Revisiting Stress "Deafness" in European Portuguese – An ERP study

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Introduction

- Lexical stress refers to the prominent syllable in a word
  - Fixed stress: stress always falls on a particular position
    - E.g., Finnish, Polish, Turkish
  - Variable stress: the position of stress in a word is not predictable
    - E.g., English, Spanish, German
    - Processing of word stress is particularly relevant in such languages
      - Minimal pairs that only differ in stress pattern (e.g., insight /ˈɪnsaɪt/ vs. incite/ ɪnˈsaɪt/ in English)
  - Speakers of languages with variable stress are **better** than speakers of languages with fixed stress in distinguishing non-words that differ only in stress pattern (e.g., Domahs et al., 2012; Dupoux et al., 1997, 2001, 2008; Peperkamp et al., 2010; Rahmani et a. 2015)

Introduction

- Lexical stress is signaled by phonetic cues:
  - E.g., Duration, F0, intensity, vowel quality
  - Languages differ in the weighing of phonetic cues
    - English: F0 contour > intensity, duration, vowel quality (Beckman, 1986; Fry, 1958)
    - Catalan: duration, spectral balance, vowel quality (Astruc & Prieto, 2006)
  - The absence of certain cues may influence listeners' perception of stress

Introduction

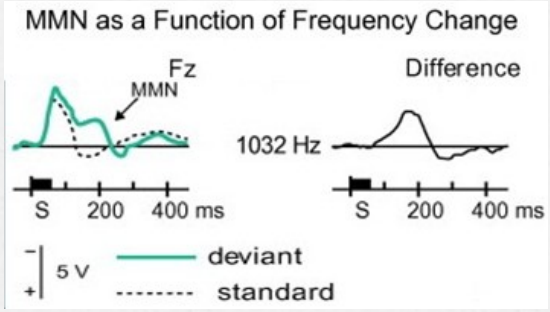
- European Portuguese (EP): Variable stress
  - **Vowel reduction:** primary cue
    - Behavioral studies (ABX, Sequence Recall Task): without vowel reduction cues → ***stress "deafness" effect*** similar to that found for languages with fixed stress (Correia et al., 2015)
  - **Duration:** main prosodic cue (Delgado-Martins, 1977; Andrade & Viana, 1989) in the absence of vowel reduction
    - But not sufficient for the processing of stress contrasts
  - **Pitch:** low correlate of stress, given sparse distribution of pitch accents (Frota, 2014)
  - **Frequency asymmetry: Trochee > iamb** (Types - Vigário et al. 2010)
  - No previous study has been conducted to examine the **unintentional processing of stress** by native EP speakers

The Current study

- Research questions:
  - Can native speakers of EP unintentionally discriminate stress in the absence of vowel reduction?
    - Previous research suggested that discrimination may occur at the unintentional level, but not at the intentional/ behavioral level (Tremblay et al., 1998)
  - Will native speakers of EP show asymmetric effects to the two stress patterns in EP?
    - Frequency based on type – advantage for trochee

The Current study

- ERP experiment: passive oddball paradigm
  - Two ERP components:
    - Mismatch Negativity (MMN): negative wave elicited by auditory stimuli that are infrequently presented and deviate from a frequently presented standard stimuli : X X X X **Y** X X X (Näätänen et al., 2004)



    - Late negativity: negative wave that occurs around 350-600ms after the onset of deviant stimuli; has been associated with neural processes of auditory rule extraction (Zachau et al. 2005)

Methods

- Participants
  - 24 native speakers of EP (6 males, 18 females)
  - Between the ages of 18-32 (M=21.92, SD=3.97)
  - Right-handed according to the Edinburgh Handedness inventory
  - Normal vision and hearing
  - No history of speech or neurological impairment

Methods

- Stimuli
  - Disyllables [bubu] with either a trochaic or an iambic stress in the absence of vowel reduction
  - Each of the stress patterns was produced twice by a female native speaker of EP [ˈbubu]1, [ˈbubu]2, [buˈbu]1, and [buˈbu]2
  - Mean durations: trochaic tokens – 872ms iambic tokens – 873ms
  - The first 100 millisecond of [ˈbubu]1, [ˈbubu]2, and [buˈbu]2 were replaced by the first 100 millisecond of [buˈbu]1, to control the acoustic onset differences.
  - After the manipulation no pitch discontinuity was observed
  - Three native EP speakers who did not participate in the ERP experiment judged all the stimuli as perceptually natural.

