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# A stress "deafness" effect in European Portuguese

# Overview

1. Background: the perception of word stress
2. Goals and hypotheses
3. Experiment 1 – stress discrimination (ABX)
4. Experiment 2 – stress contrast (sequence recall task)
5. Experiment 3 - stress contrast + vowel reduction (sequence recall task)
6. Results
7. Discussion
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# The perception of word stress

- Speakers of languages with non-predictable or variable stress (e.g., English and Spanish) are more proficient than speakers of languages with fixed stress (e.g., French and Polish) at distinguishing nonsense words contrasting in stress location (Dupoux et al. 1997, Dupoux et al. 2001, Peperkamp et al. 2002, Peperkamp et al. 2010)

- The correlates of stress vary from language to language; different combination of stress cues are possible cross-linguistically: suprasegmental (duration, F0 and intensity) and segmental (vowel quality) cues:

  * European Portuguese: duration and vowel reduction (Mateus & Andrade 2000, Delgado-Martins 1977, Castelo, 2004) ≅ English (Fry 1958) ≠ Spanish: duration > F0 > intensity (Navarro-Tomás 1964, Ortega-Llebaria et al. 2010)

# The perception of word stress (cont.)



- Languages that use stress contrastively show various cues (segmental and suprasegmental) to signal word stress – e.g. English - phonetic lengthening/shortening, stress sensitive neutralizations (Hyman, 2012);

- The co-variation between stress and pitch accent also differs cross-linguistically (Hellmuth 2007) - EP: sparse ≠ Spanish, Catalan: dense (Hualde 2002, Vigário & Frota 2003, Ortega-Llebaria et al. 2010);

- Even though pitch accents may be a cue for word stress in some languages, stress may be perceived in the absence of pitch accent, since speakers may rely on other suprasegmental cues, such as duration and/or intensity to detect stress (e.g., Spanish, Catalan – Ortega-Llebaria et al. 2010; English – Fry, 1958), or in segmental cues, such as vowel reduction (e.g., English - Campbell & Beckman 1997);

- Is there a (strict) prosodic-based cross-linguistic perception of word stress? (Ortega-Llebaria et al. 2010)

# Word stress in EP



- Variable, lexically contrastive – e.g. *bambo* ['bɐ̃bu] / *bambu* [bɐ̃'bu]; *crítico*$_{N}$ ['kritiku] / *critico*$_{Vpres.}$ [kri'tiku] / *criticou*$_{Vpast}$ [kriti'ko];

- Duration is the main acoustic correlate (Delgado-Martins 1977, Andrade & Viana 1989); duration differences are shown to be perceived by speakers (Delgado-Martins 1977);

- Low co-variation between stress and pitch accent (sparse pitch accentuation: 17% - Vigário & Frota 2003);

- Systematic vowel reduction in unstressed syllables (Mateus & Andrade 2000, Vigário 2003); segmental cues impact on the identification of stress (Castelo 2004).

# Goals and hypotheses



- Investigate the perception of word stress in EP, a language that allows for the examination of the weight of different factors in perception.

(i) EP has variable stress (= Spanish, English ≠ French) – low error rates, similar to the ones found for other variable stress languages are expected - Dupoux et al. 1997);

(ii) EP is similar to English, Catalan (≠ Spanish) as far as the acoustic correlates for stress are concerned – in the absence of segmental cues (vowel reduction) portuguese speakers may use suprasegmental cues for stress perception (duration);

(iii) EP ≠ Spanish, Catalan in the co-variation between stress and pitch accent – given the low co-variation, post-focus context is not expecteded to have a particular impact on word stress discrimination.

