

A Bayesian approach for estimating the probability of trigger failures in the stop-signal paradigm

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Introduction

- Stop-signal paradigm to measure response inhibition
 - Stop-signal RT (SSRT)



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 - Stop-signal RT (SSRT)
- Successful response inhibition requires
 - Relatively fast SSRTs
 - High probability of triggering stop response



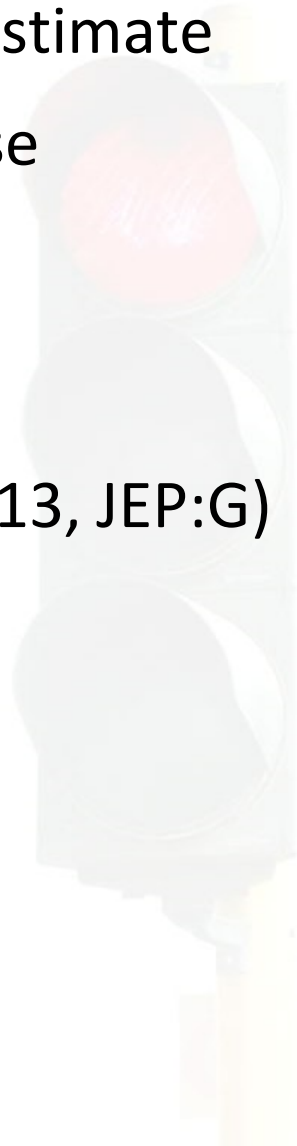
Introduction

- Stop-signal paradigm to measure response inhibition
 - Stop-signal RT (SSRT)
- Successful response inhibition requires
 - Relatively fast SSRTs
 - High probability of triggering stop response
- Why trigger failures?
 - Methodological advantages
 - Clinical research



Goal

- Bayesian parametric approach to simultaneously estimate
 - Probability of failing to trigger the stop response
 - Entire distribution of SSRT
- Matzke, Dolan, Brown, Logan & Wagenmakers (2013, JEP:G)



Outline

- Stop-signal paradigm
- Bayesian parametric approach with trigger failures
- Consequences of unaccounted-for trigger failures
- Fitting clinical data



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Stop-signal paradigm

- Go-task interrupted by stop-signal



Stop-signal paradigm

- Go-task interrupted by stop-signal
- Primary dependent variables
 - Observed: Go RTs, SRRTs, number of inhibitions
 - Unobserved: SSRT

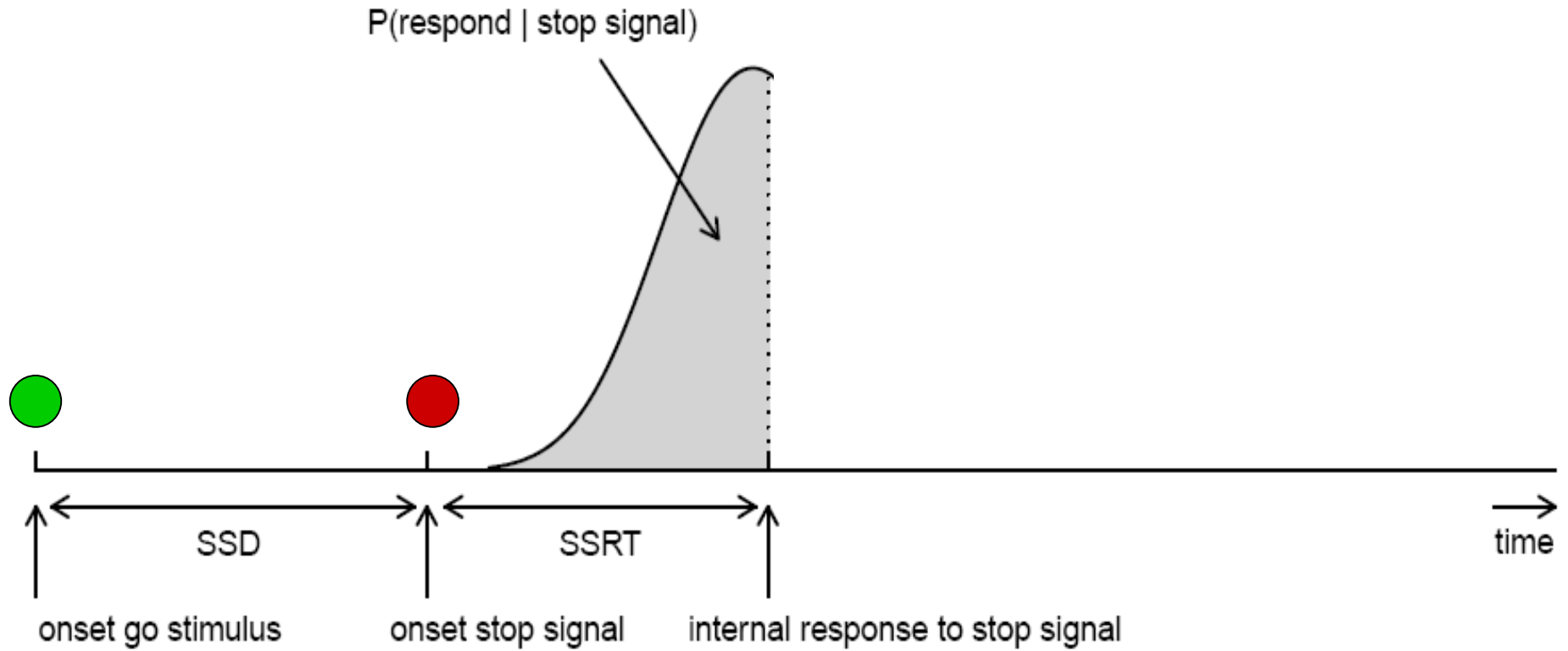


Stop-signal paradigm

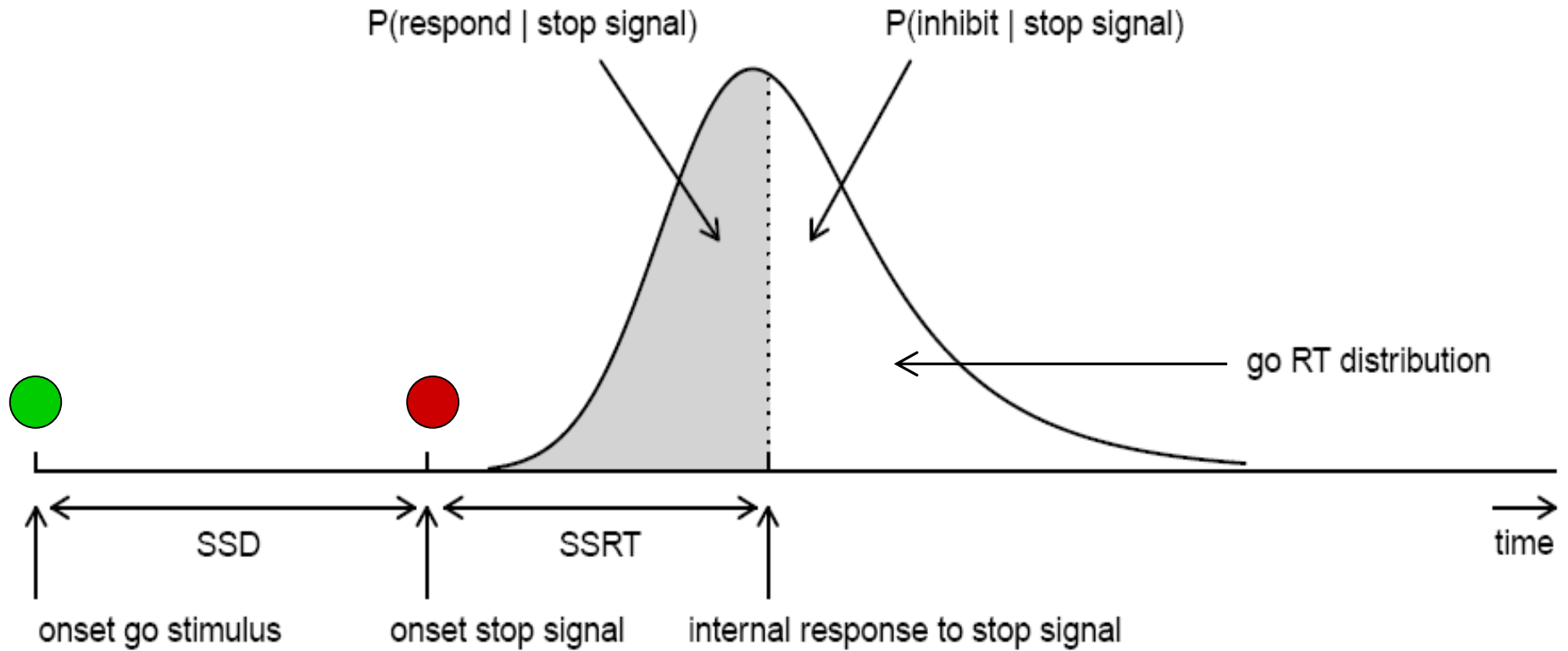
- Go-task interrupted by stop-signal
- Primary dependent variables
 - Observed: Go RTs, SRRTs, number of inhibitions
 - Unobserved: SSRT
- Horse race model (Logan & Cowan, 1984)
 - Outcome determined by relative finishing times of go and stop process



