Acoustic Convergence and Initiator Effects in Mother-Infant Conversational Blocks

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Why Study Convergence

- Amount is important, but feedback is key
- Adults converge conversational in many ways
  - E.g. Giles, Coupland, & Coupland, 1991; Levitan & Hirshberg, 2011
- Mother-infants?
  - Vowel Quality: 3-6 month olds imitate (Kuhl & Meltzoff, 1996)
  - Pause/utterance duration: (E.g., Feldstein et al. 1993; Ko, 2013)
  - Pitch patterns: 6 month olds trained to imitate (Kessen et al., 1979)
  - $f_0$: mixed (e.g. Masataka, 1992, but c.f. McRoberts & Best, 1997; Siegel et al. 1990)
  - Almost exclusively < 12 months!!
Our study

- Older infants/toddlers (13-30 months)
- Large naturalistic sample
  - N = 13, 2-5 days of recording per child [isn’t it 3-5 days? – ES]
- Multiple Cues: Duration/pitch/speaking rate
- By conversational block (within pair analysis)
Data structure

- Block Type (fixed)
  - AICF   CIC
- Age of infant (random)
- Gender of infant (random)
  - Male   Female
- Speaker ID (fixed)
  - FAN   CHN   MAN   OLN   FUZ
- Mother-infant pair (random)

- Acoustic properties (variables of interest)
  - Segment duration, pitch (min, max, avg, range), speaking rates
Step 1: ADEX output AICF and CIC only

| Number | File_Hour | CHN | Child_Voc | Child_Nor | FAN | Non | Recording | Elapsed_T | Segment | Speaker | Init_by | Block_Dur | Block_Nur | Block_Typ | Block_Info | Segment_Info |
|--------|-----------|-----|-----------|-----------|-----|-----|----------|-----------|---------|---------|---------|----------|-----------|-----------|-----------|-------------|---------------|
| 2      | 4         | 2.43| 0         | 0         | 0   | 0   | 1.97     | 0         | 100.33  | 1       | AICF    | FA       | 1.97      | FAN       | BC        |             |
| 3      | 4         | 2.43| 0         | 0         | 0   | 0   | 1.97     | 0         | 100.33  | 1       | AICF    | FA       | 1.78      | OLN       | RC        |             |
| 4      | 4         | 2.43| 0         | 0         | 0   | 0   | 3.75     | 0         | 100.33  | 1       | AICF    | FA       | 1.01      | MAN       | RC        |             |
| 5      | 4         | 2.43| 0         | 0         | 0   | 0   | 4.76     | 0         | 100.33  | 1       | AICF    | FA       | 1.14      | FUZ       | RC        |             |
| 6      | 4         | 2.43| 0         | 0         | 0   | 0   | 5.9      | 0         | 100.33  | 1       | AICF    | FA       | 1.06      | FUZ       | RC        |             |
| 7      | 4         | 2.43| 0         | 0         | 0   | 0   | 6.96     | 0         | 100.33  | 1       | AICF    | FA       | 1.46      | FUZ       | RC        |             |
| 8      | 4         | 2.43| 0         | 0         | 0   | 0   | 8.42     | 0         | 100.33  | 1       | AICF    | FA       | 1.27      | FAN       | RC        |             |
| 9      | 4         | 2.43| 0         | 0         | 0   | 0   | 9.69     | 0         | 100.33  | 1       | AICF    | FA       | 0.8       | SIL       | RC        |             |
| 10     | 4         | 2.43| 0         | 0         | 0   | 0   | 10.49    | 0         | 100.33  | 1       | AICF    | FA       | 0.91      | FUZ       | RC        |             |
| 11     | 4         | 2.43| 1.15      | 1.15      | 0   | 0   | 11.4     | 0         | 100.33  | 1       | AICF    | FA       | 1.15      | CHN       | RC        |             |
| 12     | 4         | 2.43| 0         | 0         | 0   | 0   | 12.55    | 0         | 100.33  | 1       | AICF    | FA       | 3.33      | FAN       | RC        |             |
| 13     | 4         | 2.43| 0         | 0         | 0   | 0   | 15.88    | 0         | 100.33  | 1       | AICF    | FA       | 0.8       | FUZ       | RC        |             |
| 14     | 4         | 2.43| 2.24      | 2.24      | 0   | 0   | 16.68    | 0         | 100.33  | 1       | AICF    | FA       | 2.24      | CHN       | RC        |             |
| 15     | 4         | 2.43| 0         | 0         | 0   | 0   | 18.92    | 0         | 100.33  | 1       | AICF    | FA       | 1.25      | FAN       | RC        |             |
| 16     | 4         | 2.43| 0         | 0         | 0   | 0   | 20.17    | 0         | 100.33  | 1       | AICF    | FA       | 1.28      | OLN       | RC        |             |
| 17     | 4         | 2.43| 1.8       | 1.53      | 0   | 0   | 21.45    | 0         | 100.33  | 1       | AICF    | FA       | 1.8       | CHN       | RC        |             |
| 18     | 4         | 2.43| 0         | 0         | 0   | 0   | 23.25    | 0         | 100.33  | 1       | AICF    | FA       | 1.95      | FAN       | RC        |             |
| 19     | 4         | 2.43| 0         | 0         | 0   | 0   | 25.2     | 0         | 100.33  | 1       | AICF    | FA       | 1.87      | MAN       | RC        |             |
| 20     | 4         | 2.43| 0         | 0         | 0   | 0   | 27.07    | 0         | 100.33  | 1       | AICF    | FA       | 1.56      | SIL       | RC        |             |
| 21     | 4         | 2.43| 0         | 0         | 0   | 0   | 28.63    | 0         | 100.33  | 1       | AICF    | FA       | 2.78      | OLN       | RC        |             |
| 22     | 4         | 2.43| 0         | 0         | 0   | 0   | 31.41    | 0         | 100.33  | 1       | AICF    | FA       | 1.06      | MAN       | RC        |             |
| 23     | 4         | 2.43| 0         | 0         | 0   | 0   | 32.47    | 0         | 100.33  | 1       | AICF    | FA       | 1.97      | OLN       | RC        |             |
| 24     | 4         | 2.43| 0         | 0         | 0   | 0   | 34.44    | 0         | 100.33  | 1       | AICF    | FA       | 1.57      | MAN       | RC        |             |
| 25     | 4         | 2.43| 0         | 0         | 0   | 0   | 36.01    | 0         | 100.33  | 1       | AICF    | FA       | 0.96      | OLN       | RC        |             |
| 26     | 4         | 2.43| 0         | 0         | 0   | 0   | 36.97    | 0         | 100.33  | 1       | AICF    | FA       | 1.5       | OLN       | RC        |             |
Step 2: Clean up data table

