The time course of morphological processing in speech production: an ERP study

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Outline

Introduction

- Present and past tense verb naming in Dutch
- ERP study

Introduction

Key questions:

1. Is the WEAVER model correct in its assumption that there is no competition below the lemma level?
2. How staged is processing?
3. Do we see qualitative processing differences between regular and irregular verbs?

Outline

Methods & materials

- 170 photographs of a young woman enacting verbs
- 4 blocks:
  - **familiarization**: pictures plus infinitives of verbs are shown
  - acoustic: infinitives of verbs are presented acoustically (not analyzed for current purposes)
  - **present tense naming**: participants have to name pictures by completing short phrases: ”Vandaag... [loopt ze].”
  - **past tense naming**: ”Gisteren... [liep ze].”
- Order of present and past tense naming counterbalanced between participants
- 21 participants

Methods & materials

- Example photograph:

Outline

Preprocessing

- Reference electrode: RM
- Downsampling to 125 Hz
- Manual ocular and muscle artifact removal
- Wavelet and GAM denoising

Analysis

- We used generalized additive models, GAMs
- GAMs allow for the modeling of non-linearities in two or more dimensions
- GAMs are almost twice as powerful as classic t-tests
- GAM models look like this:

$$y = X\beta + f_i(x_1, x_2, \ldots, x_n) + \ldots + \varepsilon$$

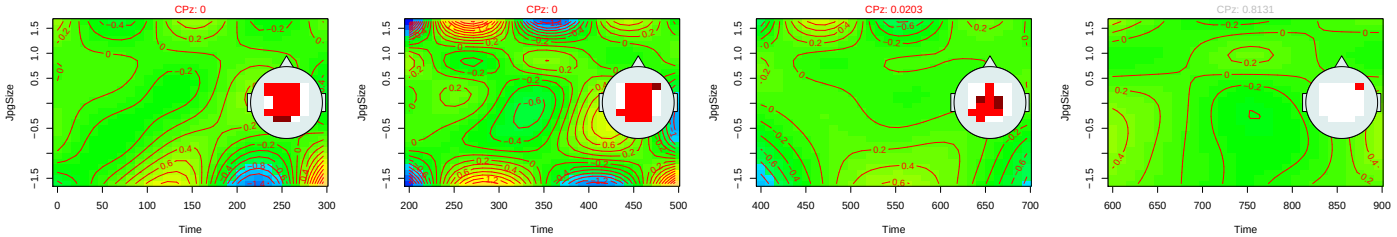
Analysis

- No prior averaging over items or subjects
- Two-step analysis:
  1. Main trends GAM
     - Looks at the main trends of Time, Subject and Item
  2. Hierarchical predictor GAMs
     - Linguistic predictors and their interaction with Regularity (e.g.; Lemma Frequency, N-Count, Family Size, Log Odds) are entered one by one in seperate GAMs
     - Least controversial predictors are entered first

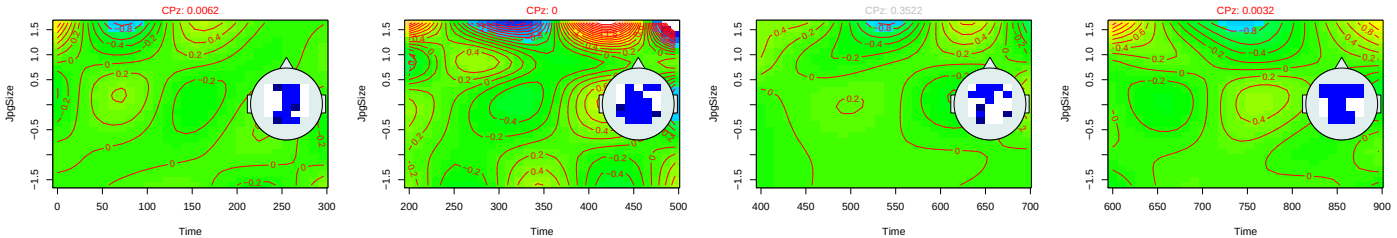
Outline

Example predictor: PictureComplexity

Present tense regulars



Present tense irregulars



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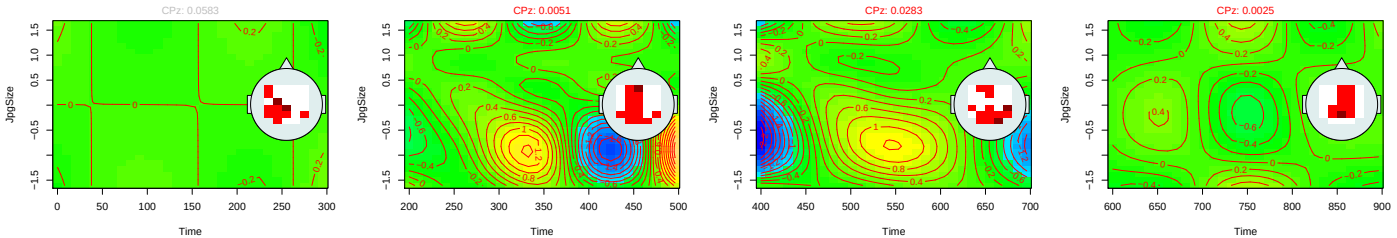

