UNIVERSAL BIASES IN PHONOLOGICAL LEARNING

ACTL SUMMER SCHOOL, DAY 2

JAMIE WHITE (UCL)
NATURALNESS AND COMPLEXITY IN VOWEL HARMONY
Simplicity hypothesis:

1. $X_\alpha \ldots X \rightarrow X_\alpha \ldots X_\alpha \rightarrow \text{easy to learn}$
2. $X_{\alpha,\beta} \ldots X \rightarrow X_{\alpha,\beta} \ldots X_\alpha \rightarrow \text{hard to learn}$

(Phonetic) Naturalness hypothesis:

3. $X_\alpha \ldots X \rightarrow X_\alpha \ldots X_\alpha \rightarrow \text{easy to learn}$
4. $X_\alpha \ldots X \rightarrow X_\alpha \ldots X_{-\alpha} \rightarrow \text{hard to learn}$

Pycha, Nowak, Shin & Shosted 2003, WCCFL
Learned one of three languages:

1. **Vowel Harmony (VH)**: Front stem vowel $\rightarrow$ front suffix; back stem vowel $\rightarrow$ back suffix.
2. **Vowel Disharmony (DH)**: Front stem vowel $\rightarrow$ back suffix; back stem vowel $\rightarrow$ front suffix.
3. **Arbitrary (ARB)**: Stem vowel $[i, æ, u] \rightarrow$ front suffix; stem vowel $[ɪ, u, ɑ] \rightarrow$ back suffix.

**Predictions for learning**

- Simplicity: VH, DH > ARB
- Phonetic naturalness: VH > DH, ARB
- Both together: VH > DH > ARB

Pycha, Nowak, Shin & Shosted 2003, WCCFL
METHOD

Participants

- 30 American English speakers; 10 per group (N.B. this is low!)

Stimuli

- CVC stems:
  - Front vowels [ɪ, i, æ]
  - Back vowels [u, ʊ, a]
  - Wide variety of Cs
- VC suffixes:
  - [ɛk] ~ [ʌk]
- Stimuli were spliced (controls for coarticulation).

Pycha, Nowak, Shin & Shusted 2003, WCCFL
METHOD

Procedure

• Participants told that they would be hearing singular-plural pairs in a novel language.

1. **Listening phase** (18 trials x 2 reps, all ‘correct’)
   
   [gip] … (.3 sec silence) … [gipɛk]

2. **Learning phase** (36 trials x 2 reps, half ‘correct/incorrect’, half old/novel)
   

3. **Test phase** (36 trials x 2 reps, half ‘correct/incorrect’, all novel)
   
   [fig] … [figɛk] … Correct plural? (No feedback)

Pycha, Nowak, Shin & Shosted 2003, *WCCFL*
RESULTS

The point of investigation was whether speakers can and do learn about the conditional sentence in their native language. However, not all languages are equally proficient in learning about novel conditional sentences. For instance, Vergnaud & Pecheyran (2003) found that Viennese German (VH) subjects performed significantly better than Dutch (DH) and Arabic (ARB) subjects, with mean correct responses of 86%, 75%, and 51%, respectively. This indicates that the ability to learn about new conditional sentences varies across different languages.
A MORE IMPLICIT TASK

Participants were familiarized to a novel ‘accent’ of French containing vowel harmony.

Familiarized to one of 3 ‘accents’:

- **Harmonic French**: Front vowels are rounded after front rounded vowels, and unrounded after front unrounded vowels.
- **Disharmonic French**: Front vowels are unrounded after front rounded vowels, and rounded after front unrounded vowels.
- **Mixed French**: Front high vowels as in Harmonic French. Front mid vowels as in Disharmonic French.

Participants then tested to see what they have learned about the speaker’s ‘accent’.

