

Connecting wavelet-based functional mixed models with R: The 'wrapfmm' and 'stepmom' packages

Introduction

The *wavelet-based functional mixed model* ('WFMM') [1] allows flexible, Bayesian mixed-effect modelling of complete curves. We present two R-packages [2] interfacing with the WFMM software. They provide user friendly interfaces for analysis of curve data in general and *event-related potential* ('ERP') data in particular (see also [3]).

Benefits of a WFMM analysis

- Curve data are not coerced to points
- No averaging, no peak extraction necessary
- Single-trial level analysis
- Include fixed effects of any kind (factors and continuous predictors) & multiple random effects
- It's Bayesian: posteriors derived via Markov chain Monte Carlo ('MCMC') sampling
- Adaptive regularisation of effect curves
- Denoising of data possible

The *wrapfmm* package

- Acts as R-wrapper for the WFMM software
- *wfmm*-function for easy specification of model via lme4-style mixed-model formula
- Automatic import of posteriors & computation of default inferences (e.g., pointwise & simultaneous credible bands / probabilities)
- *summary*-function for model output summaries
- Easy computation of post-hoc / custom posteriors
- *plot*-function for flexible data plots
- Model and MCMC-diagnostics

The *stepmom* package

- ERP-analysis via 'Spatio-Temporal ElectroPhysiological Model Maps'
- Electrode-wise WFMM modelling without temporal windows / spatial regions of interest
- Provides all of the *wrapfmm* functions
- ERP-specific plot methods for data / model output

Example data & model

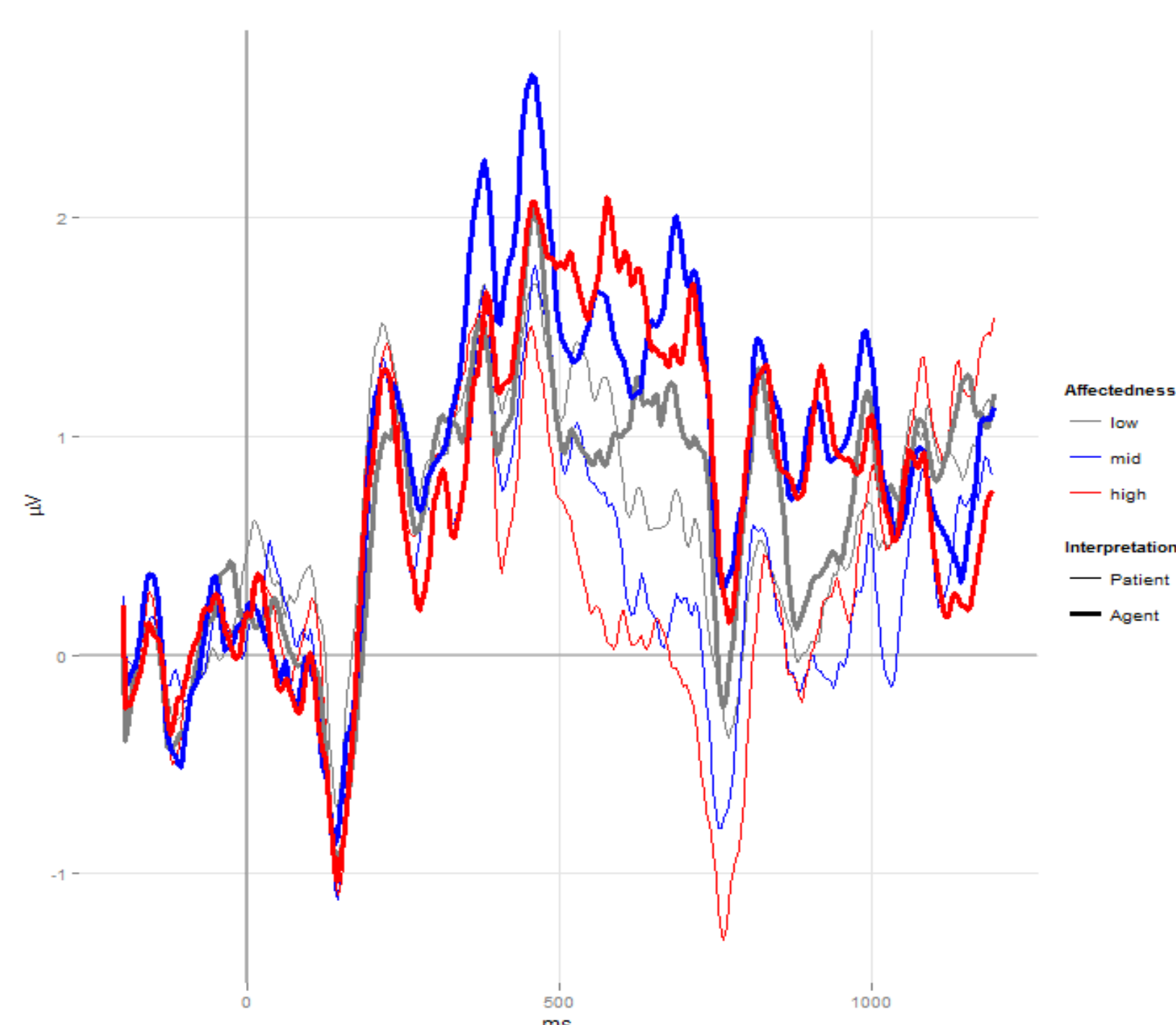
- Segment from ERP-experiment on sentence processing at semantics/syntax interface ('affectedness' and argument linking, see [4])
- *Model*:
 - 'Affectedness' (continuous) & interaction with
 - 'Interpretation' (2-level factor)
 - Control covariates (e.g., word length, frequency)
 - Random by-subject intercepts & slopes for 'Affectedness * Interpretation'
- 4283 single trials
- Results for electrode Fz & all 63 electrodes shown

