Perceptual Asymmetries in Learning
Vowel Nasalization

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Agenda

1 Learning biases
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1 Learning biases
Previous research compared the learnability of different phonological patterns with artificial languages.

- Are certain patterns learned more easily than others? Why?
- testing learning behaviour and generalization behaviour
- hypothesis: natural patterns are easier to learn than unnatural ones
Substance

- what it means to be natural – substance
  - physically definable acoustic, articulatory or auditory properties of speech (Crystal, 2008)
  - grounded in phonetics
Substantive bias

- bias – cognitive predisposition toward certain patterns; e.g. toward patterns that are phonetically natural (Wilson, 2006)

- Phonological patterns that facilitate production or perception are learned more readily and easily than those that
  - do not (Becker et al., 2011; Baer-Henney & van de Vijver, 2012; White, 2014; van de Vijver & Baer-Henney, 2014; Baer-Henney et al., 2015).
  - do so to a lesser extent (Wilson, 2006; Finley, 2012; Baer-Henney et al., submitted).
The present study wants to contribute to the debate about the nature of the bias.

- What happens when the predictions for substance differ, because the effects of production and perception differ?
- training and test with artificial language learning paradigm
- a pattern which is new for the learners
- compares learning of vowel nasalization in relation to vowel height
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Vowel nasalization
Why vowel nasalization?

- for vowel nasalization there are two different predictions
  - production prefers low vowel nasalization
  - perception prefers high vowel nasalization
left: oral vowel [e], right: nasalized vowel [ũ] (Zsiga, 2013)
Ease of production

- muscles for nasalization of the vowel (*palatoglossus*) and lowering the vowel (*hyoglossus*) are anatomically connected

Hoole (2015)
broken line: oral vowel [e], continuous line: nasalized vowel [ẽ] (Beddor, 1984)
Ease of perception

- high oral and nasalized vowels are perceptually more distinct from each other than low oral and nasalized vowels (Schwartz, 1968)

- continuous line: oral vowel, broken line: nasalized vowel
Asymmetry: typology

- some languages prefer low vowel nasalization
  - e.g. many Chinese dialects, some Eastern Algonquian languages, Thai, Amuzgo, ... (Hajek & Maeda, 2000)

- some languages prefer high vowel nasalization
  - e.g. Chamorro, Picard, Panamanian Spanish, Chatino, ... (Hajek & Maeda, 2000)
Asymmetry: previous research

- **studies using natural stimuli** (e.g. Lintz & Sherman, 1961; Bream, 1968):
  - preference for low vowel nasalization

- **studies using synthetic stimuli** (e.g. Hawkins & Stevens, 1985; Maeda, 1993):
  - preference for high vowel nasalization

- nasalized vowels were part of the phoneme inventory of the participants’ native languages
  - only natural stimuli evoked association with the own articulation
3 Experiment
In our experiment adult native speakers of German learned a new vowel nasalization pattern.

- vowels are nasalized before nasals: /V/ \(\rightarrow\) [\(\ddot{V}\)] / _ [m]
- nasalization of high vowel [i], mid vowel [ɛ] or low vowel [a]

<table>
<thead>
<tr>
<th>predictions</th>
<th></th>
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<tbody>
<tr>
<td>no substantive bias</td>
<td>substantive bias</td>
</tr>
<tr>
<td></td>
<td>ease of perception</td>
</tr>
<tr>
<td>low = high</td>
<td>high &gt; low</td>
</tr>
</tbody>
</table>
Can German native speakers perceive the difference between nasalized and oral vowels although nasalized vowels are not part of their phoneme inventory?

experiment with 75 native speakers of German

- same-different-task
- 2 x 60 stimulus pairs (oral vs. oral, nasalized vs. nasalized, oral vs. nasalized)
- CV-syllables

<table>
<thead>
<tr>
<th>C</th>
<th>V</th>
</tr>
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<tbody>
<tr>
<td>[p t k]</td>
<td>[æ i ɔ u / ã õ ū]</td>
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Pre-test: results

- no significant difference between vowels

- German native speakers can perceive the difference between all oral and nasalized vowels.
Stimuli

