Bilingual Infants' Tone Perception under Perceptual Reorganization

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Perceptual reorganization (PR)

- Young infants are able to discriminate phonetic contrasts that do not exist in their native language.

- During the second half of the first year, discrimination of non-native contrasts decreases, whereas discrimination of native contrasts is maintained and improved.

- The process of tuning to the sound contrasts of the native language is known as perceptual reorganization.

- PR is a function of specific language experience.
Timing of PR: non-native consonants vs. vowels

Consonants
before 8 months: full discrimination
**8-10 months**: decline in discrimination
10-12 months: loss of discrimination

Vowels
before 4-6 months: full discrimination
**6-8 months**: decline in discrimination
10-12 months: loss of discrimination
Timing of PR: Non-native lexical tones

• Newborns show good discrimination of pitch contours (Nazzi, Floccia & Bertoncini, 1998)

• Tonal PR seems to occur between **6-9 months** of age
  • A decline in the discrimination of Thai tonal contrasts (rising ~ falling; rising ~ low) in English infants between 6 and 9 months, versus no decline in Chinese infants (Mattock & Burnham, 2006)
  • A decline in the discrimination of Thai tonal contrasts (rising ~ low) in English and French infants between 4-6 and 9 months (Mattock, Molnar, Polka & Burnham, 2008)
  • ERP study shows different lexical tonal perceptual patterns between native and non-native tone-learning infants at 10 months (Kaan, Wayland, Bao & Barkley, 2007)
Timing of PR: acoustic salience

Not all contrasts abide by the rules of PR

Some non-native contrasts remain discriminable throughout infancy
- e.g. Zulu clicks; German /y/-/u/ (Best, McRoberts & Sithole, 1988; Best, McRoberts, LaFleur & Silver-Isenstadt, 1995; Polka & Bohn, 1996)

Some native contrasts cannot be discriminated until a relatively late stage
- e.g. Tagalog /na/-/ŋa/; Catalan/Spanish /o/-/u/ (Narayan, Werker & Beddor, 2010; Sebastián-Gallés & Bosch, 2009)

Acoustic salience is hypothesized to play a role in PR
It remains unclear whether monolingual and bilingual infants follow the same PR trajectory.

Spanish-Catalan bilingual infants show a temporary loss of discrimination of a Catalan vowel contrast at around 8 months, whereas Catalan monolingual infants do not show such a delay (Bosch & Sebastián-Gallés, 2003b).

No delay is observed in English-French bilingual infants' coronal stop and VOT contrast perception (Burns, Yoshida, Hill & Werker, 2007; Sundara, Polka & Molnar, 2008).
The current study extends this debate to PR for tones.

No previous study has discussed this issue in the tonal domain.

Unlike many consonants and vowels, no counterpart to tonal categories exists for non-tone language learning infants.

Native interference unlikely to occur in infants' tone perception.
Research questions

1. Do monolingual and bilingual infants follow the same developmental pattern for tonal PR?

2. What are the similarities and differences in their lexical tone perception across ages?

3. Does acoustic salience of the tonal contrast influence monolingual and bilingual infants' perception during PR?
Mandarin tones

Experiment

Exp.1 – Monolingual T1T4 contrast

Exp.2 – Bilingual T1T4 contrast

Exp.3 – Monolingual T1T4-shrunk contrast

Exp.4 – Bilingual T1T4-shrunk contrast
Experiment - Stimuli

Four continua of Mandarin Tone1-Tone4, 8 steps, resynthesized speech

T1T4 – tokens 1 & 8
T1T4-shrunk – tokens 3 & 6
Experiment - Participants

Monolingual and bilingual Dutch infants

Criterion for bilingual: more than 20% exposure in the non-dominant language

No exposure to tone language

5-6 months, 8-9 months, 11-12 months, 14-15 months

14 participants per group
Experiment – Procedure

A. Habituation
   Habituated on tokens of stimulus 6/8
   Criterion: window reached with 65% of total looking time of initial window

B. Dishabituation
   Dishabituated on tokens stimulus 3/1
   Fixed to 2 trials

C. Post-test
   General responsiveness
Results and analyses

Monolingual & Bilingual
T1T4 & T1T4-shrunken
End of habituation → Dishabituation
T1T4

Monolingual

Blue: Habituation
Green: Dishabituation

Bilingual
T1T4-shrunk

Monolingual

Blue: Habituation
Green: Dishabituation

Bilingual
Discussion
timing of tonal PR

• Full discrimination at 5-6 months – initial bias/sensitivity

• Discrimination drops at 8-9 months – tonal PR

• Results compatible with previous studies

• Monolingual and bilingual infants have similar tonal PR patterns
After PR, monolingual infants regain the general auditory perception for the salient contrast at 11-12 months, and non-salient one at 14-15 months.

Bilingual infants regain the general auditory perception faster: keep sensitivity for the salient contrast, and regain sensitivity at 11-12 months for the non-salient one.

This was not found in previous studies on perceptual reorganization → testing other contrasts in different domains is needed.
Acoustically salient contrasts may survive PR

On-going follow-up study in an older age group: 17-18 months

Future studies can explore the measurement of acoustic salience
Discussion
mono vs. bilingual infants

• Similar PR time window – between 5-6 and 8-9 months

• Higher sensitivity in bilingual infants – less influenced in salient contrasts at 8-9 months

• Faster general auditory recovery in bilingual infants – shortly after PR, at 11-12 months

• This sensitivity may stem from the (more) challenging language environment compared to monolingual peers
Bilingual infant perception scenarios:

A. Spanish-Catalan bilingual infants' vowel discrimination – later than monolingual peers
   (Bosch & Sebastián-Gallés, 2003b)

B. English-French bilingual infants' coronal stop and VOT contrast perception – same as monolingual peers
   (Burns, Yoshida, Hill & Werker, 2007; Sundara, Polka & Molnar, 2008)

C. Dutch bilingual infants' non-native tone discrimination – same PR, faster recovery, more sensitive in general perception
   (Liu & Kager, to appear)

Discussion

mono vs. bilingual infants
Thank you very much

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Dutch adult tone perception

• AX discrimination task
  T1T4
  accuracy rate 99.11%; one-sample t-test p < .001
  T1T4-shrunken
  accuracy rate 45.54%; one-sample t-test p = .347

• AXB discrimination task
  T1T4
  accuracy rate 96.43%, one-sample t-test p < .001
  T1T4-shrunken
  accuracy rate 86.16%; one-sample t-test p < .001
Dutch adult tone perception

- Easy to discriminate T1T4 tonal contrast
  - acoustic salience
  - general auditory perception
  - discrimination pattern resembles post-PR Dutch infants

- Difficult to discriminate T1T4-shrunk contrast
  - acoustic salience
  - easier in AXB settings – task and learning effect
  - general auditory perception
  - discrimination pattern resembles post-PR Dutch infants

- Non-native tonal perceptual pattern may be shaped very early on
Speech perception model

- WRAPSA – weighting scheme
  (Jusczyk, 1993; 1997)
Non-native tone perception

• Flexibility in tonal discrimination

• Infants
  - statistical learning (Liu & Kager, 2011)
  - bilingual exposure (Bosch & Sebastián-Gallés, 2003b; current study)

• Adults
  - lexical tone training (Wang, Jongman & Sereno, 2003)
  - musical training (Wong, Skoe, Russo, Dees & Kraus, 2007b; Mok & Zuo, 2012)
Speech perception model

- Bilingual / training / learning influence