INFANTS’ PERCEPTION OF NATIVE AND NON-NATIVE PITCH CONTRASTS: TUNE, PITCH ACCENT OR TONE?

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- Infants’ ability to distinguish between forms of phonetic variation in speech that are relevant to meaning is essential for their language development
- Learning a language >> a stronger commitment to the native language as development proceeds, modulated by perceptual assimilation and phonetic salience (e.g., Kuhl 2004, Safran et al. 2006, Best & Roberts 2003, Narayan et al. 2010)
- Across languages, pitch can mark prominence, edges, distinguish between sentence types, as in intonation languages like English or Portuguese, or signal differences in word meanings, as in a tone language like Mandarin or a pitch accent language like Japanese
### Background & Goals

#### My language?

<table>
<thead>
<tr>
<th>Lexical</th>
<th>Limited variation</th>
<th>Segmental variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress</td>
<td>✔</td>
<td>✖️ only after 6 mos &amp; native (e.g., Skoruppa et al. 2013)</td>
</tr>
<tr>
<td>Tone</td>
<td>✔ as early as 4 mos, but only tone learners &gt; 6 mos, unless very salient (Mattock &amp; Burnham, 2006; Yeung et al, 2013; Liu &amp; Kager, 2014)</td>
<td>✖️? only after 6 months, native (Shi, 2010)</td>
</tr>
<tr>
<td>Pitch accent</td>
<td></td>
<td>✔ as early as 4 mos, for Japanese learners (Sato et al., 2009)</td>
</tr>
</tbody>
</table>
Developmental course of infants’ perception of pitch contrasts, in the presence of **segmental variability** >> the ability to extract and generalize the contrastive patterns.

<table>
<thead>
<tr>
<th>Intonation</th>
<th>Limited variation</th>
<th>Segmental variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tune</td>
<td>✓ as early as 4 mos, English-learning infants (non-native tune contrasts - Sundara et al. 2015)</td>
<td>✓ as early as 4-5 mos, Portuguese learners (native – Frota et al. 2014); ✓ Basque (non-native); ✗ English (non-native) – Sundara et al. 2015</td>
</tr>
</tbody>
</table>

- Portuguese-learning infants discriminate the statement (falling)/yes-no question (falling-rising) native intonation contrast as early as 5-months (Frota et al. 2014)

- Non-native discrimination of the Portuguese contrast has different outcomes in English-learning and Basque-learning infants (Sundara et al., 2015)
Do Portuguese-learning infants also perceive the salient contrast in pitch (falling/low versus falling-rising/high) in segmentally varied non-native input? (Mandarin Chinese Tones and Japanese Pitch accents)

- Similar overall contour shapes predict early discrimination
- Effects of language experience predict NO discrimination
- Pitch accent contrast expected to be closer to the tune than the lexical tone contrast (word vs. syllable domain)
**EXPERIMENT 1**

**Native pitch contrast:** falling (statement) versus falling-rising (yes-no question) intonation (Frota et al. 2014)

**Participants**

5-6 month-olds, n=20:  
Mean age = 5 mos 29 days; 8 girls  
Range = 5 mos 3 days – 6 mos 23 days  
8-9 month-olds, n=20:  
Mean age = 8 mos 12 days; 10 girls  
Range = 7 mos 11 days – 9 mos 29 days

**Materials**

Segmentally varied, single-prosodic word utterances produced in IDS (11 ≠ segments, bisyllabic utterances)
Native pitch contrast: falling (statement) versus falling-rising (yes-no question) intonation

VISUAL HABITUATION PROCEDURE

Habituation
malo, lemo, mela, nirra...

Test
luma, milo, rina, lamo...

Same

Switch

Different pseudo-words used for the habituation and test phase
Native pitch contrast: falling (statement) versus falling-rising (yes-no question) intonation

Results

Listening time (s)

![Graph showing listening time comparison between younger (5-6 months) and older (8-9 months) infants for 'Same' and 'Switch' conditions. The graph indicates significant differences (*) in listening time between conditions.]
**Non-native Tone contrast**: Tone 1+Tone 4 and Tone 1+Tone 2 in Mandarin Chinese (also a falling versus falling-rising pitch contrast)

**Participants**
5-6 month-olds, n=20:
Mean age = 5 mos 25 days; 8 girls
Range = 5 mos 2 days – 6 mos 19 days
8-9 month-olds, n=20:
Mean age = 8 mos 21 days; 10 girls
Range = 7 mos 13 days – 10 mos 8 days

**Materials**
Tone1+Tone4 ≒ declarative intonation
Tone 1 + Tone 2 ≒ question intonation
(Braun & Johnson 2011)

Segmentally varied utterances produced in IDS (13 ≠ segments, bisyllabic)
Wang et al. 2001
**Non-native Tone contrast:** Tone 1+Tone 4 and Tone 1+Tone 2 in Mandarin Chinese (also a falling versus falling-rising pitch contrast)

