Complexity Bias and Substantive Bias in Phonotactic Learning

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Background

- To what extent do synchronic learning biases shape the phonological typology?
  - ➢ Complexity bias: bias against formally complex patterns ([1] [3])
  - ➢ Substantive (a.k.a naturalness) bias: bias against phonetically unnatural patterns ([5] [6])
  - ➢ Complexity bias well-supported while evidence for substantive bias mixed and focused on alternations ([2])
- **Research question**: Does phonetic naturalness bias phonotactic learning?
- **Approach**: Test whether learners reproduce a phonetically-motivated phonotactic implicational in an artificial grammar learning experiment
- **The implicational**: Word-final obstruent voicing contrast → word-initial voicing contrast, but not necessarily vice versa ([4])

Method

- Expose subjects to stop voicing contrast word-initially or word-finally and test whether they extend the contrast to the other position
- Four training conditions, differing in *Trained Contrast Position* and *Trained Neutralization Value*

	#T	#D	T#	D#
#D…{T, D}# (*#T)	✗	✓	✓	✓
#T…{T, D}# (*#D)	✓	✗	✓	✓
#{T, D}…D# (*T#)	✓	✓	✗	✓
*#{T, D}…T# (*D#)*	✓	✓	✓	✗

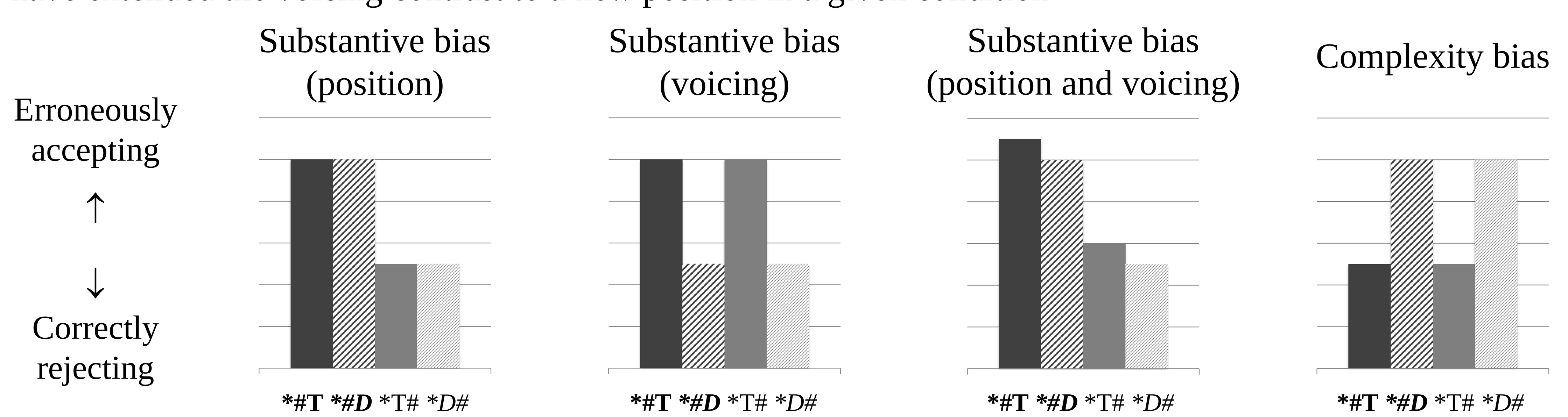
- Sample training items for *#{T, D}…T# (*D#)*:

#T	#D	T#	D#
pímir **t**ilár **k**awám …	**b**ímir **d**irín **g**awám …	míwi**p** laní**t** nuwá**k** …	

- 36 training items, 2 blocks of training (with images)
- 48 test items (same for all conditions): #T, #D, T#, and D# items (no images)
- Task: Say whether each word could also be a word of the language heard in training (Yes/No)
- 3 types of test item:
  - ➢ **Familiar Conforming**: voicing and position conform to trained pattern, and item heard in training (e.g. ***p**ímir* in *#{T, D}…T#*)
  - ➢ **Novel Conforming**: voicing and position conform to trained pattern, but item not heard in training (e.g. ***p**írum* in *#{T, D}…T#*)
  - ➢ **Novel Nonconforming**: voicing and position combination not heard in training (e.g. *nimá**b*** for *#{T, D}…T#*)

