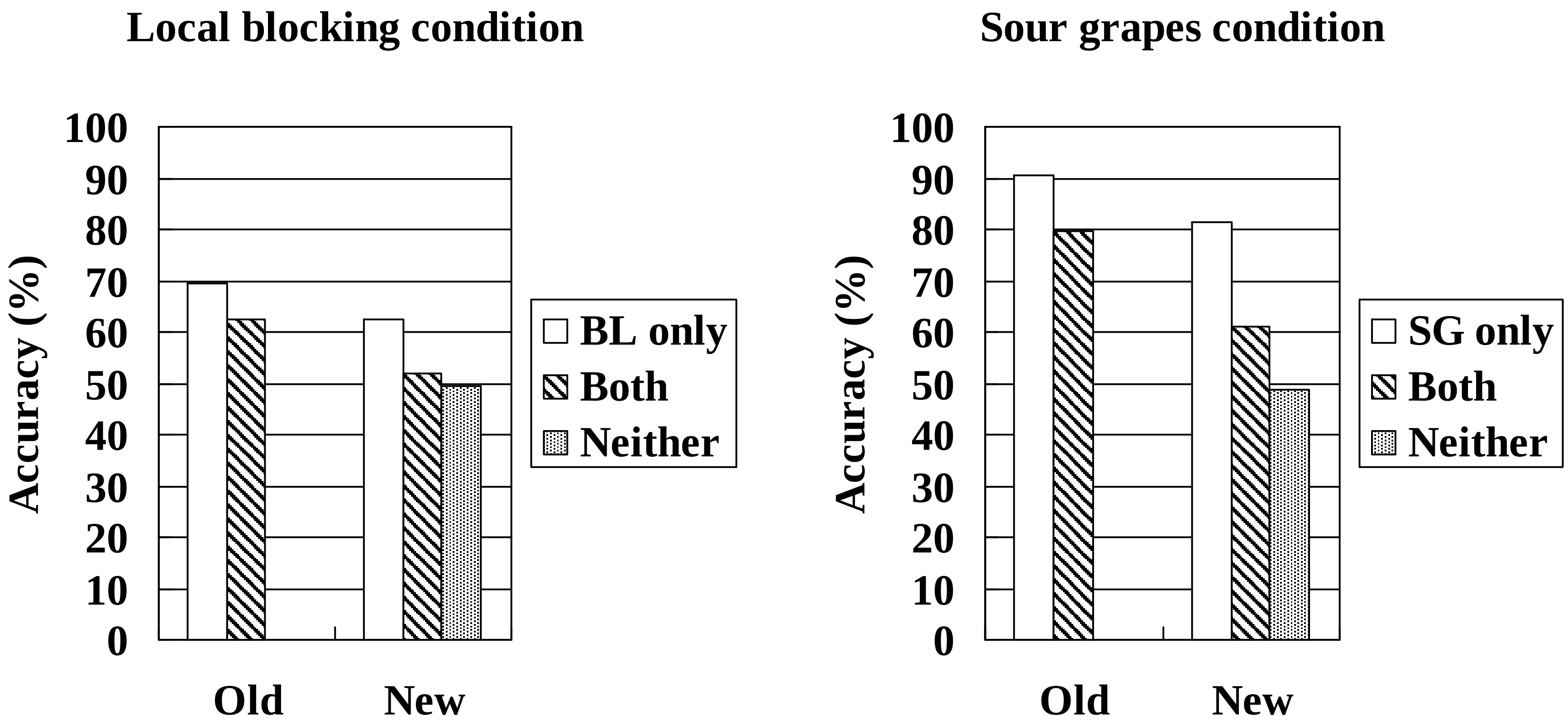


- Grammar × Old (*p* = .05): SG shows less memory influence
- Old × Trigger (p < .05): Trigger effect only in new items
- Grammar × Old × Trigger (*p* = .06): In Blocking condition, role of triggers harder to generalize to new items