# Three experiments

- Exp. 1 is an ABX discrimination task in which participants are asked to distinguish words contrasting minimally in word stress (Dupoux et al. 1997);

- Exps. 2 and 3 are a sequence recall task (Dupoux et al. 2001, Peperkamp et al. 2010) in which participants are asked to recall the order of a 5-word sequence contrasting minimally in word stress (Exp. 2)/in word stress with vowel reduction (Exp. 3);

- Same method used for studying stress perception in French and Spanish;

# Experiment 1 – ABX discrimination task



Stimuli:

- 15 disyllables and 11 trisyllables contrasting minimally in word stress + 15 disyllables as control condition with phoneme contrast only (C, RV, NRV - e.g.: [ˈdɛsu]/[ˈdɛtu]; [ˈdoku]/[ˈdɔku]; [ˈseɾu]/[ˈsiru]);

- 3 speakers (2 female, 1 male)

A: ['ʃumi] B: [ʃu'mi] - X ['ʃumi]

A: [ˈdɐmitu] B: [dɐˈmitu] – X [ˈdɐmitu]

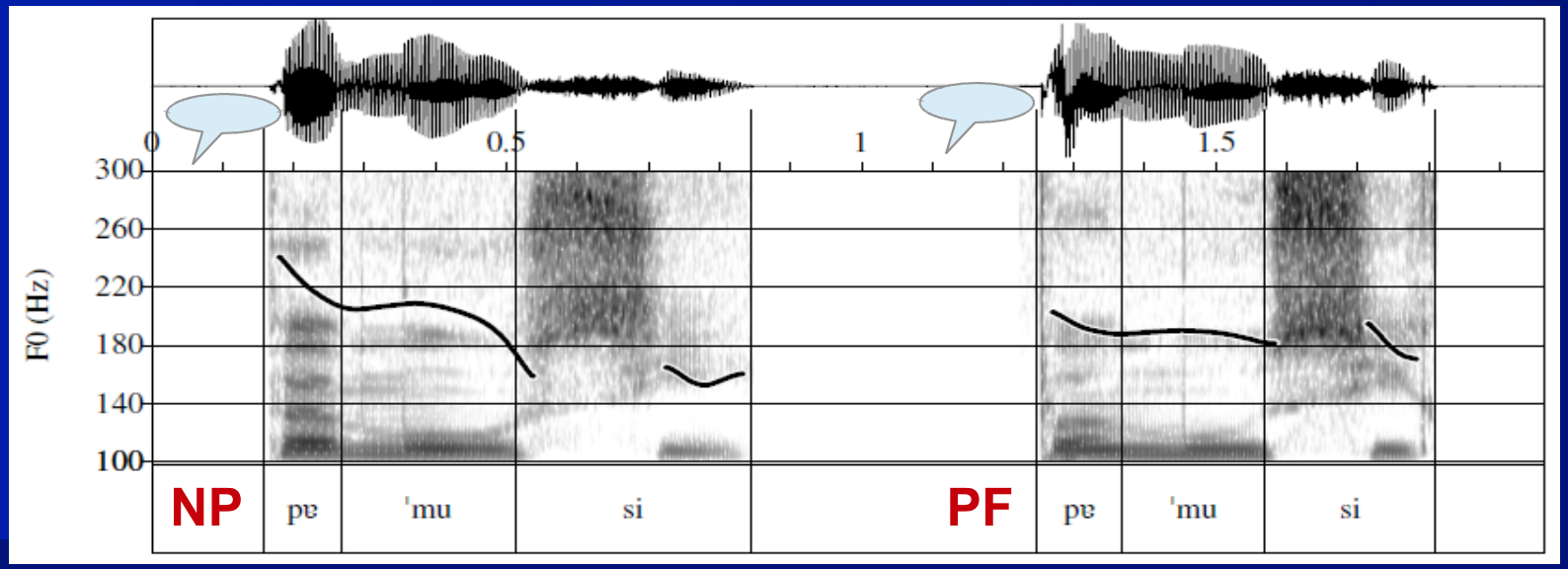
- Absent vowel reduction – e.g.: [ˈmipu]/[miˈpu] (but [ˈdɐmitu]/[dɐˈmitu]/[dɐmiˈtu]).

# Experiment 1 – ABX discrimination task

## 2 conditions:

– stress perception in nuclear position (**NP**) – citation form

– stress perception in post-focus position (**PF**) – target word cut out from carrier sentence




Falling contour (H+L*) was a further cue in NP

# Experiment 1 – ABX discrimination task



## Analysis:

- Acoustic analysis of the stimuli: $F0_{max}$, $F0_{min}$, $F0_{max}$-$F0_{min}$, intensity and duration of all syllables;

- Logistic regression carried out to test which parameter predicts better the stressed syllable:

* NP – in 77,3% of occurrences, the stressed syllable may be predicted by the $F0_{max}$-$F0_{min}$

* PF – in 69% of occurrences, the stressed syllable may be predicted by the duration.