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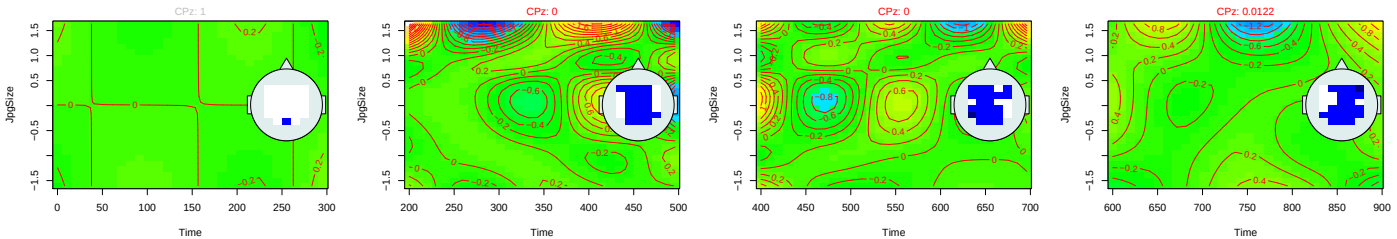


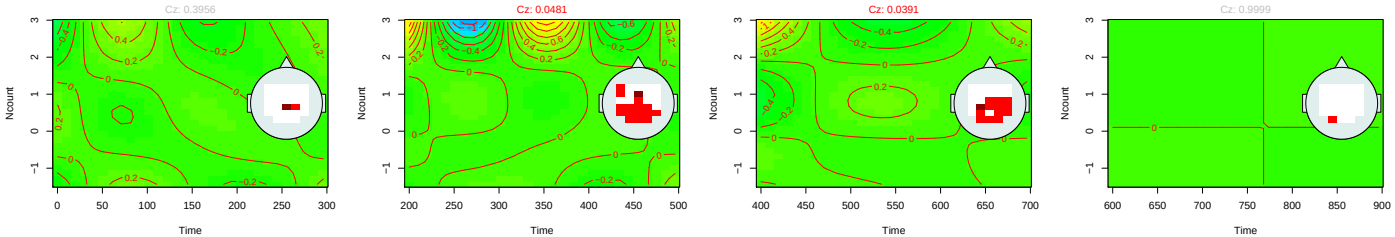
Results: key question 1

- Key question 1: is the WEAVER model correct in its assumption that there is no competition below the lemma level?
- Predictors of interest:
  - N-Count
  - Log Odds (ratio of present and past tense frequencies)

Results: key question 1

N-Count:

Present tense regulars



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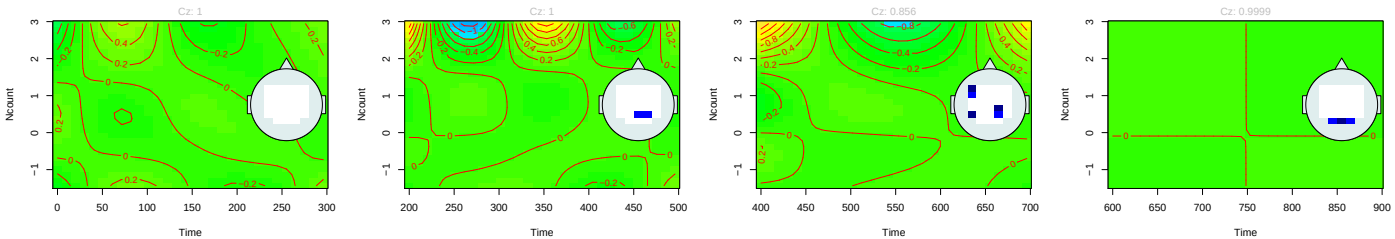

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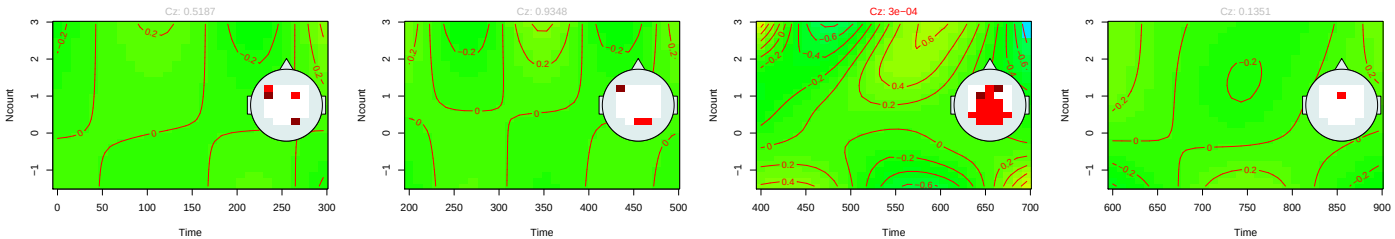