Experiment 1 Predictions—Novel Nonconforming Items

- Acceptance rates of Novel Nonconforming items (relative to Novel Conforming items) indicate whether subjects have extended the voicing contrast to a new position in a given condition



- Complexity bias: Due to presence of sonorant Cs, constraint needed to exclude Novel Nonconforming items in neutralizing-to-T (*D) conditions more complex than constraint needed in neutralizing-to-D (*T) conditions
  - ➢ #{T, D}…D# (*T#): kawá**m** ✓míwi**b** ✓ míwi**p** ✗ → *[−voice]#
  - ➢ *#{T, D}…T# (*D#)*: kawá**m** ✓míwi**b** ✗ míwi**p** ✓ → *[−son, +voice]#

Acknowledgments

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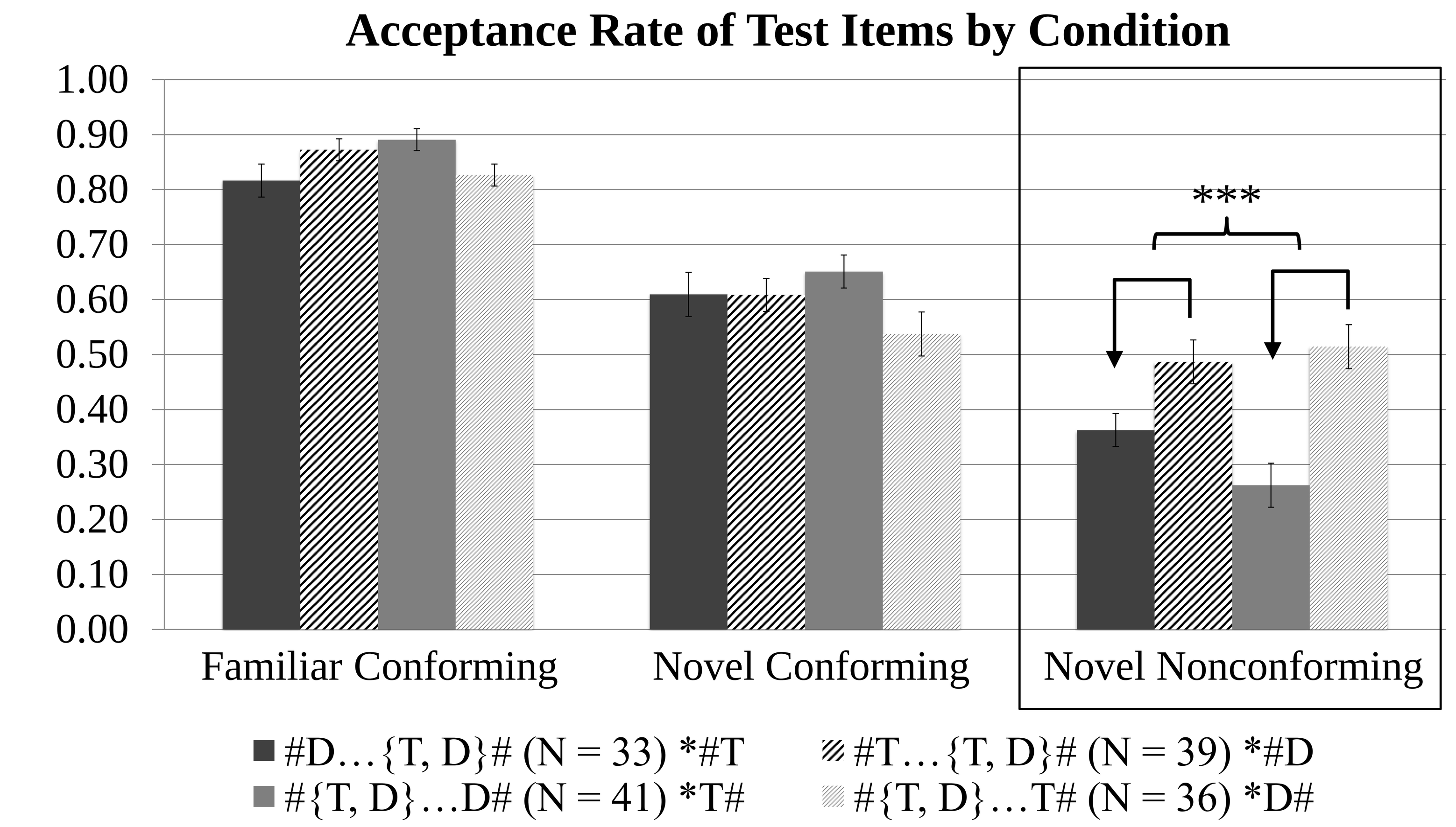
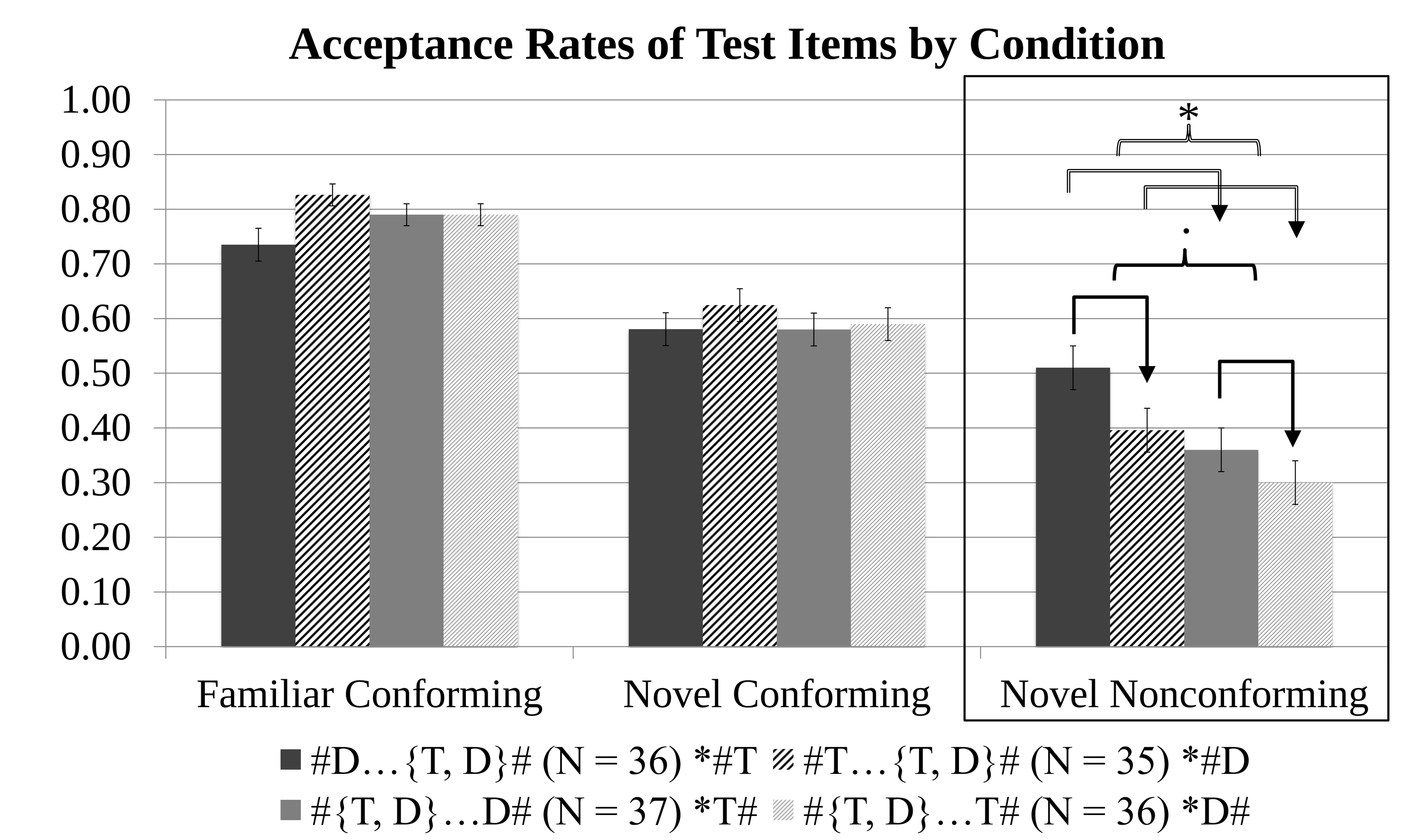
Experiment 1 Results