Outlook

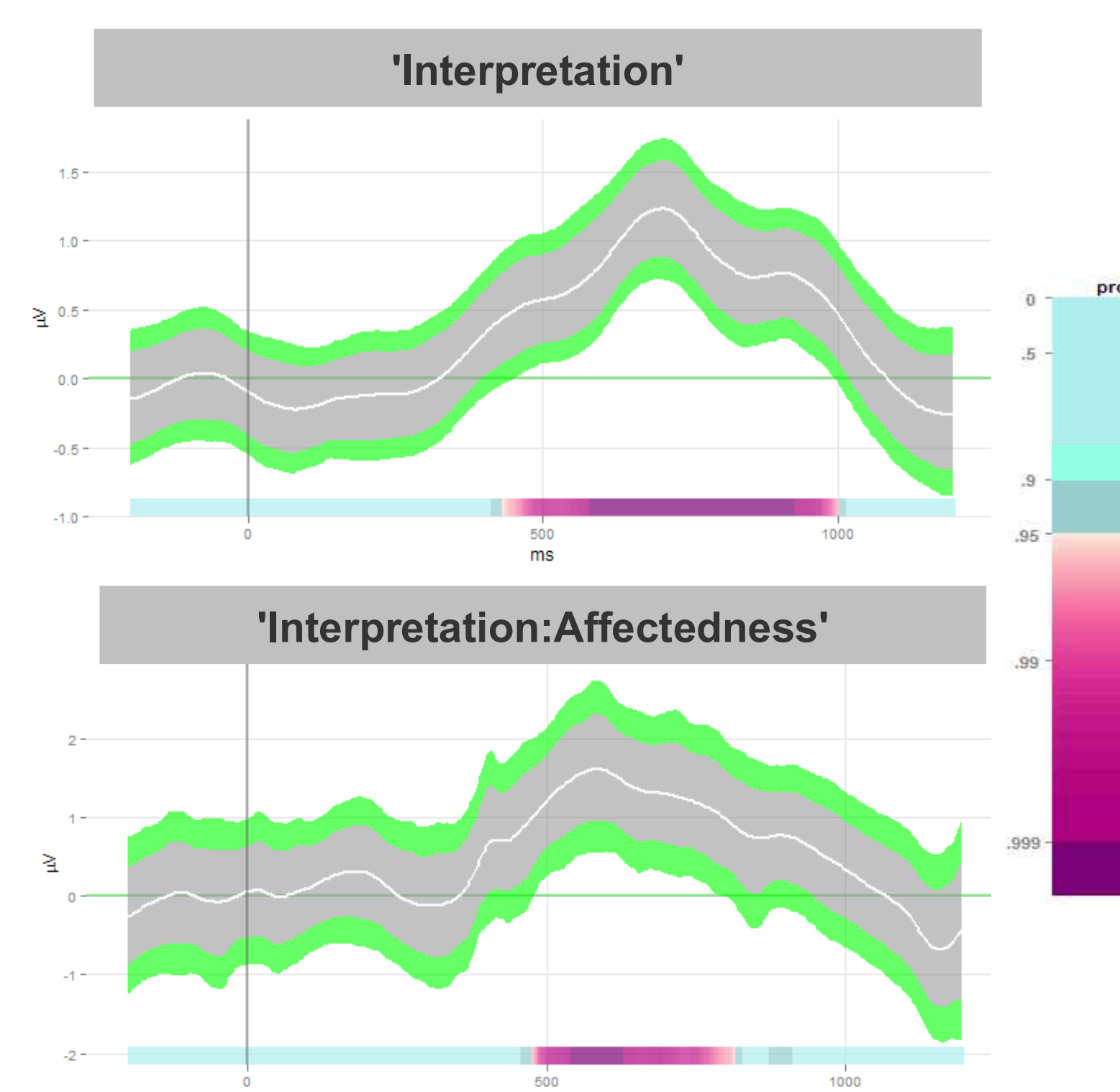
- Extensions of the R/WFMM interface for multidimensional models & big data
- Modelling of 2D time-frequency images

