UNIVERSITEIT GENT

FACULTY OF **PSYCHOLOGY AND EDUCATIONAL SCIENCES**

Wavelet-Based Functional Mixed Models

for the Analysis of Lateralized Readiness Potentials

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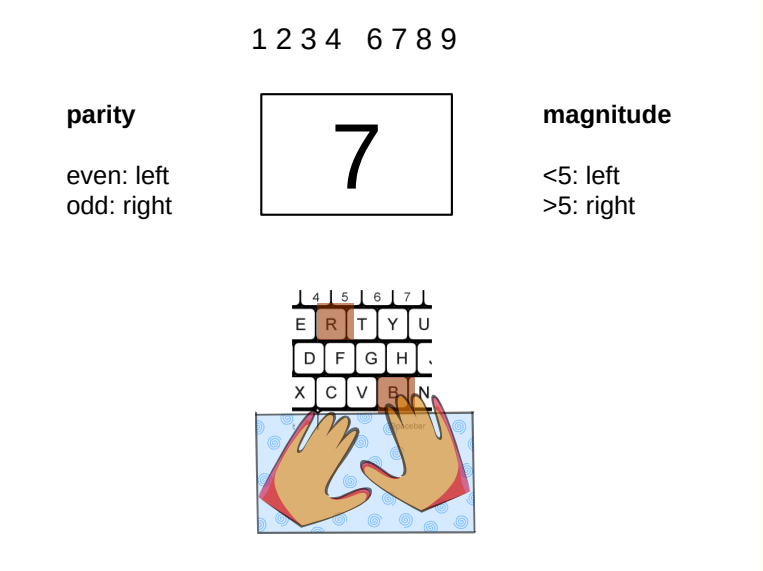
Problem Setting: Task Switching Paradigm

- Laboratory analogue of ‘real-life task switching’
- Choice Response Time tasks: 2 computer tasks which both require binary responses (left/right hand)



- Cue signals which task must be performed
- Switch Cost: slower reaction times on task switch trials (compared to repetitions)
- Locus of switch cost: cue or task processing?
- Explicit versus transition cuing:
  - **Explicit:** (Parity/Magnitude): Cue and Task Perfectly Associated
  - **Transition:** (Same/Different): Possibility to Disentangle Cue and Task Switches

Lateralized Readiness Potential

- **EEG**: Electro-encephalogram

  (registration of cortical electric potentials, brain waves)