**Materials**

<table>
<thead>
<tr>
<th>Tones14/12</th>
<th>Stat/Quest</th>
<th>t-test Man/EP</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0 patterns 1st syll</td>
<td>H / H</td>
<td>HL / HL</td>
</tr>
<tr>
<td>F0 patterns 2nd syll</td>
<td>HL / HLH</td>
<td>L / LH</td>
</tr>
<tr>
<td>F0 range 2nd syll (Hz)</td>
<td>103/35</td>
<td>25/192</td>
</tr>
<tr>
<td>Duration 1st syll (ms)</td>
<td>270/279</td>
<td>310/397</td>
</tr>
<tr>
<td>Duration 2nd syll (ms)</td>
<td>493/522</td>
<td>310/437</td>
</tr>
</tbody>
</table>

**Same procedure**

**Results**

Similar overall contour shapes, but **differences** in how the contours relate to the text

**Listening time (s)**

![Listening time graph](image)
Non-native Pitch accent contrast: HL and LH word patterns in Japanese (also a falling versus rising pitch contrast)

Participants
5-6 month-olds, n=24:
Mean age= 6 mos 3 days; 11 girls
Range= 4 mos 28 days – 7 mos 11 days
8-9 month-olds, n=24:
Mean age= 9 mos 3 days; 13 girls
Range= 7 mos 19 days – 10 mos 20 days

Materials
HL words
≡ declarative intonation
LH words
≡ question intonation
(materials from Sato, Sogabe & Mazuka 2009)

Segmentally varied utterances produced in IDS (12 ≠ segments, bisyllabic)
**EXPERIMENT 3**

**Non-native Pitch accent contrast**: HL and LH word patterns in Japanese (also a falling versus rising pitch contrast)

### Materials

<table>
<thead>
<tr>
<th></th>
<th>HL/LH</th>
<th>Stat/Quest</th>
<th>t-test Jap/EP</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0 patterns 1st syll</td>
<td>H / L</td>
<td>HL / HL</td>
<td>-</td>
</tr>
<tr>
<td>F0 patterns 2nd syll</td>
<td>L / LH</td>
<td>L / LH</td>
<td>-</td>
</tr>
<tr>
<td>F0 range 2nd syll (Hz)</td>
<td>122/75</td>
<td>25/192</td>
<td>*p &lt; .001 / p &lt; .001</td>
</tr>
<tr>
<td>Duration 1st syll (ms)</td>
<td>141/165</td>
<td>310/397</td>
<td>*p &lt; .01 / p &lt; .001</td>
</tr>
<tr>
<td>Duration 2nd syll (ms)</td>
<td>190/232</td>
<td>310/437</td>
<td>*p &lt; .001 / p &lt; .01</td>
</tr>
</tbody>
</table>

Similar overall contour shapes, but also **differences** in how the contours relate to the text.

### Results

**Listening time (s)**

- Younger (n=24)
  - Same
  - Switch

- Older (n=24)
  - Same
  - Switch

*Significance marked with asterisk (*)
Comparing the 3 Experiments

Findings support differences in discrimination abilities, with Pitch accent contrast easier to perceive, and closer to Tune, for older infants.

A GLMM was used (along the lines of Skoruppa et al. 2013)
- Effect of language \((F(2,122) = 8.26, p < .001)\)
  - Borderline interaction Language x Age \((F(2,122) = 2.91, p = .058)\)
- EP vs. Mandarin: only an effect of language \((F(1,76) = 15.28, p < .001)\)
- EP vs. Japanese: effect of language \((F(1,84) = 11.7, p < .01)\) and interaction Language x Age \((F(1,84) = 5.68, p < .05)\)
DISCUSSION

Infants discriminated the native intonation contrast at 5-6 and 8-9 mos
Results for non-native pitch contrasts were NOT alike:
- Infants failed to discriminate the non-native tone contrast at both ages
- Discrimination of the non-native pitch accent contrast was easier for older infants

Segmental content was controlled to be native-like (inventory), analogous in
degree of segmental variability, and comparable in frequency of occurrence
Results of experiment 2. Symbols represent the proportion of infants with correct anticipatory looks. Red dots represent population averages for monolinguals, and blue diamonds represent averages for bilinguals. Regression lines are shown for both groups.

- Results suggest that the similar contour shapes of lexical pitch were not *similar* enough to intonation to be fully perceived as native: No precocious discrimination abilities for pitch regardless of language experience.
- Japanese Pitch accent contrast closer to the native tune than the Mandarin lexical tone contrast.

**Tune ≠ Pitch accent vs. Tone:**
utterance/word domain vs. syllable domain

Language-specific perception for pitch emerges as early as 5 months of age, and the tune, pitch accent and tone distinction are already differentially perceived in the first year of life.
- Further research into the language-specific aspects behind infants’ precocious sensitivity to pitch differences across languages is needed (ongoing work)

- One avenue: Further explore the impact of phonetic detail
  Better control of phonetic segmental differences
  Pitch range differences and salience: e.g., Falling wider in Mandarin and Japanese; Rising wider in Portuguese

Language-specific perception for pitch emerges as early as 5 months of age, and the tune, pitch accent and tone distinction are already differentially perceived in the first year of life
Thanks to all the infants, families and nurseries that have taken part in these studies. To Catia Severino and Susana Correia for help with data collection. To Reiko Mazuka and Thierry Nazi for providing the Japanese stimuli.