Horse race model



Horse race model

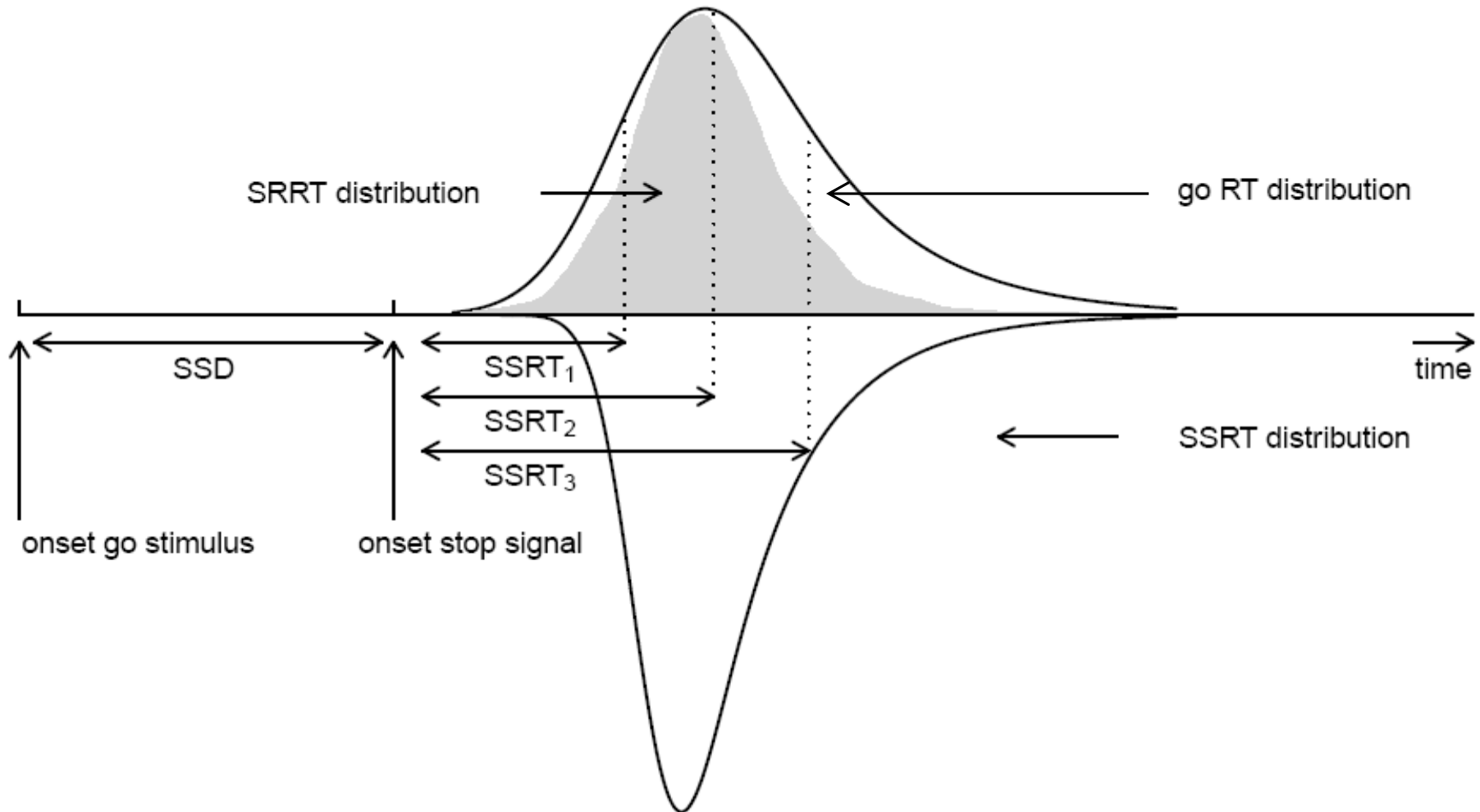


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Bayesian parametric approach: Matzke et al. (2013)

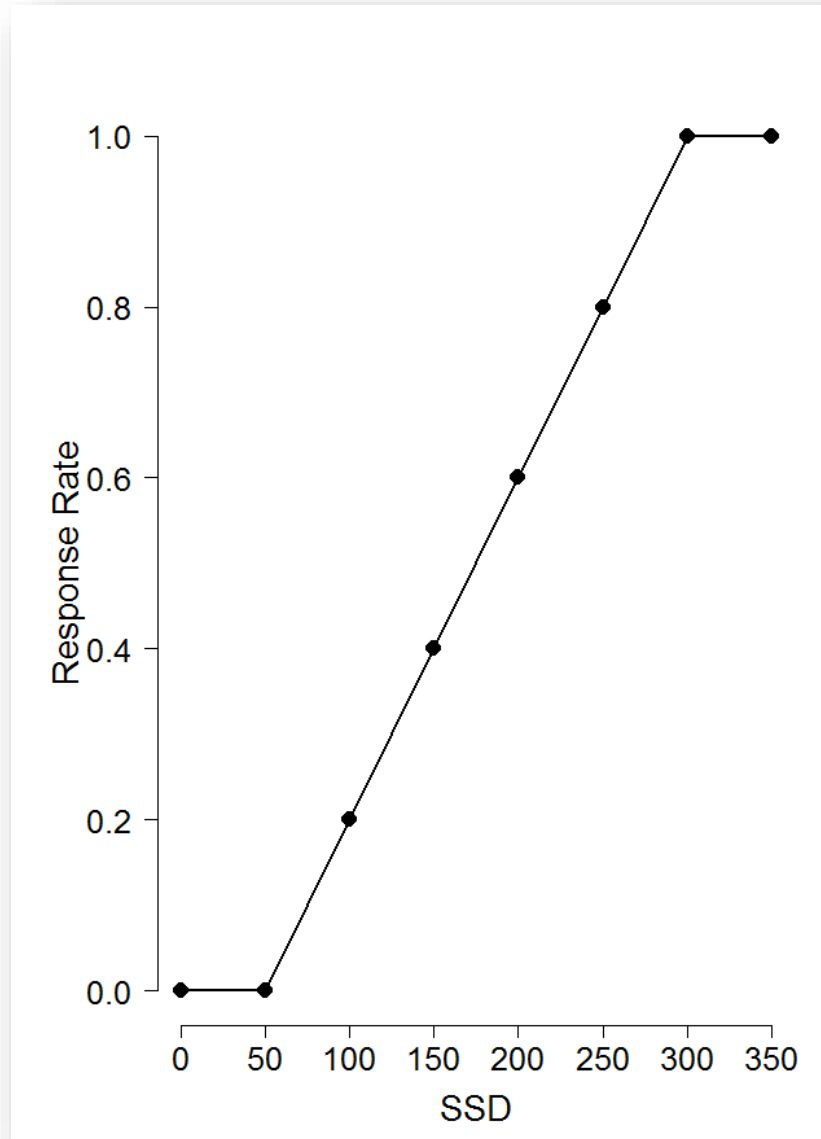


Assumptions & parameters

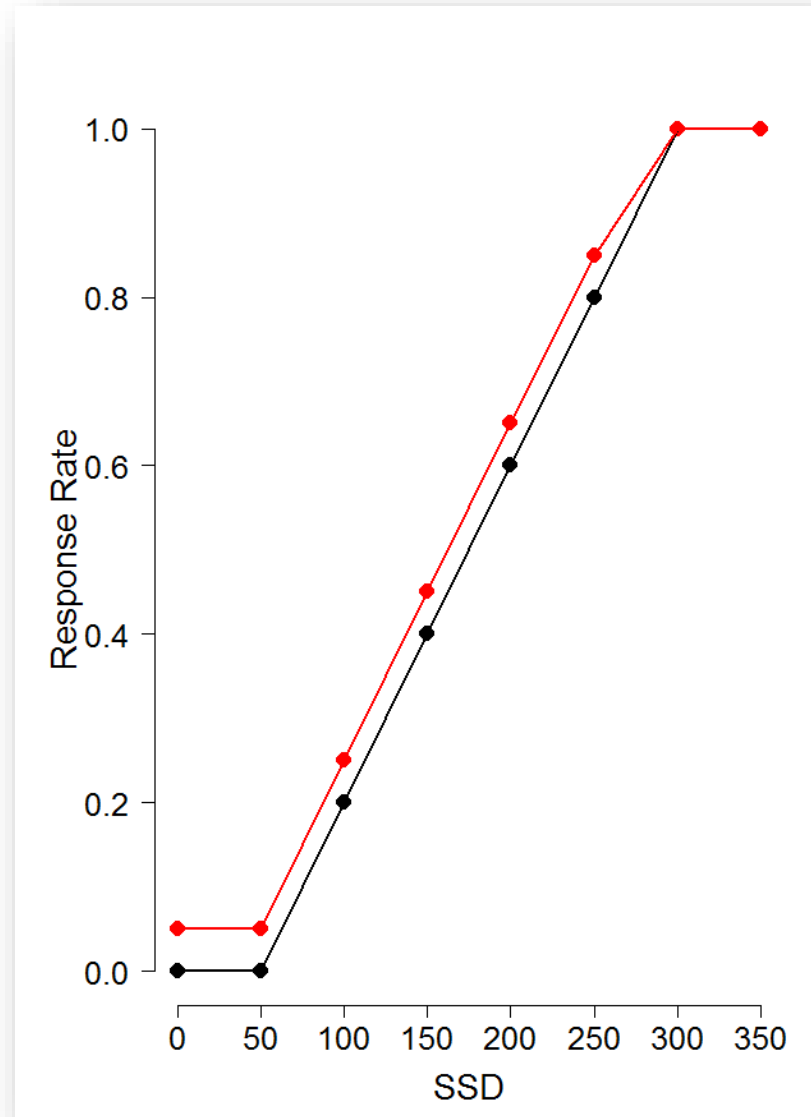
- Go RTs and SSRTs are ex-Gaussian independent random variables
 - μ_{go} , σ_{go} , and τ_{go}
 - μ_{stop} , σ_{stop} , and τ_{stop}



Inhibition function without trigger failures



Inhibition function with trigger failures



Assumptions & parameters

- Go RTs and SSRTs are ex-Gaussian independent random variables
 - μ_{go} , σ_{go} , and τ_{go}
 - μ_{stop} , σ_{stop} , and τ_{stop}
- $P(TF)$ quantifies probability of trigger failure



Parameter estimation: Bayes & priors

- Bayesian parameter estimation using MCMC
 - Posterior \propto likelihood \times prior



Parameter estimation: Bayes & priors

- Bayesian parameter estimation using MCMC
- Individual model
 - Weakly informative independent uniform priors
- Hierarchical model
 - Truncated normal population-level distributions



