

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* ['bēbu]/*bambu* [bē'bu], 'lax'/'bamboo'; *explícito* [ˈplisitu]/*explícito* [pli'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, ε, a, o, o, u/ > [i, i, e, 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: [ˈmilu] / [miˈlu] (Frota et al. 2012)

Predictions

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- 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)

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., [ˈmilu] / [miˈlu], [ˈtenu] / [teˈnu] (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, C₁ was different between words. V₁ ([ɛ], [i] or [u]) was balanced across training and testing. V₂ 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 screen
- 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

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,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)

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, η²=.22). No effects of order (F(1,20)=2.55,p=.13,η²=.11) or stimuli (F(1,20)<1), and no interactions

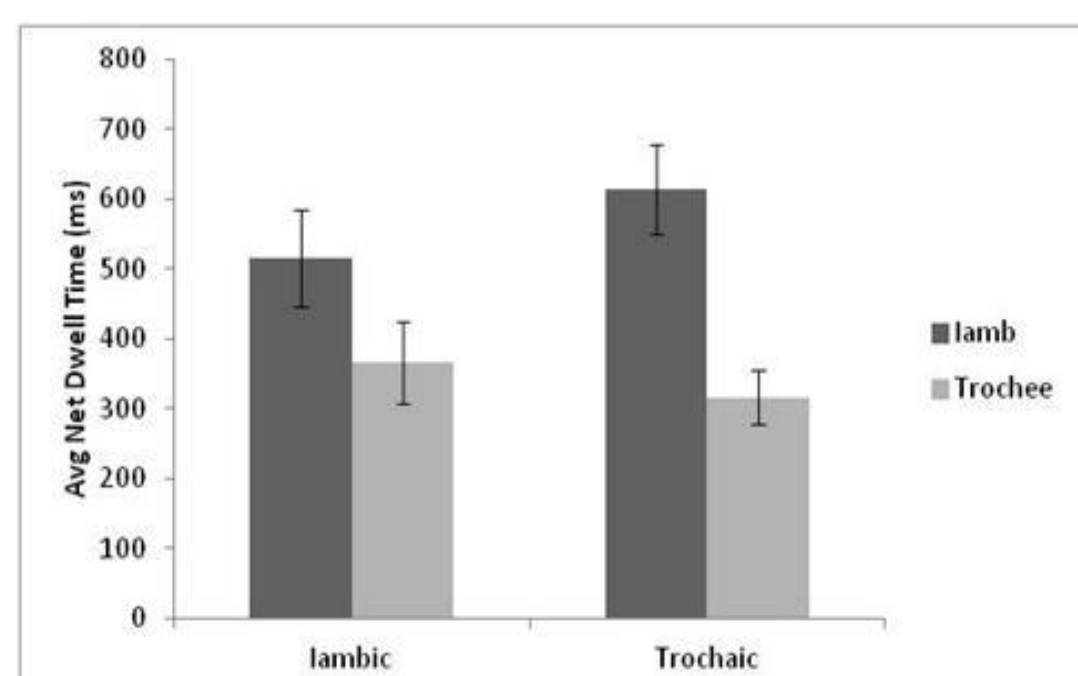


Figure 6: Mean net dwell time (ms) to the iamb and Trochee trained sides, by iambic and Trochaic test trials