# Experiment 1 – ABX discrimination task



## Analysis:

- order of response (A or B) counter-balanced within-subjects;

- 2 blocks (disyllables + trisyllables) counter-balanced between-subjects + 1 block as a control condition; all blocks started with practice trials.

- 16 subjects in NP condition, and 16 subjects in PF condition;

- responses and reaction times (RT) recorded in SuperLab Pro (v4.5);

- ANOVA for two dependent variables: error rate (ERR) and RT.

# Experiment 1 – ABX discrimination task



Results:

| | SC | | CTR | |
|---|---|---|---|---|
| | ERR | RT | ERR | RT |
| NP | 21%* | 403ms* | 5%* | 321ms* |
| PF | 36%* | 546ms | 13%* | 545ms |

* $p<.05$

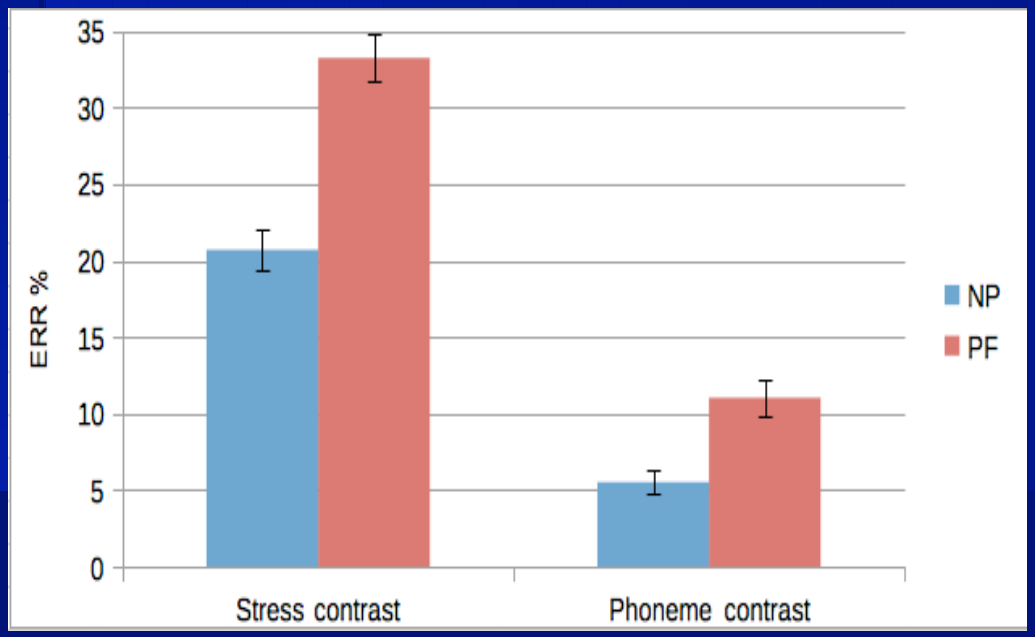
**NP:** The ERR in the stress contrast (SC) condition is significantly higher than in the control (CTR) condition; RT are significantly slower in SC than in CTR;

**PF:** ERR (but not RT) is significantly higher in SC than in CTR.

# Experiment 1 – ABX discrimination task



- ERR were significantly higher in the stress contrast condition than in the phoneme condition (control), both in nuclear (F1(1,14) = 71.07, p < .001, $\eta^2$ = .84; F2(1,98) = 23.8, *p* < .001, $\eta^2$ = .2) and in post-nuclear position ((F1(1,14) = 108.88, p < .001, $\eta^2$ = .89; F2(1,98) = 52, p < .001, $\eta^2$ = .35);




- PF generated sig. more errors overall (F1(1,28) = 8, p < .01, $\eta^2$ = . 22; F2(1,196) = 15.54, p < .001, $\eta^2$ = .07);
- No sig. interaction between stimuli type (stress *vs* phoneme contrast) and position (nuclear *vs* post-nuclear position) (F1(1,30) = 1.77, p = .19, $\eta^2$ = .06; F2(1,196) = 2.12, p = .16, $\eta^2$= .01).

