Early perception of lexical stress by European Portuguese learning infants

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Introduction

- This study focuses on early perception of lexical stress.
- Word stress is a prosodic dimension that varies across languages.
  - Properties of stress in the phonological grammar: variable stress (Catalan, English, Spanish, Russian) / fixed stress (French, Finnish, Polish, Turkish).
  - Correlates of stress: particular cues (pitch, duration, intensity, vowel quality), the weighting of cues for stress prominence.
- Stress plays a central role.
  - Phonological organization of prosody.
  - Language processing, and Language acquisition.
Facilitates language acquisition:

Converging evidence on infants’ early sensitivity to the prosodic properties of speech, suggesting infants are equipped with an input processing mechanism initially tuned to prosodic information (e.g. Morgan 1986, Morgan & Demuth 1996, Jusczyk 1997, Höhle 2009)

Stress

- **Segmentation of the speech signal** into words (Jusczyk et al. 1999, Nazzi et al. 2006, Polka & Sundara 2012, Shukla et al. 2011)
- **Segmentation of the speech signal** into phrases (Bion et al. 2011; Christophe et al. 2003; Gout et al. 2004)
- **Word categorization** (Shi et al. 2006)
- **Word-level and phrase-level meaning** (Curtin 2009, 2010; Frota et al. 2012; Butler et al. 2015)
- **Early marker of later language abilities** (typical or impaired – Friedrich et al. 2009; Weber et al. 2005)
Overview

1. Previous research on infant lexical stress perception
2. Stress in European Portuguese (EP)
   - Phonological grammar and Correlates of stress
   - Frequency patterns
   - Rhythmic properties
3. Method
   - Participants
   - Materials
   - Procedure
4. Results
5. Discussion
1. Previous research

Difference across languages in the development of infants’ perception of stress

<table>
<thead>
<tr>
<th>Stress</th>
<th>Unpredictable/variable</th>
<th>Predictable/fixed</th>
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<tbody>
<tr>
<td>Discrimination no variation</td>
<td>✓ At 6 mos Spanish</td>
<td>✓ At 6 mos French (but better sensitivity in bilinguals)</td>
</tr>
<tr>
<td>Discrimination with variation</td>
<td>✓ after 6 mos ONLY if native English, German, Spanish</td>
<td>❌ French</td>
</tr>
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1. Previous research

- **Main finding:** perception of word stress is language-specific > grammar, rhythm, input frequency

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- Perception develops as a function as the prosodic features of the native language
2. Stress in European Portuguese

1. EP has **variable stress** (=Catalan, Spanish, English)
   - Stress may fall within the last 3 syllables of the prosodic word
   - Stress is **lexically contrastive**: bambo ['bɐ̃бу] / bambu [bɐ̃'bu], 'lax' / 'bamboo'; explicito [ʃˈplisitu] / explicito [ʃpliˈsitu], 'explicit' / 'I make explicit'

2. Correlates of stress – diverse set of cues
   - Suprasegmental cues: 
     - **Duration** (=Spanish, Catalan), low co-variation between stress and pitch accents (≠Spanish, Catalan, English)
   - Segmental cues: Vowel quality > **reduction of unstressed vowels** (=English, Catalan) /i, e, ɛ, a, o, ɔ, u/ > [i, i, ɛ, u]
     General phenomenon with exceptions
2. Stress in European Portuguese

1. EP has **variable stress** (=Catalan, Spanish, English)
2. Correlates of stress – diverse set of cues (=Cat, Eng)
   - **Uncommon combination**: longer duration in stressed syllables, vowel reduction in unstressed syllables, low co-variation stress/accent (most stressed syllables unaccented)
3. Frequency data (disyllabic words: % trochaic - token, type)
   - English 74%, 78%; **EP** 66%, 74%; Spanish 60%~70% (Pons & Bosch 2010; FrePoP database http://frepop.letras.ulisboa.pt)
4. Rhythm - **Mixed properties**
   - Combines Germanic & Romance features: mix of stress-timed and syllable-timed rhythm, however **NOT** perceived as a stress-timed language (Frota et al. 2001, 2002)
2. Stress in European Portuguese

