Default and exceptional stress processing in Spanish as a testing ground for generative versus exemplar-based phonology models

evidence from ERPs

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Approaches to lexical storage

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1. Generativist models

- only unpredictable information that cannot be derived by rules is stored in the UR
- non-contrastive data and phonetic detail redundant for the processing of a given word are excluded
- by extension, predictable stress markers are excluded from the lexicon

Approaches to lexical storage

2. Usage-based models

- the theory of exemplars (Bybee, 2001, 2006): focus on the effects of frequency and other external factors on sound production and perception
- abandons fully abstract, phonemic representations of words or morphemes
- gradient, lexically diffuse differences in pronunciation are all stored in the mental lexicon as they are
- by extension, stress cannot be a derived or abstract category it is a bundle of acoustic and auditory features stored with each word represented in the exemplar cloud

Aim of the experiment

Put the two approaches to the test

Focus of the experiment

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- over 64% (78.9%) of all Spanish words are stressed on the penultimate syllable (Morales-Front 2014, Quilis 1981)
- antepenults constitute merely 8% (or 2.76%): exceptional
- so: default penult pattern derivable by rules, with lexical exceptions

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Is the exceptional stress stored to facilitate word retrieval, as opposed to the default?

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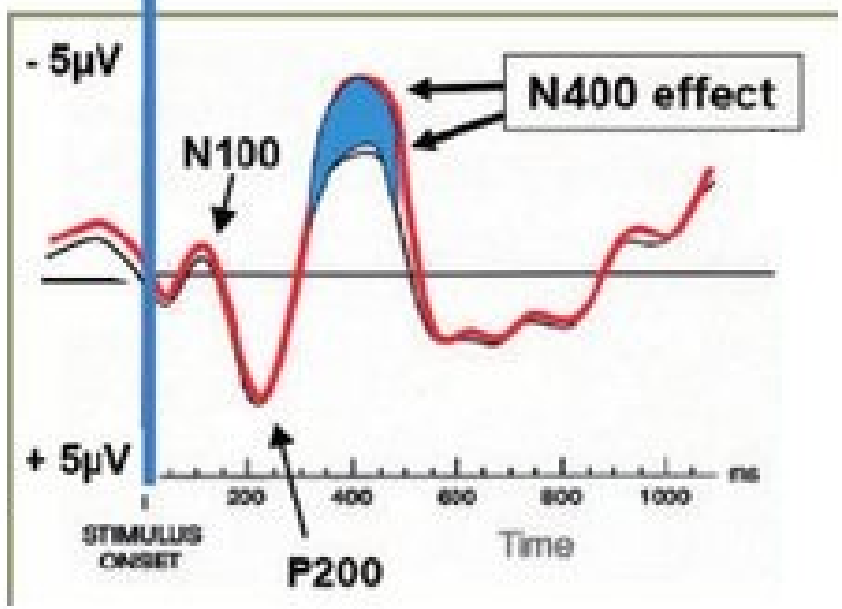
3. **A paradigm evoking the N400 negativity effect**

John ate broccoli at dinner.
John ate democracy at dinner.



Stress perception studies using EEG

Knaus et al. (2007). The processing of word stress: EEG studies on task-related components.

Domahs et al. (2012). Stress 'deafness' in a language with fixed word stress: an ERP study on Polish.

Domahs et al. (2013). Processing (un)predictable word stress: ERP evidence from Turkish.

Molczanow et al. (2013). The lexical representation of word stress in Russian: Evidence from event-related potentials.

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- controlled for phonological neighbourhood

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e) Words which have a phonological neighbour with the other stress pattern under investigation were excluded.