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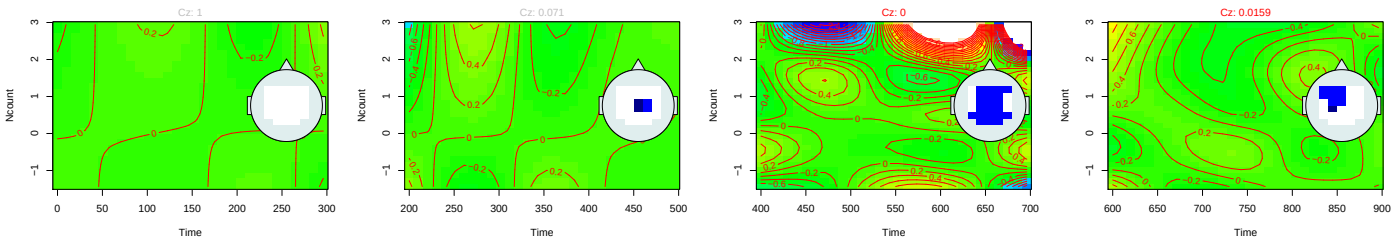
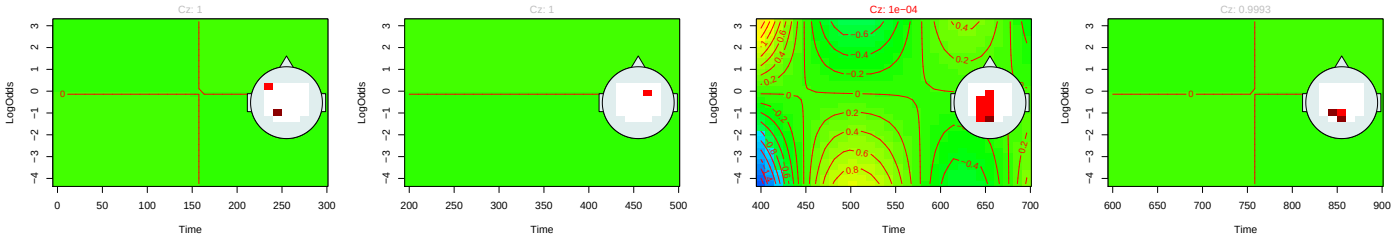


Results: key question 1

Log Odds:

Present tense regulars



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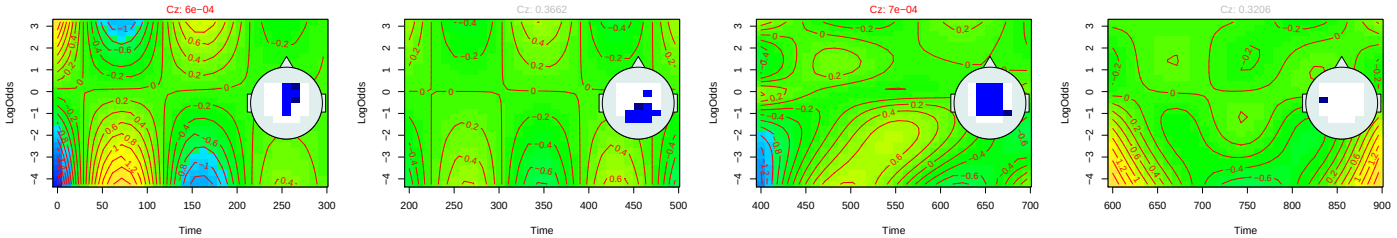

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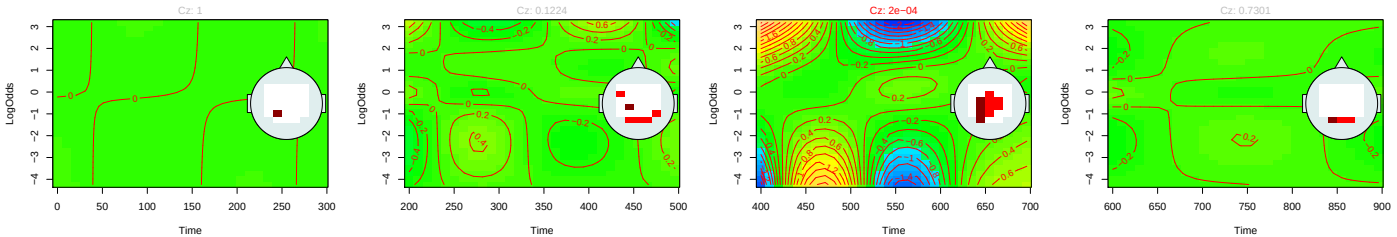

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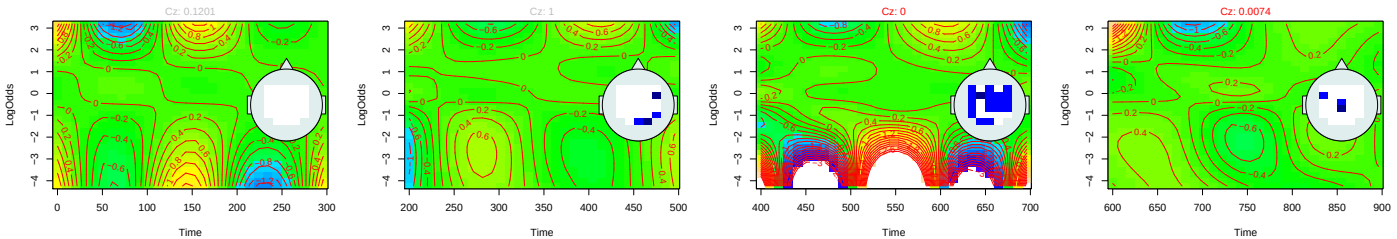