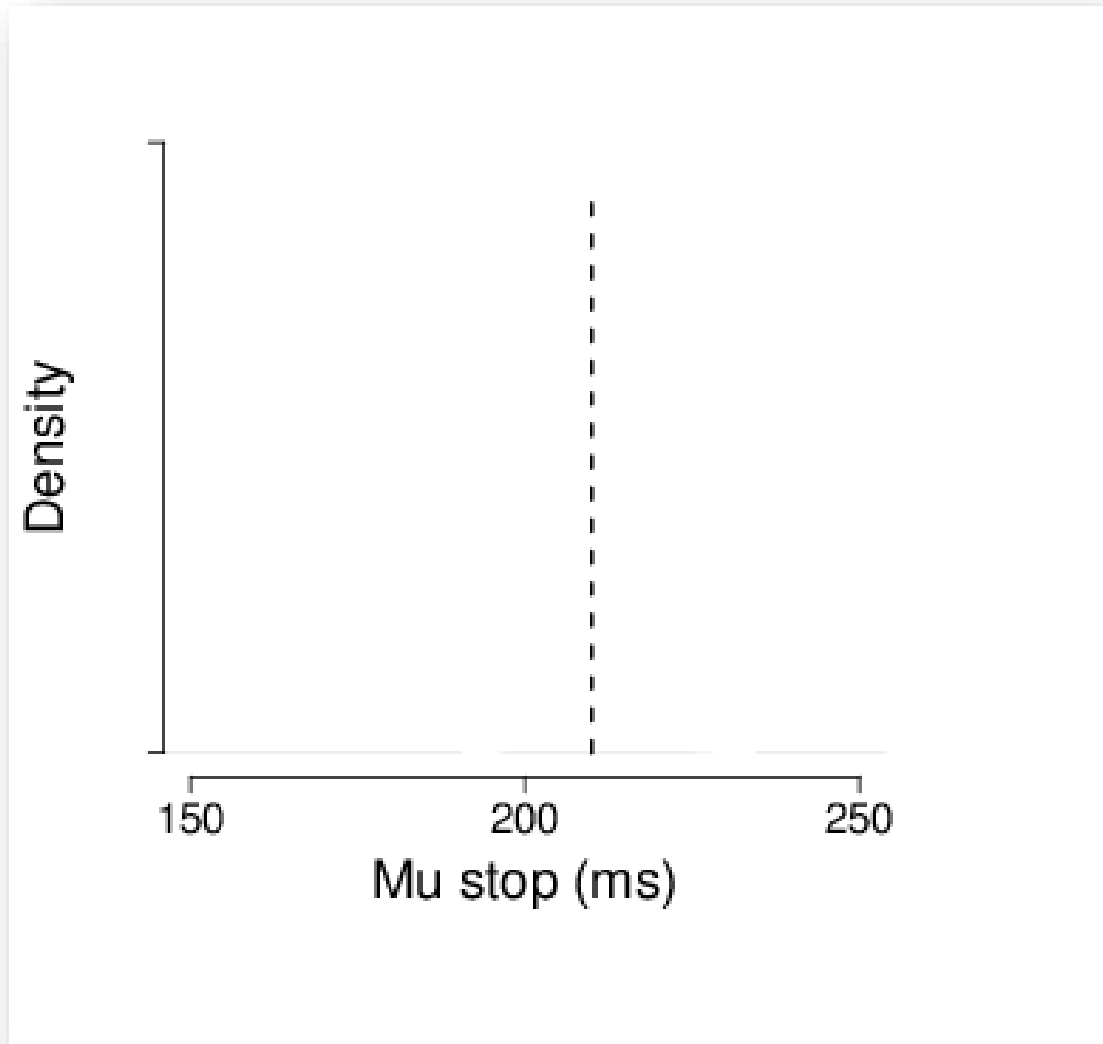
Outline

- Stop-signal paradigm
- Bayesian parametric approach with trigger failures
- **Consequences of unaccounted-for trigger failures**
- Fitting clinical data



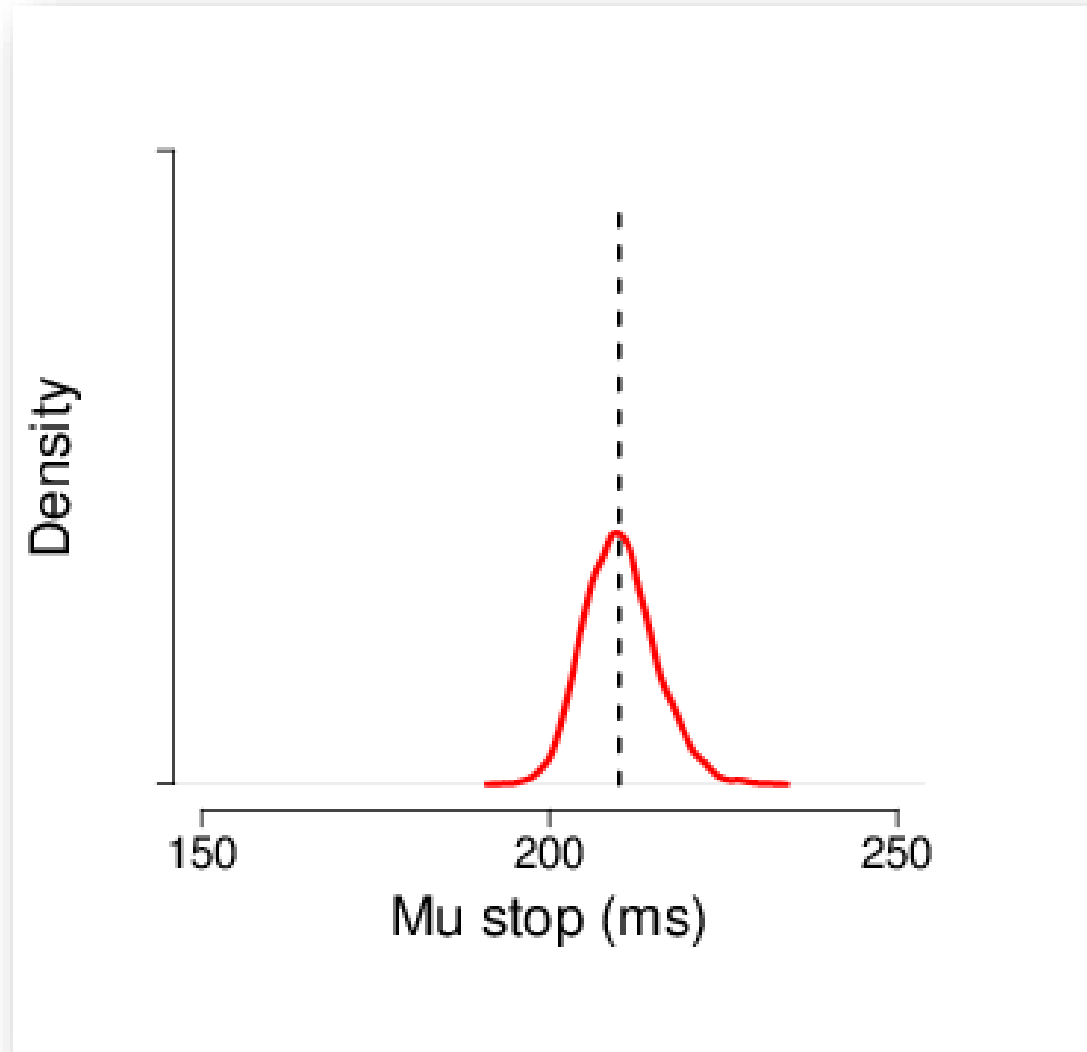
How things go wrong with only 10% trigger failures...