Stimuli

4 conditions:

seMAna (PUs – standard)

PAjaro (APUs – standard)

SEmana (PUd – deviant)

paJAro (APUd – deviant)

Stimuli

Pedro pronunció la palabra [target word] *otra vez*

Pablo pronunció la palabra [target word] *otra vez*

Dani pronunció la palabra [target word] *otra vez*

Lupe pronunció la palabra [target word] *otra vez*

Marta pronunció la palabra [target word] *otra vez*

Laura pronunció la palabra [target word] *otra vez*

Sonia pronunció la palabra [target word] *otra vez*

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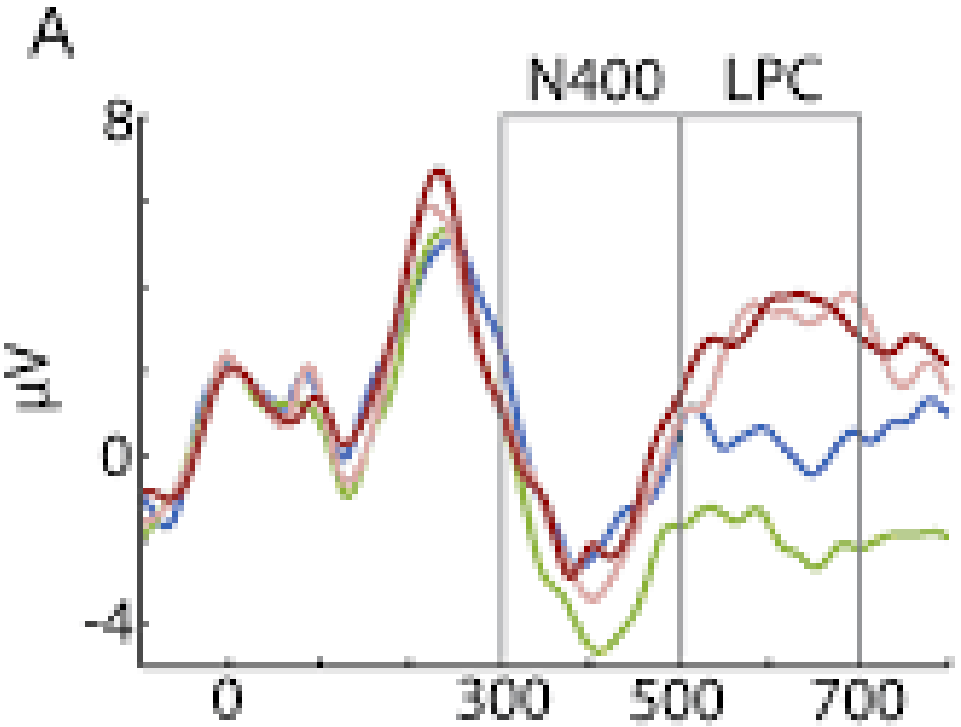
A
N400
LPC
8
0
-4
μV
0
300
500
700

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  difficulty with antepenults but not penults supports
  the generative view

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APUd condition is especially difficult and caused most errors in stress correctness detection