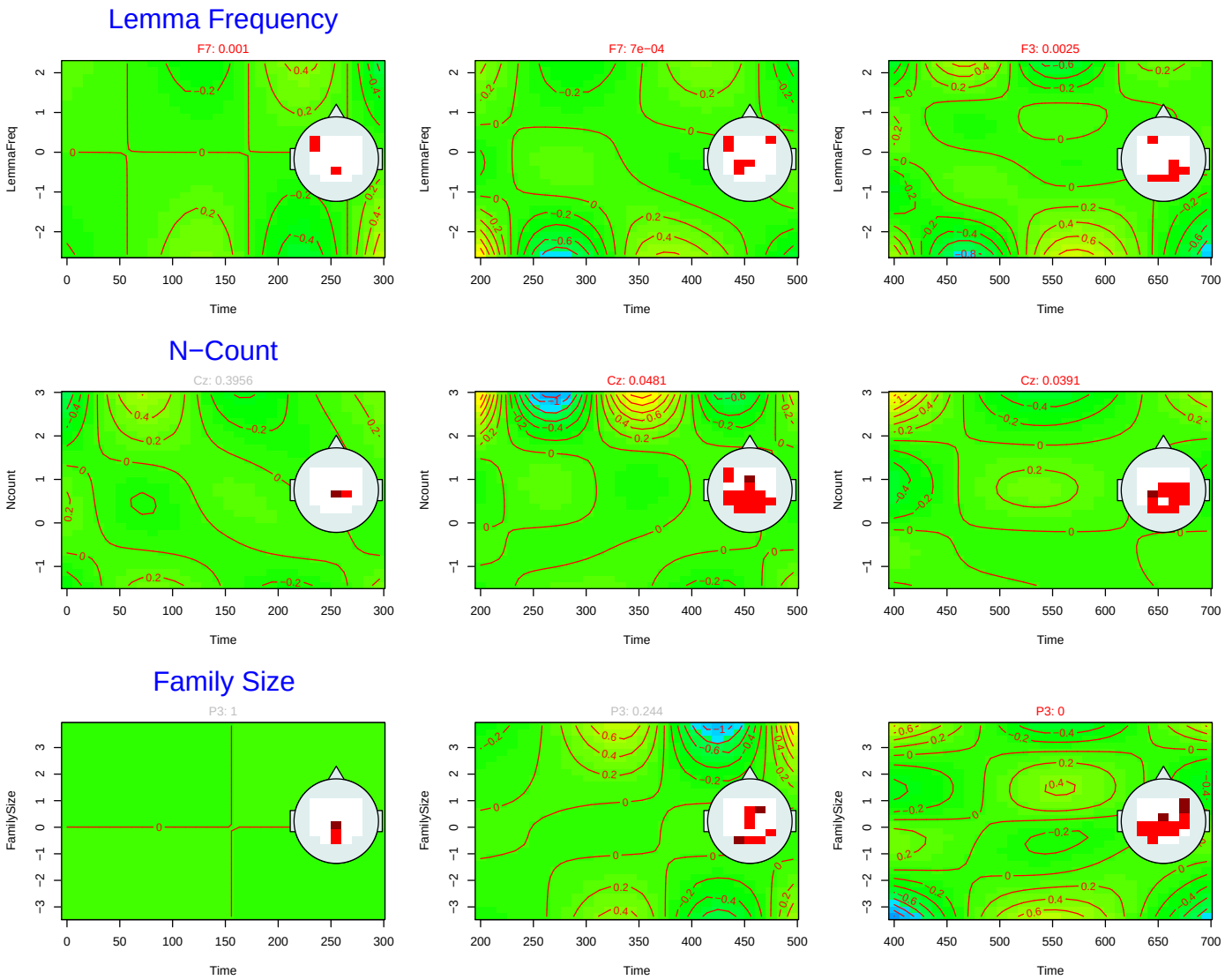
Results: key question 1

- We see clear evidence of lexical competition
- N-Count:
  - Oscillations for words with many neighbors
  - Oscillations for both regulars and irregulars
- LogOdds:
  - Oscillations for both regulars and irregulars in both present and past tense
- The assumption of WEAVER that competition is restricted to lemma selection must be wrong