- - - : True value
- : TF model
- : Standard model



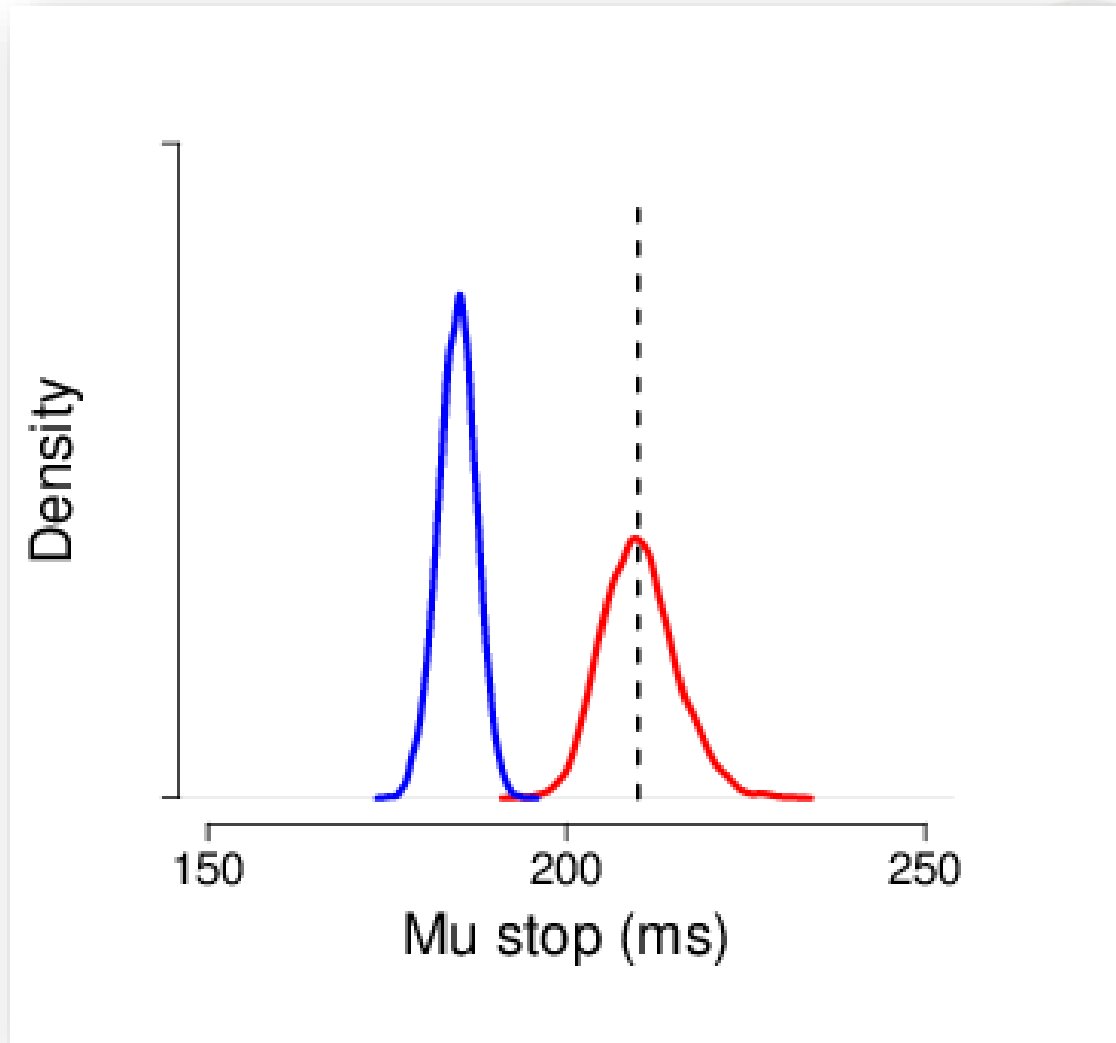
μ_{stop}

- - - : True value
- : TF model
- : Standard model



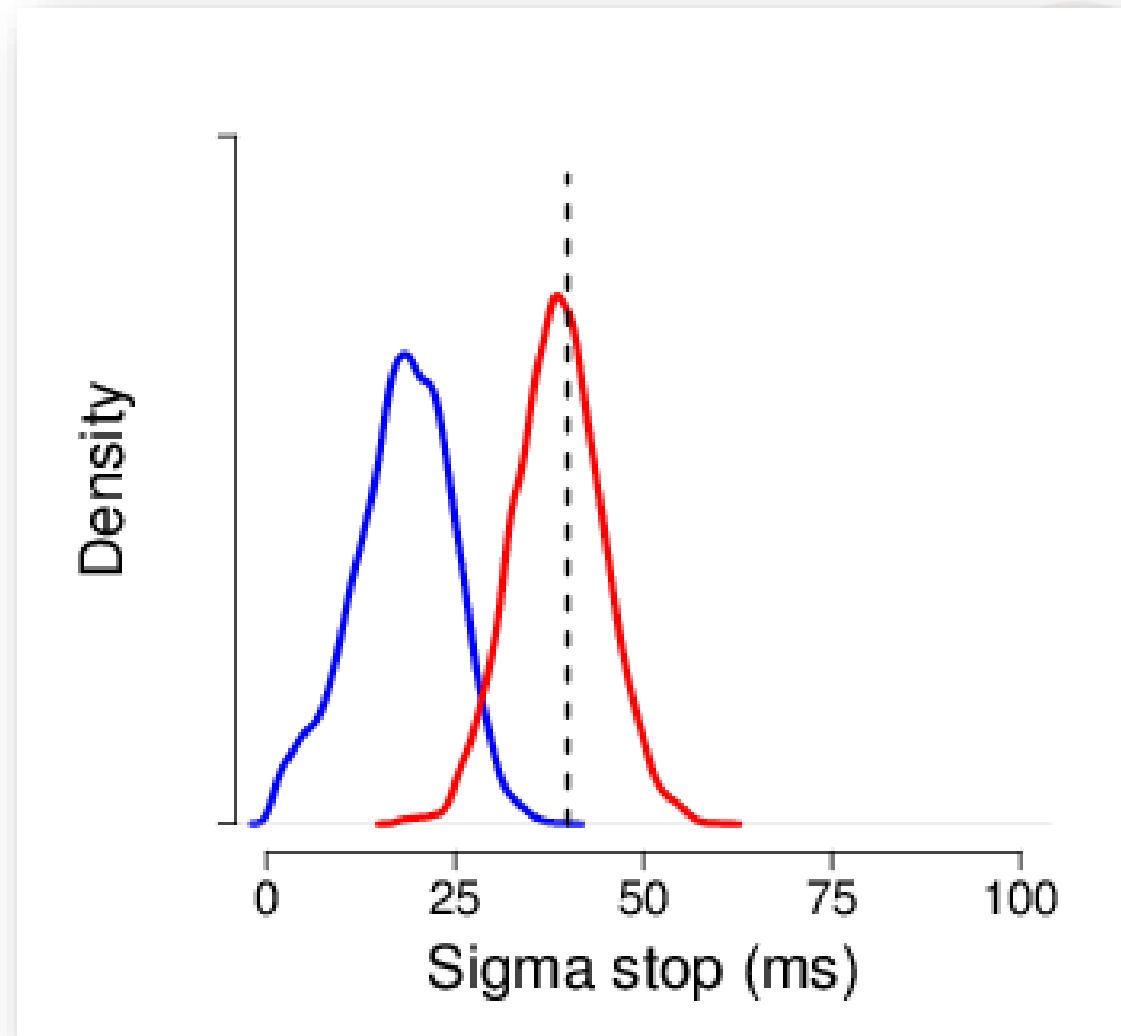
μ_{stop}

- - - : True value
- : TF model
- : Standard model



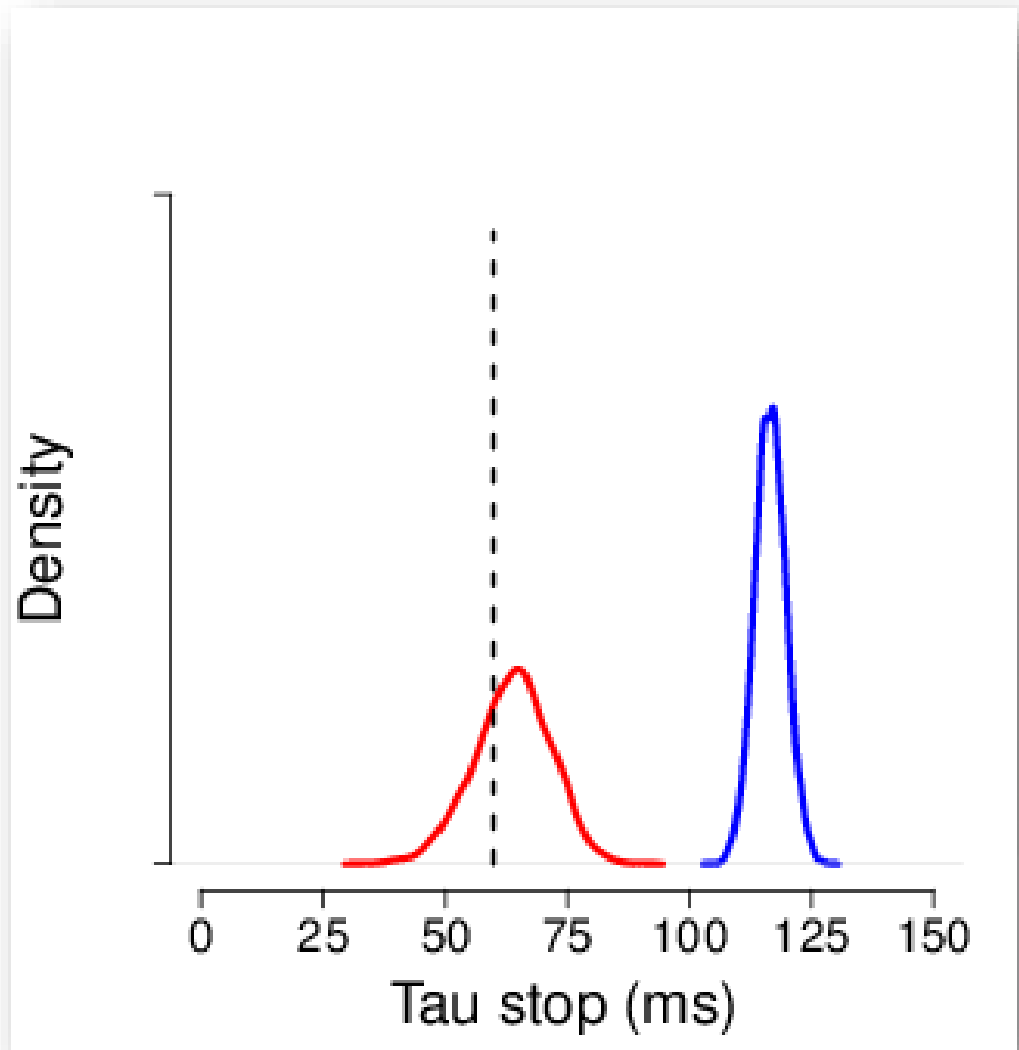
σ_{stop}

- - - : True value
- : TF model
- : Standard model



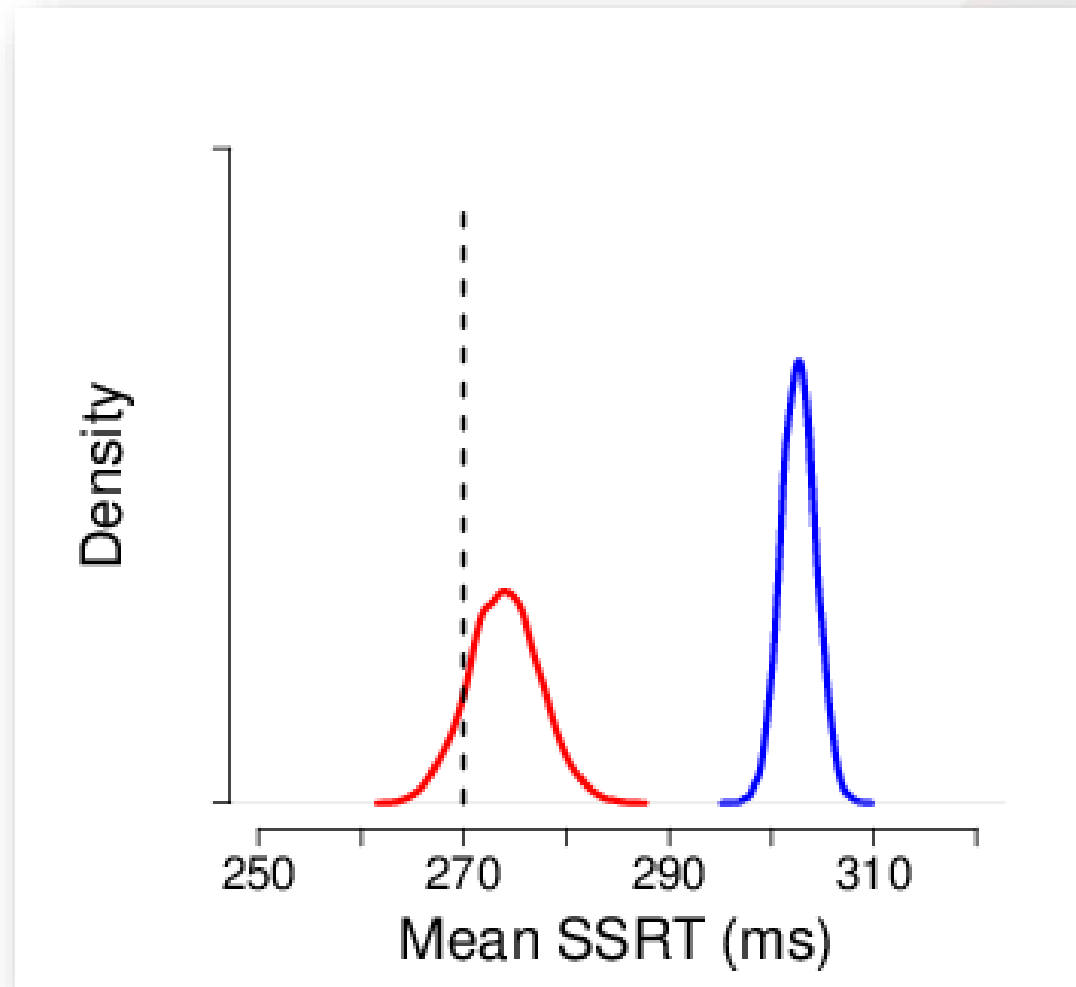
τ_{stop}

- - - : True value
- : TF model
- : Standard model



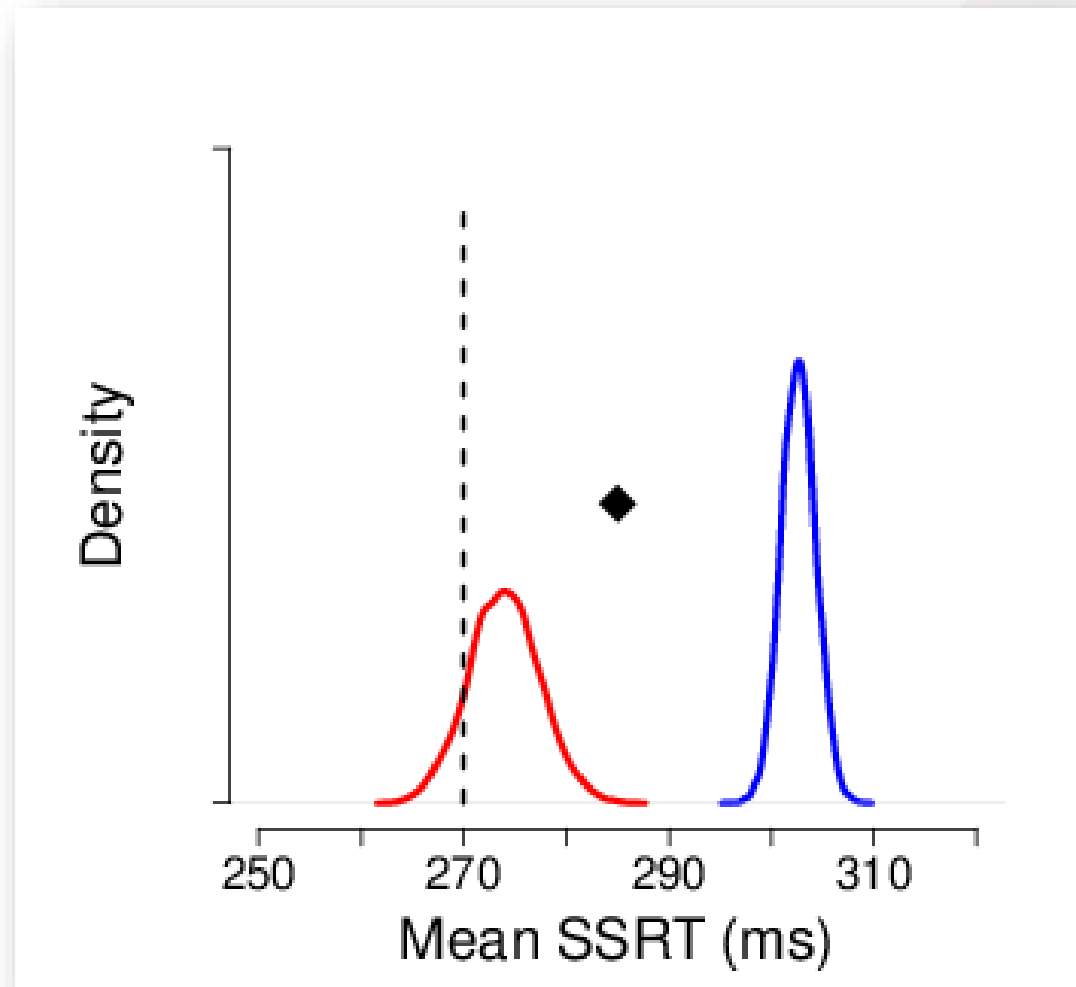
Mean SSRT = $\mu_{\text{stop}} + \tau_{\text{stop}}$

- - - : True value
- : TF model
- : Standard model