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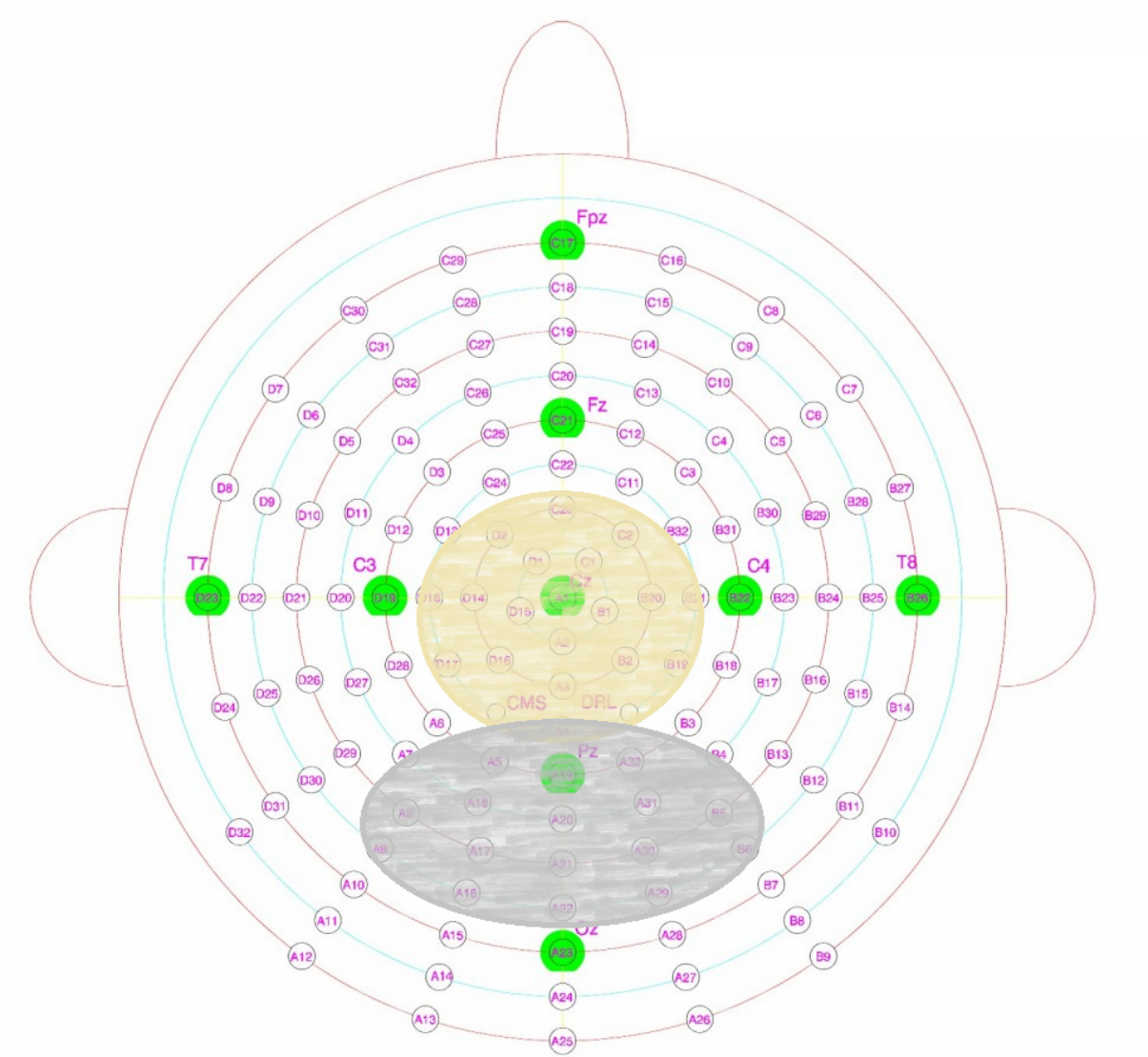
RT results match those of accuracy scores

EEG results: Regions of interest (ROIs)



EEG results: Grand averages

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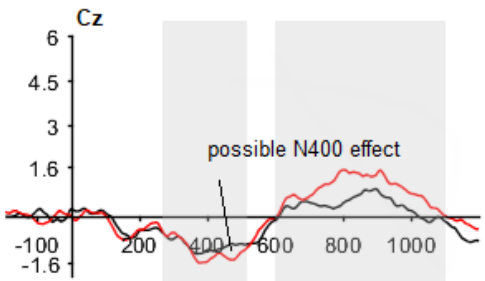