- artificial language: singular, plural and diminutive forms
- subset of German and Portuguese phoneme inventory
- recorded by a native speaker of Portuguese

<table>
<thead>
<tr>
<th></th>
<th>$C_1$</th>
<th>$V_1$</th>
<th>$C_2$</th>
<th>$V_2$</th>
<th>suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>singular</td>
<td>[p d kʃ v]</td>
<td>[o u]</td>
<td>[b t g f z]</td>
<td>[a ɛ i]</td>
<td>Ø</td>
</tr>
<tr>
<td>plural</td>
<td>[p d kʃ v]</td>
<td>[o u]</td>
<td>[b t g f z]</td>
<td>[ã ẽ i]</td>
<td>[m]</td>
</tr>
<tr>
<td>diminutive</td>
<td>[p d kʃ v]</td>
<td>[o u]</td>
<td>[b t g f z]</td>
<td>[a ɛ i]</td>
<td>[l]</td>
</tr>
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Method

- Poverty of the Stimulus Method (Wilson, 2006) with three experimental groups

<table>
<thead>
<tr>
<th>participants</th>
<th>training</th>
<th>test</th>
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<tr>
<td>n = 20</td>
<td>high</td>
<td>high, mid, low</td>
</tr>
<tr>
<td>n = 20</td>
<td>mid</td>
<td>high, mid, low</td>
</tr>
<tr>
<td>n = 20</td>
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</tr>
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Training

- 2 x 48 stimuli (16 singulars, 16 plurals, 16 diminutives) in randomized order
- **forced choice** task
  - correct vs. incorrect form; oral vs. nasalized vowel
- 48 stimulus pairs (24 plurals, 24 diminutives)
  - 16 pairs with high, mid and low vowels

![Diagram showing the test process with visual and auditory stimuli and response options.](image-url)
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Results
Plural formation: learning

- analysed by means of logistic regression
- \([i]\)-learners & \([\varepsilon]\)-learners \(\ast \) > \([a]\)-learners
- \([i]\)-learners = \([\varepsilon]\)-learners
Plural formation: Generalization

- [a]-learners: [ɛ]-items = [i]-items
- [ɛ]-learners: [i]-items * > [a]-items
- [i]-learners: [ɛ]-items * > [a]-items
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Discussion
### Predictions & results

- High and mid vowel nasalization is learned better than low vowel nasalization
- Evidence in favour of a substantive bias which eases perception

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our results are in line with previous studies using synthetic stimuli although we used natural stimuli
our participants have no experience with the articulation of nasalized vowels
ease of perception is independent of language-specific experience
Explanation

- Wilson (2006): generalization to unmarked patterns
- present study
  - /i/-learners generalize more to /ɛ/- than to /a/-items
  - /ɛ/-learners generalize more to /i/- than to /a/-items
  - /a/-learners do not generalize to other items
- Participants generalize more to non-low vowels because they are unmarked for perception.
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Conclusion
- successful learning of a vowel nasalization rule depends on vowel height
- further evidence for a substantive bias
- in line with recent research (Wilson, 2006; Finley, 2012; Baer-Henney et al., submitted)
- ease of perception is favoured over ease of production
  - perception before production hypothesis (Flege, 1991)
Future research

- Can this pattern be generalized to other languages?
  - experiment with native speakers of another language without nasalized vowels (e.g. Hungarian)
- Would a similar production task show the same results?
Thank you for your attention!
Köszönöm szépen a figyelmet!
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References


Results: plural & diminutive formation

- Learning Nasalization as an a-learner
  - Proportion correct: 0.63, 0.59, 0.55

- Learning Nasalization as an ε-learner
  - Proportion correct: 0.83, 0.72

- Learning Nasalization as an i-learner
  - Proportion correct: 0.67, 0.79
Sounds

- a-Sg
- a-Pl
- a-Dim
- ε-Sg
- ε-Pl
- ε-Dim
- i-Sg
- i-Pl
- i-Dim

- a-Pl (oral)
- a-Dim (nasalized)
- ε-Pl (oral)
- ε-Dim (nasalized)
- i-Pl (oral)
- i-Dim (nasalized)