Mean SSRT = $\mu_{\text{stop}} + \tau_{\text{stop}}$

- - - : True value
- : TF model
- : Standard model



Outline

- Stop-signal paradigm
- Bayesian parametric approach with trigger failures
- Parameter recovery
- Consequences of unaccounted-for trigger failures
- **Fitting clinical data**



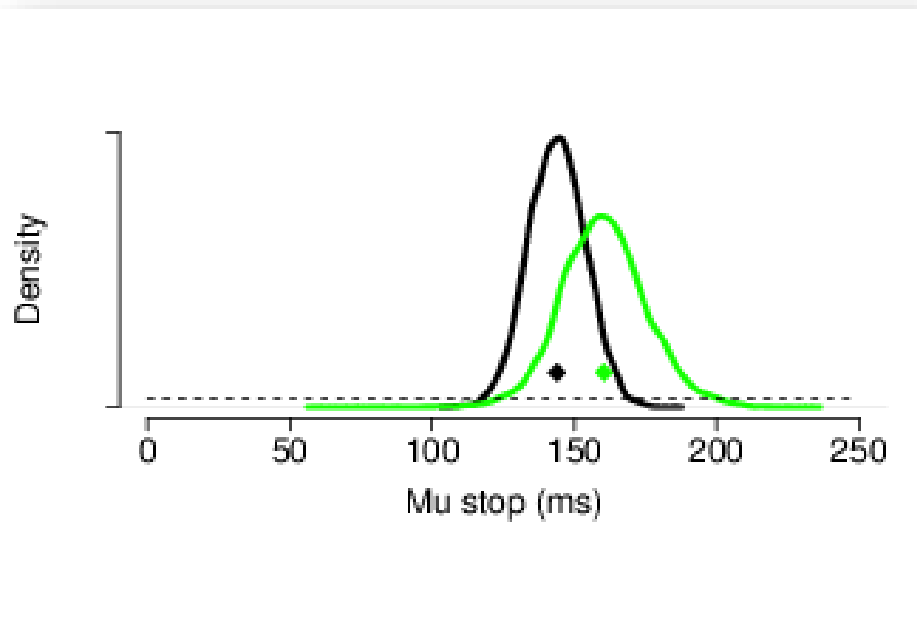
Fitting real data: Hierarchical trigger failure model

- Badcock, Michie, Johnson & Combrink (2002)
- 22 schizophrenia patients & 31 controls
- 288 go trials & 96 stop-signal trials /participant



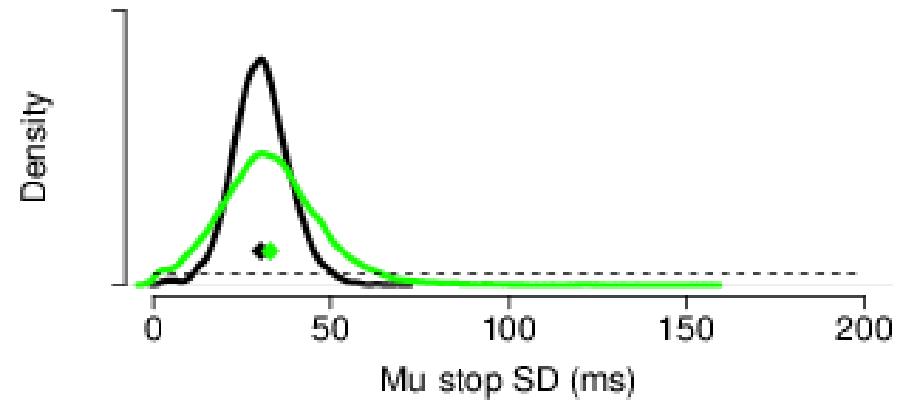
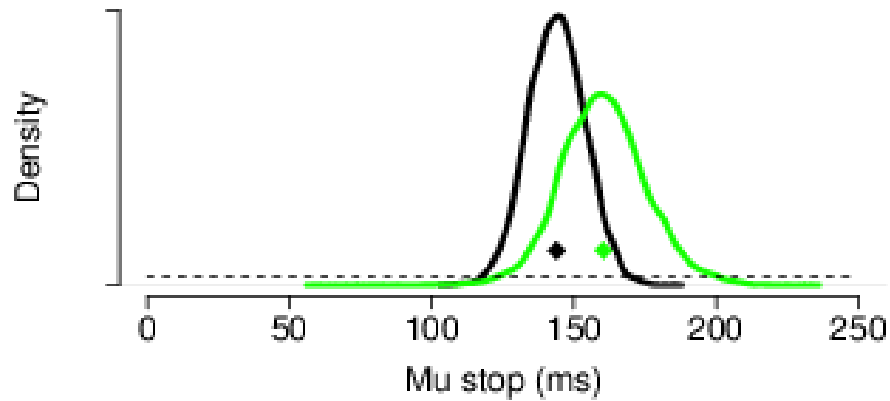
μ_{stop} : Group mean