wrapfmm

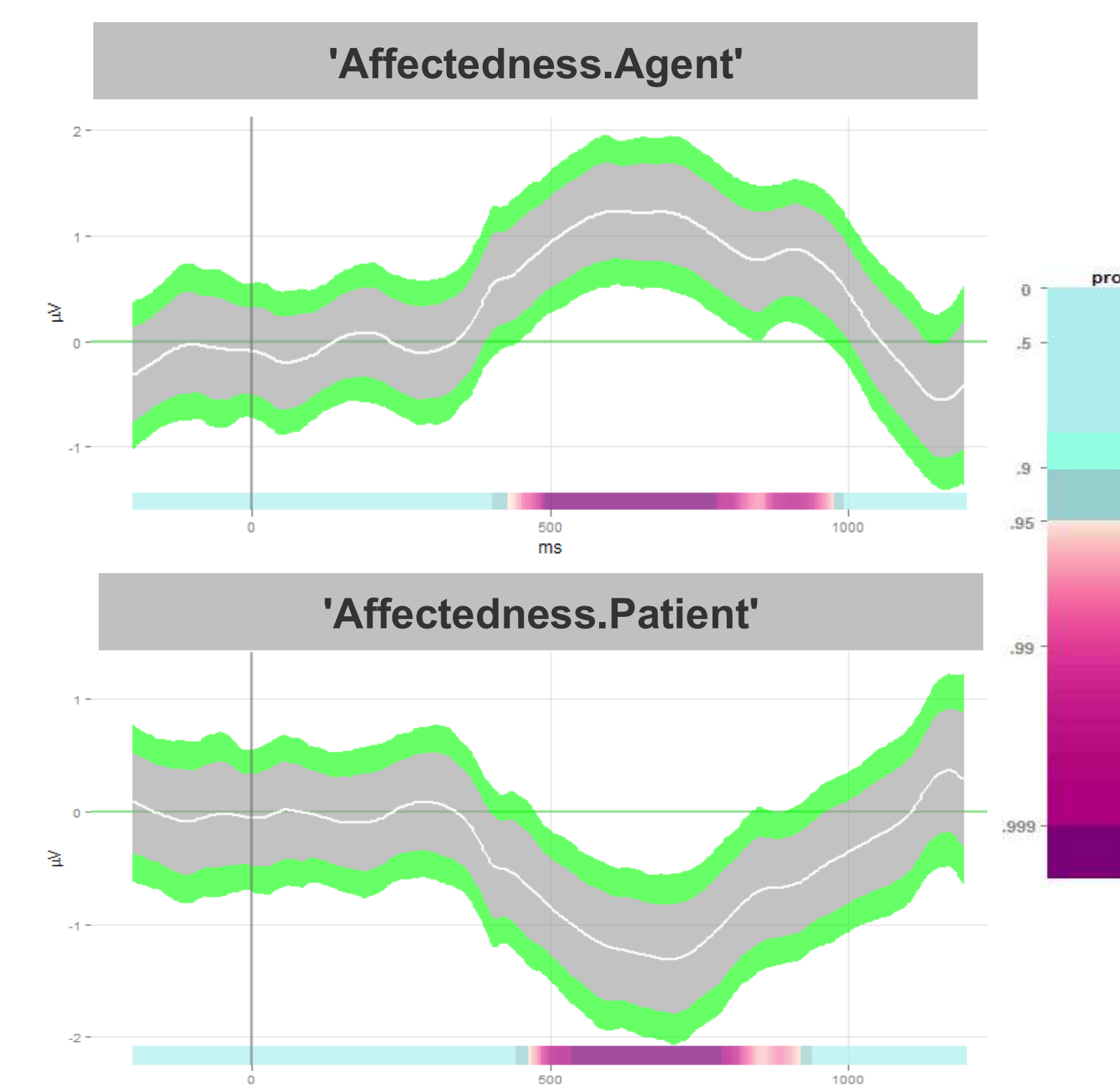
Data @ Fz split by 'Interpretation' levels & 3 'Affectedness' levels



