

Markov-Switching Models of Trial-level Pupil Dilation Time Courses

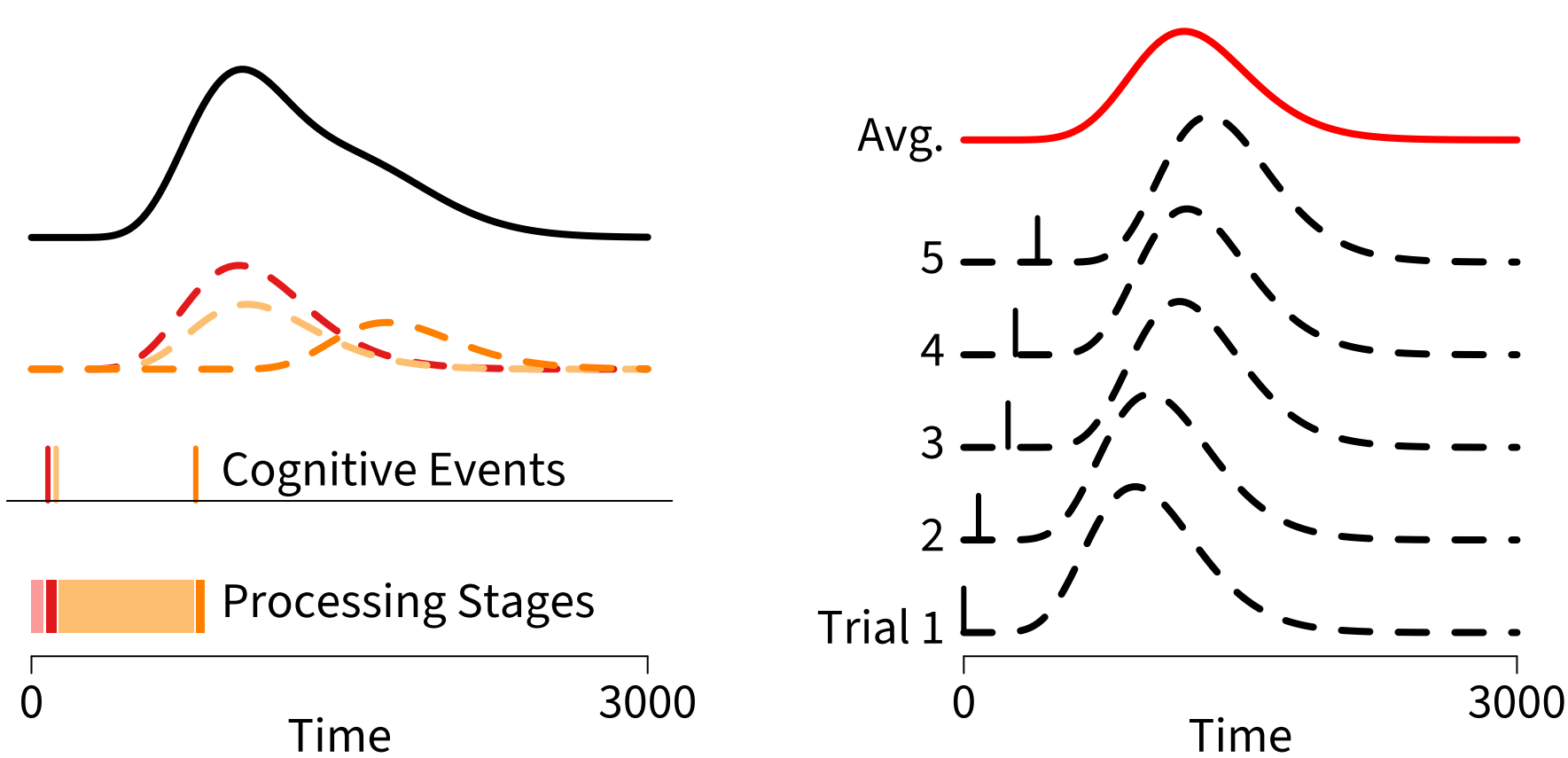
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Introduction

- Pupil dilation indirectly reflects cognitive processing¹
- Pupil deconvolution aims to recover cognitive events underlying the pupil dilation time course²⁻⁵
- Conventional deconvolution approaches²⁻⁵ neglect trial and event-level variability in event onset and response
- To address this, we **estimate event responses** and perform the **deconvolution on the trial-level**

