European Portuguese-learning infants' early perception of lexical stress

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Introduction

Study focusing 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 in:

- Phonological organisation of prosody
- Language processing and **language acquisition**

Converging evidence suggesting that infants are equipped with an input processing mechanism initially tuned to prosodic information. Word stress suggested to facilitate:

- **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. in press)
- **Early marker of later language abilities** (typical or impaired – Friedrich et al. 2009; Weber et al. 2005)

Differences 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
Preference/ Asymmetry	✔ After 4-6 mos Dutch, English, German > Trochaic pattern	✖ After 4-6 mos, French > NO preference
Preference/ Asymmetry	✖ After 4-6 Catalan, Spanish NO preference	✔ After 6 in French/German-bilinguals, not 'syllable-based'

Main finding from previous research: **The perception of word stress is language specific > grammar, rhythm, input frequency**. Perception develops as a function as the prosodic features of the native language:

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)

Stress in European Portuguese (EP)

EP has **variable stress** (= Catalan, Spanish, English)

- stress may fall within 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')

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, ɨ, ɐ, u] (general phenomenon with exceptions)
- **uncommon combination**: longer duration in stressed syllables, vowel reduction in unstressed syllables, low co-variation stress/accent (most stressed syllables unaccented)

Frequency data (% trochaic disyllabic words: token, type):

- English 74%, 78%; **EP 66%, 74%**; Spanish 60%~70% // **EP in CDS 63%, 70%**
  (Pons & Bosch 2010; FrePoP database http://frepop.letras.ulisboa.pt)

Rhythm – mixed properties

- combines Germanic and Romance features: mix of stress- timed and syllable-times rhythm, but **NOT** perceived as a stress-timed language (Frota et al. 2001, 2002)

No previous infant studies

- Infants & toddlers sensitive to stress location in a word learning study:['**mi**lu] / [mi'**lu**] (Frota et al. 2012)

Predictions

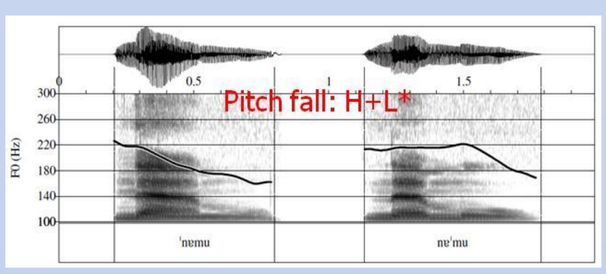
Perception of STRESS		
Development of discrimination abilities	✔ Unpredictable/variable stress	✖ Predictable/fixed stress
Rhythmic-based (Nazzi et al. 2006)	✔ Stress-timed languages > trochaic bias	✖ Syllable-timed languages > NO trochaic bias, NO preference
Input frequency	✔ Dutch, English, German (Trochaic>Trochaic)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

- EP infants as learners of a variable stress language (where stress is used contrastively) are expected to develop their stress processing skills and *show discrimination abilities at some point in the first year of life*.
- The prediction related to rhythm is not clear, given the mixed rhythm. However, since EP is not perceived as stress-timed, *no trochaic preference and in fact no preference at all is expected* (as in Catalan or Spanish, and unlike in English).
- Input frequency prediction is not clear.

Method

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

Figure 1: Location of the pitch fall in stimuli



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], ['tɐnu] / [tɐ'nu] (Citation forms). $C_1V_1C_2V_2$

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

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

Procedure:
Anticipatory Eye Movement (AEM) paradigm (McMurray & Aslin, 2004; Albareda-Castello et al., 2011; Richardson & Kirkham, 2004)

Training
- infants trained to associate each stress pattern (Trochee/Iamb) with one image and side of scr
- 6 training trials (3 trochee, 3 iamb, pseudo-randomised)
- 4 nonsense words per trial

Test
- screen with 2 frames but no images while listening to novel tokens
- 2 test trials (1 trochee, 1 iamb, counterbalanced)

Total of 8 blocks
Side/image associated with stress pattern counterbalanced between infants
Colour of the images alternated between blocks