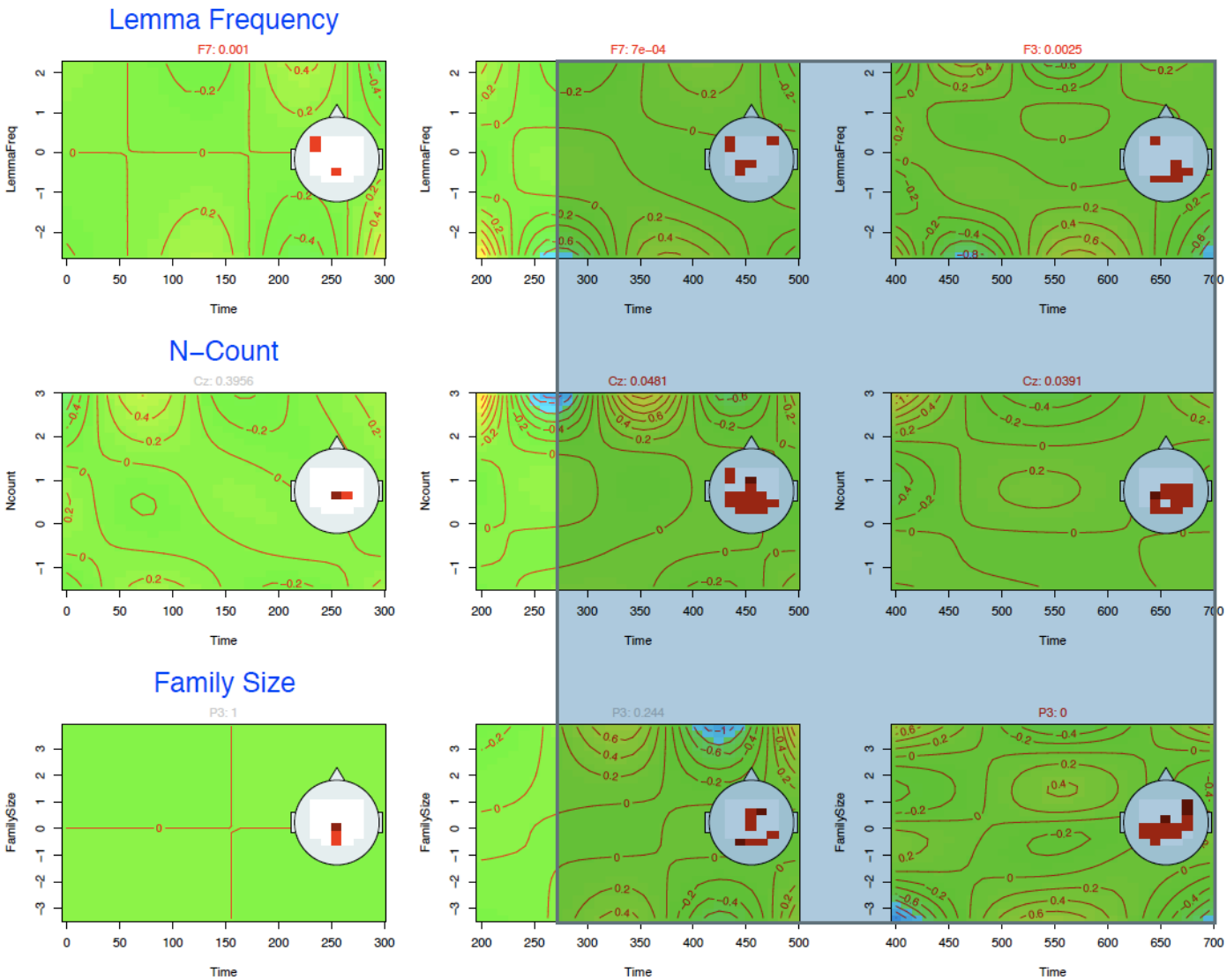
Results: key question 2

- Key question 2: how staged is processing?
- Predictors of interest:
  - Lemma Frequency
  - N-Count
  - Family Size
- Are the effects of predictors more or less seperated in time or do processing stages substantially overlap?

Results: key question 2



Results: key question 2



Results: key question 2

- The effects of LemmaFrequency, N-Count and FamilySize overlap in time
- Many processes are active simultaneously, for prolonged periods of time
- Processing is highly cascaded

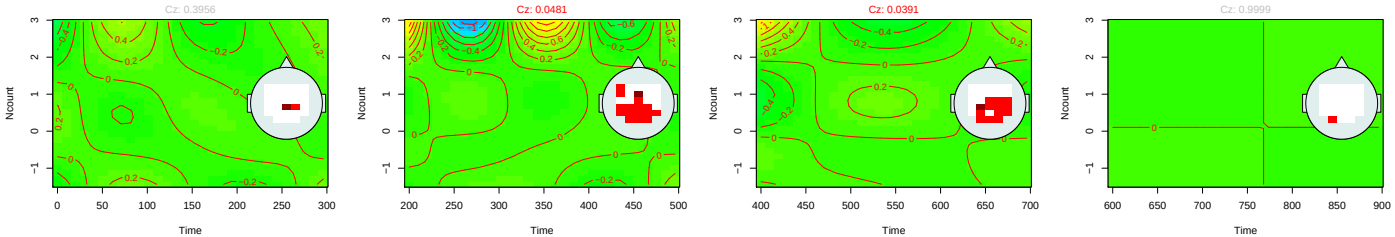
Results: key question 3

- Key question 3: do we see qualitative processing differences between regular and irregular verbs?
- Predictors of interest:
  - N-Count
  - Family Size
  - LogOdds

Results: key question 3

N-Count:

Present tense regulars



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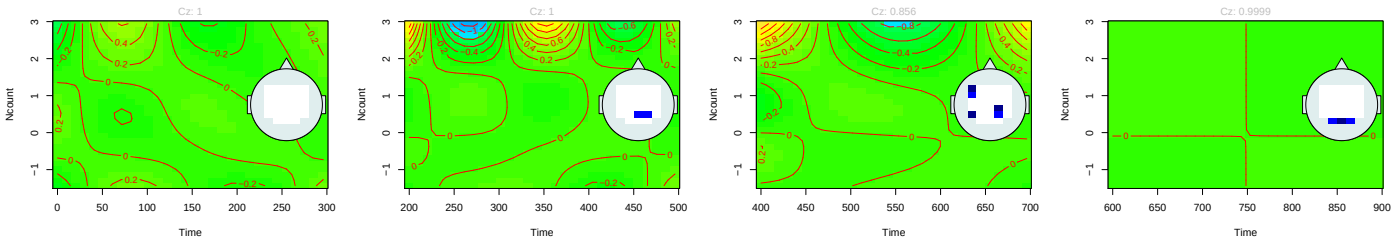