Skoruppa & Peperkamp 2011, *Cognitive Science*
Predictions for learning (same as in Pycha et al. 2003)

- Simplicity: **Harmonic**, **Disharmonic** > **Mixed**
- Phonetic naturalness: **Harmonic** > **Disharmonic**, **Mixed**
- Both together: **Harmonic** > **Disharmonic** > **Mixed**
METHOD

Participants
- 90 European French speakers (30 per group)

Stimuli
- 304 target words (2+ syllables) selected from the Lexique corpus.
- All contain two adjacent syllables with front vowels.
- Half (152) harmonic in standard French (i.e. both front vowels rounded or unrounded).
- Half (152) disharmonic in standard French.
- Test stimuli matched for frequency, n. of phonemes, etc.

Skoruppa & Peperkamp 2011, Cognitive Science
METHOD

Procedure

• Participants told to memorize the content of the story while ignoring the speaker’s accent.

1. Exposure phase

• 4 stories written such that each exposure item (304 in total) occurred at least once.

• Participants listened to each story twice; answered two multiple-choice Qs after each to check for attention.

Examples:
Standard French (not heard):  Sans pudeur, il se versa un verre de liqueur.
Harmonic French:  Sans pudeur, il se versa un verre de liqueère.
Disharmonic French:  Sans pudère, il se versa un verre de liqueur.
Mixed French:  (mid vowels: harmonic; high vowels: disharmonic)
Procedure

2. Test phase

• Each participant heard 30 pairs of target items (10 from exposure, 20 novel).
• Pairs consisted of one harmonic item and one disharmonic item (e.g. *liquère* – *pudère*).
  • Both nonwords in Standard French.
  • One legal in Harmonic French; one legal in Disharmonic French.
  • Order counterbalanced.
• **Task:** Select whether the 1st word or 2nd word is pronounced in the same accent as exposure (button press).
RESULTS

Skoruppa & Peperkamp 2011, *Cognitive Science*
ON THE HORIZON

Recent work by Sharon Peperkamp and Alexander Martin (presented at 2015 DGfS):

• Artificial grammar study (similar to Pycha et al. 2003).
• Participants trained, then tested before and after sleep.
• Vowel harmony pattern, but not vowel disharmony pattern, retained after sleep.

Stay tuned!
NATURAL CLASSES AND FEATURE-BASED LEARNING
FEATURES?

Assume exposure to input like this:

- [kap] ‘cow’     [kabe] ‘cows’
- [fat] ‘sheep’    [fade] ‘sheep (pl.)’
- [vak] ‘goat’     [vage] ‘goats’

Do people learn this:

\[
\begin{align*}
p & \rightarrow b / a \_ e \\
t & \rightarrow d / a \_ e \\
k & \rightarrow g / a \_ e
\end{align*}
\]

Or this:

\[
\begin{align*}
[-\text{cont}] & \rightarrow [+\text{voice}] / [+\text{syll}] \_ [+\text{syll}]
\end{align*}
\]

What if they only get exposed to:

- [kap] ‘cow’     [kabe] ‘cows’
- [vak] ‘goat’     [vage] ‘goats’

Or only to:

- [kap] ‘cow’     [kabe] ‘cows’
Questions:

• Is there any psychological reality to the notion of the feature?

• If so, when and how is it used *during* learning?

• Do learners tend towards maximal generalization, or more towards minimal generalization?
EXP 1

Participants familiarized to one of two artificial languages:

- **Language A**: allophonic intervocalic fricative voicing.
- **Language B**: allophonic intervocalic stop voicing.

Exposure phase: heard determiner + noun phrases paired with pictures on the screen.

- Determiner: either *nel* (meaning ‘two’) or *ra* (meaning ‘three’)
- Noun: CVCV or CVCVC

Asked to memorize as many words as possible.