- **Novel Conforming**:
  - ➢ Above chance in all conditions (generalization → learning of trained pattern)
  - ➢ Not significantly different across conditions
- Mixed-effects logistic regression fit to **Novel Nonconforming** items with fixed effects **Trained Contrast Position** and **Trained Neutralization Value**
  - ➢ Main effect of **Trained Neutralization Value**: Neutralizing-to-T > neutralizing-to-D (***)
    - ▪ Supports complexity bias
- **Experiment 2**:
  - ➢ To further test complexity bias effect, non-critical (non-stop) Cs changed from sonorants to voiceless fricatives
  - ➢ Now constraint needed to exclude Novel Nonconforming items more complex in neutralizing-to-D (*T) conditions than in neutralizing-to-T (*D) conditions → complexity bias prediction flips
    - ▪ #{T, D}…D# (*T#): túsi**f** ✓físi**b** ✓ físi**p** ✗ → *[−cont, −voice]#
    - ▪ *#{T, D}…T# (*D#)*: túsi**f** ✓físi**b** ✗ físi**p** ✓ → *[+voice]#

Experiment 2 Results



- **Novel Conforming**:
  - ➢ Above chance in all conditions
  - ➢ Not significantly different across conditions
- Mixed-effects logistic regression fit to **Novel Nonconforming** items with fixed effects **Trained Contrast Position** and **Trained Neutralization Value**
  - ➢ Main effect of **Trained Neutralization Value**: Neutralizing-to-D > neutralizing-to-T (p = 0.065)
    - ▪ Supports complexity bias
  - ➢ Main effect of **Trained Contrast Position**: Final contrast > initial contrast (*)
    - ▪ Supports positional substantive bias

Conclusion

- Experiments 1 and 2 yield mixed support for substantive bias but stronger support for complexity bias
- An artificial language's non-critical sounds crucially affect performance
  - ➢ Subjects infer phonotactic constraints according to experiment-internal distribution of sounds, opting for simplest constraint with which they can master pattern

References

[1] Moreton, E. (2008). Analytic bias and phonological typology. *Phonology*, *25*, 83–127. [2] Moreton, E. & Pater, J. (2012). Structure and Substance in Artificial-phonology Learning, Part II: Substance. *Language and Linguistics Compass*, *6*(11), 702–718. [3] Skoruppa, K. & Peperkamp, S. (2011). Adaptation to Novel Accents: Feature-Based Learning of Context-Sensitive Phonological Regularities. *Cognitive Science*, *35*, 348–366. [4] Steriade, D. (1997). Phonetics in phonology: The case of laryngeal neutralization. Ms. University of California, Los Angeles. [5] White, J. (2013). *Bias in phonological learning: Evidence from saltation*. Ph.D. dissertation. University of California, Los Angeles. [6] Wilson, C. (2006). Learning phonology with a substantive bias: An experimental and computational study of velar palatalization. *Cognitive Science*, *30*, 945–982.

Appendix

Experiment 1 (Sonorant Filler Consonants) Regression Model

Dependent variable: response (accept or reject)
Fixed effects: Trained Contrast Position, Trained Neutralization Value[1]
Random effects: intercepts for subject and item

	Coefficient	***p***
Intercept	-0.964	<0.001***
Trained Contrast Position = initial (vs. final)	-0.197	0.522
Trained Neutralization Value = T (vs. D)	1.063	<0.001***

Experiment 2 (Fricative Filler Consonants) Regression Model

Dependent variable: response (accept or reject)
Fixed effects: Trained Contrast Position, Trained Neutralization Value[2]
Random effects: intercepts for subject and item

	Coefficient	***p***
Intercept	0.033	0.892
Trained Contrast Position = initial (vs. final)	-0.711	0.012*
Trained Neutralization Value = T (vs. D)	-0.522	0.065

[1] If the interaction of Trained Contrast Position and Trained Neutralization Value is included as a fixed effect in the model, it is not significant ($p = 0.208$).
[2] If the interaction of Trained Contrast Position and Trained Neutralization Value is included as a fixed effect in the model, it is not significant ($p = 0.727$).