Posterior fixed effect curves @ Fz (95% pointwise & simultaneous credible intervals)

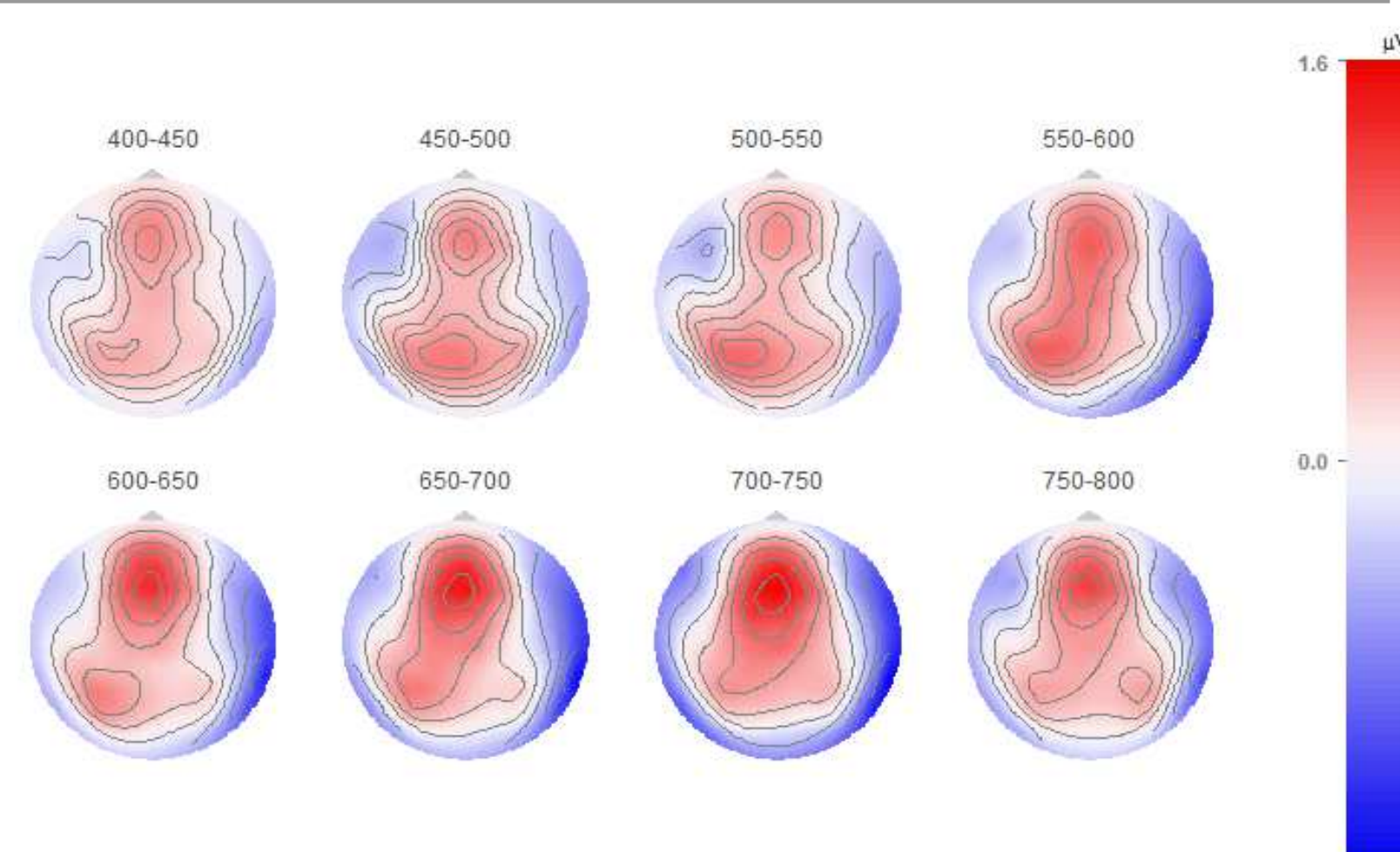


Simple effects of 'Affectedness' by 