



Early perception of lexical stress by European Portuguese learning infants

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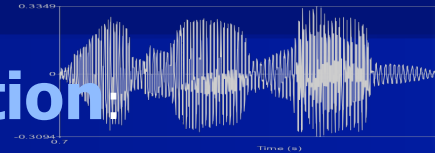


Introduction

- This study focus 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**



Introduction



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

| Stress | Unpredictable/variable | Predictable/fixed |
|----------------------------------|--|---|
| Discrimination no variation | ✓ At 6 mos Spanish | ✓ At 6 mos French (but better sensitivity in bilinguals) |
| Discrimination with variation | ✓ after 6 mos ONLY if native English, German, Spanish | ✗ French |

Bijeljac-Babic et al. 2012, 2013; Friederici et al. 2007; Hohle et al. 2009; Jusczyk et al. 1993; Pons & Bosch 2007; Skoruppa et al. 2009, 2011, 2013; Weber et al. 2004



1. Previous research

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

| Perception of STRESS | | |
|---|--|--|
| Development of discrimination abilities | ✓ Unpredictable/variable stress | ✗ Predictable/fixed stress |
| Rhythmic-based (Nazzi et al. 2006) | ✓ Stress-timed languages > trochaic bias | ✗ Syllable-timed languages > NO trochaic bias, NO preference |
| Input frequency | ✓ Dutch, English, German (Trochaic>Trochaic) | ✗ Spanish (Trochaic> NO asym) French (Iambic > NO asym) |

- 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* ['bẽbu] / *bambu* [bẽ'bu], 'lax' / 'bamboo'; *explícito* [ʃ'plisitu] / *explicito* [ʃpli'situ], '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 (\neq Spanish, Catalan, English)
 - Segmental cues: Vowel quality > **reduction of unstressed vowels** (=English, Catalan) /i, e, ε, a, o, ɔ, u/ > [i, ɨ, e, u]
General phenomenon with exceptions

Uncommon combination of prosodic properties
Uncommon combination of cues for word stress



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)

CDS: 63%, 70%



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

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

| Perception of STRESS | | |
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?



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 (Friedrich, et al. 2009; Weber et al. 2005)



3. Method

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

| N | Social composite | | Speech composite | | Symbolic composite | | Total | |
|---------|------------------|------|------------------|------|--------------------|------|-------|------|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 24 | 10.83 | 2.82 | 3.29 | 1.33 | 3.71 | 1.90 | 17.83 | 4.79 |
| 50 | 10.00 | 2.95 | 3.74 | 1.76 | 4.32 | 1.48 | 18.06 | 4.70 |
| Cut-off | >7 | | >1 | | >2 | | >12 | |

A comparison with the means and SD in the English standardization sample:
All infants were showing social communication, language and symbolic functioning skills as expected for their age (including eye gaze, gestures, use of sounds and understanding)



3. Method

■ Materials:

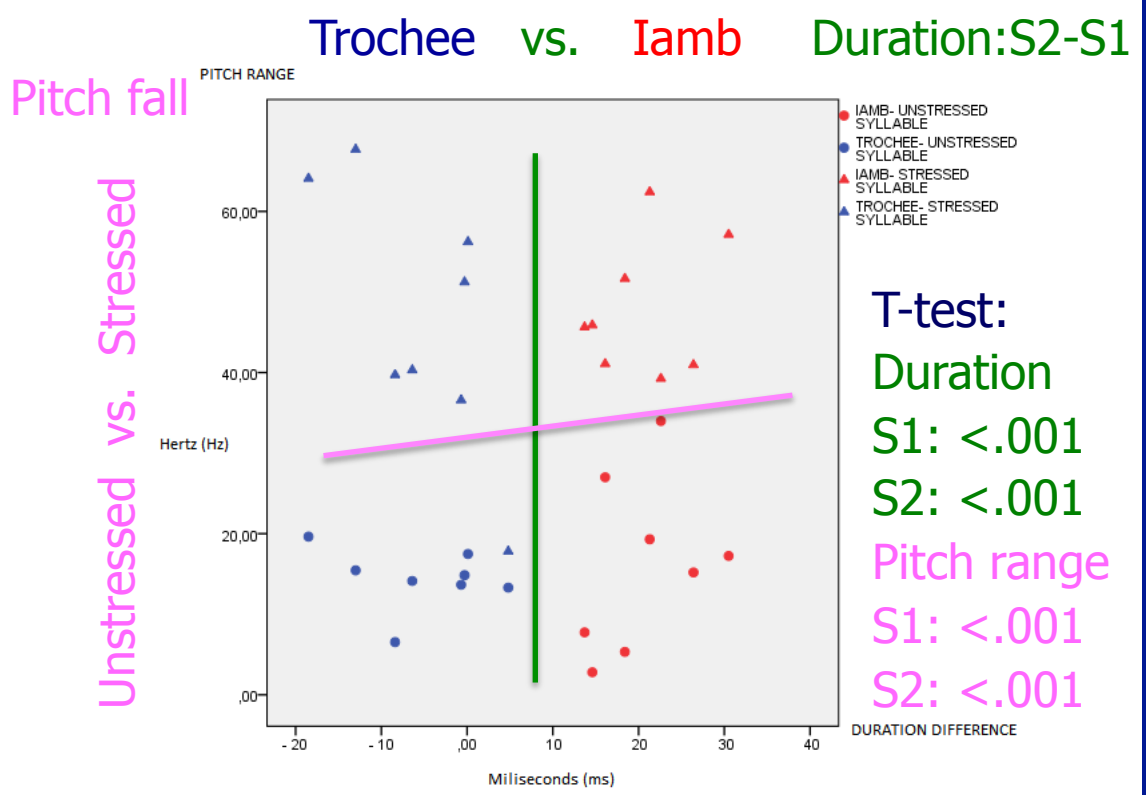
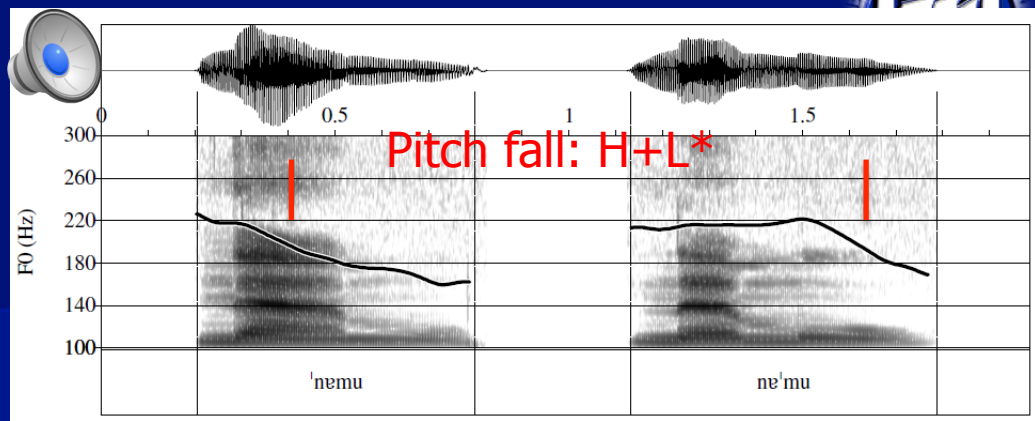
- Disyllabic **segmentally varied** nonsense words with penult and final stress, uttered by female speaker in CDS. Suprasegmental cues the **only** cues to stress e.g., [**'**milu] / [mi'**lu**], [**'**tenu] / [te'**nu**] (Citation forms)

$$C_1V_1C_2V_2$$

- 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 ([e] , [i] or [u]) was balanced across training and testing. V_2 was always [u].

3. Method

Materials:

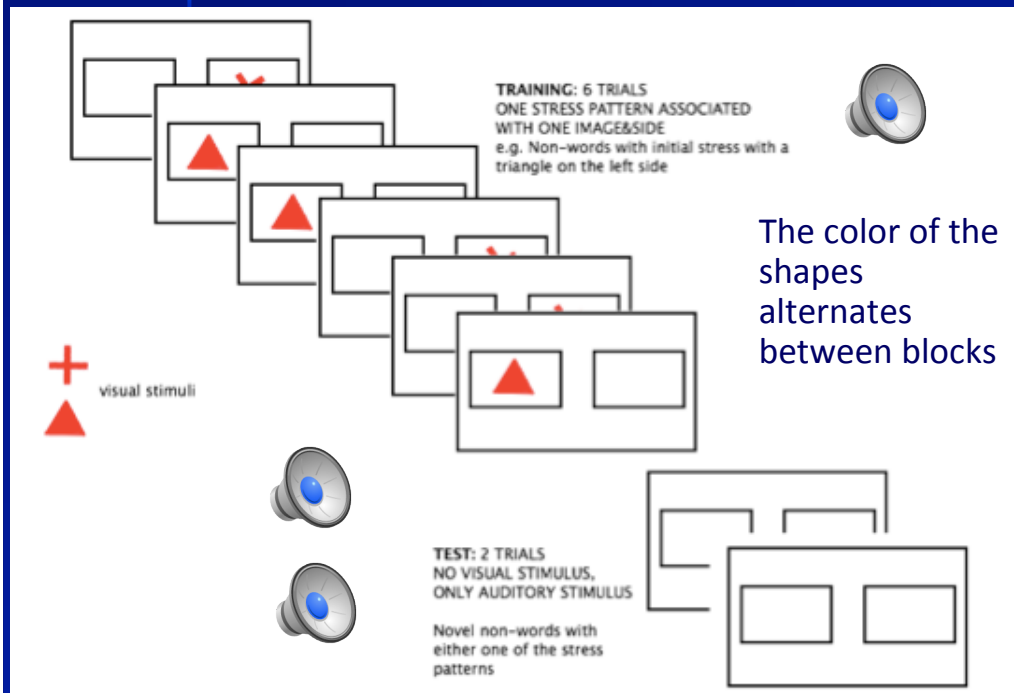


Suprasegmental cues
 the **only** cues to stress:
 Duration (stressed syllable longer) and
 location of the pitch fall



3. Method

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



Structure of an experimental block

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

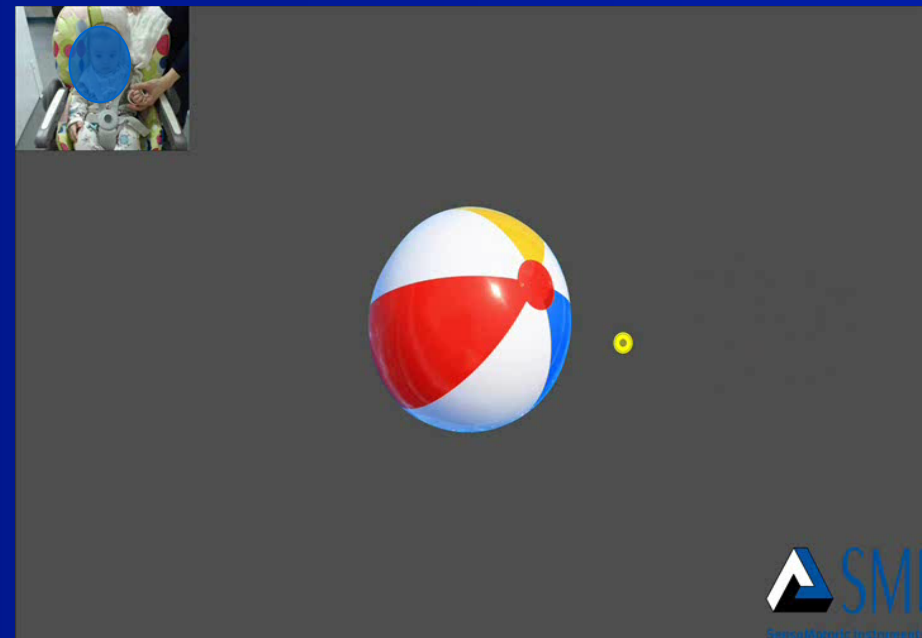
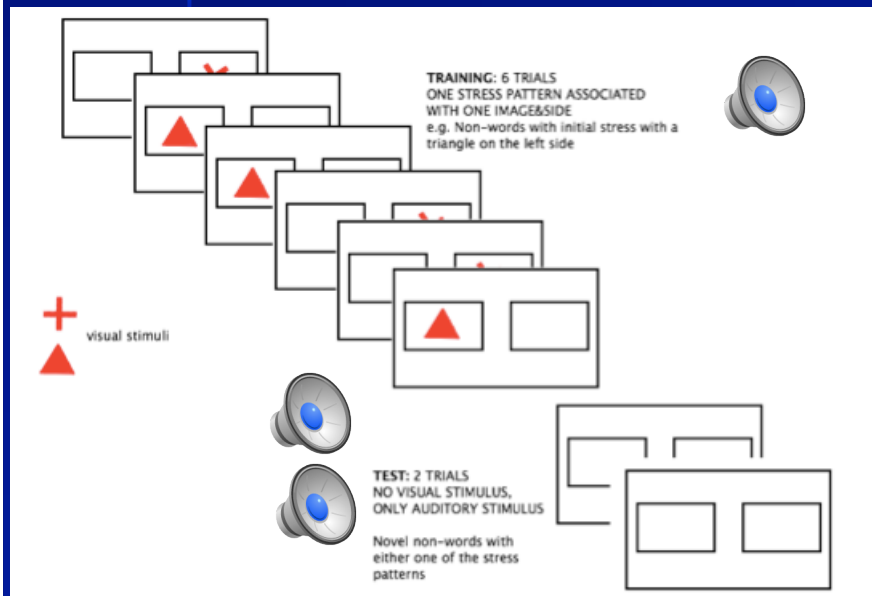
Test