# Experiment 1 – ABX discrimination task

Comparing results, comparing languages...

| Exp. 1 | French | Spanish | EP |
|---|---|---|---|
| Stress | 19% | 4% | 21% |
| Phoneme | 3% | 6% | 5% |

- ERR in EP similar to the one found for French; phoneme contrast similar to the one found for other languages.

- Are EP speakers stress-"deaf"? Unexpected result...

- Further testing with another, more robust, method (next experiment)

# Exp. 2 – sequence recall task

Stimuli:

- 1 pair of nonsense words contrasting minimally in word stress: ['numi] vs. [nu'mi] + control condition with 1 pair of nonsense words with phoneme contrast: ['mupɐ] vs. ['munɐ]

- 2 speakers (1 female, 1 male)

- ['numi] vs. [nu'mi]
- ['mupɐ] vs. ['munɐ]

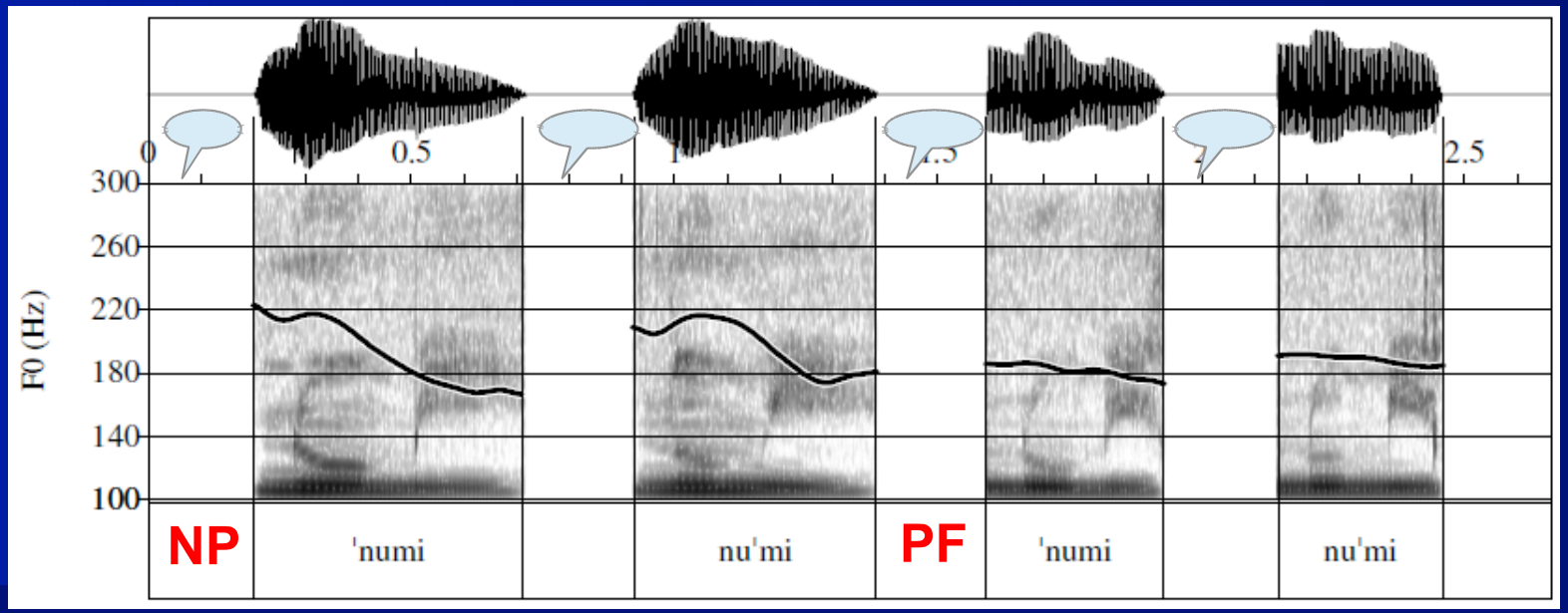
- Absent vowel reduction in the words contrasting in word stress;