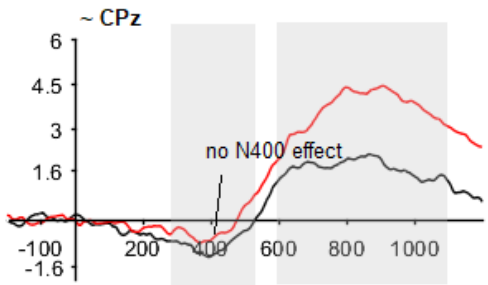

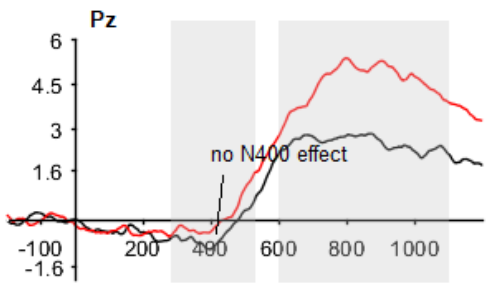

correctly stressed penults followed by correct response

incorrectly stressed penults followed by correct response

ANOVA results: no N400 effect was confirmed for the penults ($F(1,26) = 1.562$, $p = 0.222$). The hypothetical effect in the Cz electrode region was not confirmed statistically. In other regions, an opposite effect is seen instead: incorrect stress causes a less negative inflection in the 350-600 ms windows than correct stress (cf. antepenults).

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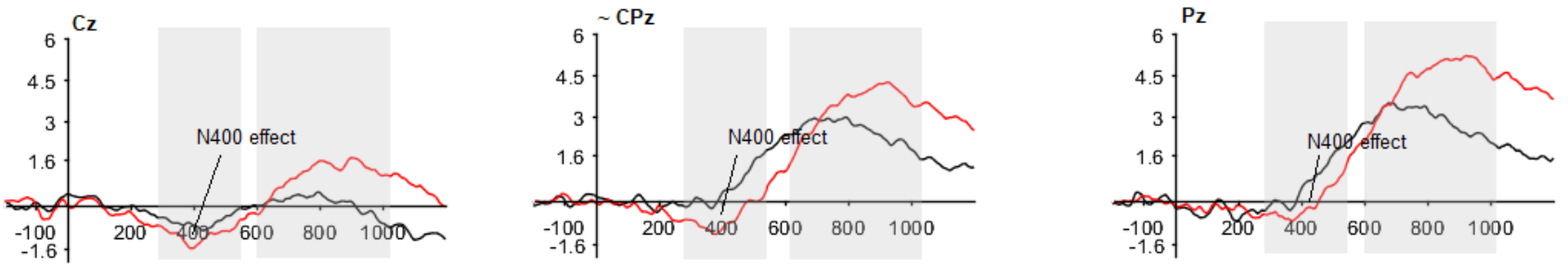

correctly stressed antepenults followed by correct response

incorrectly stressed antepenults followed by correct response

ANOVA results: main effect of condition (correct/incorrect) for the antepenults in the range of 350-600 ms from word onset ($F(1,26) = 20.38$, $p < 0.001$)

Statistical analysis

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APU condition

main effect of condition ($F(1,26) = 20.38$, $p < 0.001$)
main effect of region ($F(1,26) = 30.36$, $p < 0.001$)
no interaction ($F(1,26) = 0.68$, $p = 0.417$)

