# 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#)* | ✓ | ✓ | ✓ | ✗ |

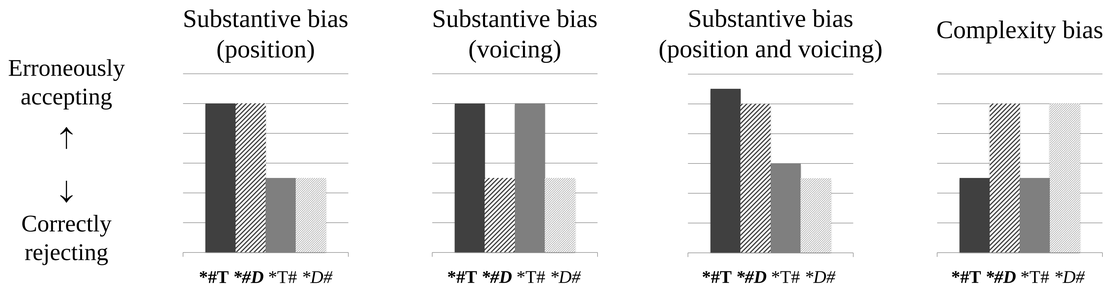
- Sample training items for *#{T, D}…T# (*D#)*:

| #T | #D | T# | D# |
|---|---|---|---|
| **p**ímir | **b**ímir | míwi**p** | |
| **t**ilár | **d**irín | laní**t** | |
| **k**awám | **g**awám | 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

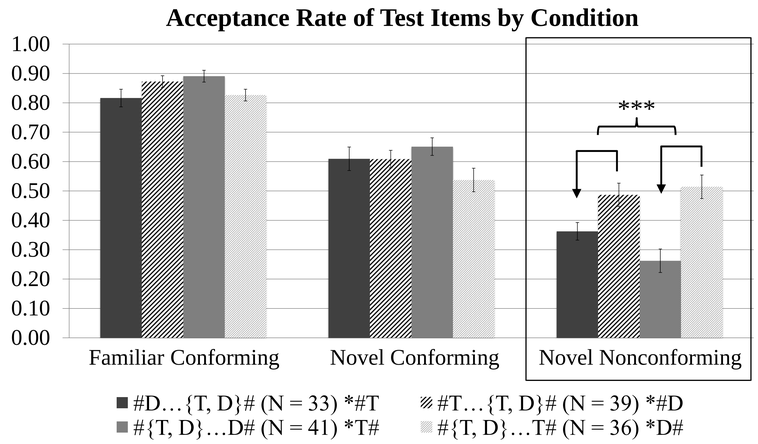



- Complexity bias: Due to presence of sonorant Cs, constraint needed to exclude Novel Nonconforming items in neutralizing-to-T (*D) conditions more complex than constraint needed in neutralizing-to-D (*T) conditions
  - ➢ #{T, D}…D# (*T#): kawá**m** ✓míwi**b** ✓ míwi**p** ✗ → *[–voice]#
  - ➢ *#{T, D}…T#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

## Acknowledgments

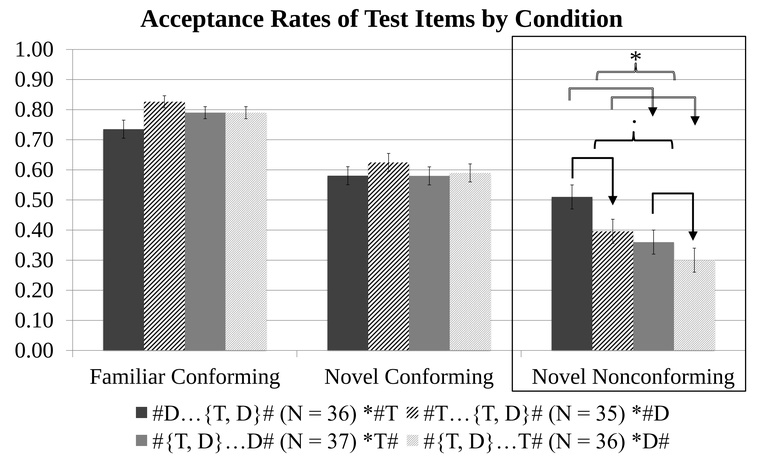
Many thanks to Kie Zuraw, Megha Sundara, Robert Daland, and Bruce Hayes for their guidance and advice. Thanks also to Adam Chong, Elliot Moreton, and audiences at CLS 53, the Southern California Meeting on Phonology 2017, AMP 5, and the UCLA Phonology Seminar.

## 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.