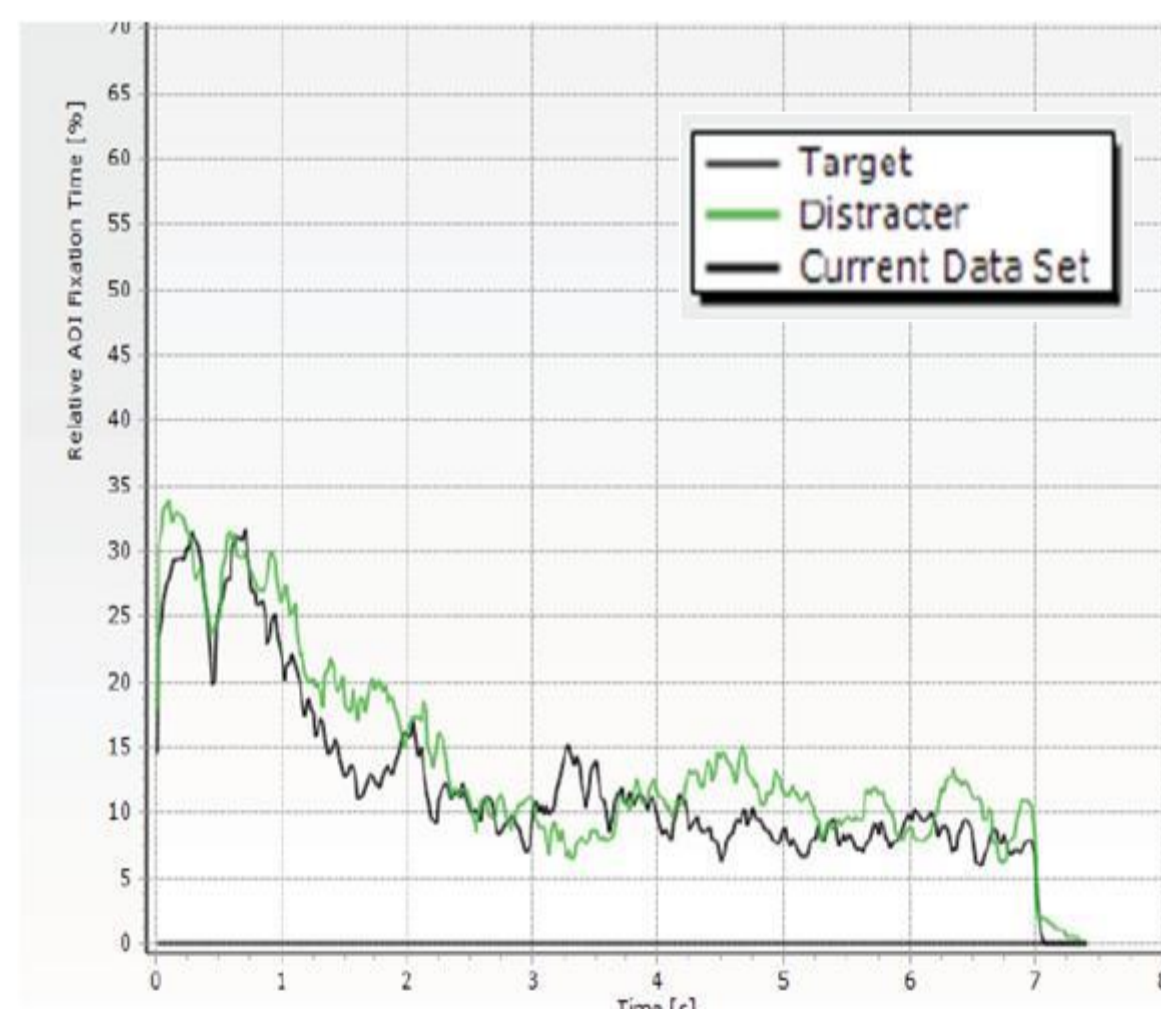


Figure 4: Proportional looking at the target vs distracter side in test trials