- : Control
- : Schizophrenia
- - - : Prior



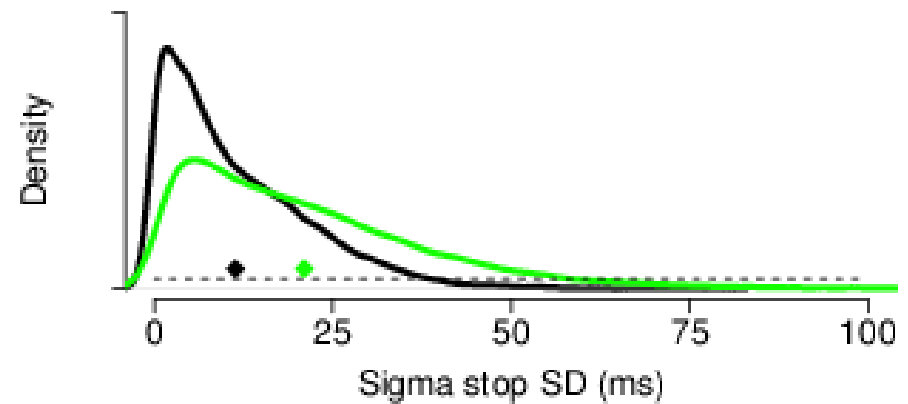
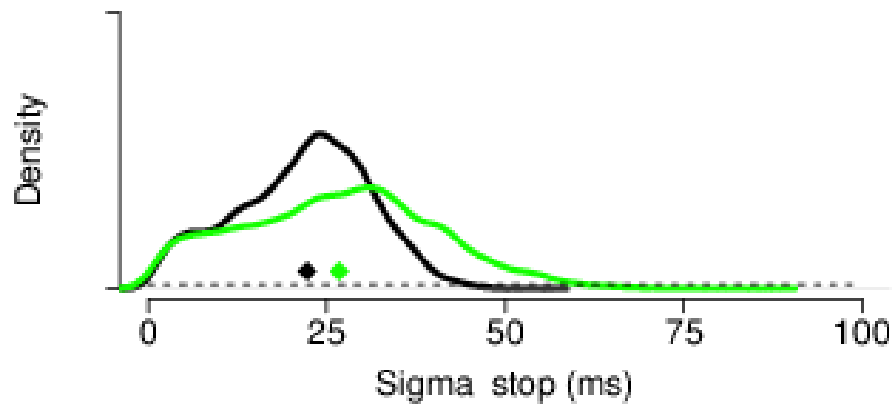
μ_{stop} : Group SD

- : Control
- : Schizophrenia
- - - : Prior



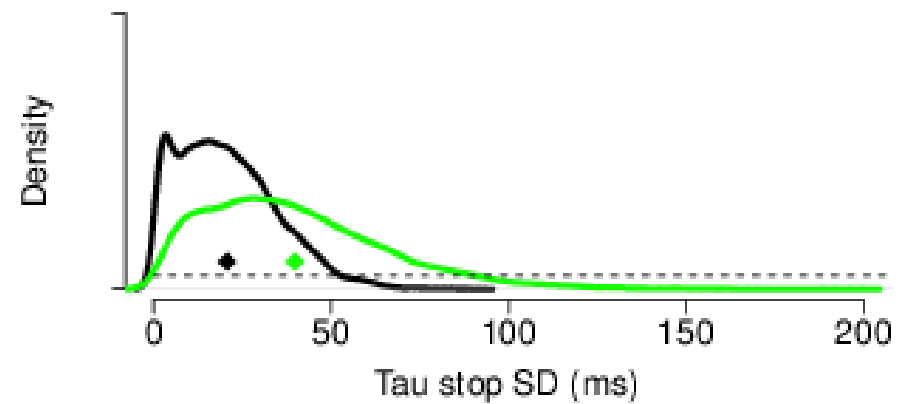
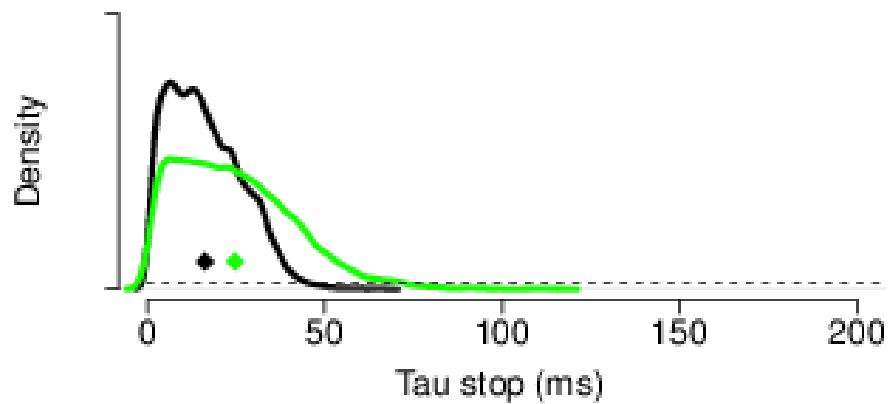
σ_{stop} : Group mean and SD

- : Control
- : Schizophrenia
- - - : Prior



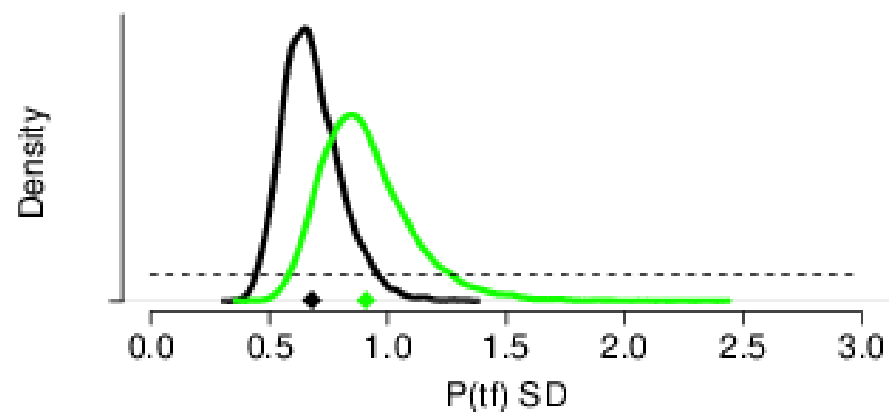
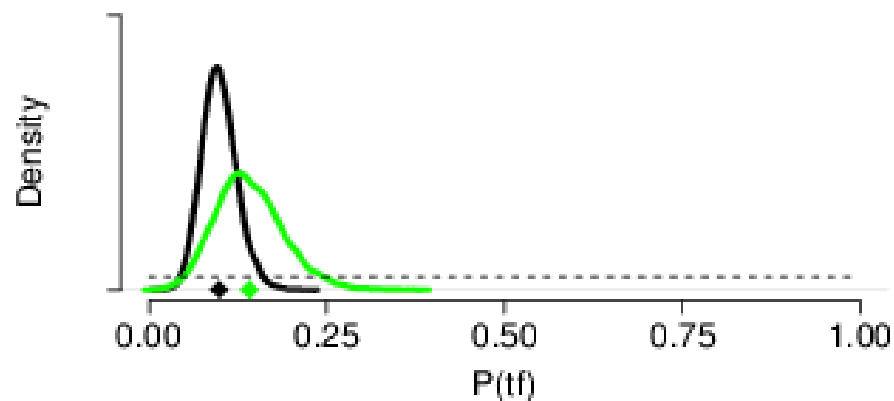
τ_{stop} : Group mean and SD

