Neutralization avoidance and naturalness in artificial language learning

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Neutralization

/ t /  / d /  / pæt /  / pæd /

[ɾ]  [ɾ]  [pæt]  [pæd]
Neutralization avoidance (contrast preservation)

Previous studies have appealed to neutralization avoidance in analyses of phonological patterns:

- **Diachronic perspective**: selection process against neutralizing patterns, especially those resulting in ambiguous speech; functional load hypothesis. (e.g., Wedel, 2006; Silverman, 2010; Wedel et al., 2013)

- **Synchronic perspective**:
  - MAXIMIZE CONTRASTS (Flemming, 1996, 2004)
  - *NEUT (Bolognesi, 1998)
  - *MERGE (Padgett, 2003, 2009)
  - PRESERVE CONTRAST (Lubowicz 2007)
Research questions

◆ A lot of work discussing the role of the speaker and listener in neutralization avoidance. (see Silverman 2012 for an overview)
  ◆ But not much work looking at the role of the learner.

◆ Questions:
  ◆ Are learners biased against neutralizing alternations in comparison with non-neutralizing ones?
  ◆ If so, what is the basis for such a bias?

◆ Artificial language approach:
  ◆ Present equal input for neutralizing and non-neutralizing alternations.
  ◆ Test how well learners acquire the two types of alternation.
Main points

◆ **Experiment 1**: Neutralizing alternations are harder to learn than non-neutralizing alternations.

◆ **Experiment 2**: Neutralization avoidance effect during learning is driven by homophony avoidance.
Experiment 1
Experiment 1: method

- **Participants**: native English speakers (n=30)

- **3 phases**:
  - Exposure phase
  - Test phase 1: trained items
  - Test phase 2: novel items

- **4 novel alternations** involving palatalization /t, d, s, z/ $\rightarrow [\text{tf, dʒ, ʃ, ʒ}]$

- **2 counterbalancing groups**: Language A vs. Language B
Experiment 1: design

Alternations

Language A

/ t / → [ tʃ ]
/ d / → [ dʒ ]
/ s / → [ s ]
/ z / → [ ʒ ]

Language B

/ t / → [ tʃ ]
/ d / → [ dʒ ]
/ s / → [ s ]
/ z / → [ ʒ ]

Critical non-alternating phonemes

/ tʃ, dʒ /

/ s, ʒ /

Filler non-alternating phonemes

/ p, b, k, g, f, v/

/ p, b, k, g, f, v/
Experiment 1: stimuli

- Exposure stimuli: 48 CVCVC singular nonwords with CVCVC-i plural forms:
  - 8 alternating [t ~ tf] and [d ~ dʒ] (Neutralizing in Language A)
    [tusut] → [tusutʃi]
  - 8 alternating [s ~ ŋ] and [z ~ ʒ] (Neutralizing in Language B)
    [duvis] → [duviʃi]
  - 8 critical non-alternating trials ending in [tf, dʒ] (Language A) or [ŋ, ʒ] (Language B)
    [buvatʃ] → [buvatʃi]
  - 24 non-alternating filler trials ending in [p, b, k, g, f, v].
    [vatuk] → [vatuki]
Experiment 1: stimuli

◆ ‘Illegal’ sequences never presented.
  ◆ *[ti, di] in Language A.
  ◆ *[si, zi] in Language B.

◆ Otherwise, consonant and vowel distribution roughly balanced across positions.
Experiment 1: exposure phase
Experiment 1: test phases

- **2 test phases**: 24 trained items, then 48 untrained items.

- **Forced-choice task**: choose the correct plural form between an alternating option and a non-alternating option.
Experiment 1: test phase options

◆ Incorrect changing options for non-alternating phonemes:

\[
\begin{align*}
/ \text{tʃ} / & \rightarrow [ʃ] & / p / & \rightarrow [\text{tʃ}] \\
/ \text{dʒ} / & \rightarrow [ʒ] & / b / & \rightarrow [\text{dʒ}] \\
/ \text{ʃ} / & \rightarrow [tʃ] & / k / & \rightarrow [tʃ] \\
/ \text{ʒ} / & \rightarrow [dʒ] & / g / & \rightarrow [dʒ] \\
/ \text{ʃ} / & \rightarrow [ʃ] & / f / & \rightarrow [ʃ] \\
/ \text{ʒ} / & \rightarrow [ʒ] & / v / & \rightarrow [ʒ]
\end{align*}
\]
Experiment 1: results (Neut. vs. Non-neut. overall)

Better learning for Non-neutralizing trials.
Experiment 1: results (trained and new items)

- **Main effect of training.** Trained > New
- **Main effect of Trial Type.** Non-neut. > neut.
- **No interaction.**
Summary

• Neutralizing alternations dispreferred relative to Non-neutralizing alternations, despite equal evidence for both.
  – Independent of which alternations were being learned.
A second interesting result: velar vs. labial fillers

More errors on velar fillers than labial fillers!
Accounting for the anti-neutralization effect

- Why are neutralizing rules more difficult to learn?