Using R and Praat scripts:

1. Calculate segment location/length
   - Calculated the beginning and end of each segment, i.e. each row, based on “elapsed time” and “segment duration”.

2. Exclude segments
   - Other than CHN, FAN
   - where ChildVoc/Female speech < 50% of segment

3. Calculate pitch values (max, min, mean)
   - using ERB scale

4. Calculate speaking rates
   - Based on intensity/voicing to locate vowels
Step 3: Take mean across conversational block

- CHN and FAN each has one entry value of acoustic properties for each block of conversation.

<table>
<thead>
<tr>
<th>Block.N</th>
<th>Block.T</th>
<th>CHI</th>
<th>Age</th>
<th>CHN.avg</th>
<th>FAN.avg</th>
<th>CHN.min</th>
<th>FAN.min</th>
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<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>AICF</td>
<td>C003</td>
<td>765</td>
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<td>7.257332</td>
<td>7.619782</td>
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<td>6.319403</td>
<td>4.455857</td>
</tr>
</tbody>
</table>

Columns and Rows clipped
Step 4: Exclude segments < 1 s

Raw data N 81578 > 43112
Blocks N 17586 > 8794
Segment duration not significantly correlated
Correlated Mean Speaking Rate

Mean Speaking Rate in Mother-Child Speech

Mother Speaking Rate (syl/sec)
Child Speaking Rate (syl/sec)
Block.T
AICF
CIC
Mean Speaking Rate in Mother-Child Speech
Correlated Mean Pitch

Mean Pitch in Mother-Child Speech

Mother Mean Pitch (ERB)
Child Mean Pitch (ER)

Mean Pitch in Mother-Child Speech
Initiator effects in duration and rate

- **Logistic Regression**
  - Can the Block Type (AICF, CIC) be predicted by any factors?

- **Best model predicts Block Type by the following factors**
  - FAN duration (p < 0.001)
  - FAN Speaking Rate (p < 0.005)
  - CHN Speaking Rate (p = 0.06)

\[ lmer(Block.T \sim FAN.dur + rFAN.rate + CHN.rate \\
\quad (1|CHI) + (1|Age), data=data2.block, \ 
\quad family=binomial) \]
Longer FAN duration in AICF blocks

Mother segment duration in each block type

Block Type

AICF

CIC

Mother segment duration (sec)
Faster FAN speaking rate in AICF blocks

Mother speaking rate in AICF and CIC

- AICF
- CIC

Mother speaking rate (syl/sec)

Block Type

0 2 4 6

AICF CIC
Faster CHN Speaking Rate in CIC blocks
Summary

- **Process**
  - Relatively smooth interface between ADEX, Praat and R
  - Min length constraints/segment assignment process creates anomalies in data – need a better solution

- **Findings**
  - Evidence for mother-infant acoustic convergence
  - Mother duration/speaking rate effects predict whether block is mother- or infant-initiated
  - Infants speak faster in infant-initiated blocks

- **Implications**: Evidence of feedback effects, crucial for language learning
Future Directions

- Refine data set
  - Only one-on-one interactions
  - Exclude non-linguistic vocalization
  - Better solution for small durations

- Examine Father-infant convergence

- Within-block convergence
  - Contingent analysis
  - Who is leading whom?

- ASD: lack of convergence a predictor?
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