'Interpretation' (95% pointwise & simultaneous credible intervals)

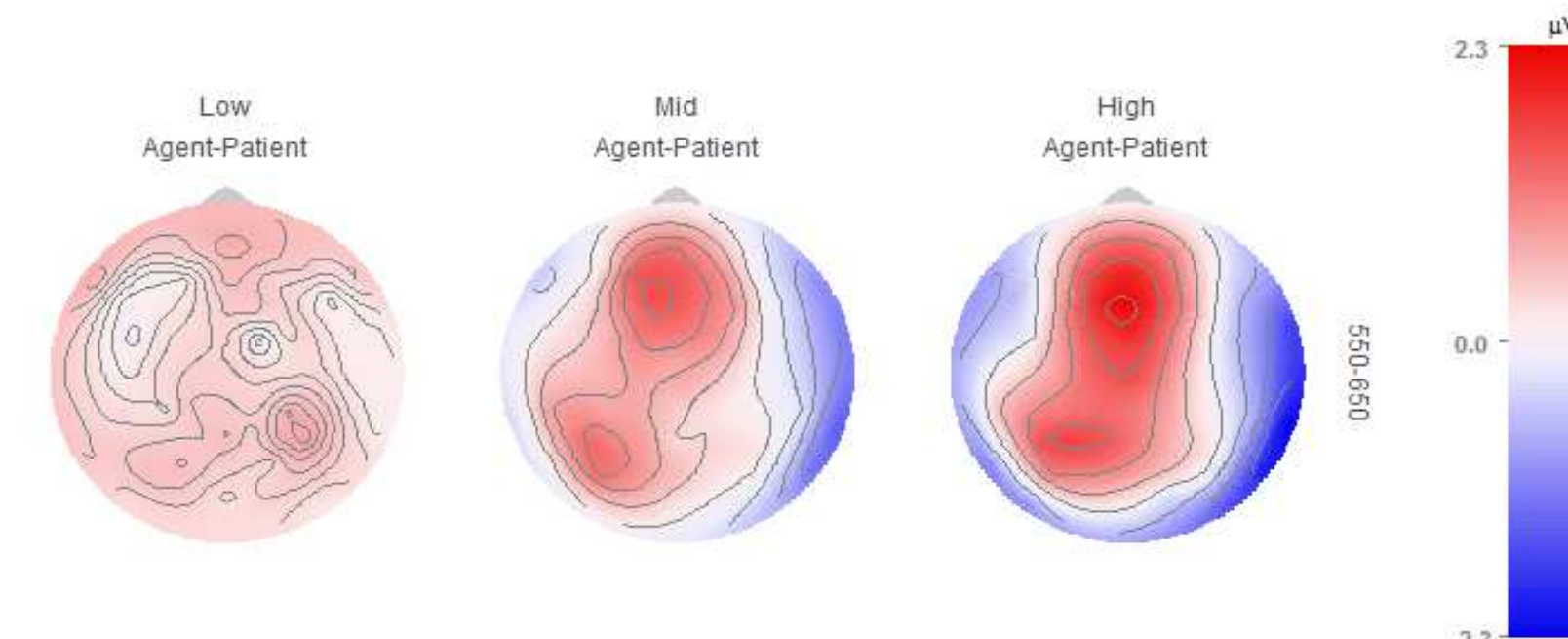


Data plots

Difference maps for 'Interpretation' levels (400-800 ms)