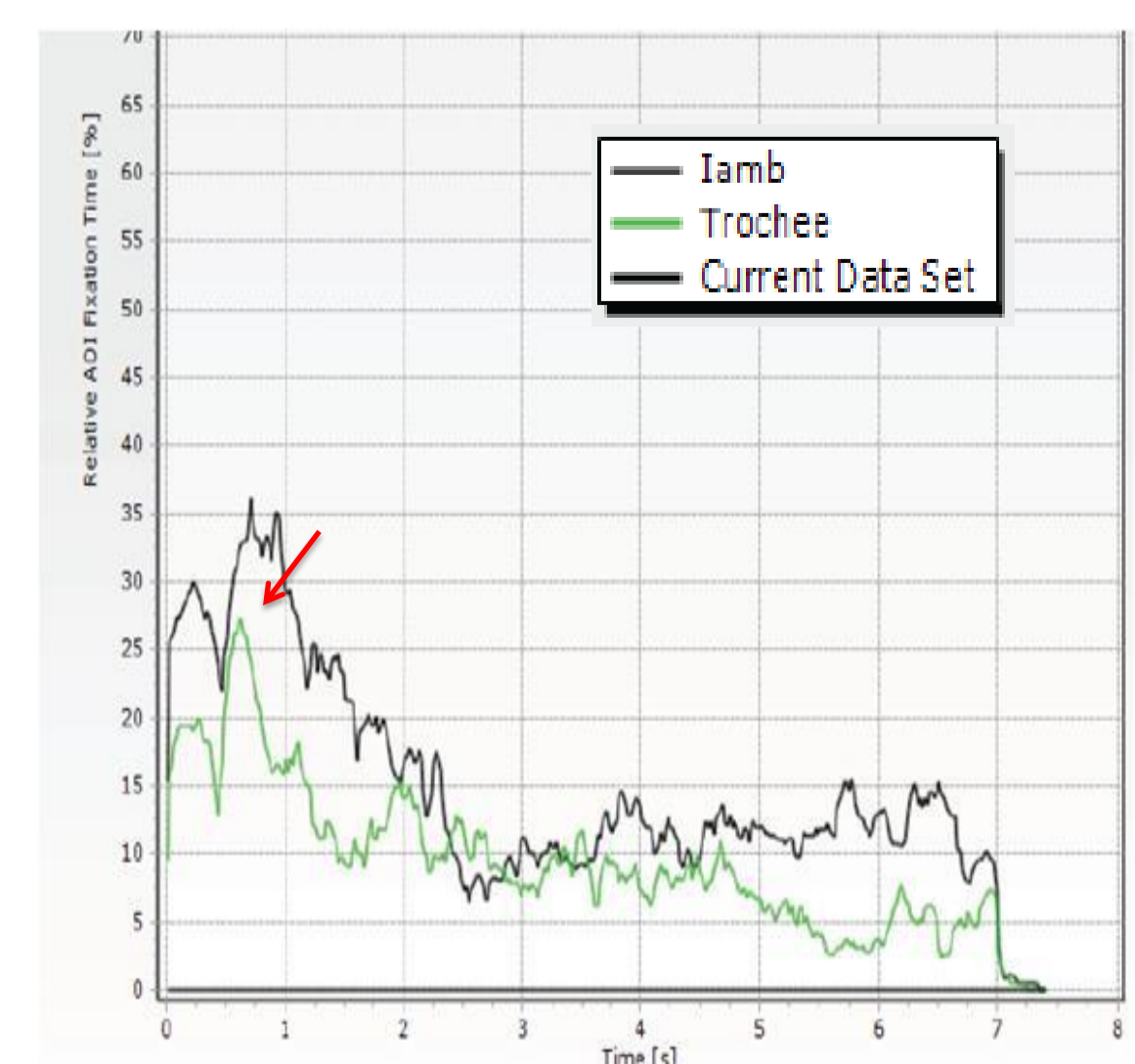


Figure 5: Proportional looking at the iambic vs Trochaic trained sides in test trials