Participants = 12, 6 per counterbalancing group
Table 2. Phrases in Languages A and B used in exposure phase of Experiment 1

<table>
<thead>
<tr>
<th>Language A: allophonic fricative voicing</th>
<th>Language B: allophonic stop voicing</th>
</tr>
</thead>
<tbody>
<tr>
<td>'rabbit'</td>
<td>nel pemusf ra pemusf</td>
</tr>
<tr>
<td>'flower'</td>
<td>nel bovi ra bovi</td>
</tr>
<tr>
<td>'apple'</td>
<td>nel kelaf ra kelaf</td>
</tr>
<tr>
<td>'fork'</td>
<td>nel ginel ra ginel</td>
</tr>
<tr>
<td>'hat'</td>
<td>nel timu ra daru</td>
</tr>
<tr>
<td>'tree'</td>
<td>nel timu ra daru</td>
</tr>
<tr>
<td>'cat'</td>
<td>nel fo3am ra vo3am</td>
</tr>
<tr>
<td>'nose'</td>
<td>nel fulek ra vulek</td>
</tr>
<tr>
<td>'bottle'</td>
<td>nel jagip ra jagip</td>
</tr>
<tr>
<td>'house'</td>
<td>nel jub0 ra jub0</td>
</tr>
<tr>
<td>'balloon'</td>
<td>nel sano ra zelum</td>
</tr>
<tr>
<td>'snail'</td>
<td>nel sano ra zelum</td>
</tr>
</tbody>
</table>
PROCEDURE

Exposure phase:
• 20 phrases, presented 16 times each (non-dentals) or 8 times each (dentals). Semi-random order.

Test phase (identical for both lang.)
• Hear a phrase from exposure, followed by the corresponding phrase with a change in voicing.
• Task: Is it the same or different object?
• First tested on old items (12 test, 6 filler), then novel items (48 test, 24 filler).

Peperkamp & Dupoux 2007
RESULTS

Peperkamp & Dupoux 2007
EXP 3

Same design, except with highly unnatural alternations.

Table 5. Phrases in Languages A and B used in exposure phase of Experiment 3

<table>
<thead>
<tr>
<th>Language C:</th>
<th>Language D:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/p/ → [ʒ]</td>
<td>/ʃ/ → [b]</td>
</tr>
<tr>
<td>/g/ → [f]</td>
<td>/v/ → [k]</td>
</tr>
<tr>
<td>(/z/ → [t])</td>
<td>(/d/ → [s])</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phrase</th>
<th>Language C</th>
<th>Language D</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘rabbit’</td>
<td>nel pemufj</td>
<td>ra ʒemufj</td>
</tr>
<tr>
<td>‘flower’</td>
<td>nel bomi</td>
<td>ra bomi</td>
</tr>
<tr>
<td>‘apple’</td>
<td>nel kela</td>
<td>ra kela</td>
</tr>
<tr>
<td>‘fork’</td>
<td>nel girel</td>
<td>ra girel</td>
</tr>
<tr>
<td>‘balloon’</td>
<td>nel doba</td>
<td>ra ʒirur</td>
</tr>
<tr>
<td>‘tree’</td>
<td></td>
<td>ra ʒirur</td>
</tr>
<tr>
<td>‘cat’</td>
<td>nel go3a</td>
<td>ra fo3a</td>
</tr>
<tr>
<td>‘nose’</td>
<td>nel vusen</td>
<td>ra vusen</td>
</tr>
<tr>
<td>‘bottle’</td>
<td>nel ʒanip</td>
<td>ra ʒanip</td>
</tr>
<tr>
<td>‘house’</td>
<td>nel puko</td>
<td>ra ʒuko</td>
</tr>
<tr>
<td>‘hat’</td>
<td>nel zifu</td>
<td>ra ʒifu</td>
</tr>
<tr>
<td>‘snail’</td>
<td></td>
<td>ra setum</td>
</tr>
</tbody>
</table>

Peperkamp & Dupoux 2007
EXP 3 RESULTS

Peperkamp & Dupoux 2007
FOLLOW-UP STUDY

Same design and stimuli as Exp. 1 & Exp. 3 in previous study.

Change in task:

• Same Exposure Phase.

• Different Test Phase:
  • Participants presented with one item/picture.
  • Then, presented with corresponding picture.
  • Task: produce the correct phrase for the picture.
  • Productions recorded, then coded.