Conventional Deconvolution



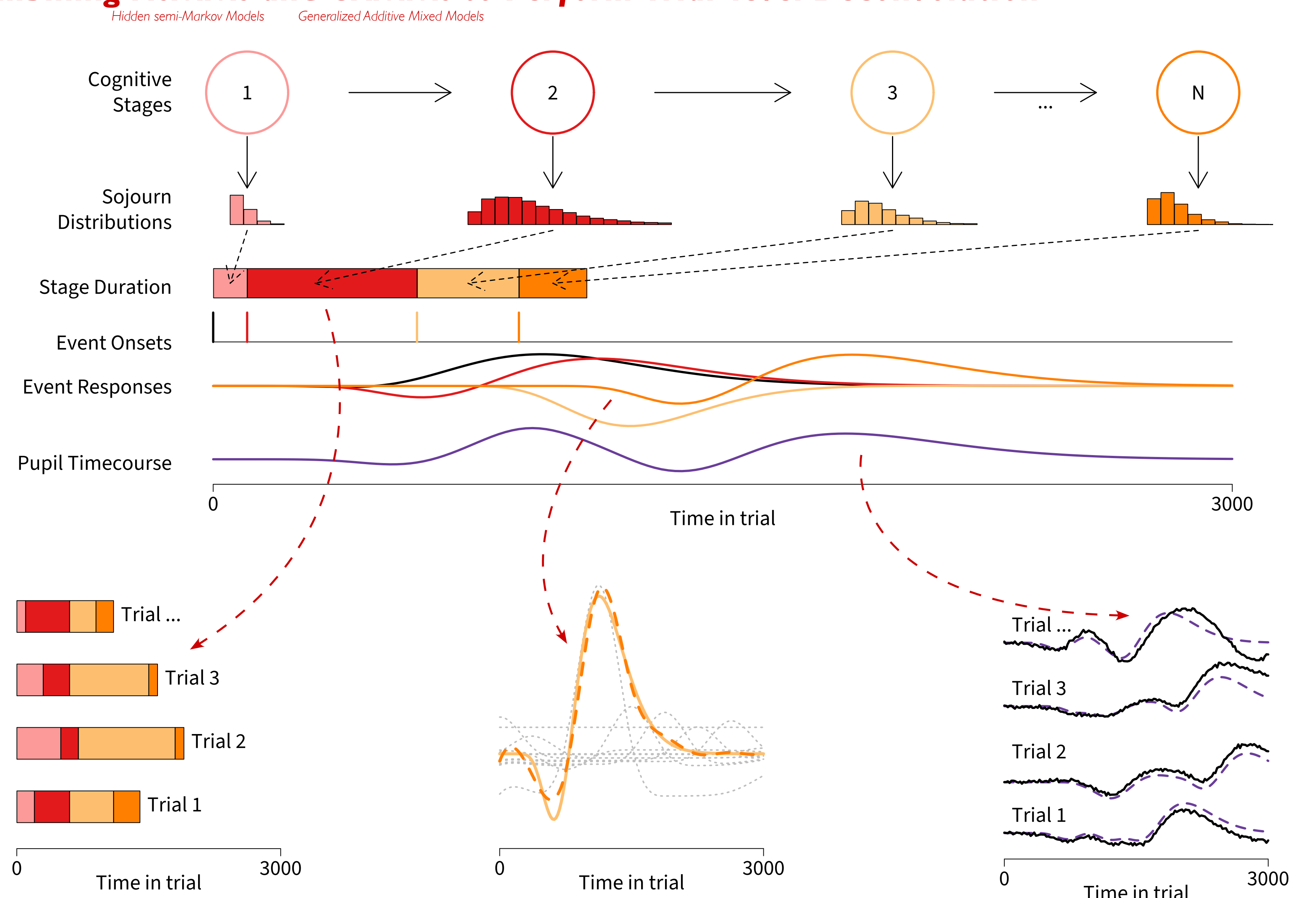
Cognitive events elicit a delayed pupil response. The average observed time course reflects an additive model of responses.