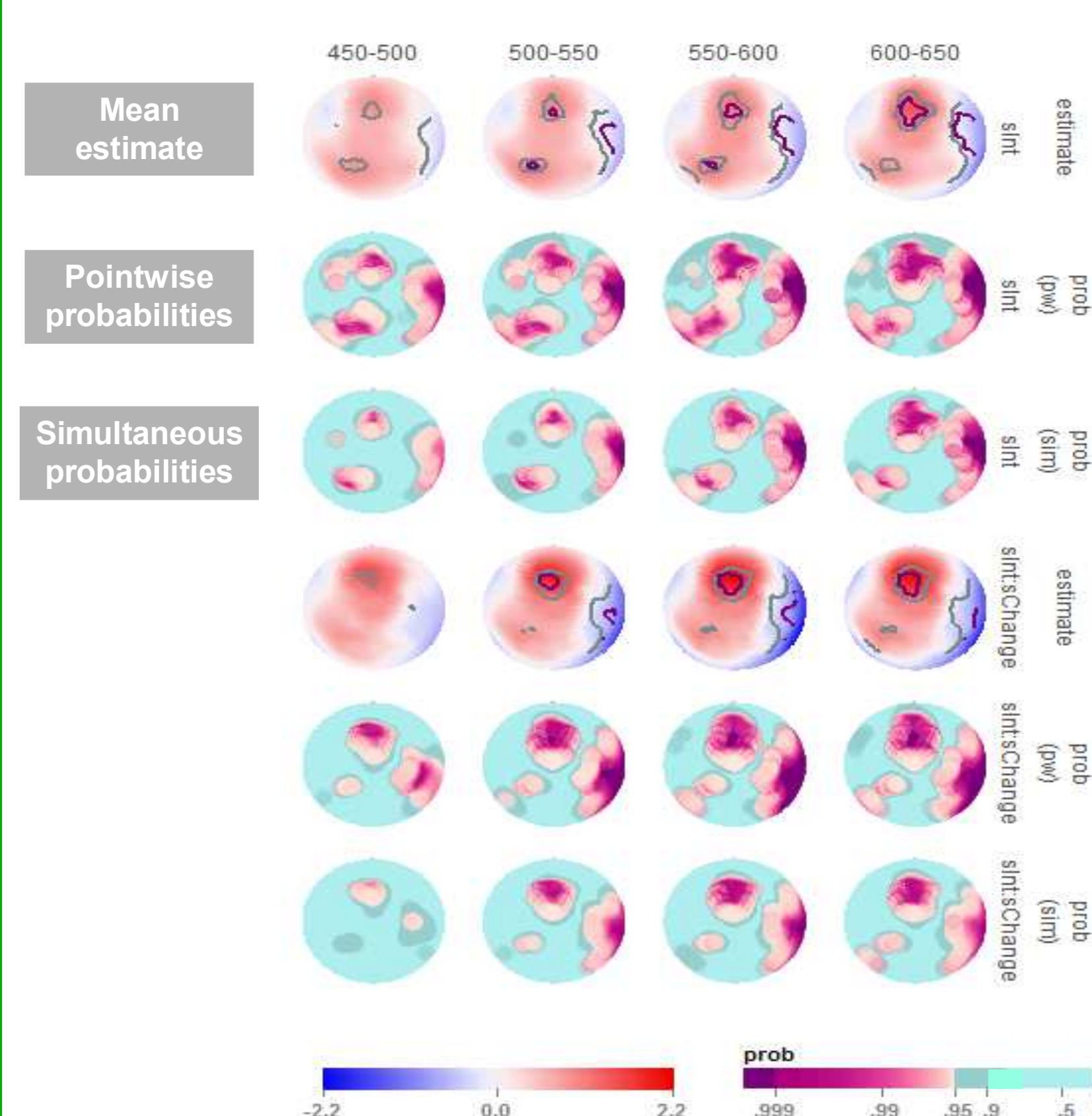
Difference maps for 'Interpretation' factor at 3 'Affectedness' levels (550-650 ms)



