Introduction

Infants are excellent at statistical learning: 
- Discriminating speech sounds (Anderson et al., 2001)
- Phonotactics (Chambers et al., 2003)
- Word segmentation (Saffran et al., 1996)

Tracking statistics likely plays a role in learning phonological alternations as well:
- Computational work (Peperkamp et al., 2006)
- Experimental work with infants (K. White et al., 2008)

Evidence mounting that learners are biased by phonetic similarity – they prefer alternations between phonetically similar sounds.
- Typology (Sundara, 2001; Hayes & J. White, sub.)
- Adult artificial language studies (Skoruppa et al., 2007; White & Sundara, 2014)
- Computational modeling (Peperkamp et al., 2006; Wilson, 2006; J. White, 2013)

- Virtually no work with infant learners!!

Research questions:
1. Are 12-month-olds biased by phonetic similarity when generalizing newly learned alternations in an artificial language? (Study 1)

2. Are 12-month-olds biased by similarity when learning alternations in their first language? (Study 2)

Study 1 (White & Sundara, 2014)

Question:
Do 12-month-olds’ generalization of newly learned phonological alternations depend on phonetic similarity?

Participants:
- 50 monolingual English-learning 12-month-olds at UCLA.

Procedure:
Visual Fixation Procedure

1. Familiarization: Phrases providing evidence for an alternation.
   - ‘Function’ element (na or rom) + CVCCV
     - ‘content’ word (e.g. rom poli...na timu...)
     - 16 phrases, repeated twice per trial
     - 3 trials (45s each, 135s total exposure)

2. Test: Novel pairs of CVCCV words (e.g. buni...vuni...)

Results:

<table>
<thead>
<tr>
<th>Bias condition</th>
<th>Mean looking times</th>
</tr>
</thead>
<tbody>
<tr>
<td>[p ~ v] or [t ~ z]</td>
<td>Alternating place</td>
</tr>
<tr>
<td>[p ~ v] or [t ~ z]</td>
<td>Contrasting place</td>
</tr>
</tbody>
</table>

- 12-month-olds generalized the alternations to new pairs of sounds that were more similar, but not ones that were less similar.

Study 2 (Sundara, Kim, White, & Chong, submitted)

Question:
Do 12-month-olds depend solely on input statistics when learning phonological alternations in their first language, or is this learning biased by phonetic similarity?

Tapping in American English: /t/ and /d/ (partially) neutralized to [ɾ] in certain contexts:

<table>
<thead>
<tr>
<th>/t/</th>
<th>/d/</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ɾ]</td>
<td>[ɾ]</td>
</tr>
</tbody>
</table>

Corpus search of infant-directed speech:
- 15 infants
- 9-month-old dyads chosen (infant ages 0:9–2:2)
- All words ending in –ting/–ding extracted.

Results:

<table>
<thead>
<tr>
<th>Types</th>
<th>Tokens</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>44</td>
</tr>
<tr>
<td>146</td>
<td>598</td>
</tr>
</tbody>
</table>

Infants hear far more –ting words than –ding words in IDS.

Phonetic similarity:
- [d] and [ɾ] more similar than [t] and [ɾ] (Hayes et al., 2010)

Predictions:
Based solely on input statistics: [t ~ r] learned first.
Bias based on phonetic similarity: [d ~ r] learned first.

Participants:
- 48 monolingual English-learning 12-month-olds (24 in each exp.)

Procedure:
Headturn Preference Procedure (HPP)

1. Familiarization: 2 passages (45s each)
   - E.g. Cutting papers with scissors is a lot of fun...
   - Target word appeared 6 times/ passage.
   - 2 groups (cutting/meeting or patting/shooting, counterbalanced)

2. Test:
   - 4 wordlists, 2 familiar and 2 novel (4 trials x 2 blocks).
   - Exp. 1: cut...cut...cut... (also: meet, pat, shoot)
   - Exp. 2: cut...cut...cut... (also: meet, pad, shoot)

Results:

<table>
<thead>
<tr>
<th>Exp. 1 [t ~ r]</th>
<th>Exp. 2 [d ~ r]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiar</td>
<td>Novel</td>
</tr>
</tbody>
</table>

- 12-month-olds know [d ~ r], but not [t ~ r], despite greater evidence for [t ~ r] in the input.

- Exp. 3: Confirmed that 12-month-olds can discriminate [d] and [ɾ] perceptually.

- Note: if [t ~ r] learned first, this would be a salutary alternation:
  - Particularly egregious P-map violation.
  - Poses theoretical difficulties. (Hayes & J. White, sub.)
  - Disfavoured by learners (J. White, 2014).

References

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General Discussion

Input statistics are not sufficient for explaining infants’ learning and generalization of phonological alternations.

- Instead, this learning is biased by phonetic similarity.

- Previous experimental work with adults (J. White, 2014) and computational modeling (J. White, 2013) suggests that this bias is a substantive bias favouring alternation between perceptually similar sounds (i.e. a P-map bias).

- Future infant work will look more into the type of bias (e.g. perceptual vs. features).

- Prediction: alternations between similar sounds learned first, all else being equal.

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