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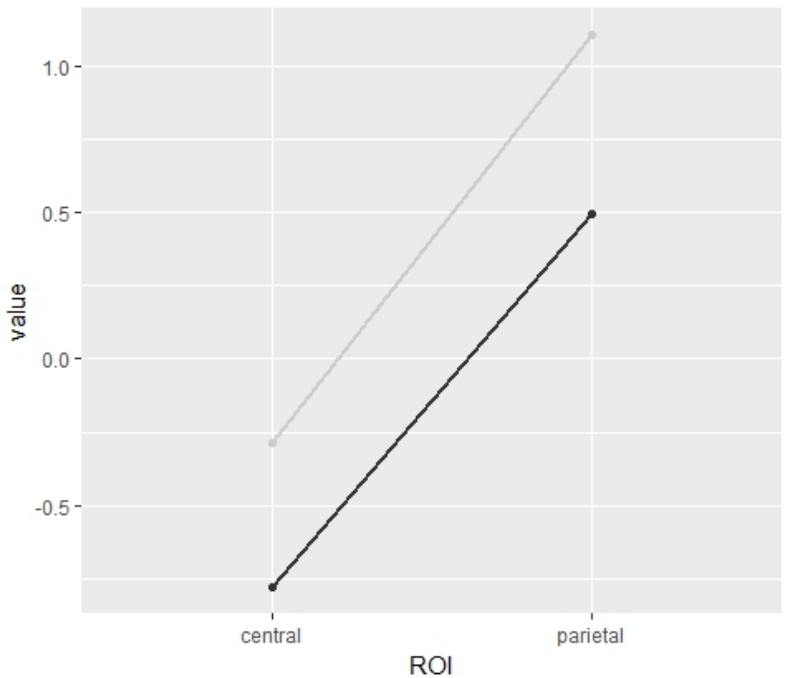
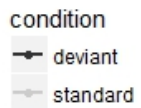
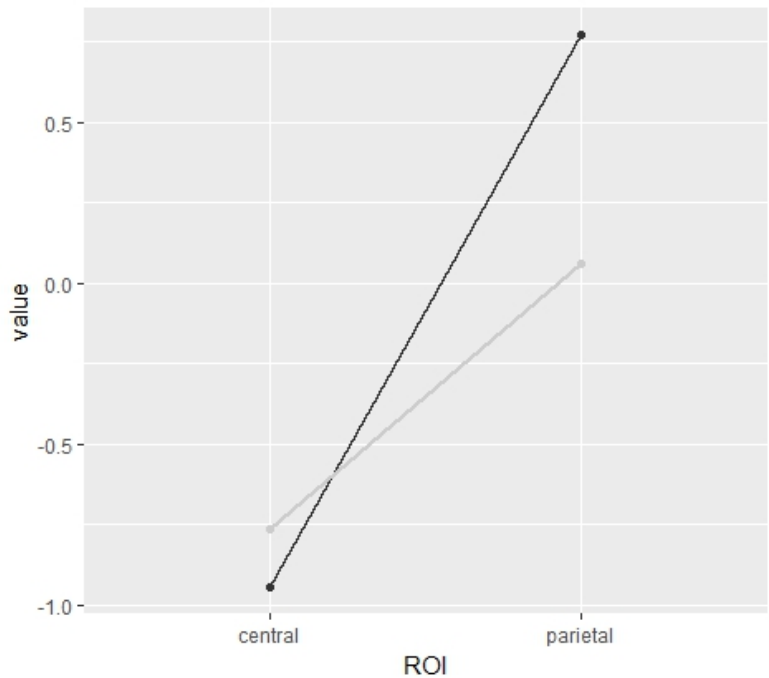
PU condition

no N400 effect ($F(1,26) = 1.562$, $p = 0.222$)
main effect of region ($F(1,26) = 23.63$, $p < 0.001$)
reverse interaction ($F(1,26) = 23.56$, $p < 0.001$)

Interaction plots







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Hypothesis confirmed:

1. Significant difference between penults and antepenults

2. N400 effect only in the case of changes to the exceptional pattern

Results

General ANOVA on the centroparietal data:

– main effect of stress ($F(1,26) = 13.9$, $p < 0.001$)

– interaction between stress and cond ($F(1,26) = 12.88$, $p = 0.001$)

– **no main effect of condition** ($F(1,26) = 1.192$, $p = 0.285$)