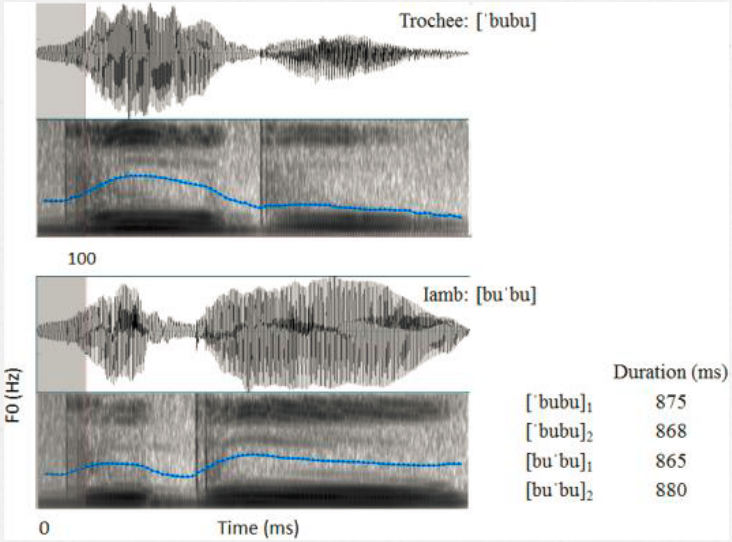


Figure 1: *Spectrograms of the trochaic and iambic stress patterns*

Methods

- Procedure
  - Iambic block: trochaic standards (250 times) vs. iambic deviants (50 times)
  - Trochaic block: iambic standards (250 times） vs. trochaic deviants (50 times)
  - 600 trials (250 x 2 tokens + 50 x 2 tokens)
  - Pseudo-random order, with at least 2 standards preceding each deviant
  - Offset-to-onset inter-stimulus interval randomly varied between 800~850ms

Methods

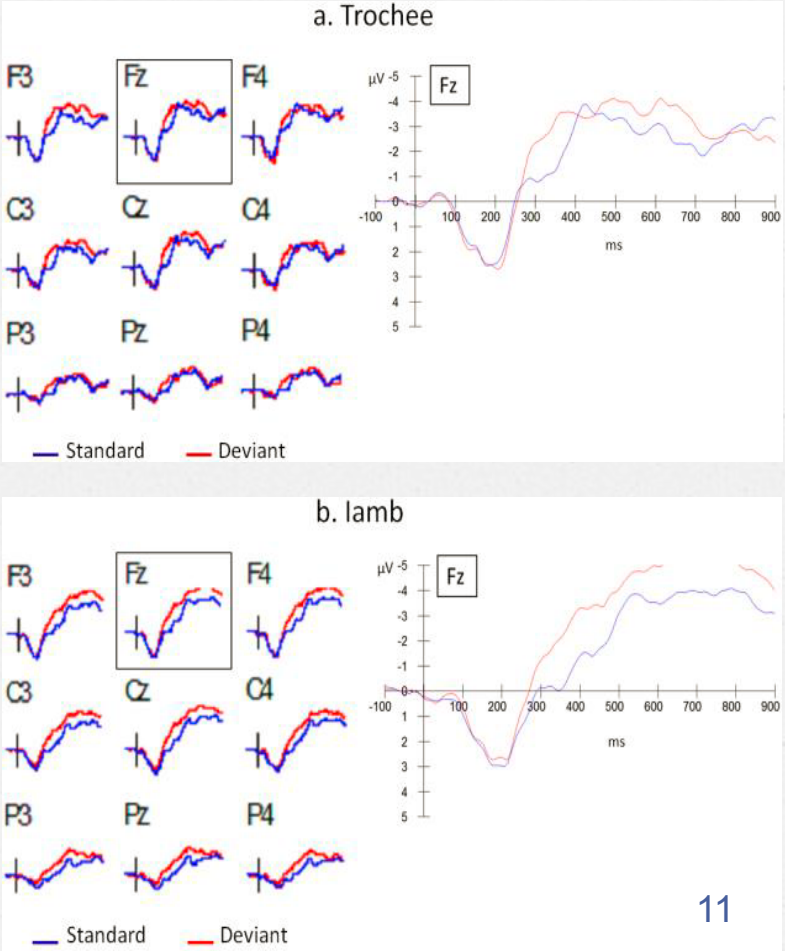
- Procedure
  - Participants were watching a muted movie (*The Gold Rush* by Charlie Chaplin) in a sound-attenuating booth, while the stimuli were presented through a loudspeaker
  - Participants were asked to ignore the sounds and focus on the movie.
    - They received comprehension questions regarding the movie after each block
  - E-Prime 2.0 software was used
  - 29 Ag/AgCl scalp electrodes were recorded (Easy-Cap, SynAmps1, NeuroScan)
  - After EEG data processing, on average 96 trials for each stimulus type were included in data analysis

Results

- Both the Trochaic and Iambic conditions yielded MMN and late negativity

a. Trochee	300-400	400-500	500-600	600-700	700-800	800-900
Disc	***			*		
Ante	***	***	**	**	***	***
Hemi		*	**	*	**	**
Disc × Hemi		*				*
Disc × Ante				*		
Hemi × Group		**	*			
Disc × Hemi × Ante	*	**	**	**	*	
Disc × Hemi × Ante × Group			**	*		
b. Iamb	**300-400**	**400-500**	**500-600**	**600-700**	**700-800**	**800-900**
Disc	***	***	***	***	**	*
Ante	***	***	***	***	***	***
Hemi		*				
Group						*
Disc × Ante					***	**
Hemi × Ante			*	*		*
Hemi × Ante × Group			*	**	**	**

Figure 2: *Grand averages*



Results

- The MMN and late negativity components in the iambic condition span over a larger temporal window than in the trochaic condition:

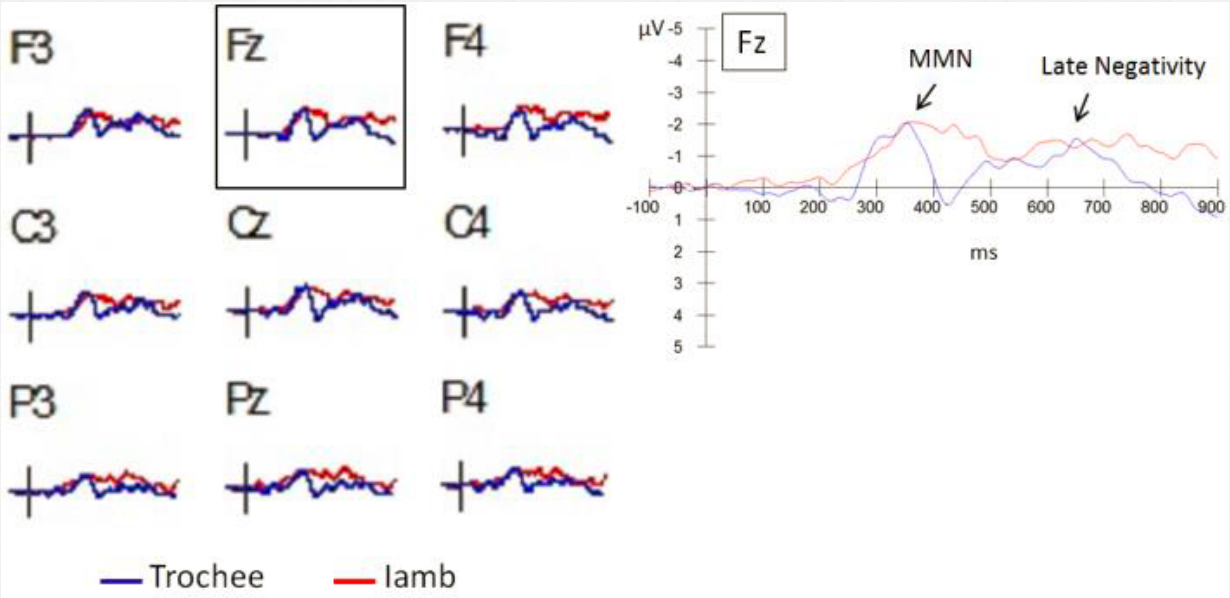


Figure 3: *Grand-average difference waves*

Follow-up: behavioral study

- ABX discrimination task (as in Correia et al., 2015): Goal – replicate previous findings of a ***stress "deafness" effect***
  - Participants
    - 21 native speakers of EP who had participated in the ERP experiment
  - Stimuli
    - 9 pairs of disyllabic nonsense words with trochaic and iambic stress, ***without vowel reduction***, e.g., [ˈmidu], [miˈdu]
  - Procedure
    - A,B were always produced by two female speakers (same or different) and X by a male speaker
    - AB/BA counterbalanced
    - The participant's task is to respond whether X=A or X=B

Follow-up: behavioral study

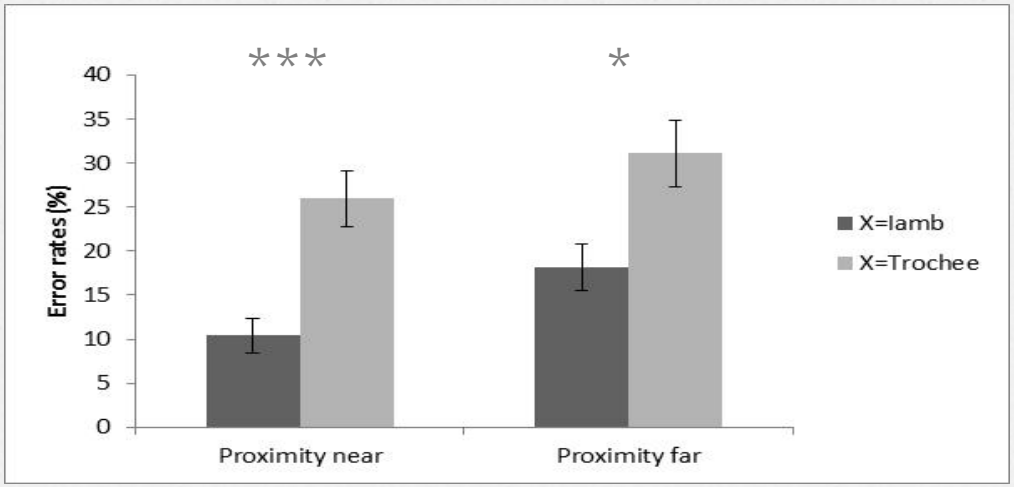
- Results
  - Mean error rate: 21.4%
    - A stress "deafness" effect similar to French (Dupoux et al., 1997)

Stress ABX	French	Spanish	EP
Error rate	19%	4%	21%

  - Replicates the findings from Correia et al. (2015):
    - Same task, different participants
    - EP – 21% error rate (vs. 5% with a phoneme contrast)

Follow-up: behavioral study

- Results
  - A difference was found between Iamb and Trochee
    - Lower error rate when X=Iamb, both when X is the same or different from the preceding stimuli



    - RTs faster when X=Iamb

Discussion

- Can native speakers of EP unintentionally discriminate stress in the absence of vowel reduction?
  - **YES!** Trochaic and iambic conditions yielded MMN and late negativity
  - However, previous behavioral studies demonstrated ***a stress "deafness" effect***; ABX results replicated in the current study
  - Suggests listeners are using some **acoustics-based strategy**, relying on phonetics similarity/difference in the ERP task
  - Results from the ABX tasks (more variation in the stimuli) show that the **acoustic cues are not that robust** in EP (or French, unlike Spanish) > EP listeners have more difficulty, but do not fail
  - Results from the Sequence Recall Task tap into a **more abstract/ phonological representation** (Dupoux et al. 2001; Rahmani et al. 2015) > EP listeners fail (in the presence of prosodic cues only)

Discussion

- Perceptual discrimination may occur at the unintentional level, but not at the intentional/behavioral level
  - Consistent with findings for Polish: Polish speakers are "deaf" to stress manipulations in a behavioral task but show different neural responses towards default stress vs. exceptions (Domahs et al. 2012)
  - Polish is a fixed stress language (penult stress), with well-defined exceptions

- Neural response to stress contrasts even in languages with (some degree of) stress "deafness"

Discussion

- Will native speakers of EP show asymmetric effects to the two stress patterns?
  - YES! They are more sensitive to the **iambic** pattern
  - Arguably contrary to the frequency distribution of stress patterns in EP (type) and previous literature on other languages using EPR
    - E.g. native speakers of Russian are more sensitive to the trochaic stress pattern, which faithfully represents the frequency asymmetries of the stress patterns in the language (Molczanow et al. 2013).
  - But frequency distribution changes if based on token, if monosyllabic words are included with final stress words (Vigário et al. 2010)
  - Some ERP studies show less sensitivity to the most frequent (or default) pattern in the language (Friederici et al. 2007)

Discussion

- Will native speakers of EP show asymmetric effects to the two stress patterns?
  - **YES!** They are more sensitive to the **iambic** pattern
  - Consistent with behavioral results in adult and infant studies
    - Adult studies show lower error rates when X=lamb in the ABX task
    - A study on infants' perception of stress showed that 5-6 month old EP-learning infants prefer the iambic to the trochaic pattern (Butler et al. 2015)

- The current findings
  - Differences in how stress information is encoded in a perception task
  - EP speakers are more sensitive to iambic stress

Thank you !
Obrigada!
谢谢！

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