No previous infant studies
- Infants & toddlers sensitive to stress location in a word learning study: ['milu] / [mi'lu] (Frota et al. 2012)

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EP > new data contributing to the understanding of the role of native phonological grammar, rhythm (and frequency) in how stress perception develops in language acquisition
3. Method

- **Participants:**
  - 24 infants from monolingual homes in the Lisbon area
    (16 boys, mean age = 5 months 26 days, range 5 months 2 days – 6 months 28 days)
  - 6 infants excluded due to fussiness (2) and poor tracking (4)

- **Why 5-6 months?**
  - Discrimination with segmental variability not evident before 8 months, perhaps due to method sensitivity – *eye tracking*?
  - Preference/Asymmetry emerges after 4 months in some languages (between 4 and 6)
  - Language-specific perception in the pitch domain at 4-5 mos
    (Frota et al. 2014; Yeung et al. 2013)
  - Early marker of risk for later language impairments at 5 mos
### 3. Method

- All infants completed the CSBS-DP Checklist (a developmental screening tool – Wetherby & Prizant 2003), adapted for Portuguese.

<table>
<thead>
<tr>
<th>N</th>
<th>Social composite</th>
<th>Speech composite</th>
<th>Symbolic composite</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>24</td>
<td>10.83</td>
<td>2.82</td>
<td>3.29</td>
<td>1.33</td>
</tr>
<tr>
<td>50</td>
<td>10.00</td>
<td>2.95</td>
<td>3.74</td>
<td>1.76</td>
</tr>
<tr>
<td>Cut-off</td>
<td>&gt;7</td>
<td>&gt;1</td>
<td>&gt;2</td>
<td>&gt;12</td>
</tr>
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A comparison with the means and SD in the English standardization sample: All infants were showing social communication, language and symbolic functionning skills as expected for their age (including eye gaze, gestures, use of sounds and understanding)
3. Method

- **Materials:**
  - Disyllabic **segmentally varied** nonsense words with penult and final stress, uttered by female speaker in CDS. Suprasegmental cues the **only** cues to stress e.g., ['milu] / [mi̞lu], ['těnu] / [tě'nu] (Citation forms)

\[ C_1V_1C_2V_2 \]

- Consonants were selected from the most-used consonants in Portuguese. Stops, fricatives and liquids were balanced. Both in training and testing there were 4 stops, 1 nasal, 1 fricative and 1 liquid. Within a trial, \( C_1 \) was different between words. \( V_1 ([\varepsilon] , [i] or [u]) \) was balanced across training and testing. \( V_2 \) was always [u].
3. Method

- Materials:

Trochee vs. Iamb  
Duration: S2 - S1

-- Pitch fall

- T-test:
  - Duration
    - S1: < .001
    - S2: < .001
  - Pitch range
    - S1: < .001
    - S2: < .001

Suprasegmental cues: the only cues to stress:
Duration (stressed syllable longer) and location of the pitch fall

Pitch fall: H+L*
3. Method

- **Procedure:** Version of the *Antecipatory Eye Movement* (AEM) paradigm to examine infants’ discrimination of stress (McMurray & Aslin 2004; Albareda-Castellot et al. 2011; Richardson & Kirkham 2004)

**Training**

Infants’ trained to associate each stress pattern with one image & side of the screen: 6 training trials (3 trochee, 3 iamb, pseudo-randomized); 4 nonsense words per trial

**Test**

Screen with two frames but no images while listening to novel tokens: 2 test trials (1 trochee, 1 iamb, counterbalanced)

Structure of an experimental block

- Total of 8 blocks. Side/Image association to stress pattern counterbalanced between subjects
3. Method

**Procedure** *(SMI RED500 eye-tracker)*:

- **Discrimination**: longer looking time to the target side
- Interaction between target side and stimuli > suggest a *preference* for one of the stress patterns
4. Results

- Infants completed between 2 and 6 blocks (mean 4), between 3 and 12 test trials (mean 7.5)

- **Training phase** - Looking times to the image in the iambic and trochaic training trials were compared across the 4 counterbalancing conditions (tri-iamb-left, tri-iamb-right, tri-trochee-left, tri-trochee-right) > **No differences** found in looking between the two types of training trials (iambic/trochaic) and no effect of the counterbalancing condition.