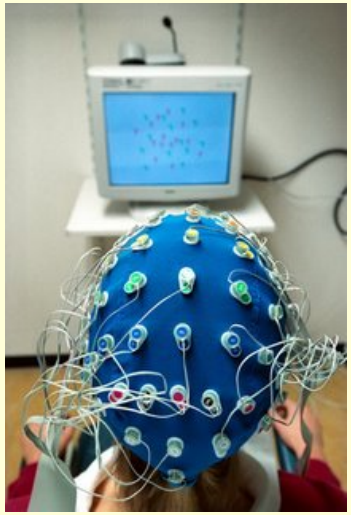
- **ERP**: Event-related potential

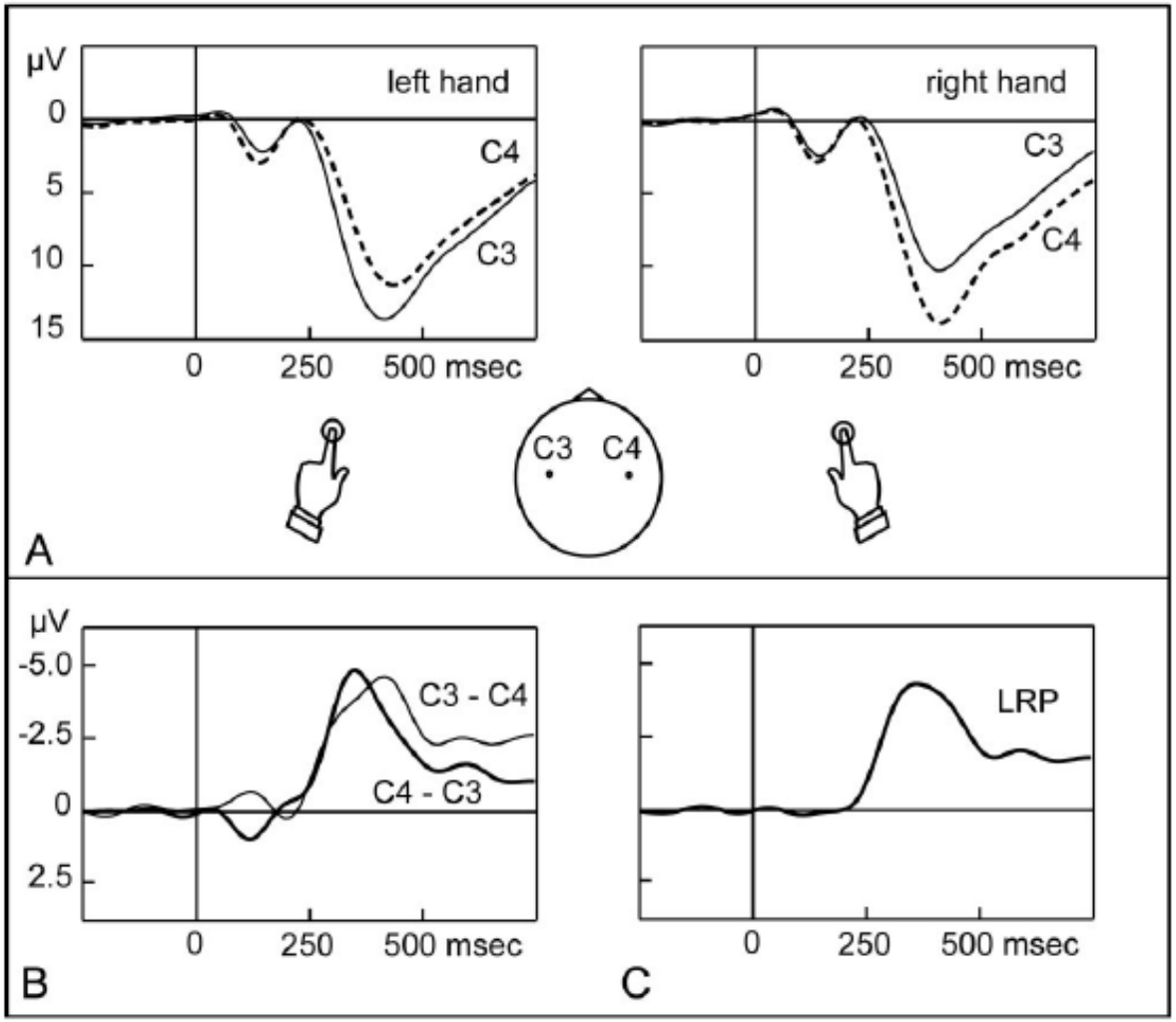
  (experimental psychology)

- **LRP**: Lateralized Readiness Potential

  (neurophysiological measure of motor preparation:

  motor cortex: C3, C4)





$$LRP = [Mean\ (C4 - C3)_{left\ hand} + Mean\ (C3 - C4)_{right\ hand}\ ] / 2$$

Study Design

- **Task switching paradigm** (magnitude vs parity task) + **Double registration** (task indication + task response)
- LRP = outcome of interest
- 2 X 2 X 2 design:
  - **transition**: task repetition vs switch (within)
  - **cuing type**: explicit vs transition (between)
  - **indication**: selection vs no selection (between)
- 32 participants: 72 blocks (each 17 trials)

Wavelet-Based Functional Mixed Models

- Wavelets widely applied to EEG analyses:

  to characterize time-varying properties of unaveraged EEG signal

- Discrete wavelet transform (DWT) to denoise signal:

  transform the signal into the wavelet domain, shrink relatively small coefficients towards zero and use inverse DWT

  to project the signal back to the data domain

- Functional Mixed Models: $\mathbf{Y}(t) = X\mathbf{B}(t) + Z\mathbf{U}(t) + \mathbf{E}(t)$

  $\mathbf{Y}(t) = (Y_1(t), \ldots, Y_N(t))$ vector of observed functions

  $\mathbf{B}(t) = (B_1(t), \ldots, B_p(t))$ vector of fixed-effect functions with $N \times p$ design matrix X

  $\mathbf{U}(t) = (U_1(t), \ldots, U_m(t))$ vector of random-effects functions with $N \times m$ design matrix Z

  $\mathbf{E}(t) = (E_1(t), \ldots, E_N(t))$ vector of functions representing the residual error process

Multiplicity issue

Determine time interval where condition has significant effect.