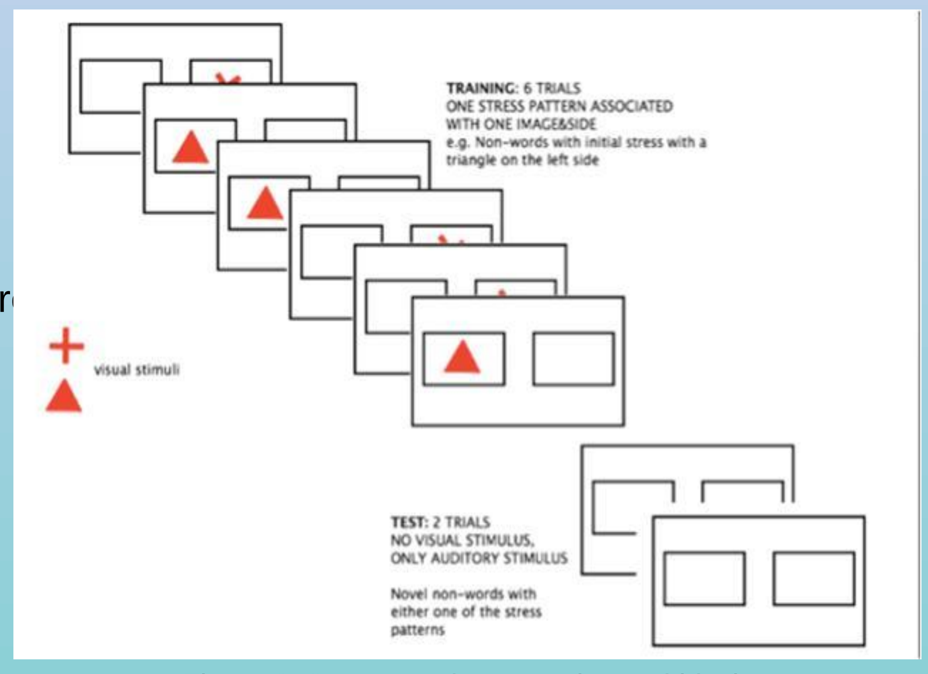


Figure 3: Structure of an experimental block

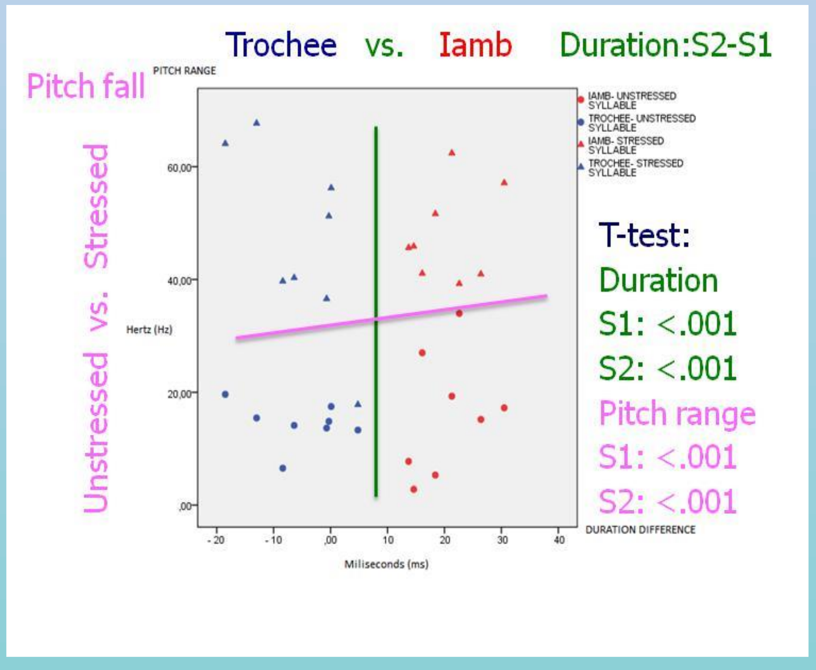


Figure 2: Duration and pitch range information for the stimuli

Results

Discrimination: longer looking time to the target side
No difference in looking times to iambic/trochaic training trials, NO Discrimination

Training phase: 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)

Window: 500ms after onset to 2000ms
ANOVA: **No effect of target side** (F(1,20)=1.53,p= 23,η^2=.07), order (F(1,20)=2.55,p=.13,η^2= .11) or stimuli (F(1,20)<1),
BUT a **significant interaction between target side and stimuli** (F(1,20)=5.85,p<.05,η^2=.23)

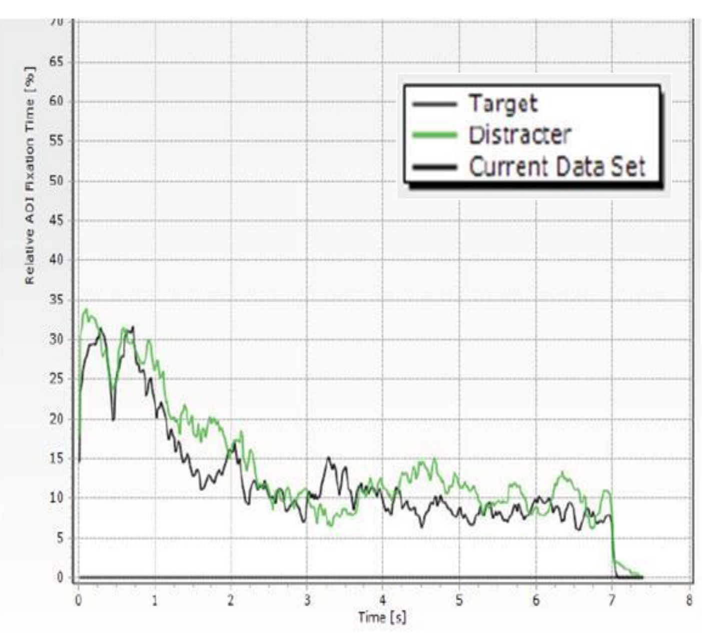


Figure 4: Proportional looking at the target vs distracter side in test trials

Interaction between target side and stimuli > suggest a preference for one of the stress patterns, possibly shown by **an asymmetry in looking behaviour**