# Exp. 2 – sequence recall task

2 conditions:

– stress perception in nuclear position (**NP**) – citation form

– stress perception in post-focus position (**PF**) – target word cut out from carrier sentence




Falling contour (H+L*) was a further cue in NP

# Exp. 2 – sequence recall task

Analysis:

- Acoustic analysis has shown that duration was the main cue to stress both in the NP and in PF.

| | Stressed syll. | Unstressed syll. | Sig. diff. |
|---|---|---|---|
| NP | M=233; SD=28 | M=166; SD=29 | *p*=.000 |
| PF | M=151; SD=22 | M=129; SD=16 | *p*=.000 |

Duration

| | Stressed syll. | Unstressed syll. | Sig. diff. |
|---|---|---|---|
| NP | M=10.29; SD=6.05 | M=5.03; SD=4.87 | *p*=.09 |
| PF | M=3.68; SD=2.15 | M=3.83; SD=1.98 | *p*=.87 |

$F0_{Max}$ -$F0_{Min}$

# Exp. 2 – sequence recall task

Part 1: participants tested for phoneme contrast;

Part 2: participants tested for stress contrast.

Training phase: learning by means of the association of keys [1] and [2] to two words (['mupɐ]/['munɐ] or ['numi]/[nu'mi]) + warm-up set of trials (4 sequences of two of the newly learned words - with feedback).

Test phase: participants listened to 20 sequences composed of 5 tokens each, followed by the word 'OK'. Participants should recall the order in which the two words appeared in the 5-token sequence. Only 100% correct transcription of the 5-word sequence was coded as correct; Responses that were 100% incorrect = *reversals*. Participants with more *reversals* than correct responses in either the phonemic or the stress contrast condition were not included.

e.g., [ˈnumi]-[nuˈmi]-[nuˈmi]-[ˈnumi]-[nuˈmi] OK! - 12212

# Exp. 2 – sequence recall task

- 2 blocks = 1 block as a control condition + 1 block for stress contrast (test);

- 12 subjects in NP condition and 12 subjects in PF condition;

- responses were recorded in SuperLab Pro (v4.5)

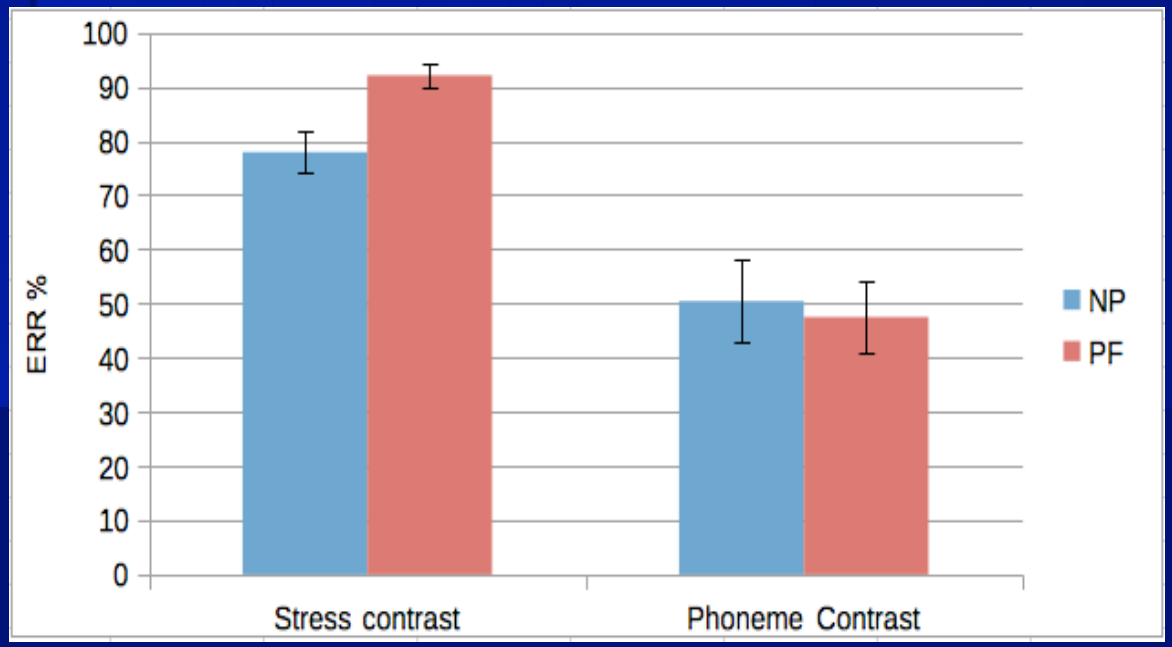
- data subjected to an ANOVA with position (nuclear *vs* post-nuclear) as a between-subject factor and type of contrast (stress *vs* phoneme) as a within-subject factor.