ANOVA: **no effect of trained side** (F(1,20) = 1.96, p = .18, η² = .09) or counterbalancing F(3,20) = 1.3, p = .18, η² = .09), and no interaction (F(3,20) < 1)
4. Results: Test phase

- No difference in looking times to iambic/trochaic training trials, no other effects. **NO Discrimination**

Proportional looking at the target and distracter trained sides

Target side(2) X order(2) X stimuli(2)

Window: 500ms after onset to 2000ms

ANOVA: **no effect of target side** (F(1,20) = 1.53, p = .23, η² = .07), order (F(1,20) = 2.55, p = .13, η² = .11) or stimuli (F(1,20) < 1), BUT a significant interaction between target side and stimuli (F(1,20) = 5.85, p < .05, η² = .23)

**Discrimination: longer looking time to the target side**

Interaction between target side and stimuli > suggest a **preference** for one of the stress patterns, possibly shown by an **asymmetry** in looking behavior
4. Results: Test phase

- Results: Significant difference in looking to the iamb and trochee trained sides. **Longer looking time to Iamb**

Proportional looking at the Iamb and Trochee trained sides

Discrimination: longer looking time to the target side
Interaction between target side and stimuli > suggest a **preference** for one of the stress patterns, shown by an **asymmetry** in looking behavior
4. Results: Test phase

- **Results:** Significant difference in looking to the iamb and trochee trained sides. **Longer looking time to Iamb** (mean 578 vs. 366 for trochee)

Trained side(2) X order(2) X stimuli(2)

Window: 500ms after onset to 2000ms

ANOVA: **significant effect of trained side** (F(1,20) = 5.7, p < .05, $\eta^2 = .22$). No effects of order (F(1,20) = 2.55, p = .13, $\eta^2 = .11$) or stimuli (F(1,20) < 1), and no interactions

**Discrimination:** longer looking time to the target side

Interaction between target side and stimuli > suggest a **preference** for one of the stress patterns, shown by an **asymmetry** in looking behavior
## 5. Discussion

### Perception of STRESS

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<td>✗ Syllable-timed languages &gt; NO trochaic bias, NO preference</td>
</tr>
<tr>
<td>Input frequency</td>
<td>✔ Dutch, English, German (Trochaic&gt;Trochaic)</td>
<td>✗ Spanish (Trochaic&gt; NO asym) French (Iambic &gt; NO asym)</td>
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5. Discussion

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✔ Iambic bias > new finding (at 5 mos), in a variable stress language with mixed (but arguably syllable-timed) rhythm, and a dominant trochaic input frequency pattern
5. Discussion

- Our findings confirm that asymmetries in stress perception emerge early (4-6) in development and are language-specific.

- We add a new pattern to the previously described dichotomy between a *Trochaic preference* (stress-timed) and *No preference* (syllable-timed): **Iambic bias**

- This new finding is in line with two so far unrelated facts in the literature on EP:
  - Early children’s productions: (0;11-2;06) $\sigma > WS$ (Correia 2009); more *iambic targets* attempted (Vigário et al. 2006)
  - Recent findings show an advantage for iambs in adult perception of stress (Lu et al., in progress)
5. Discussion

What language-specific factors shape early perception of stress?

- Native phonological grammar:
  - variable stress / fixed stress / stress domain
- Rhythmic properties
  - Stress-timing, Syllable-timing, mix
- Input frequency
  - Relative distribution of trochees and iambs (modulated by other factors)
- Others ???

Infants: first develop the familiar native language pattern!
Thank you

All infants and parents. The baby lab team: Cátia, Marisa, Cláudia

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