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

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

3. Method

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



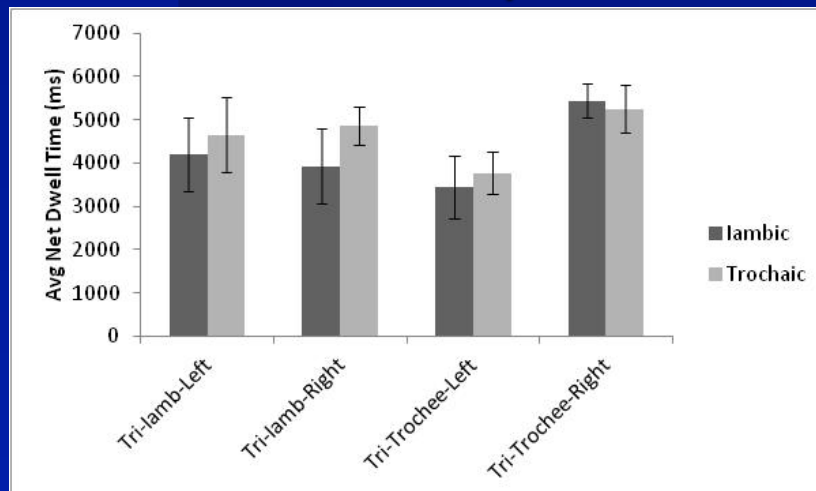
Discrimination: longer looking time to the target side

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.

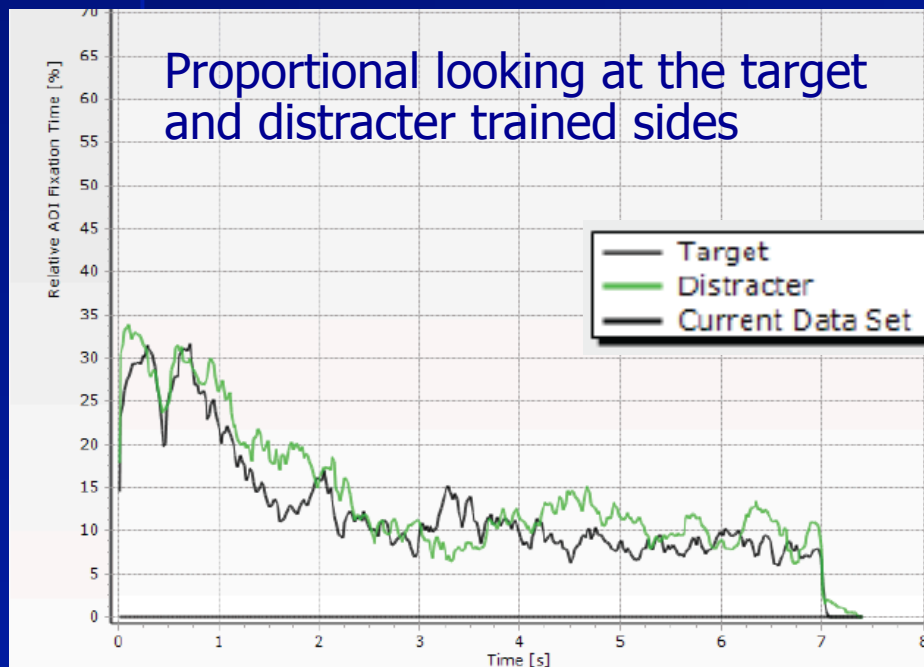


ANOVA: **no effect of trained side** ($F(1,20) = 1.96, p = .18, \eta^2 = .09$) or counterbalancing ($F(3,20) = 1.3, p = .18, \eta^2 = .09$), and no interaction ($F(3,20) < 1$)