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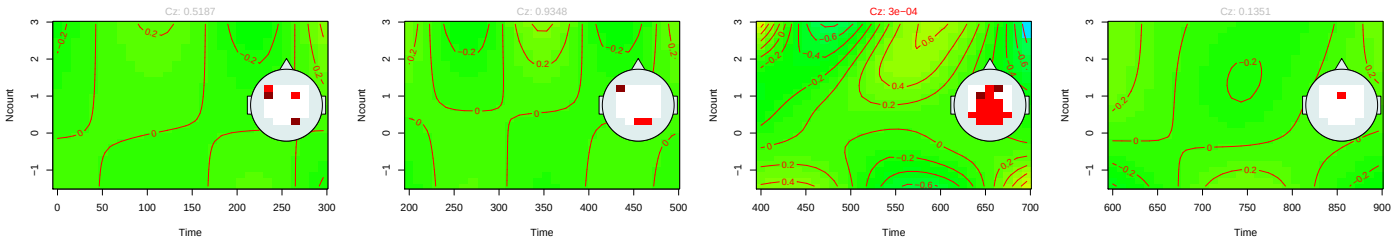

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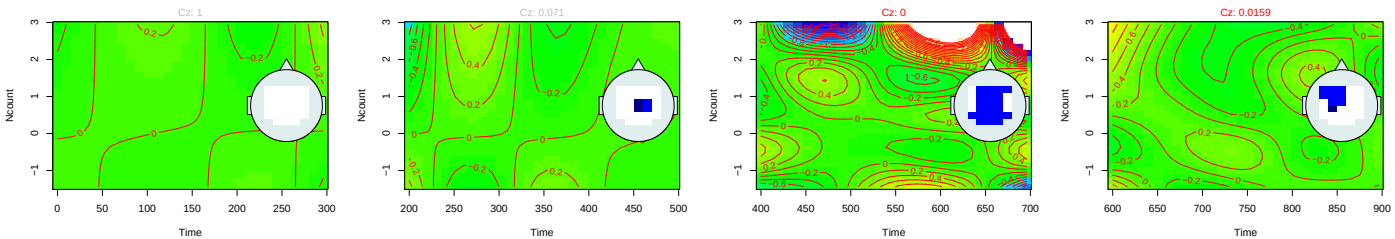


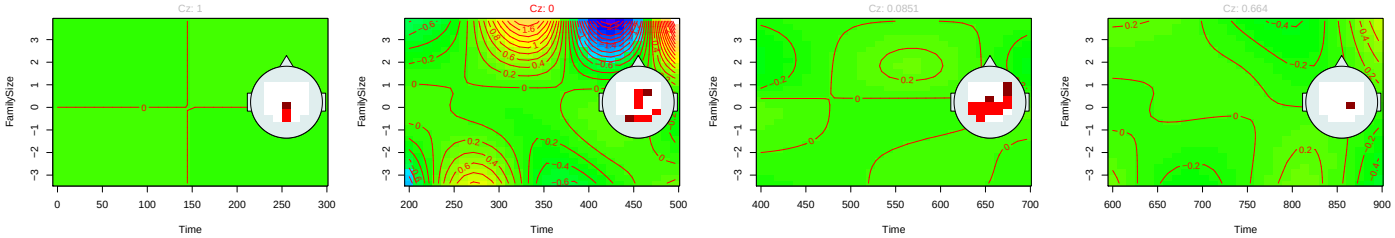
Results: key question 3

- N-Count:
- Large oscillations for past tense irregulars
- Past tense irregulars have dense phonological neighborhoods
- Retrieving words from these dense neighborhoods requires extra work

Results: key question 3

Family Size:

Present tense regulars



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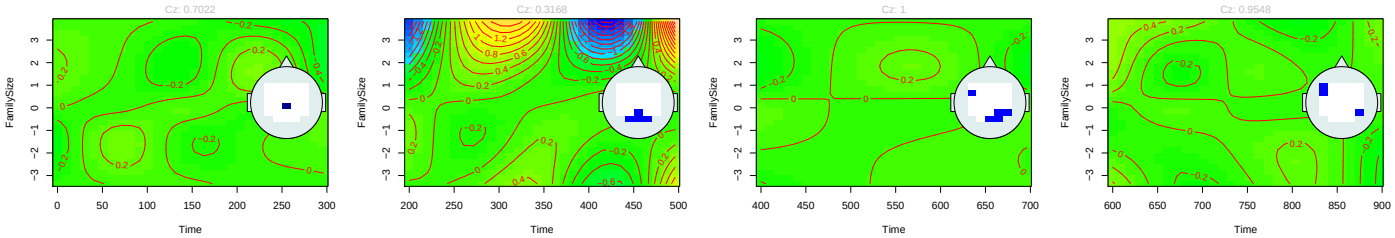