Problems

- **Gamma Erlang functions**² for all event responses
- Events are recovered from average dilation time courses, neglecting **trial-level variability** in event onset²⁻⁵
- Shape of event responses also cannot **vary as a function of trial-level continuous predictors**

Semi-Markov-Switching Pupil Models

Combining HsMMs and GAMMs to Perform Trial-level Deconvolution

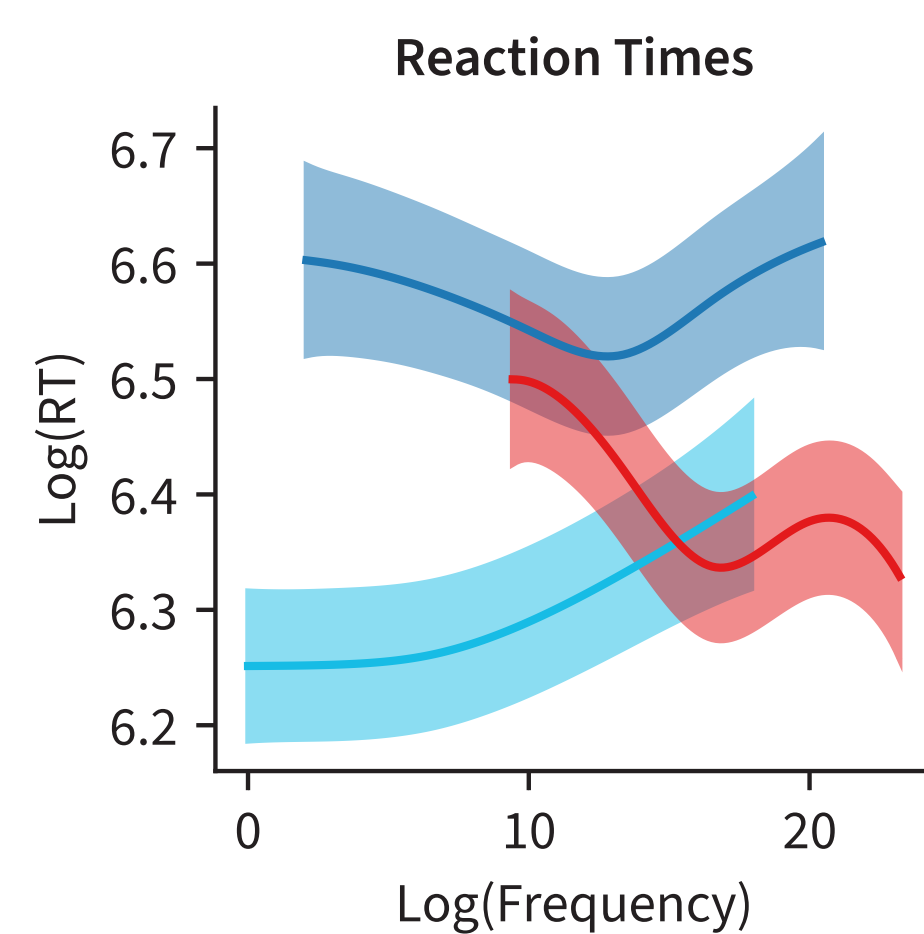


- **Gamma distributions** capture stage duration variability across trials⁶
- And across experimental conditions
- **Event responses** are parameterized with time-shifted smoothing spline⁷
- Shape can vary between experimental conditions
- Shifted event responses cannot account for all **dependencies** in the data
- (Non-linear) **random effects** are needed⁷

Preliminary Results

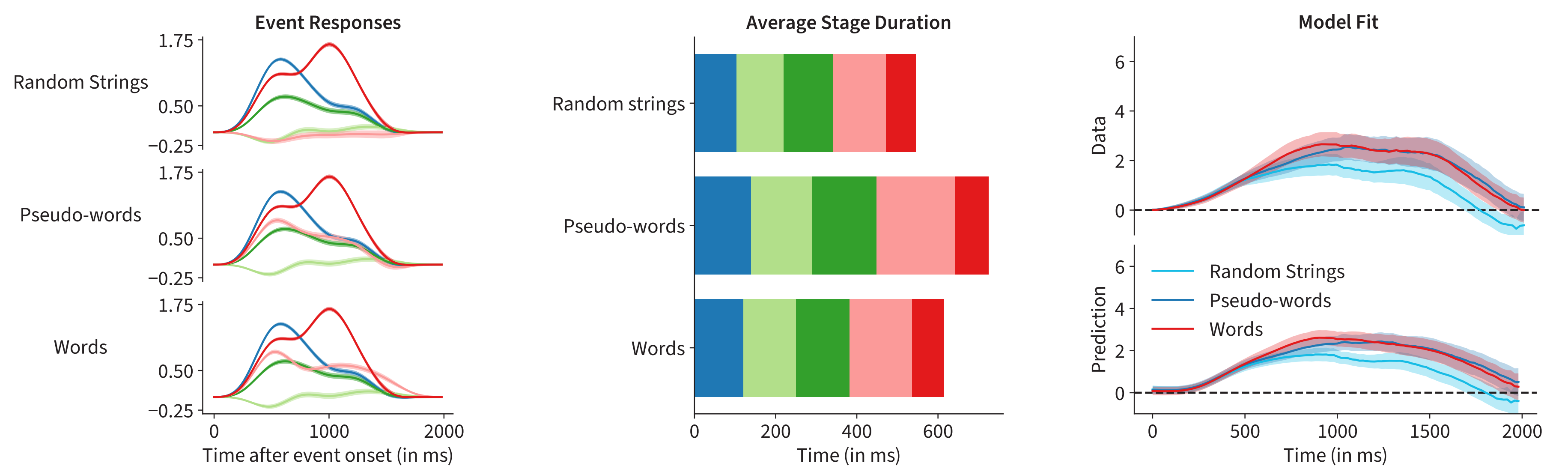
Testing sMs IR GAMMs via Lexical Decisions