Recall task: Other results

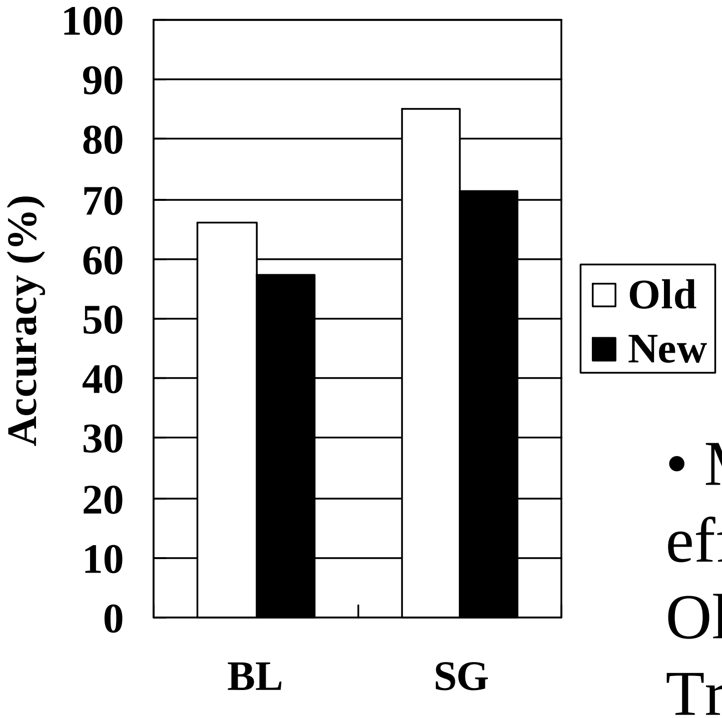
- Blocker did not interact with Grammar
  - Items with blockers more accurate ($p < .05$)
  - Old × Trigger × Blocker ($p = .05$)
- Summary
  - Grammatical status affected (mis)recall
  - Sour grapes grammar generalized better than the local blocking grammar to new items, particularly in learning role of trigger

Judgment task: Overall results

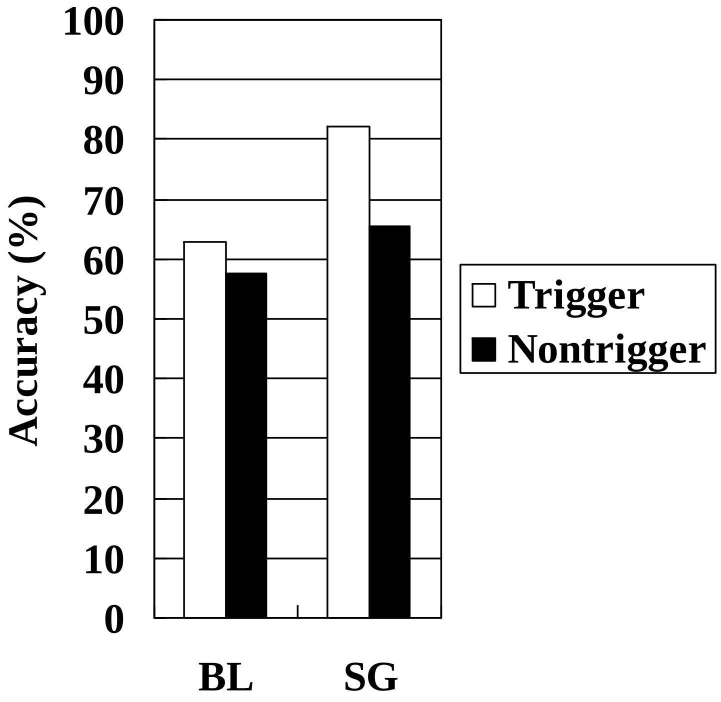


- Both grammars significantly better than chance (50%) accuracy
- Sour grapes more accurate than Blocking (p < .01): a stronger effect than in the recall task

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 × 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:	[anw̃ãC...]	C must be a glide
Local blocking:	[anw̃ãC...]	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!

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