# Exp. 2 – sequence recall task

## Results:

- sig. effect of type of contrast ($F(1,22) = 66.93$, $p < .001$, $\eta^2 = .75$)
- more errors in the stress than in the phoneme contrast;

- marginal interaction between contrast and position ($F(1,22) = 3.76$, $p = .065$, $\eta^2 = .15$), due to the fact that stress, but not phoneme, showed more errors in the PF position;




- no sig. difference between NP and PF for the phoneme contrast ($F(1,23) < 1$), sig. difference between NP and PF for the stress contrast ($F(1,23) = 10.01$, $p < .01$).

# Exp. 2 – sequence recall task

## Comparing results, comparing languages...

| Exp. 1 | French | Spanish | EP |
|---|---|---|---|
| Stress | 78%* | 48%* | 78% |
| Phoneme | 34%* | 56% | 50% |

- Again, ERR in EP is similar to the one found for French; phoneme contrast is similar to the one found for other languages;
- Again, stress "deafness"? Unexpected result...
- Are EP subjects 'stress-deaf'? Or are they stress-deaf to the suprasegmental cues to stress (in this case, evidence against the universal use of such cues for stress perception suggested by Ortega-Llebaria et al. 2010, including languages with vowel reduction, like Catalan)?
- Exp. 3: Is the segmental cue the one that matterns for stress perception in EP?

# Exp. 3 – sequence recall task (SC + VR)

- ≈ Exp. 2
- sequence recall task (≈Dupoux et al. 2001, Peperkamp et al. 2010) with nonsense words contrasting in stress with vowel reduction;

['nemi] vs. [nɨ'mi] (vowel reduction incl.)

(/e/ reduces to [ɨ] in unstressed position)

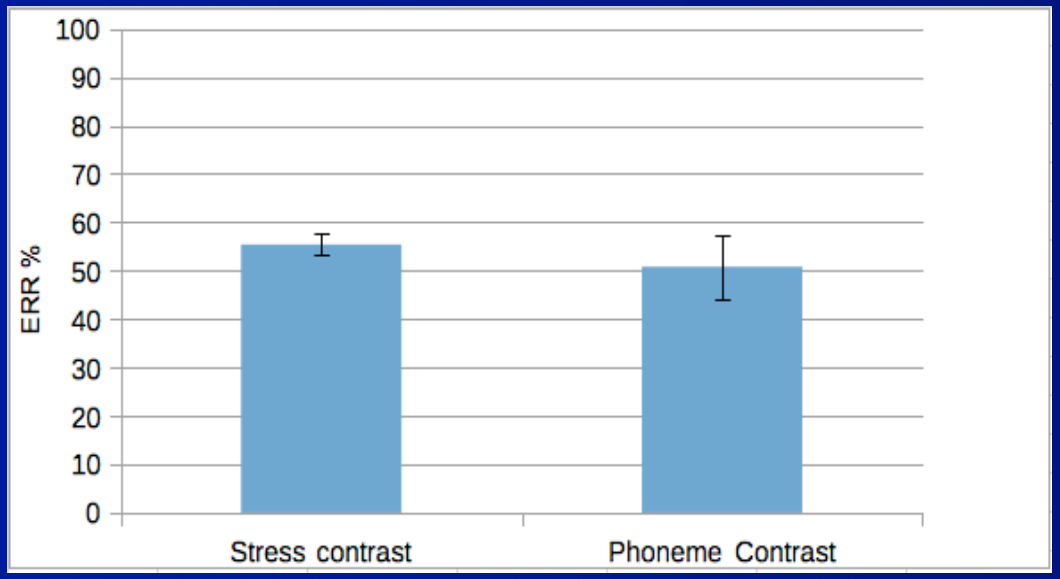
- control condition: phoneme contrast with the same stress pattern (= exp. 2 - ['mupɐ]/['munɐ])
- NP only (PF experiment ongoing)
- 12 subjects