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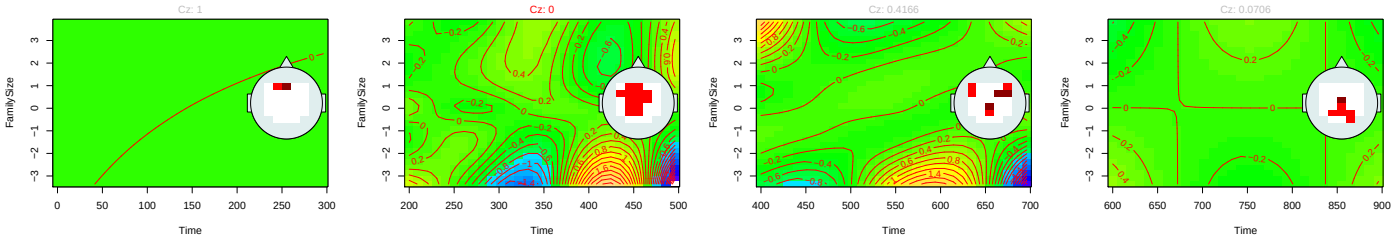

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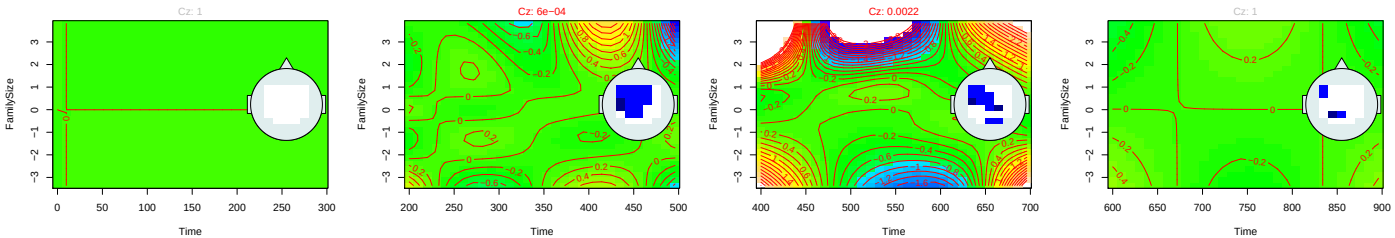


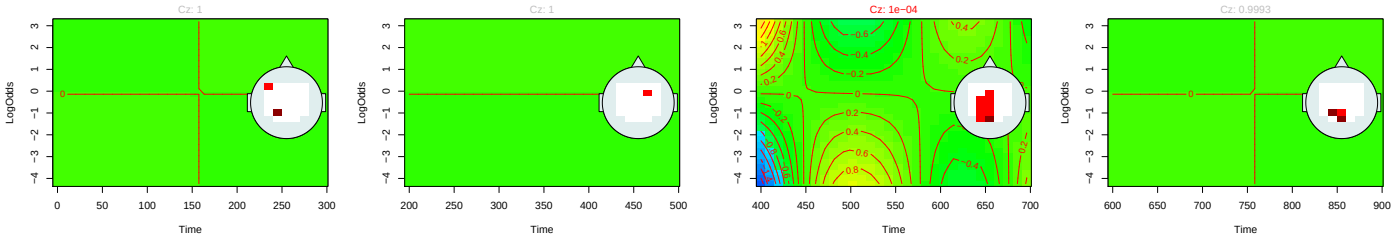
Results: key question 3

- Family Size:
- Strong oscillations for words with large families for past tense irregulars
- These oscillations are absent for regulars
- Hypothesis: more competition from non-verbal family members for irregulars?
  - e.g.; *loop* as ”gait” or ”barrel of a gun”

Results: key question 3

Log Odds:

Present tense regulars



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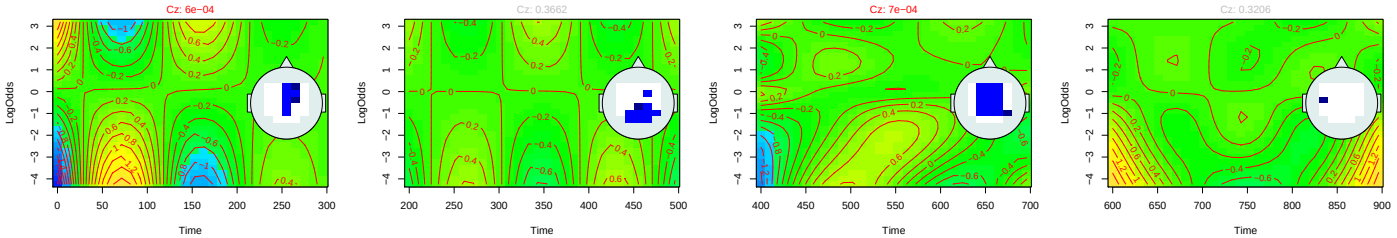

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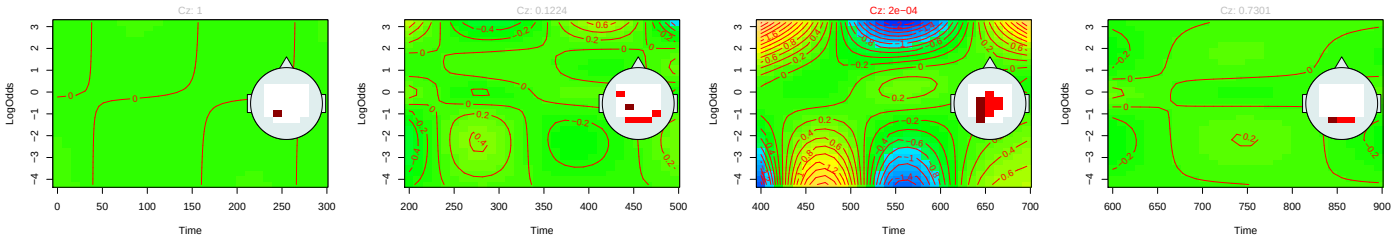