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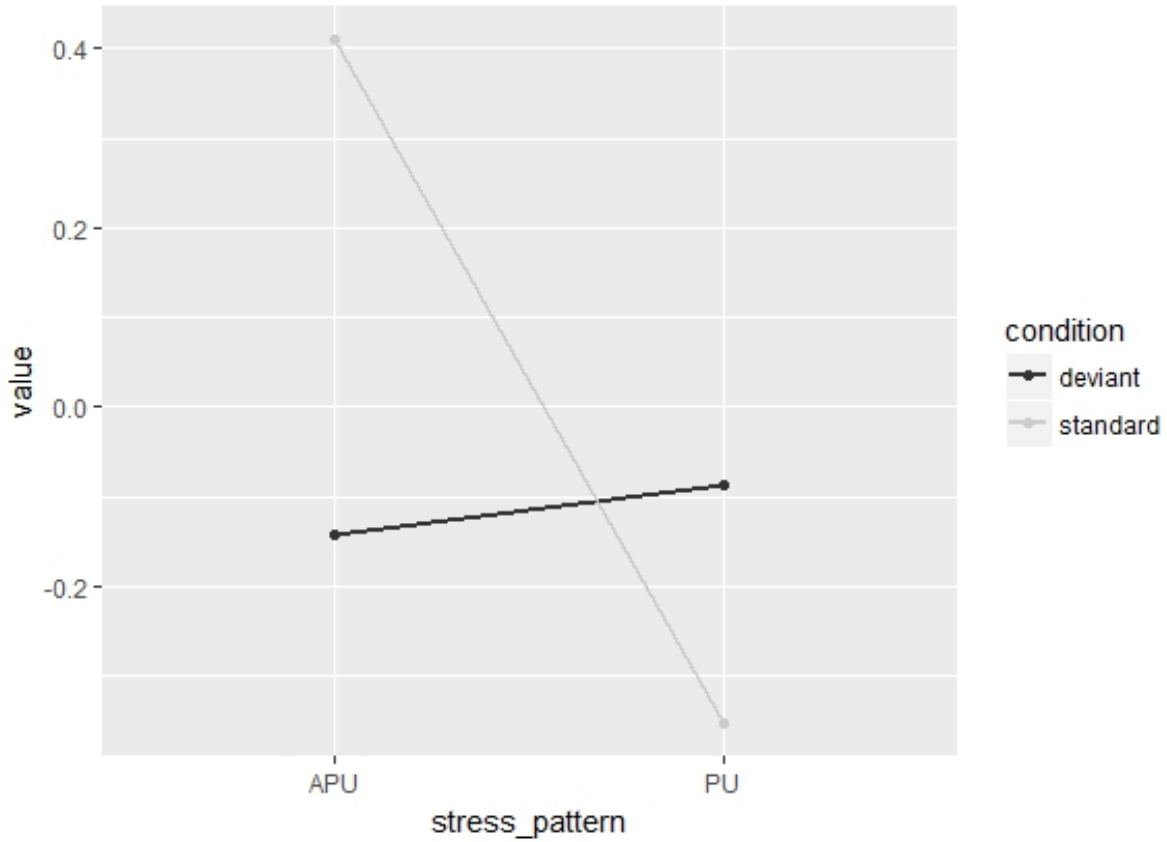
- **stress matters in the standard condition only**
- 'levelling' of the negativity effect between the two stresses

Interaction plot: N400 time window



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APU words:

– mean F0 of the stressed antepenult is 222.9-224.0 Hz
– unstressed syllables have 267.5-264.2 Hz values
– **pitch is quite high at the beginning and steadily rising**
– duration: 187-196 ms in the stressed syllable
– falls to 151-153 ms in the unstressed one

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PU words:
– the second syllable is equally long or shorter than the first (182-193 ms vs. 190-200 ms)
– pitch is rising from 180 Hz to 200 Hz, never as high as in APUs
– **the rise is much greater in APU words (40 Hz)**

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- Human perceptual system cannot distinguish differences in pitch below 3 semitones (12Hz/220Hz, Nooteboom 1997)
- Confirmed by our data: no latency difference in electrophysiological response

LPC results

- significant effect of condition ($F(1,26) = 23.05$, $p < 0.001$)
- no effect of stress ($F(1,26) = 0.125$, $p = 0.726$)
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- **correctness judgment occurs at this stage**
- **prevalence of stress effects in the first TW points to the processing of prosody (stress pattern)**
- **later on the hearer has to decide whether what (s)he heard was correct or incorrect: phonological-semantic integration must have taken place**

Conclusions

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The data **support the generative phonology framework** which assumes that only unpredictable information is stored in the mental lexicon

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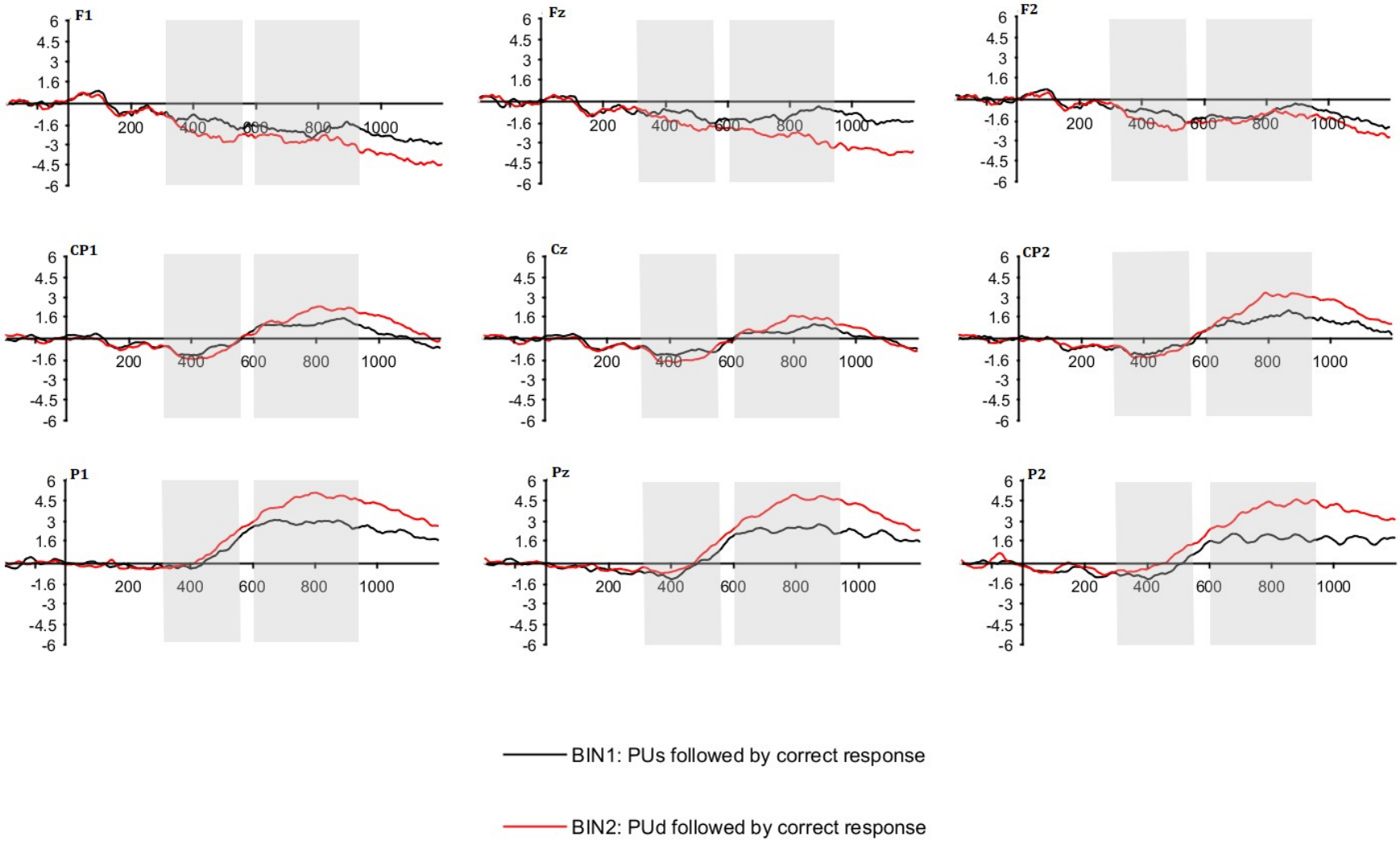
– Hearers respond to stress separately from the meaning of the word
– Bottom-up speech perception approach (Norris et al. 2000)
– Top-down wrap-up, integration of prosody and semantics
– compatible with Poeppel et al.'s (2008) speech perception theory

Thank You!

Slides available at: *www.karolinabros.eu*

EEG results: Grand averages



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