Peperkamp, Skoruppa, & Dupoux 2006, *BUCLD*
**STIMULI**

### Natural rules

<table>
<thead>
<tr>
<th>Nat_A: allophonic fricative voicing</th>
<th>Nat_B: allophonic stop voicing</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘rabbit’ nel pemuf’ ka pemuf’</td>
<td>nel pemuf’ ka pemuf’</td>
</tr>
<tr>
<td>‘flower’ nel bovi’ ka bovi’</td>
<td>nel bovi’ ka bovi’</td>
</tr>
<tr>
<td>‘apple’ nel kelaf’ ka kelaf’</td>
<td>nel kelaf’ ka kelaf’</td>
</tr>
<tr>
<td>‘fork’ nel ginel’ ka ginel’</td>
<td>nel ginel’ ka ginel’</td>
</tr>
<tr>
<td>‘hat’ nel timu’ ka daku’</td>
<td>nel timu’ ka daku’</td>
</tr>
<tr>
<td>‘cat’ nel fozam’ ka fozam’</td>
<td>nel fozam’ ka fozam’</td>
</tr>
<tr>
<td>‘nose’ nel vulek’ ka vulek’</td>
<td>nel vulek’ ka vulek’</td>
</tr>
<tr>
<td>‘bottle’ nel jagip’ ka jagip’</td>
<td>nel jagip’ ka jagip’</td>
</tr>
<tr>
<td>‘house’ nel jubo’ ka jubo’</td>
<td>nel jubo’ ka jubo’</td>
</tr>
<tr>
<td>‘balloon’ nel sano’ ka zelum’</td>
<td>nel sano’ ka zelum’</td>
</tr>
</tbody>
</table>

### Unnatural rules

<table>
<thead>
<tr>
<th>Unnat_A: /p,g,z/ → [3,f,t] / V_V</th>
<th>Unnat_B: /j,v,d/ → [b,k,s] / V_V</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘rabbit’ nel pemuf’ ka zemuf’</td>
<td>nel pemuf’ ka pemuf’</td>
</tr>
<tr>
<td>‘flower’ nel bomi’ ka bomi’</td>
<td>nel bomi’ ka bomi’</td>
</tr>
<tr>
<td>‘apple’ nel kela’ ka kela’</td>
<td>nel kela’ ka kela’</td>
</tr>
<tr>
<td>‘fork’ nel girel’ ka girel’</td>
<td>nel girel’ ka girel’</td>
</tr>
<tr>
<td>‘hat’ nel doba’ ka tiku’</td>
<td>nel doba’ ka tiku’</td>
</tr>
<tr>
<td>‘cat’ nel gozia’ ka foza’</td>
<td>nel gozia’ ka foza’</td>
</tr>
<tr>
<td>‘nose’ nel vug’ ka vug’</td>
<td>nel vug’ ka vug’</td>
</tr>
<tr>
<td>‘bottle’ nel janip’ ka janip’</td>
<td>nel janip’ ka janip’</td>
</tr>
<tr>
<td>‘house’ nel juko’ ka juko’</td>
<td>nel juko’ ka juko’</td>
</tr>
<tr>
<td>‘balloon’ nel zifu’ ka setum’</td>
<td>nel zifu’ ka setum’</td>
</tr>
</tbody>
</table>

Participants: 32 (16 for natural, 16 for unnatural)

Peperkamp, Skoruppa, & Dupoux 2006, *BUCLD*
RESULTS

(N.B. Virtually no generalization to untrained dental sounds.)

Peperkamp, Skoruppa, & Dupoux 2006, BUCLD
BACK TO VOWEL HARMONY
Participants exposed to artificial language with back harmony:

- CVCV stem.
- [-mi] or [-mu] suffix, depending on stem vowels.
- Stem consonants: [p, b, t, d, k, ɡ, m, n]
- Stem vowels: [i, u, e, o, æ, ɑ]
- E.g.: [bidimi], [madumu]

Finley & Badecker 2009, *Journal of Memory and Language*
DESIGN

Four exposure groups:

• **Mid Hold-out**
  • Stem vowel inventory = [i, u, æ, ɑ]; mid vowels [e, o] missing.
  • All forms harmonic.