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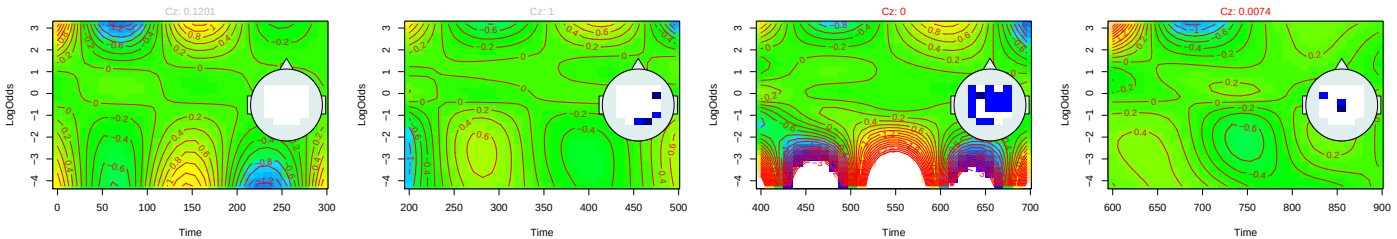


Results: key question 3

- Log Odds:
- Strong oscillations for past tense irregulars that are relatively frequent in the past tense
- Compensation mechanism for the competition effects of N-Count and FamilySize, allowing for the quick activation of highly frequent irregular past tense forms?

Results: key question 3

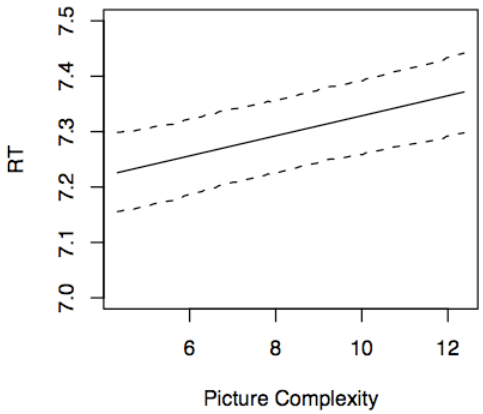
- We see qualitative differences between regular and irregular verb processing, especially in the past tense
- Processing specific to past tense irregulars:
  - Increased neighborhood effects for words with many neighbors
  - More competition from large families
  - Competition balanced by greater inflectional frequency?

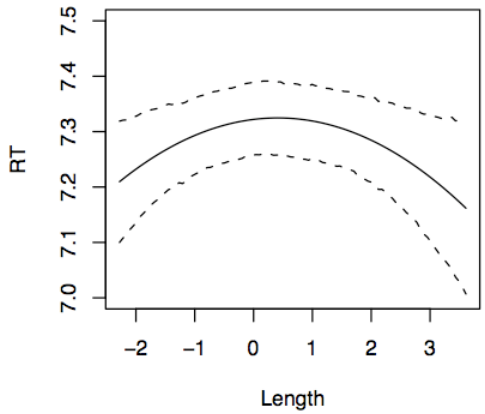
Concluding remarks

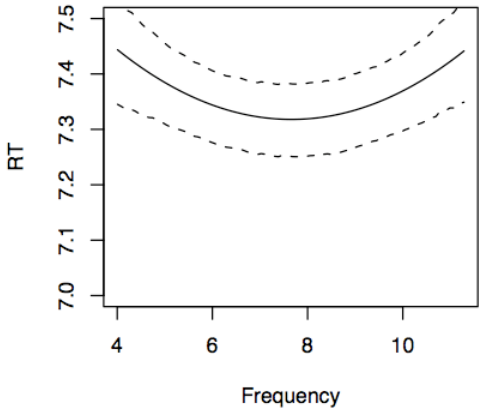
- The use of ERPs provides us with information that is not available in traditional reaction times experiments:
  - We see effects that are not visible in the reaction times
  - We have access to the temporal development of processes
- The language production process is subject to much more competition effects than previously thought
- There is substantial overlap of processing stages, with different processes being simultaneously active for prolonged periods of time
- Competitor effects are strongest for (past tense) irregulars

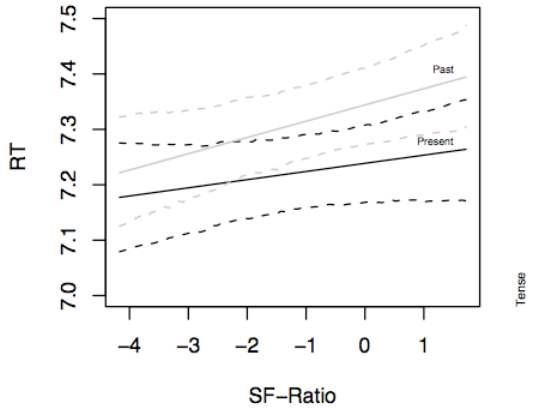
The end

Reaction time effects









GAM simulations

- Power and type II error (1000 simulations):

	GAM	t test
effect absent	0.054	0.054
effect present	0.879	0.537

- The t-test is carried out for the epoch where the difference is known to be
- The GAM is evaluated without such prior knowledge

GAM simulations