- We consider two possibilities:
  - pure distributional learning
  - learning bias
Just distributional learning?

- Non-neutralizing alternation
- Neutralizing alternation
- Non-alternating fillers

- Fully complementary distribution
- Partially overlapping distribution
- Fully overlapping distribution

Harder to learn?
Anti-neutralization learning bias?

◆ Learners have a neutralization avoidance bias when learning alternations.

Dispreferred relationship:

\[
\text{form}_1^x \quad \text{form}_2^x
\]

\[
\text{form}_y
\]
Anti-neutralization learning bias?

◆ Learners have a neutralization avoidance bias when learning alternations.

◆ What type of bias?
  
  – Relevant to contrasts at phonological level or lexical level?

  → Does homophony play a role?
Experiment 2
Experiment 2: Is neutralization avoidance driven by homophony avoidance?

- Phonologically neutralizing alternations tolerated when they result in little lexical neutralization. (e.g. Silverman 2010 on Korean)

- Existing neutralizing rules in a language create far fewer homophones than similar, non-existing neutralizing rules would. (Kaplan, 2011)

- Diachronically, mergers less likely when they would result in high amounts of homophony. (Wedel et al. 2013)

- Synchronically, stochastic processes may occur less frequently when they result in potential homophones. (e.g. Kaplan & Muratani 2015 on Japanese nasal contraction)
Experiment 2: design

Exp. 1: Half lexical neutralization

<table>
<thead>
<tr>
<th>t-final</th>
<th>tusut</th>
<th>tusutʃi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>buvat</td>
<td>buvatʃi</td>
</tr>
<tr>
<td>tf-uzat</td>
<td>tf-uzatʃi</td>
<td></td>
</tr>
<tr>
<td>faput</td>
<td>faputʃi</td>
<td></td>
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</table>

Exp. 2: Homophony Condition

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<tr>
<td>faput</td>
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Exp. 2: No Homophony Condition

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<td>tavutʃi</td>
<td>tavutʃi</td>
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<td>pifitʃi</td>
<td>pifitʃi</td>
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<tr>
<td>gizutʃi</td>
<td>gizutʃi</td>
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</table>
Experiment 2: results (Neut. vs. Non-neut. overall)

Better performance for Non-neutralizing trials.

Replicated main effect from Exp. 1.
Experiment 2: results (trained vs. novel items)

No effect of Trial Type for trained items.

Significant difference observed for novel items.

* Significant difference observed for novel items.

n.s. No effect of Trial Type for trained items.
**Experiment 2: results (novel items by condition)**

Significant interaction.

Significant difference in Homophony condition, but **not** in No Homophony condition.
General discussion
Distributional learning or learning bias?

- Effect **not** just due to distributional learning at a segmental level.
  - Could explain why neutralizing alternations are harder to learn (Exp. 1).
  - But does not explain why this effect is only seen when it leads to homophony (Exp. 2).

- Learning likely paradigm-based, but more complicated than just learning rules.
  - Rules were completely regular.
  - Should be no problem learning rules like $X_t[sing] \rightarrow X_t[\text{plur}]$ from pairs like *[tusut]*…*[tusutf]*. (e.g. MGL; Albright & Hayes, 2002)
  - Yet learning impaired if the rule leads to neutralization, and especially homophony.

→ Suggests an **anti-neutralization learning bias**, sensitive to lexical neutralization.
Interaction between lexical/semantic learning and phonological learning

• Learners must track homophones that they encounter during learning.
  – Otherwise, amount of homophony in the input would have no effect on learning.

• But, homophony avoidance (Exp. 2) was found in novel items, where there was no actual homophony.

→ The observed homophony affected the generalization to novel items, i.e. the ability to induce the phonological rule.
How might the bias work?

Interaction of paradigm uniformity and homophony avoidance?
Future directions

• What happens if paradigm uniformity is taken out of the picture?

• More implicit experiment (pairs of the paradigm less explicit).

• Does the amount of homophony have a gradient effect?
  – Test with multiple homophony levels.

• Do we see the same effect with infants?

• Implemented learning model.
Conclusions

• Neutralizing alternations dispreferred relative to non-neutralizing alternations.

• This neutralization avoidance seems to be driven by homophony avoidance, suggesting an interaction between lexical/semantic learning and phonological learning.
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References:


References:


References:


