Revisiting Stress “Deafness” in European Portuguese – An ERP study

Shuang Lu, Susana Correia, Rita Jerónimo, Marina Vigário, Sónia Frota
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 /ˈɪnsaɪt/ 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 al. 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)

- 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: $X \ X \ X \ Y \ X \ X \ X$ (Naätänen 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

O Stimuli

O Disyllables [bubu] with either a trochaic or an iambic stress in the absence of vowel reduction

O Each of the stress patterns was produced twice by a female native speaker of EP [ˈbubu]1, [ˈbubu]2, [buˈbu]1, and [buˈbu]2

O Mean durations: trochaic tokens – 872ms iambic tokens – 873ms

O 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.

O After the manipulation no pitch discontinuity was observed

O 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.

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Figure 2: Grand averages

a. Trochee

b. Iamb
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., [ǐmidu], [miǐdu]

- 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)

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<th>Stress ABX</th>
<th>French</th>
<th>Spanish</th>
<th>EP</th>
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<td>Error rate</td>
<td>19%</td>
<td>4%</td>
<td>21%</td>
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- 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 $X=\text{Iamb}$, both when $X$ is the same or different from the preceding stimuli

RTs faster when $X=\text{Iamb}$
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=iamb 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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