stepmom

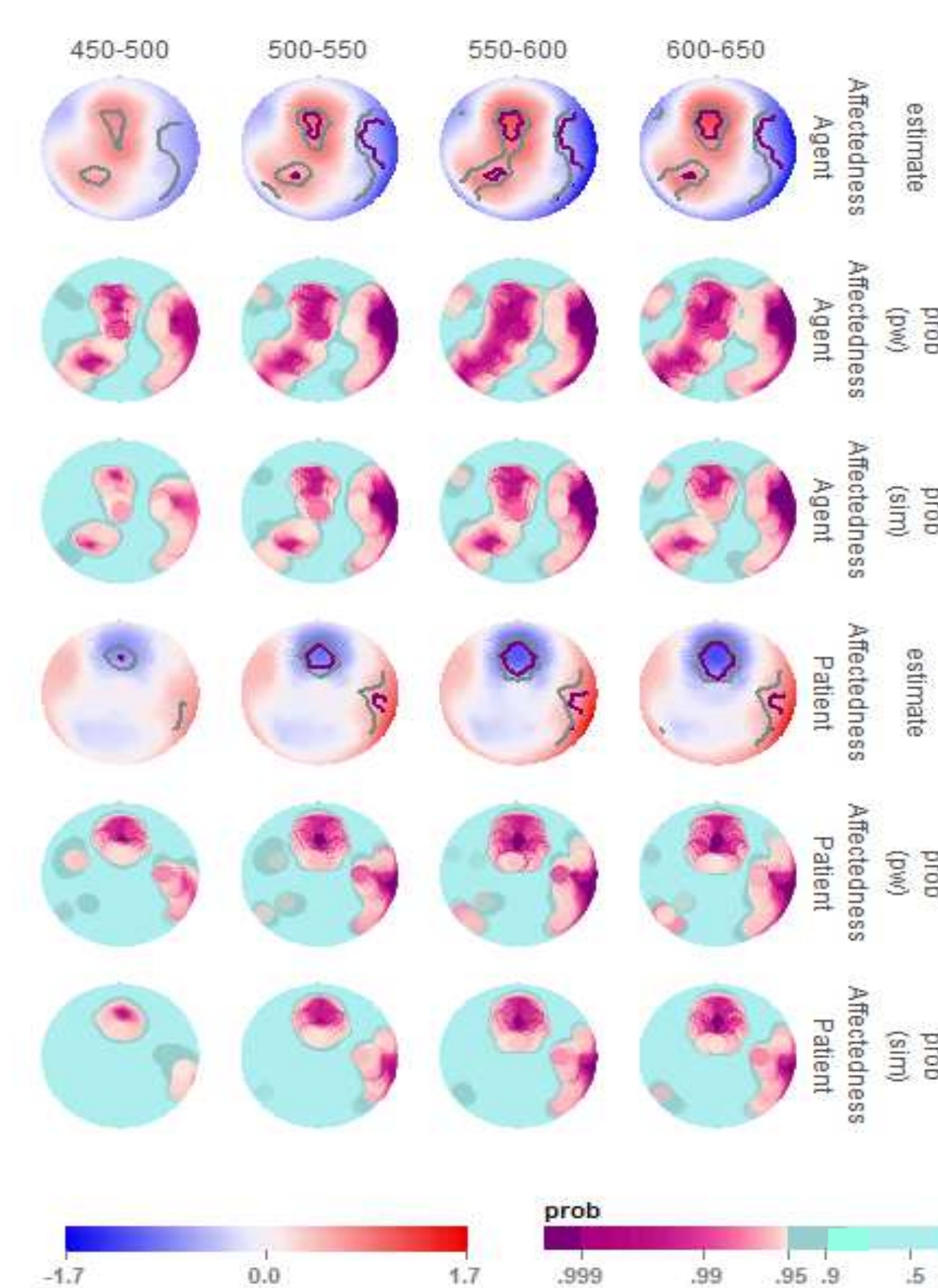
Model summaries

Model maps for 'Interpretation' & 'Interpretation:Affectedness' fixed effects (450-650 ms)



Custom posteriors

Model maps for simple effects of 'Affectedness' by 'Interpretation' levels (450-650 ms)



Affiliations

- ¹ Berlin School of Mind and Brain, Humboldt Universität zu Berlin
² Department of German Language and Linguistics, Humboldt Universität zu Berlin
³ Department of Psychology, Humboldt Universität zu Berlin
⁴ ZAS Berlin (Center for General Linguistics Berlin)

Contact

philip.rausch@gmail.com

References

- [1] Morris, J.S., & Carroll, R.J. (2006). Wavelet-Based Functional Mixed Models. *Journal of the Royal Statistical Society, Series B*, 68, 179-199.
- [2] R Development Core Team (2012). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>.
- [3] Davidson, D.J. (2009). Functional Mixed-Effect Models for Electrophysiological Responses. *Neurophysiology*, 41, 71-79.
- [4] Beavers, J. (2011). On Affectedness. *Natural Language and Linguistic Theory*, 29, 335-370.