e.g., [ˈnemi]-[nɨˈmi]-[nɨˈmi]-[ˈnemi]-[nɨˈmi] OK! - 12212

# Exp. 3 – sequence recall task (SC + VR)

## Results:

- no sig. difference between stress and phoneme contrast conditions ($F(1,11) < 1$);

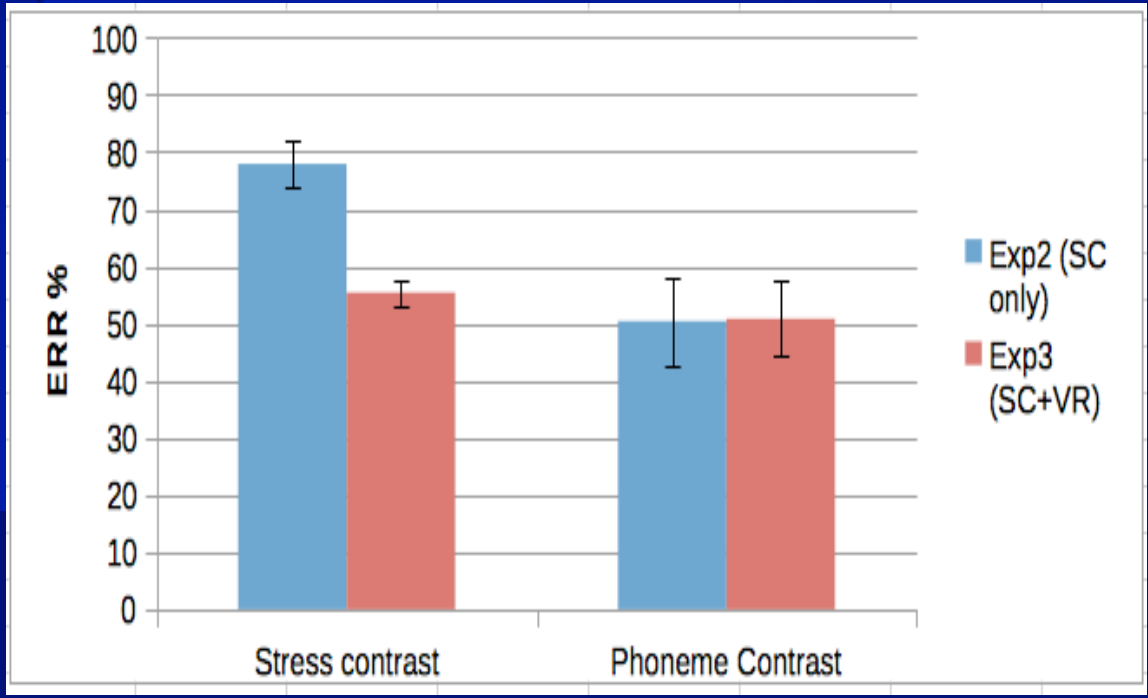



- Vowel reduction enhances the perception of word stress.

# Exp. 3 – sequence recall task (SC + VR)

## Comparing Exp. 2 and 3:

- significant effect of stress contrast ($F(1,22) = 14.31$, $p < .001$, $n^2 = .39$) and a significant interaction between contrast and experiment ($F(1,22) = 7.3$, $p < .05$, $n^2 = .25$)




- stress contrast – sig. difference between experiment ($t(22) = 4.98$, $p < .001$)

- phoneme contrast - no difference between experiments ($t(22) = .04$, $p = .97$)

# General discussion

## Main findings:

### Exp. 1 and 2:

– In the absence of vowel reduction, stress contrasts are difficult to perceive in EP; these results differ from the performance for phoneme contrasts (similar to that found in other languages);

- In the absence of vowel reduction, a stress “deafness” effect is found – suprasegmental cues (duration, and duration and pitch in the NP condition) are not attended to (unlike results for Catalan – Ortega-Llebaria et al. 2010);

- PF has a impairing effect on discrimination overall - stress and phonemes - in Exp. 2 stress contrast, but not phoneme contrast, was harder in the PF condition, but marginal interaction.