— : Control
— : Schizophrenia
- - - : Prior



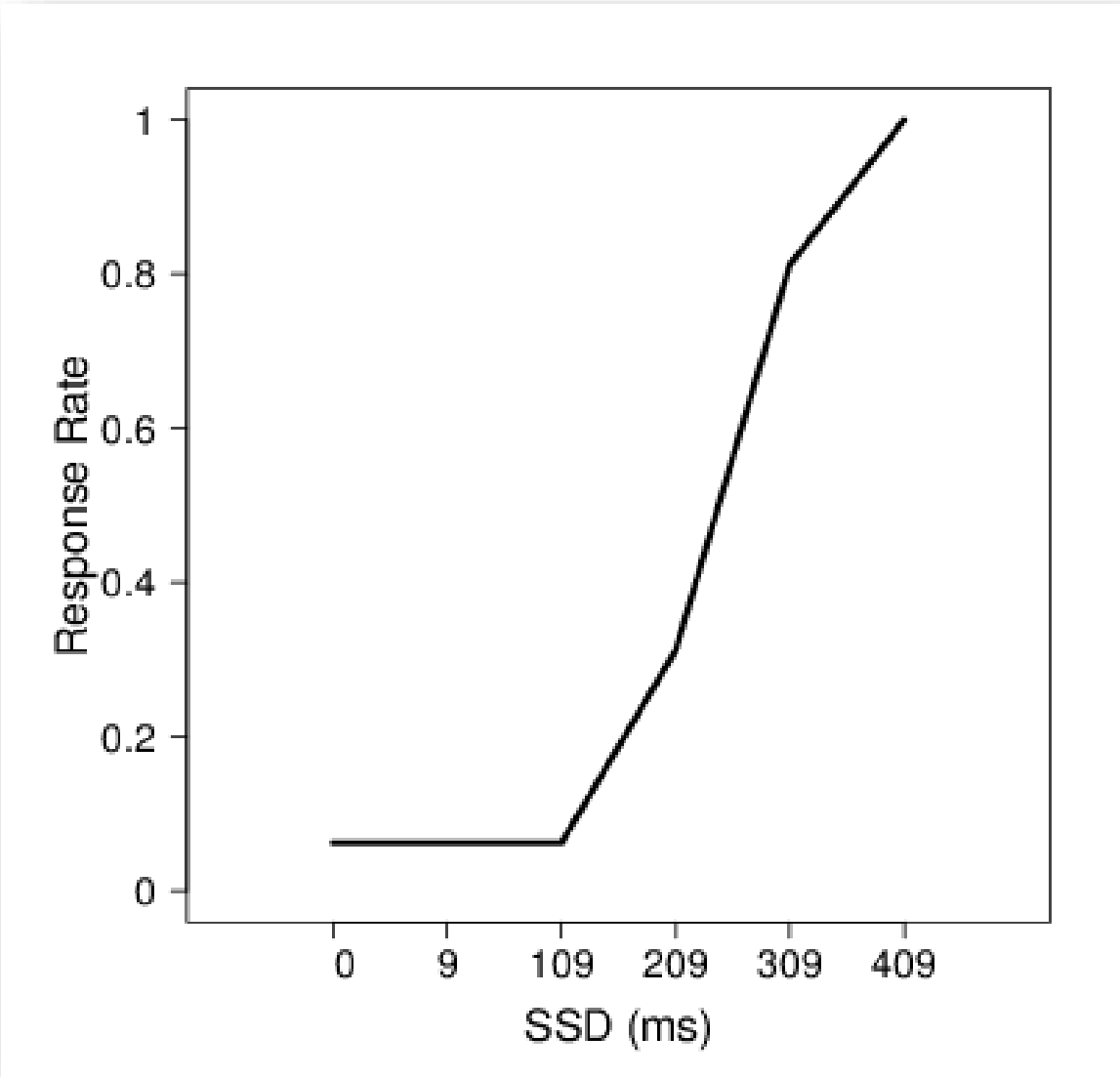
P(TF): Group mean and SD

— : Control
— : Schizophrenia
- - - : Prior



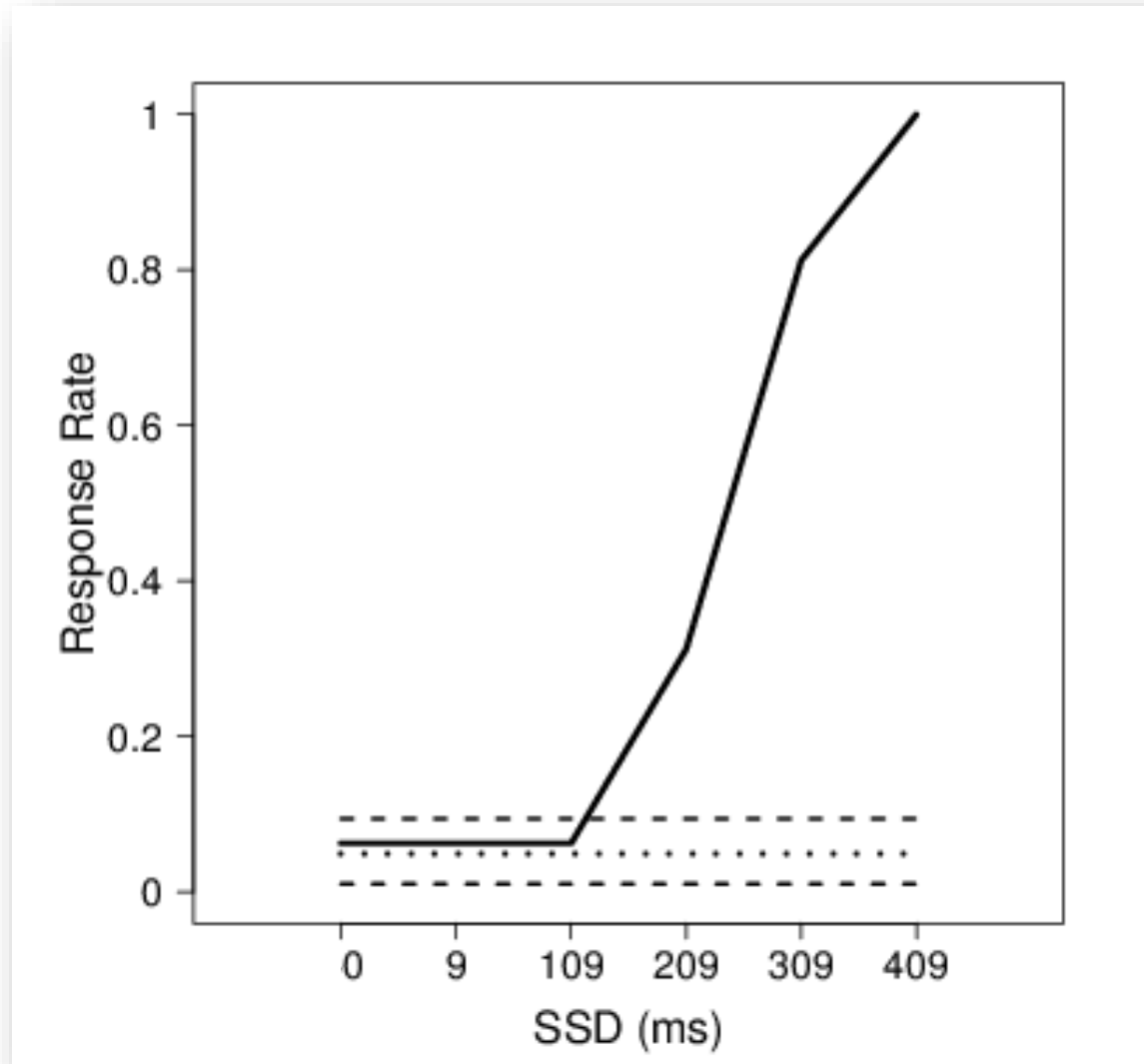
Observed inhibition function

— : Observed



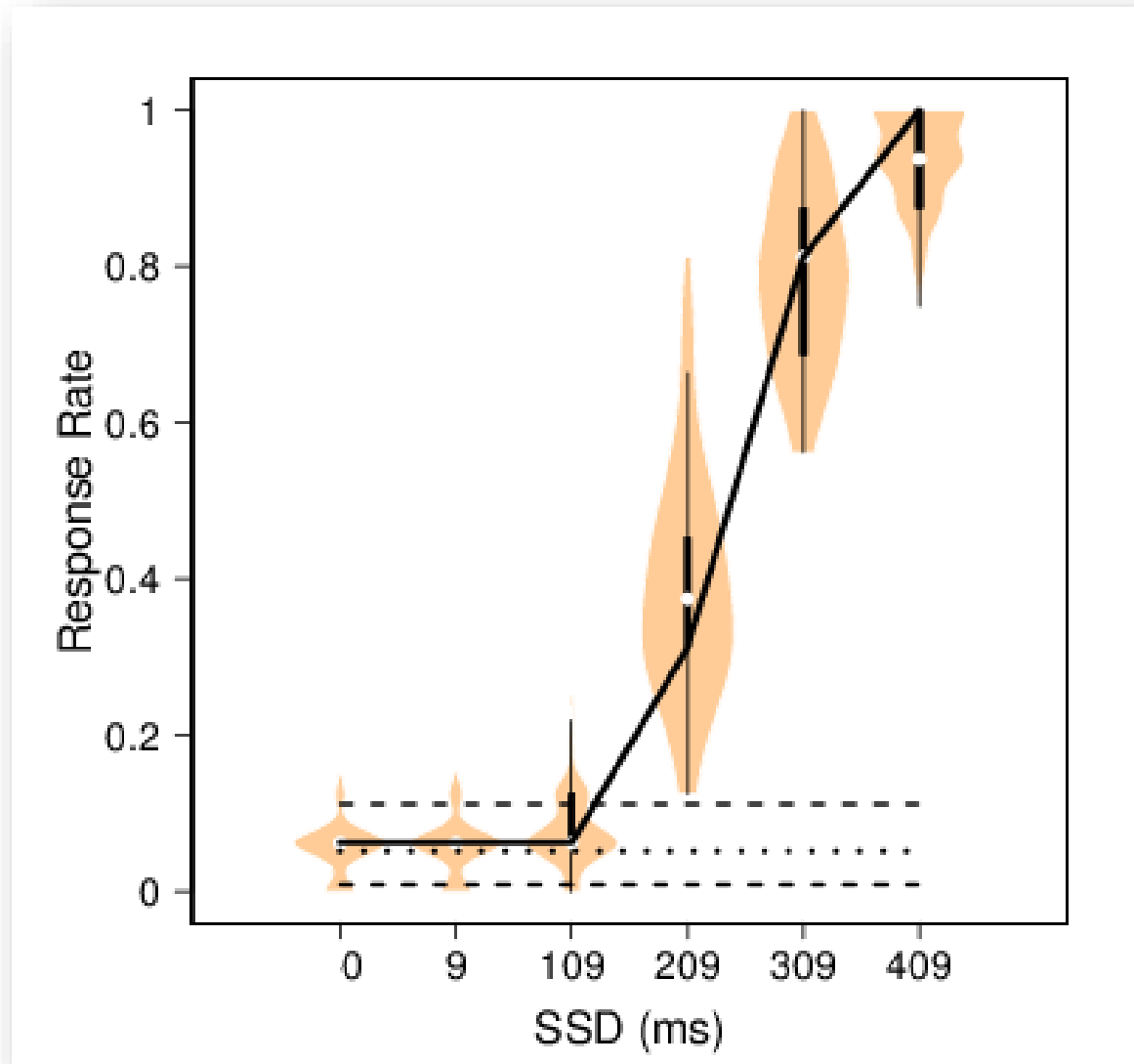
Estimated P(TF)