- pointwise posterior credible bands $\Rightarrow$ multiple looks
- use of Bayesian False Discovery Rate
  - calculated by summing the posterior samples from the MCMC
  - assuming an effect size of at least δ

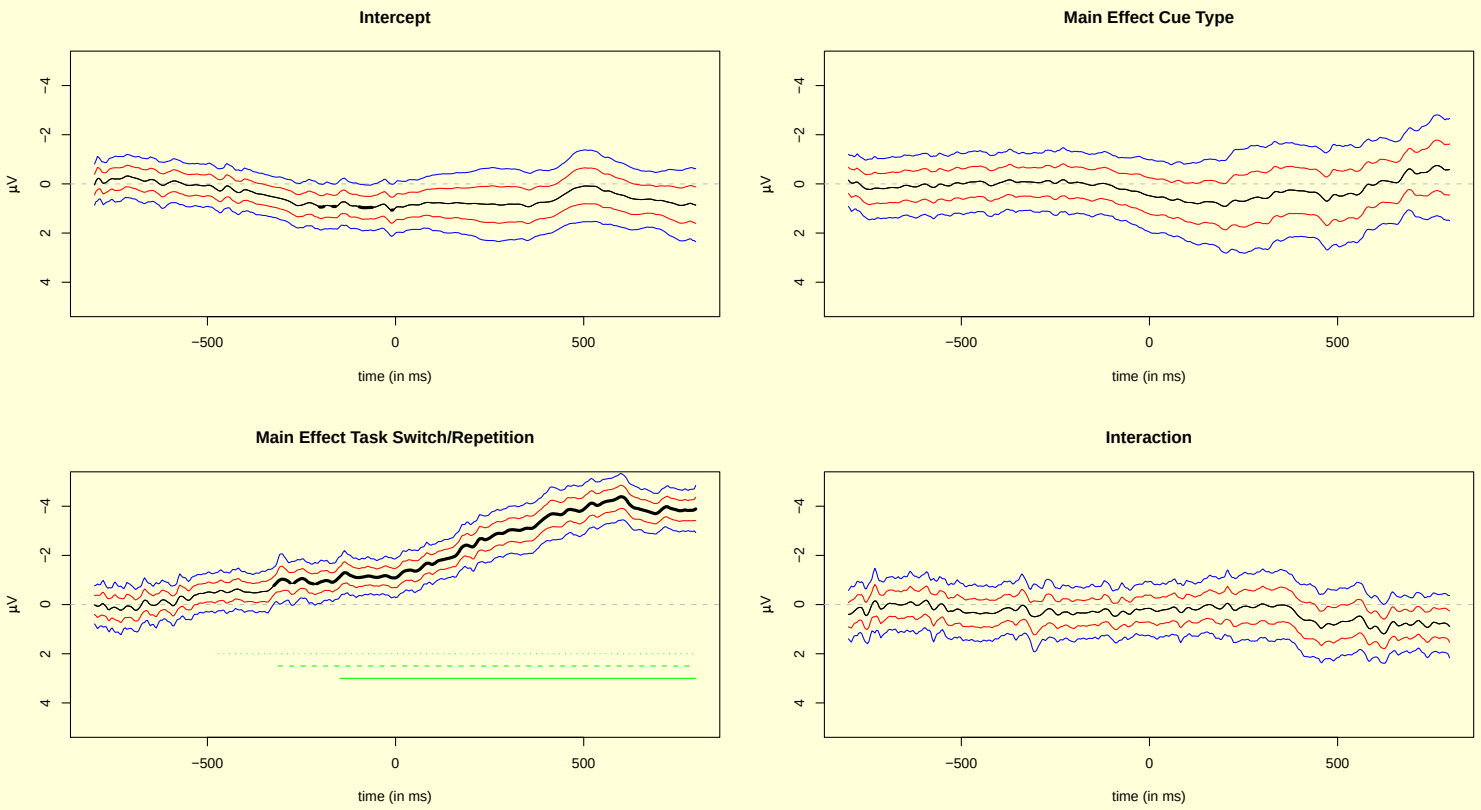
- joint posterior credible bands
  - no unique way to identify joint posterior credible bands
  - based here on the pointwise credible intervals derived from the $\alpha/2$ and $1-\alpha/2$ quantiles of the samples
  - next, scale these pointwise intervals with a constant factor until $1-\alpha$ of all sampled curves are contained in credible band

Results

Model with main effects for cuing type and transition and its interaction.

- no effect of cuing type
- clear divergence between task switches and task repetitions
- no interaction between cuing type and transition
- onset of divergence with FDR depends on *subjective* choice of δ
- performance of *objective* joint posterior band relatively good

$\Rightarrow$ needs further exploration with simulations.



Posterior Mean- Pointwise 90% Credible Band - Joint 90% Credible Band

Bayesian FDR ($\delta = 0.75$: dotted line,$\delta = 1.00$: dashed line,$\delta = 1.25$: solid line) at $\alpha = 10\%$

References

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