• **Mid Hold-out Control**
  • Same inventory.
  • Mix of harmonic and disharmonic stems only (half of each).

• **Low Hold-out**
  • Stem vowel inventory = [i, u, e, o]; mid vowels [æ, ɑ] missing.
  • All forms show harmony.

• **Low Hold-out Control**
  • Same inventory.
  • Mix of harmonic and disharmonic stems only (half of each).

Finley & Badecker 2009, *Journal of Memory and Language*
PROCEDURE

Exposure phase

- Instructions: pay attention; don’t worry about memorizing.
- 24 stems, followed by stem+suffix. (e.g. [bidi] … [bidimi] )
- For controls: 48 stems (no suffixed forms).
- 5 repetitions for each item.

Test phase

- Presented with stem, then two possible suffixed options.
  - E.g.: [bidi] … [bidimi]  [bidimu]
- **Task**: Choose the word belonging to the language (button press).
- 36 trials, including Old Stems, New Stems, and New Vowel Stems.
- Stimuli spliced (same stem recording in both suffixed options).

Finley & Badecker 2009, *Journal of Memory and Language*
EXP. 1 - RESULTS

Finley & Badecker 2009, *Journal of Memory and Language*
WHY NOT GENERALIZE TO LOW VOWELS?

Possibility #1:
• Substantive bias against extending back harmony to low vowels.

Possibility #2:
• Those in the Low Hold-out condition learned round harmony, not back harmony.

Possibility #3:
• Phonetic interpolation hypothesis.
EXP. 2 - DESIGN

Same as Experiment 1, except:

• High Hold-out condition, instead of Low Hold-out.

If it is just phonetic interpolation, then the High Hold-out condition should be just like the Low Hold-out condition:

• I.e. No generalization from Mid/Low vowels to novel High vowels.

Finley & Badecker 2009, *Journal of Memory and Language*
EXP. 2 - RESULTS

Finley & Badecker 2009, *Journal of Memory and Language*
INFANT ARTIFICIAL PHONOTACTIC LEARNING
EXP. 2 (I'M SKIPPING 1) - DESIGN

Participants: 30 infants (9-month-old).

Familiarized to CVCCVC nonce words with one of two phonotactic restrictions:


Basic idea:

- Train infants on a novel phonotactic pattern.
- Then, play them a stream of speech with nonce words that conform or do not conform to the pattern.
- See if they differentiate the conforming vs. non-conforming words.

Saffran & Thiessen 2003, Dev. Psych.
HEADTURN PREFERENCE PROCEDURE

Saffran & Thiessen 2003, Dev. Psych.
PROCEDURE

Pattern induction phase (2 min.)

- 30 conforming nonce forms played repeatedly through both speakers.

Segmentation phase (1 min.)

- Listened to 4 new nonce words (2 conforming, 2 non-conforming) presented as a continuous speech stream.
- E.g.: kibpugbupgokpagkobgikbapbupgokkibpug…
- Stimuli synthesized; no acoustic cues for word boundaries.

Test phase (12 trials)

- 4 words from segmentation; 3 blocks of repetitions.
- Center light flashes until infant looks. Then one side light flashes.
- Once infant looks, a test item is played until infant looks away for more than 2s.

RESULTS

Saffran & Thiessen 2003, Dev. Psych.
EXP. 3

Same design as Exp. 1, except with phonotactic generalizations that do not follow natural classes:

- [p, d, k] only in onset; [b, t, g] only in coda.
- Or the opposite pattern.

Participants: 30 new 9-month-olds

RESULTS

Saffran & Thiessen 2003, Dev. Psych.
REFERENCES