Window: 500ms after onset to 2000ms
ANOVA: **significant effect of trained side** (F(1,20)=5.7,p<.05, η^2=.22). No effects of order (F(1,20)=2.55,p=.13,η^2=.11) or stimuli (F(1,20)<1), and no interactions

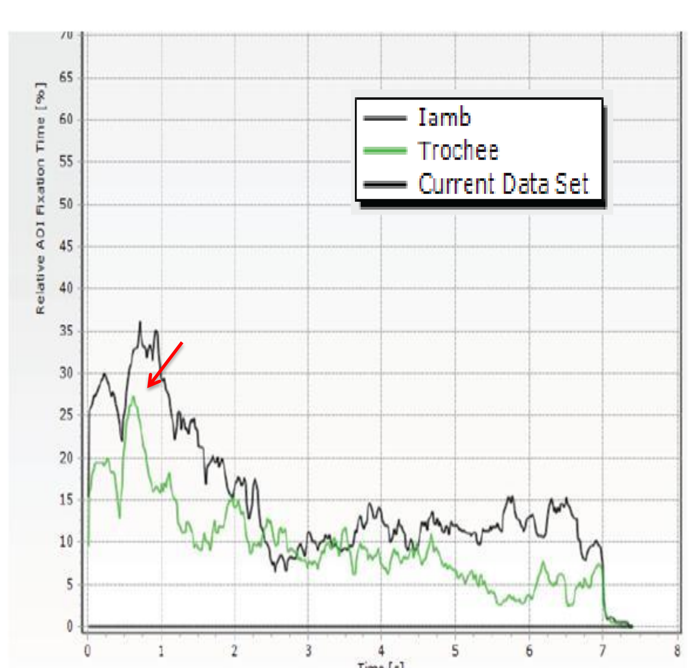


Figure 5: Proportional looking at the Iambic vs Trochaic trained sides in test trials

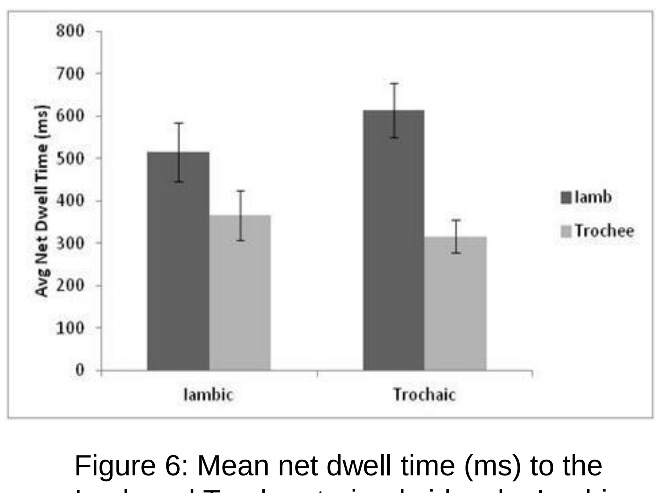


Figure 6: Mean net dwell time (ms) to the Iamb and Trochee trained sides, by Iambic and Trochaic test trials

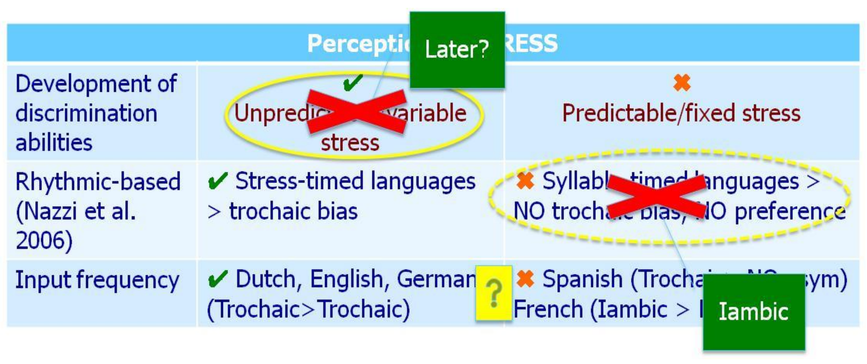
Discussion

Findings confirm that asymmetries in stress perception emerge early in development and are language specific.

We add a new pattern to the previously described dichotomy between *Trochaic preference* and *No preference* – ***Iambic preference***.

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) **σ > WS** (Correia 2009); and 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).



Infants first develop the familiar native language pattern.

What language-specific factors shape early perception of stress?

- Native phonological grammar – variable stress/fixed stress/stress domain (foot, word, phrase)
- Rhythmic properties – stress timing, syllable timing, mix
- Input frequency – relative distribution of trochees and iambs (modulated by other factors? E.g., direction of cliticization)
- Others???

A combination of factors > Ambient language cluster of cues

Trochaic bias
No preference
Iambic bias

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