4. Results: Test phase

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



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

Window: 500ms after onset to 2000ms

ANOVA: **no effect of target side** ($F(1,20) = 1.53, p = .23, \eta^2 = .07$), order ($F(1,20) = 2.55, p = .13, \eta^2 = .11$) or stimuli ($F(1,20) < 1$), BUT a **significant interaction between target side and stimuli** ($F(1,20) = 5.85, p < .05, \eta^2 = .23$)

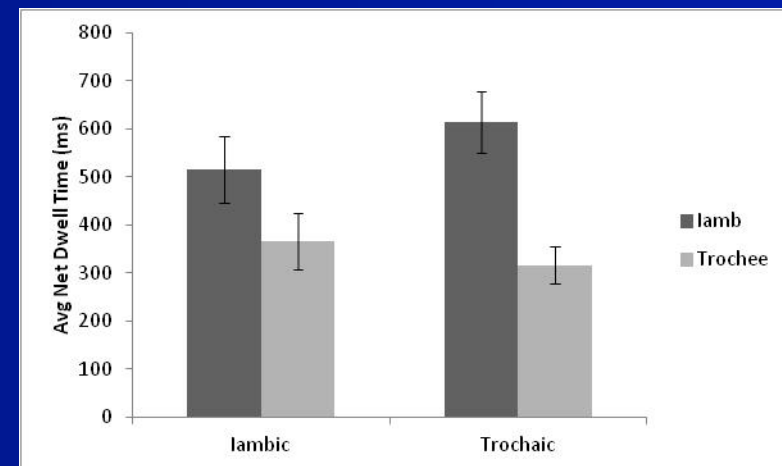
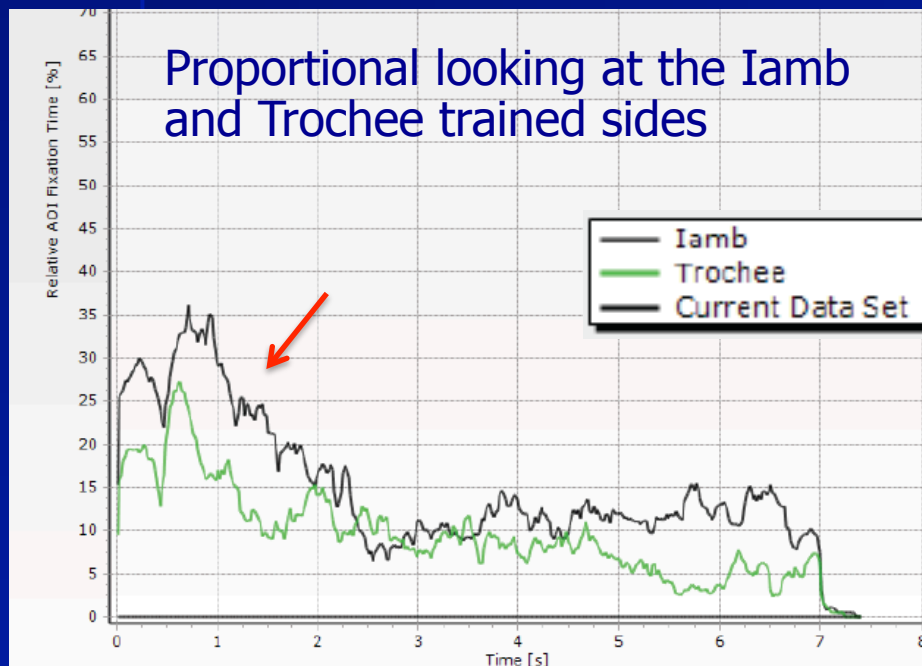
Discrimination: longer looking time to the target side

