• Young infants are supposed to be sensitive to both native and non-native sounds before the perceptual reorganization starts (e.g. Werker & Tees 1984).

• Not all sounds are equally discriminable for young infants.

• It has been assumed that the discrimination failure is due to the acoustic non-salience.
Introduction 2

Discrimination of Thai low and rising tone

<table>
<thead>
<tr>
<th></th>
<th>4-month-old</th>
<th>6-month-old</th>
<th>9-month-old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese infants</td>
<td>N.A.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>English infants</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>French infants</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Discrimination of non-speech analogs

<table>
<thead>
<tr>
<th></th>
<th>6 months</th>
<th>9 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese infants</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>English infants</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Lexical tone PR occurs between 6 and 9 months, and it is speech specific.

Mattock & Burnham 2006, Mattock et al. 2008
Introduction 3

Discrepancy remains in the early discrimination of Mandarin lexical tones.

<table>
<thead>
<tr>
<th></th>
<th>T2-T3 contrast</th>
<th>T1-T4 contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chinese infants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>6 months</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td><strong>10-12m</strong></td>
<td>discriminate T1-T3 better than T2-T3 and T2-T4</td>
<td></td>
</tr>
<tr>
<td><strong>Canadian French infants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>6 months</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Dutch infants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

T2-T3 is perceptually the most confusing contrast for both native and non-native listeners.

Acoustically more salient contrasts are discriminated better.

**Successful discrimination:**
- 5 tokens single speaker (Mattock & Burnham 2006, 2008)
- 4 tokens single speaker (Liu & Kager 2010)
- 1 token single speaker (Tsao 2008)
- 12 tokens single speaker (Gao et al. 2011)

**Failed discrimination:**
- 2 tokens of 2 speakers (Chen & Kager 2012)
  - too much speaker normalization?
- processing pitch dynamics of T2 and T3 is too difficult?
- For not-so-salient contrast? PR occurs earlier than 6 months
Introduction 5

• Pitch processing is needed for both speech and music.

• Critical pitch difference in music: 1 semitone
  Critical pitch difference in speech: min. 3-4 semitones

• Among non-tone language listeners, perception of lexical tone is enhanced by training and aptitude in music (e.g. Wong et al. 2007, Deutsch et al. 2004, 2006)

• Amusic Mandarin listeners may also show deficiency in lexical tone perception (Nan et al. 2012)
Introduction 6

• 6-month-old infants are able to recognize songs played at home (Plantinga & Trainor 2005)
• 8-month-old infants are able to do statistical computation with musical notes (Saffran et al. 2001, 2003)

How do infants discriminate pitch patterns realized in speech and music?
Research questions

1. Will young non-tone language infants succeed in discriminating Mandarin T2 and T3? Failure at 6-month-old, but success at 4 months?

2. In early infancy, how are pitch patterns perceived across different domains? music mode and speech mode

3. Is acoustical salience alone enough to account for the failure in lexical tone perception? Less salient difference is perceived moor poorly?
Participants and tasks

4-month-old native Dutch infants

1. Single token Mandarin lexical tone (T2-T3) discrimination

2. Musical relative pitch discrimination

3. Musical absolute pitch discrimination
Habituation criteria: 65%
Maximum looking away: 2s
Predictions

In the test phase, one “old” trial and one “novel” trial alternated.

If the infants were able to discriminate between the two sounds, then their attention should be recovered when hearing something new:

Looking time novel trial > Looking time old trial
Experiment 1 Single token T2-T3 discrimination

Pitch (semitones re 100 Hz)

T2

T3

6 semitones

5 semitones
Experiment 1 Results and discussion

N=21

\( T_{\text{old-novel}} (20) = 0.334, \)

p>0.05
Experiment 2 Music relative pitch discrimination

DEF and DCF synthesized on a middle C scale in piano timber, duration=830ms
Experiment 2 results and discussion

N = 22

T_{old-novel} (21) = -1.942, p < 0.05.
Experiment 3 Musical absolute pitch discrimination

Synthesized DEF <> #D#E#F with one semitone difference, duration = 830ms
Experiment 3 Results and discussion

N = 17

$T_{\text{old-novel}} \, (16) = -2.122, \ p < 0.05.$
Cross-task comparison

16 infants participated in all three tasks.

RM ANOVA
Dependent variable: looking time
Within-subject factor: trial type, experiment

\[
F_{\text{trial type}}(1, 15) = 8.45, \quad p < 0.05
\]

\[
F_{\text{tasks}}(2, 14) = 3.40, \quad p < 0.05
\]

Interaction, \( p > 0.05 \)
General discussion

- Native Dutch infants fail to discriminate between Mandarin T2 and T3 at 4 months.

- With equal or even smaller pitch magnitude in music, 4-month-old Dutch infants are able to discriminate between rising and dipping pitch contours, detect a pitch change of one semitone.

- Either pitch dynamics or acoustic salience alone is not enough to account for the failure observed in lexical tone discrimination.

- Possible separate domains for music and speech processing in early infancy.

- But what makes T2-T3 so difficult?
Thanks!