Relating Intonational Pragmatics to the Pitch Realizations of Highly Frequent Words in English Speech to Infants

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Finding the relevant variation

- Speech varies in ways relevant and irrelevant to word learning
  - “Ball” vs. “doll”: important to distinguish
  - “Ball” spoken by Mom vs. Dad is not

- How does the child figure out which features distinguish words?
Pitch variation

- Pitch contrasts words in many languages
- In English, it’s relevant at other levels of structure
  - Marking yes/no questions
  - Conveying the speaker’s emotions
- How does the input tell children that pitch doesn’t contrast words in English?
  - Consistent pitch: suggests pitch is part of the word
  - Variable pitch: suggests it’s not

Pitch realizations of English words

- English is not a tone language
  - We expect variability in pitch for individual words
- But the simplicity of infant-directed speech might lead to consistency in a word’s pitch
  - Exaggerated intonation
  - Short, simple phrases
  - Small inventory of emotional & pragmatic meanings
Motivation

- If English words have consistent pitch, this would pose a learning puzzle
- How does the speech infants hear tell them that pitch does not differentiate words in English?
- We look at the pitch patterns of highly frequent words
  - How consistent is their pitch across tokens?
  - What influences their pitch patterns?

The Brent corpus (Brent & Siskind, 2001)

- 16 American mothers’ speech to their 9- to 15-month-olds
- Roughly 200 hours of naturalistic interaction (about 400,000 words)
- Transcription divides the corpus into utterances
Getting the pitch contours of words

- Time stamps in Brent transcription let us locate each utterance in the sound files

- For each utterance, we extracted fundamental frequency in Hertz (perceived as pitch)
  - Excluded pitch-sample outliers
  - Conversion from Hertz to the Mel scale
  - Z-score normalization for each speaker

- To find the words, we used **HTK forced alignment**
  - Automated method of splitting the sound file up into words

Analyzing a subset of tokens

- Eight highly-frequent words
  - Good, right, no, okay, up, down, ball, & book

- Excluded noisy, whispered, or sung tokens

- Tokens in *final position*
  - Where word’s pitch is most likely to be realized fully
  - Infants recognize words better in final position

- Tokens in *statements*
  - Avoids effects of sentence-level intonation
Typical contexts for each word

**Good**: “...very good” (106 tokens); “...so good” (46); “...that’s good” (36); “...mmmm good” (29); “...it’s good” (27).

**Right**: “...that’s right” (464); “you’re right” (15).

Both have approving function

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**Right**: “...that’s right” (464); “you’re right” (15).

**No**: “...no no” (607); “...oh no” (133).

**Okay**: “...it’s okay” (147); “...you’re okay” (41); “...that’s okay” (32).

**No**: mostly prohibitive

**Okay**: mostly comforting
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**Up:** “...it up” (60); “...you up” (54); “...stand up” (15); “...clean(ed) up” (23).

**Down:** “...fall/fell down” (57); “...sit down” (30); “...upside down” (20); “...get down” (17); “...up and down” (11)

Both prepositions, but opposite meanings

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*Both concrete nouns*
Assigning each token a contour type

Examples of the Five Contour Types

- rise
- fall
- risefall
- fallrise
- *complex

Pitch (Z-scored Mels)

Normalized Time

0 1 2 3 4 5 6 7 8 9 10
Assigning each token a contour type

Examples of the Five Contour Types

Pitch (Z-scored Mels)

Normalized Time

0 1 2 3 4 5 6 7 8 9 10

Good Right No Okay Up Down Ball Book

- .08 .15 - .15 .05 .21 - .20 - .17 - .05 Pitch Mean

Contour-type distributions and pitch means
Lots of flat tokens

- Surprising, since exaggerated pitch movement is the hallmark of infant-directed prosody

Contour Similarity $\text{Good/Right} = \sum \text{(differences)}$

Difference $\text{Fall} = \text{Abs} (\text{Good Fall}\% \ - \ \text{Right Fall}\%)$
**Good & right versus no**

- **Good & right** have the highest contour similarity
- **Good & no** and **right & no** are much less similar (23rd of 28) (21st of 28)
- **Right** and **no** also differ in pitch mean ($p < .05$)

**Up vs. down**

- **Up** and **down** are below average in contour similarity (16th of 28)
  - **Up** has more rises ($p = .13$), **down** has more falls ($p = .14$)
- **Up** has a higher pitch mean ($p < .001$)
Ball vs. book

- Both words are concrete nouns, but they’re below average in contour similarity (19th of 28)
- No evidence that pitch indicates category *noun*

Discussion

- Though words are variable, some words differ in their pitch patterns
- But how large are these differences?
- We can calibrate the differences between words against a function we know pitch plays in English
  - Marking yes/no questions
Every word has more rises than it does in statements \( (p < .001 \text{ for each test}) \)
And higher pitch means \( (p < .001 \text{ for each test}) \)

**Yes/No Questions**

<table>
<thead>
<tr>
<th>Good</th>
<th>Okay</th>
<th>Up</th>
<th>Down</th>
<th>Ball</th>
<th>Book</th>
<th>Pitch Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>.31</td>
<td>.43</td>
<td>.59</td>
<td>.19</td>
<td>.38</td>
<td>.59</td>
<td></td>
</tr>
</tbody>
</table>

**Statements**

<table>
<thead>
<tr>
<th>Good</th>
<th>Okay</th>
<th>Up</th>
<th>Down</th>
<th>Ball</th>
<th>Book</th>
<th>Yes/No Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>-.09</td>
<td>.11</td>
<td>.21</td>
<td>-.21</td>
<td>-.17</td>
<td>-.07</td>
<td></td>
</tr>
</tbody>
</table>

**Pitch Mean**

<table>
<thead>
<tr>
<th>Good</th>
<th>Okay</th>
<th>Up</th>
<th>Down</th>
<th>Ball</th>
<th>Book</th>
<th>Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>.31</td>
<td>.43</td>
<td>.59</td>
<td>.19</td>
<td>.38</td>
<td>.59</td>
<td></td>
</tr>
</tbody>
</table>
Discussion

- Children must attach the salient pitch movements they hear to some level of structure
  - Mostly, they don’t seem to indicate particular words
  - They perform other functions, like indicating pragmatic function and marking yes/no questions

Conclusions

- But what about the differences between words?
  - Large within-word variability may convey that English is not a tone language
  - And the differences between words seem to mostly reflect pragmatic functions
    - E.g., *good* and *right* are used approvingly, and have similar pitch patterns
    - *No* is used in prohibitions, and has different pitch patterns
The importance of corpus analyses

- Knowledge of phonological development comes mostly from experimental work
  - Demonstrates children’s knowledge of native language sounds—but how do they learn them?

- Corpus analyses characterize the complex input to children
  - Important if we want an accurate view of the language-learning problem

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