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**



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

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



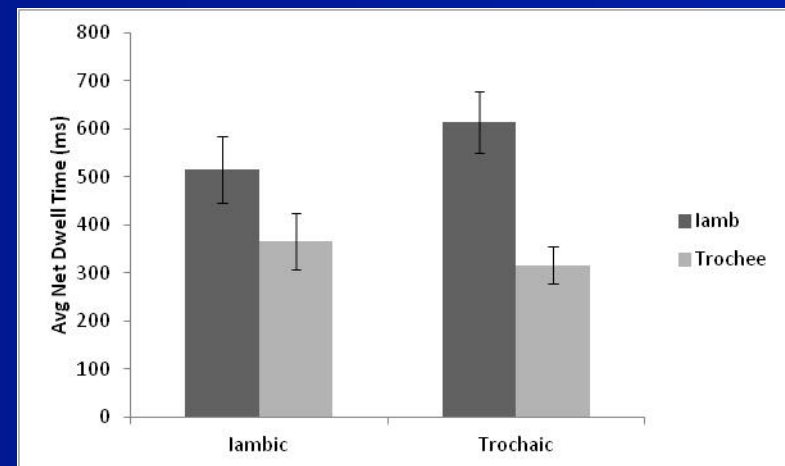
4. Results: Test phase

- 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



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

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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5. Discussion

| | Perception | Later? | Stress |
|---|--|--|--|
| Development of discrimination abilities |  Unpredictable variable stress | |  Predictable/fixed stress |
| Rhythmic-based (Nazzi et al. 2006) |  Stress-timed languages > trochaic bias | |  Syllable-timed languages > NO trochaic bias, NO preference |
| Input frequency |  Dutch, English, German (Trochaic > Trochaic) |  |  Spanish (Trochaic > Iambic) French (Iambic > Iambic) |


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

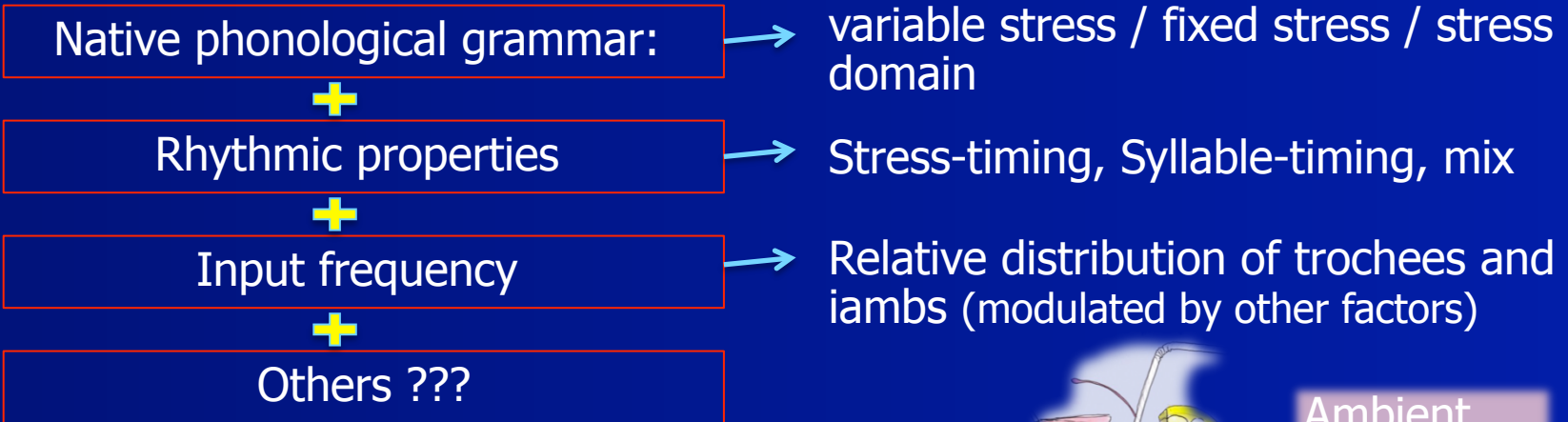
- Our findings confirm that asymmetries in stress perception emerge early (4-6) in development and are language-specific
- We add a new pattern to the previously described dichotomy between a *Trochaic preference* (stress-timed) and *No preference* (syllable-timed): **Iambic bias**
- This new finding is in line with two so far unrelated facts in the literature on EP
 - Early children's productions: (0;11-2;06) $\sigma > \mathbf{WS}$ (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

Infants: first develop the familiar native language pattern!

- What language-specific factors shape early perception of stress?



Iambic bias



Ambient language Cluster of cues



Longer
duration

*Obri**GA**da*

Pitch fall

Thank you

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

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