- 26 native Dutch speakers performed 500 lexical decision (LD) trials
- 125 pseudo-words, 125 random strings, 250 words
- Google result count⁸ was used as frequency measure for all stimuli



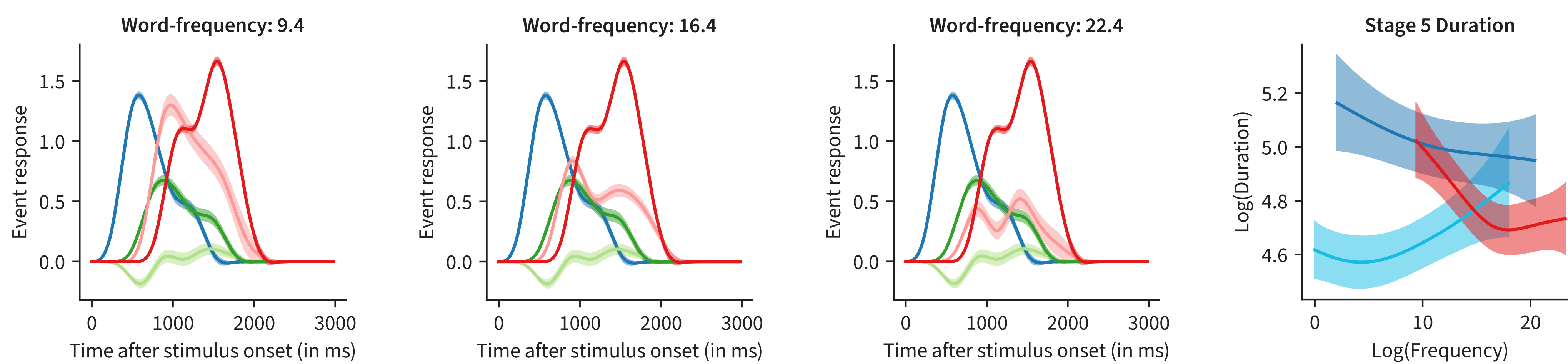
What can Trial-level Pupil Deconvolution reveal about the **processing stages involved in LDs** and the **effect of frequency** on these stages?

Six Processing Stages are involved in LDs for Words and Non-words



Stages seem to generally last longer for pseudo-words. The duration of stage five appears to differ most prominently between all word-types.

Frequency and Word Type Affect Stage Five Duration and Response



- Stage five response amplitude decreases as frequency increases
- Could reflect that stage five process gets **less effortful**^{1,2}

- Word-type and frequency effects on duration of stage five are similar to effects on **RTs**
- Could suggest that RT effects **originate** from stage five, but match is worse for pseudo-words
- **Either** RT effects do not originate from single stage for pseudo-words only
- **Or** the model was unable to separate stages five and six precisely for pseudo-words

Discussion

- Frequency and word type effects on RTs largely match the effects on the duration of stage five and the response preceding it, so maybe this stage partially reflects the **decision process**?⁹⁻¹⁰
- Direction of effect for pseudo-words is however not very plausible! Also, that **all** stages generally last longer for pseudo-words is not supported by previous EEG evidence¹¹
- Solutions also vary quite drastically when re-fitting the model. Untangling different responses and different stages appears to be very difficult - many fits are required to find "best" solution!
- Model is thus not yet practical - but the results are at least promising!

References:

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