‘Old’ paradigms, New measures: infants’ language processing assessed with eye-tracking

Simão Cortês, Joseph Butler, Cátia Severino, Ertugrul Uysal, Marina Vigário & Sónia Frota

Universidade de Lisboa
Introduction

- This presentation focuses on the use of classical experimental paradigms for studying language development implemented exploring eye-tracking.
- These are useful paradigms that could be further developed as eye-tracking paradigms > more accurate and sensitive data, more attractive to infants.
  - We explored two of these paradigms:
    - Anticipatory Looking Paradigm (e.g., used in classical work in the Conditioned Head Turn Procedure, Werker & Tees, 1984)
    - Visual Fixation Paradigm (e.g., used in many versions of habituation/familiarization procedures, Polka & Werker, 1994)
Study 1: Perception of stress by 5 month-olds

- This study used the **Antecipatory Looking Paradigm** in order to study early stress processing in 5 mos.
- Word stress is a prosodic dimension that varies across languages:
  - **Variable stress** (Catalan, English, Spanish, Russian) / **fixed stress** (French, Finnish, Polish, Turkish)
  - **Trochaic pattern** (English, Dutch) / **Iambic Pattern** (Hebrew, French)
- Stress plays a central role:
  - Sound structure of language
  - Language processing, and **Language acquisition**
1.1. Previous research

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

<table>
<thead>
<tr>
<th>Perception of STRESS</th>
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<tbody>
<tr>
<td>Development of discrimination abilities</td>
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<tr>
<td>Rhythmic-based (Nazzi et al. 2006)</td>
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<td>Input frequency</td>
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1.2. Stress in European Portuguese (EP)

1. EP has **variable stress** (=Catalan, Spanish, English)
2. Trochaic? (Not clear – lexicon or use; types or tokens)
3. 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/ > [ɨ, i, ɐ, u]

**RESEARCH QUESTION**: How good will Portuguese infants be at perceiving stress?
1.3. 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 – could eye tracking be more sensitive?
  - Preference/Asymmetry emerges after 4 months in some languages (with ERP methodology) - could eye tracking be as sensitive?
1.3. Method

- **Materials:**
  - Disyllabic *segmentally varied* nonsense words with penult and final stress, uttered by female speaker in Child Directed Speech. Suprasegmental cues the **only** cues to stress
  e.g., ['milu] / [mi\'lu], ['t\'enu] / [te\'nu]  (Citation forms)

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

<table>
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<th>T-test:</th>
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<tr>
<td>Duration</td>
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<td>S1: &lt; .001</td>
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<td>S2: &lt; .001</td>
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<td>Pitch range</td>
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<td>S1: &lt; .001</td>
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<tr>
<td>S2: &lt; .001</td>
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</tbody>
</table>
1.3. Method

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

We used an 8-block structure in order to have usable data even if children did not complete the whole experiment.
1.3. Method

**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)

The color of the shapes alternates between blocks.

Structure of an experimental block
Total of 8 blocks. Side/Image association to stress pattern counterbalanced between subjects.
1.3. 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
1.4. Results

- **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

Mean net dwell time (ms) to the lamb and Trochee trained sides, by lambic and Trochaic test trials

Significant difference between trained side Iambic/Tochaic > suggest a preference for one of the stress patterns, shown by an **asymmetry** in looking behavior.
1.5. Discussion

- We were able to successfully use this paradigm implemented with eye-tacking in very young children.
- Our findings confirm that asymmetries in stress perception emerge very early in development and are language-specific.
- Portuguese children seem to have an Iambic Preference > New finding in a variable stress language.
- Eye tracking was sensitive enough to capture early patterns in stress processing.
Study 2: Perception of prosodic boundaries by 8-9 month olds

- This study adapted the Visual Fixation paradigm (Polka & Werker, 1994, Jusczyk & Aslin 1995, Bosch & Sebastian-Galles, 2001, 2003) in order to examine 8-9 mos infants perception of Prosodic Boundaries

- Pitch is a fundamental cue to the organization of speech or speech chunking, across languages
  - *Pitch can mark different things in grammar*: the difference between declaratives and interrogatives, the most proeminent information both structurally and semantically, or the specific chunking of a sentence, via prosodic boundaries

- As stress, pitch plays a central role
  - Sound structure of language
  - Language processing, and *Language acquisition*
2.1. Prosodic boundaries in European Portuguese

1. EP uses pitch to mark Prosodic Boundaries that signal speech chunks (and impact on meaning)
   e.g., [As meninas deram bonecas] vs. [Às meninas] [deram bonecas]
   “The girls gave dolls” vs. “To the girls, (they) gave the dolls”
   [A miúda deu à Maria] vs. [A miúda] [deu à Maria]
   “The girl gave (it) to May” vs. “As to the girl, she gave (it) to Mary”

**RESEARCH QUESTION:** How good will Portuguese infants be at discriminating presence/absence of such boundaries?
2.2. Method

- **Participants**
  - 11 infants from monolingual homes in the Lisbon area and one infant from a bilingual home (but both language with similar boundary marking cues)

- **Materials:**
  - We used two pairs of **de-lexicalized utterances**, each pair having a sentence with a prosodic boundary and a sentence without a prosodic boundary.
  - The utterances were de-lexicalized in order to remove segmental differences and **ONLY** preserve prosodic cues.
2.2. Method

- **Procedure:**
  - Familiarization procedure (until 1 minute looking time, max 2 minutes)

Test phase: each trial presented the item 4x

Test phase: 2 novel, and 2 familiar trials

ORDER OF TEST TRIALS: Notice that the only constraint in the test trials is that the first two trials are different from each other. The type of the first trial is randomized, as well as the order of the rest of the trials.
2.2. Method

While exposed to the stimuli the infants had an interesting video on screen with a moving pattern. Two AOI were defined: the screen and the moving pattern.

**Discrimination**: longer looking time to the familiar stimuli

Examine the sensitiveness of the two AOI measures > the eye-tracker offers a more powerful method than the traditional implementations of the visual fixation paradigm.
2.3. Results

- Results: Significant difference in looking time between familiar and novel stimuli. **Longer looking time to familiar**

Discrimination was obtained: longer looking time to the familiar stimuli.
The effect is more prominent in the whole screen condition: the eye-tracker is more powerful as it allows the comparison of different AOIs within the visual fixation paradigm in terms of AOIS.

Further and more accurate implementation of the moving AOI, taking into account the processing time of the infant’s oculomotor system.
2.4. Discussion

- Our findings demonstrate infants’ ability to discriminate Prosodic Boundaries at a very young age (captured using eye-tracking).
- The use of eye tracking in this study offers a more powerful method than the traditional visual fixation paradigm as a means to examine the sensitiveness of the different AOI measures.

Both studies have demonstrated that eye-tracking is a valuable tool to measure children’s language processing during the first year of life.
Thank you

All infants and parents. The baby lab team

labfon@letras.ulisboa.pt
http://labfon.letras.ulisboa.pt/babylab/

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