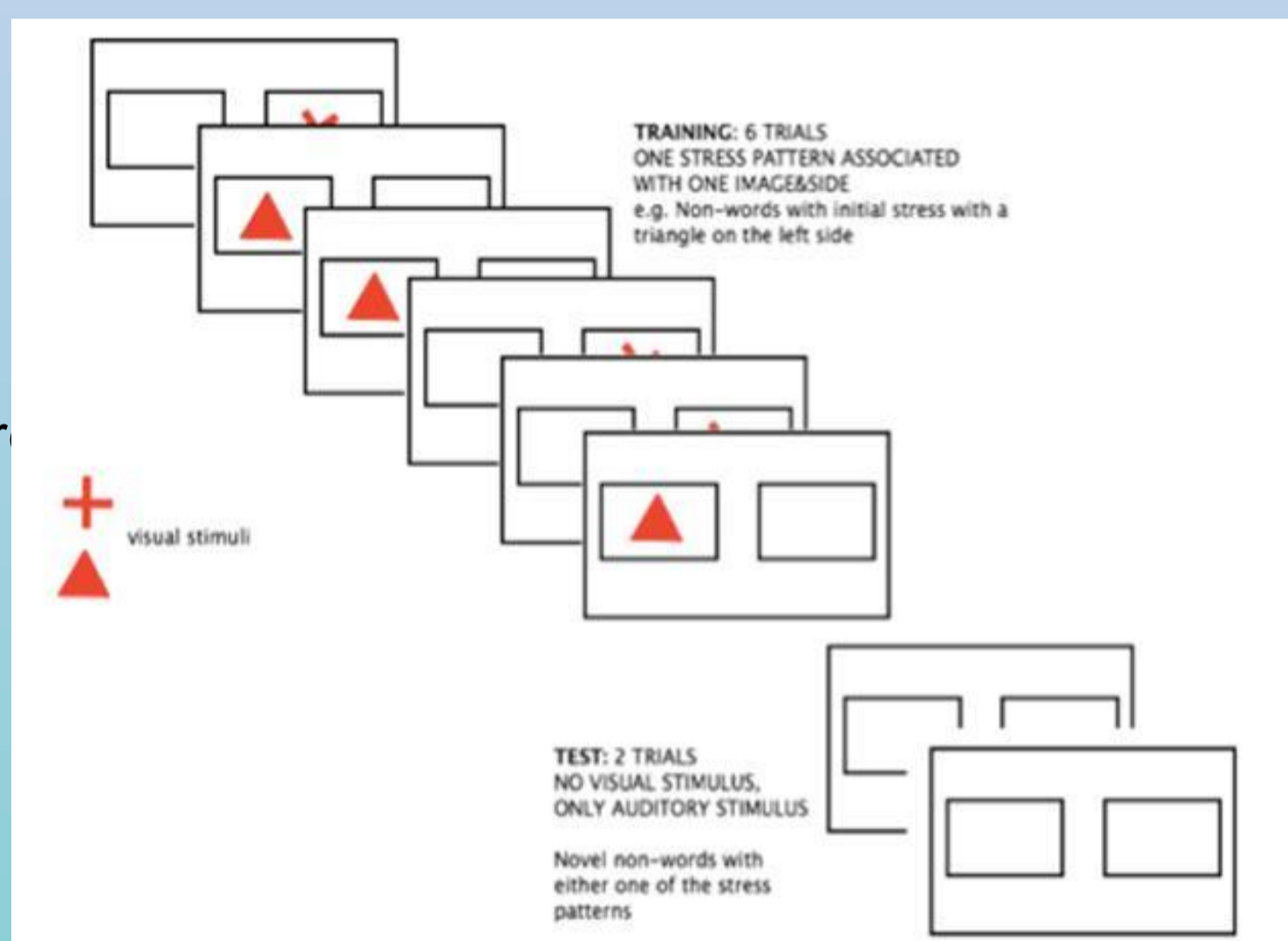
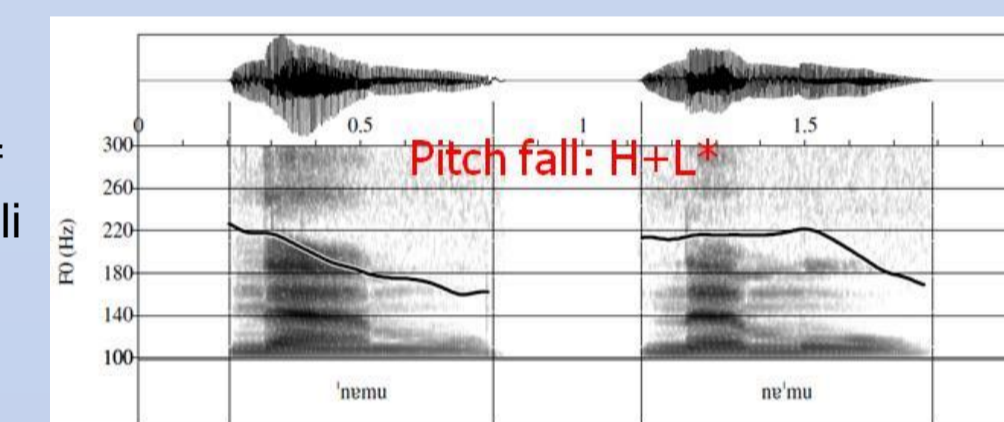


Figure 3: Structure of an experimental block

Figure 1: Location of the pitch fall in stimuli



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

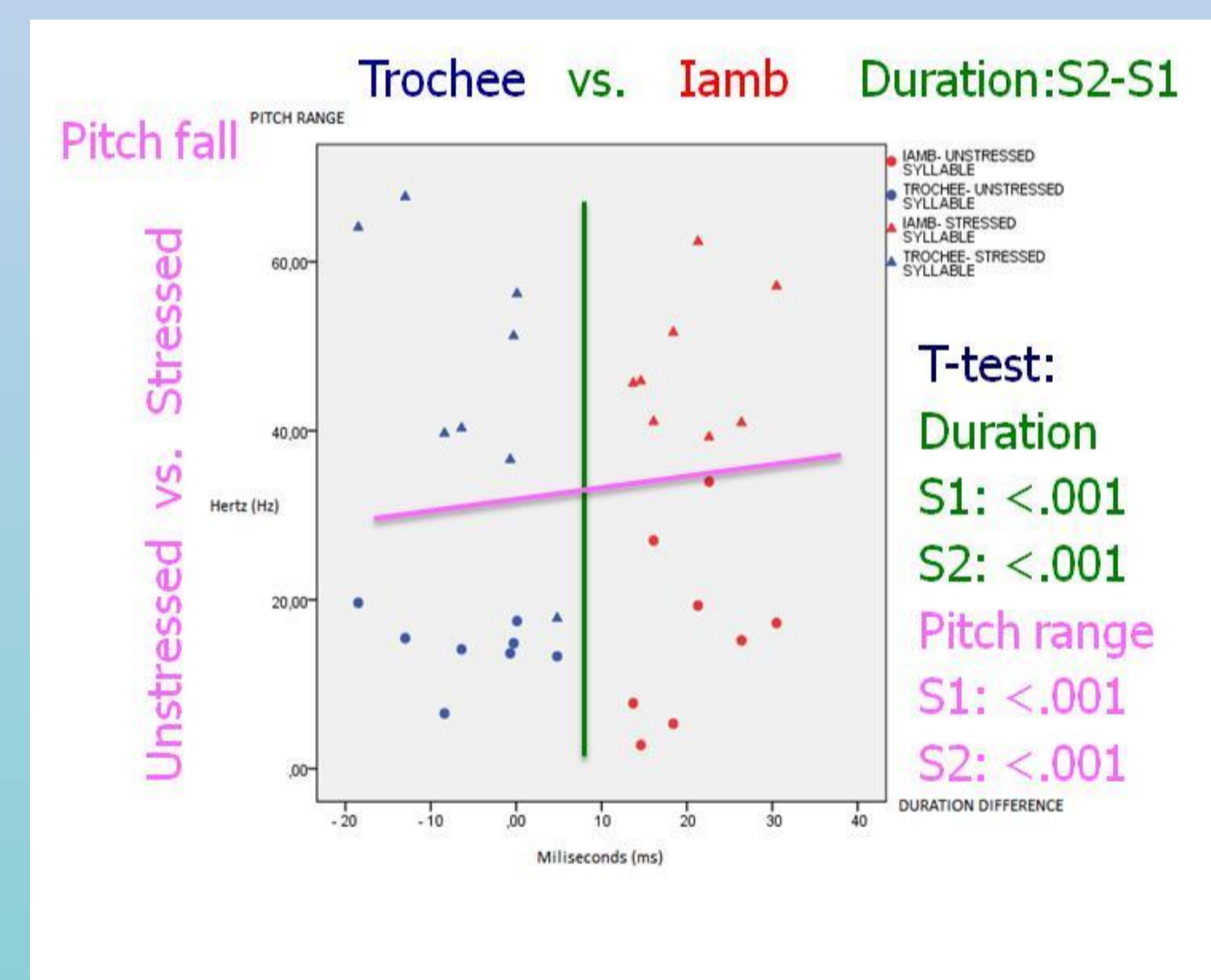


Figure 2: Duration and pitch range information for the stimuli

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).

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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