— : Observed



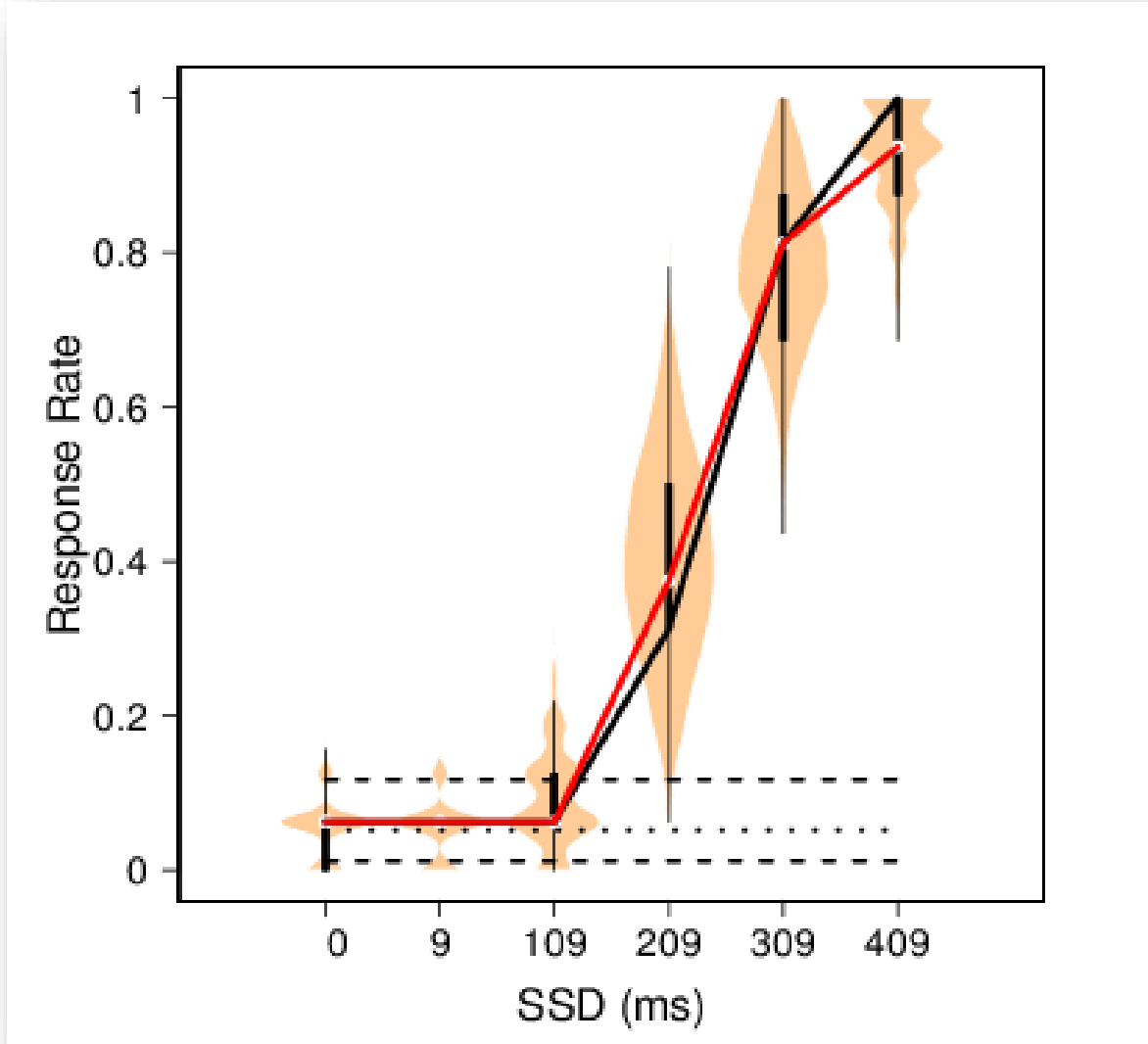
Posterior predictive checks: Predicted response rate

— : Observed



Posterior predictive checks: Predicted inhibition function

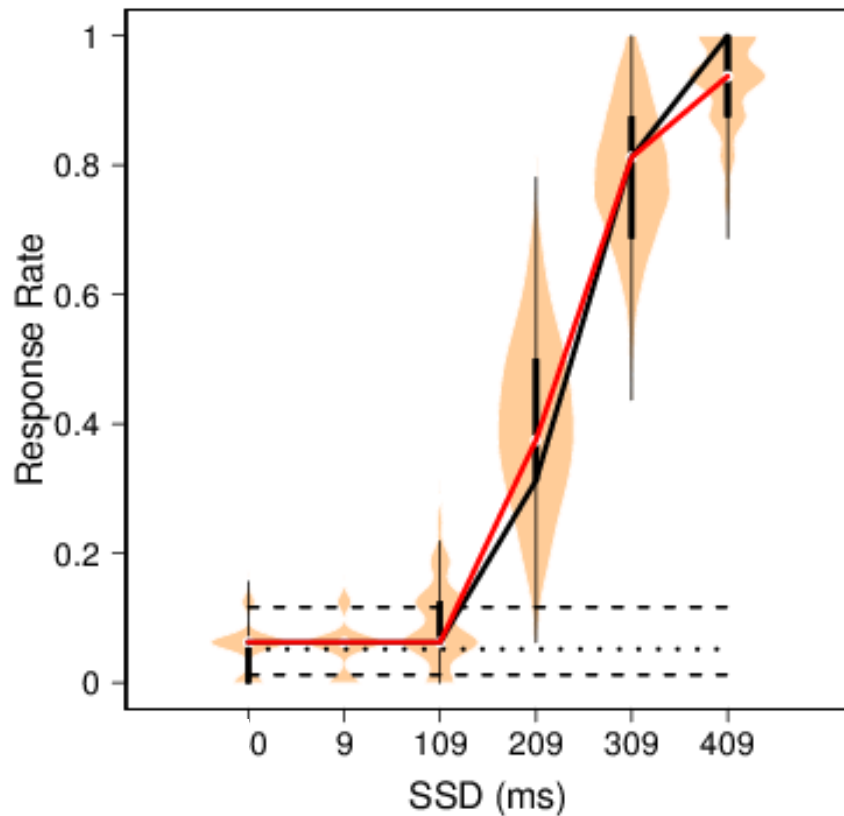
— : Observed
— : Predicted TF



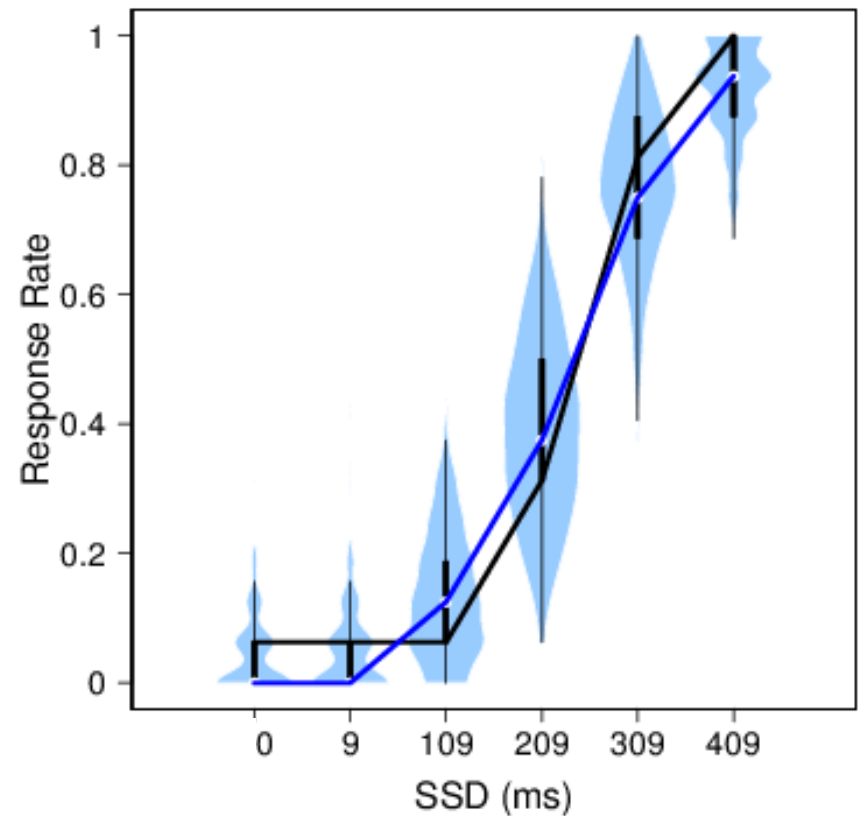
Trigger failure vs. standard model

- : Observed
- : Predicted TF
- : Predicted standard

TF model



Standard model



Summary

- Bayesian parametric approach to simultaneously estimate
 - Probability of failing to trigger the stop response
 - Entire distribution of SSRT
- Individual and hierarchical data structures
- Biased SSRT estimates if trigger failures are not taken into account





BEESTS: Bayesian Ex-Gaussian Estimation of Stop-Signal Reaction Time Distributions

The screenshot shows the BEESTS software interface. The window title is "BEESTS". It has a menu bar with "File", "Data", "Analysis", and "Help". The "Data" tab is selected. The interface is divided into three main sections: "Sampling", "Output", and "Options".

Sampling:

- Number of chains: 3
- Samples: 36000
- Burn-in: 12000
- Thinning: 12

Output:

- Estimates for: All (dropdown)
- Summary statistics
- Posterior distributions
- MCMC chains
- Deviance
- Goodness-of-fit
- Predictions: 1000

Options:

- Max CPU cores to use: 3

Buttons: "Run" and "Clear".

Terminal Output:

```
[*****94*****] 33700 of 36000 complete
[*****94*****] 33800 of 36000 complete
[*****94*****] 33900 of 36000 complete
[*****94*****] 34000 of 36000 complete
[*****94*****] 34100 of 36000 complete
[*****95*****] 34200 of 36000 complete
[*****95*****] 34300 of 36000 complete
[*****95*****] 34400 of 36000 complete
[*****96*****] 34500 of 36000 complete
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[*****99*****] 35600 of 36000 complete
[*****99*****] 35700 of 36000 complete
[*****99*****] 35800 of 36000 complete
[*****100*****] 35900 of 36000 complete
[*****100*****] 36000 of 36000 complete
Waiting for the other chains to finish...
Finished sampling!

Gelman-Rubin Rhat diagnostic:
('mu_stop', 1.0010090205434465)
('tau_stop', 1.0005724142392744)
('tau_go', 0.99966038652743971)
('sigma_go', 1.0002760362550855)
('sigma_stop', 0.99957673163376592)
('mu_go', 0.99990035394249821)
Posterior samples are saved to file.
Deviance values are saved to file.
[1]"Summary statistics are saved to file."

[1]"Posterior distributions are saved to file."

[1]"MCMC chains are saved to file."

[1] "Running posterior predictive model checks. This might take a while..."
```



Available at <http://dora.erbe-matzke.com/software.html>

Thanks for your attention!

Questions?