# General discussion

## Main findings:

### Exp. 2 and 3:

– Stress “deafness” w/r to the suprasegmental cues to stress;

- Stress contrasts with vowel reduction are as easily perceived as phoneme contrasts (similar ERR);

Suprasegmental cues are not enough or are discarded for stress perception (contra findings by Delgado-Martins 1977 – different task!)

The crucial cue for stress perception is vowel reduction (in line with Castelo's 2004 findings on stress identification).

# General discussion



- Comparing results cross-linguistically, on the basis of the same method:

| | French | Spanish | EP |
|---|---|---|---|
| Exp. 1 | 19% | 4% | 21% |
| Exp. 2 | 78%* | 48%* | 78% |
| Exp. 3 | -- | -- | 55% |

*Error rates for stress contrast (nuclear position only)*

| | French | Spanish | EP |
|---|---|---|---|
| Exp. 1 | 3% | 6% | 5% |
| Exp. 2 | 34%* | 56% | 50% |
| Exp. 3 | -- | -- | 51% |

*Error rates for phoneme contrast (nuclear position only)*

# General discussion

Going back to the initial goals and hypotheses...

(i) EP has variable stress (= Spanish, English ≠ French) – low error rates similar to the ones found for other variable stress languages were expected - Dupoux et al. 1997);

* BUT ERR in the perception of stress contrasts in EP = French (21% - Dupoux et al. 1997; 78% - Peperkamp et al. 2010)

* ERR in the perception of phoneme contrasts in EP = ERR in the perception of stress contrasts in Spanish (≈4% - Dupoux et al. 1997; ≈50% - Peperkamp et al. 2010)

In the absence of vowel reduction, EP speakers show a stress "*deafness*" effect similar to that reported for fixed stress languages

# General discussion

(ii) EP is similar to English and Catalan (≠ Spanish) as far as the acoustic correlates for stress are concerned – in the absence of segmental cues (vowel reduction) portuguese speakers may use suprasegmental cues for stress perception (namely duration)

* Results show that suprasegmental cues (duration and F0) are not enough or are not attended to in stress perception.

* The results from exp. 1 and 2 show that the PF condition makes stress discrimination harder *in general*.

# General discussion

- Contrary to Catalan, a language with vowel reduction and whose speakers mostly rely on duration to detect word stress (in the absence of pitch accent – Ortega-Llebaria et al. 2010), EP speakers perceive word stress relying on segmental information (≈ Castelo, 2004);

- Vowel reduction appears to be the most robust cue for stress perception; EP speakers seem to neglect suprasegmental information - only in exp. 2 and in a highly demanding task there is a marginal effect of nuclear pitch accent);

# General discussion

(iii) EP ≠ Spanish, Catalan in the co-variation between stress and pitch accent – given the low co-variation, the post-focus context is not expected to have a particular impact on word stress discrimination.

* in EP, F0 has a very weak effect on stress perception (only a small effect in exp. 2, increasing in the ERR rate) → duration alone is not enough to detect stress, but duration *and* pitch are also not enough.

# Concluding remarks

- Word stress perception in EP does not seem to be based on suprasegmental/prosodic information (F0 or duration);
- In NP and in the absence of segmental cues, EP speakers show a stress “deafness” effect similar to the one observed for fixed-stress languages;
- EP results, both in accented and unaccented position, show that suprasegmental properties alone are not enough for stress perception in a language that uses both suprasegmental and vowel quality cues to stress;
- The present findings do not support the claims of prosodic based cross-linguistic perception of stress in the absence of vowel quality cues (Ortega-Llebaria et al. 2010).
- Implications for the understanding of word stress perception across languages and for the acquisition of word stress.

***Muito obrigada!***

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