Universiteit van Amsterdam

# A Bayesian Parametric Approach for Estimating the Distribution of Stop-Signal Reaction Times

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# Introduction

- Stop-signal paradigm to measure response inhibition
  - Stop-signal RT (SSRT)
- Various methods to estimate SSRT
  - Only summary measures, such as mean SSRT
- New Bayesian parametric approach to estimate the entire distribution of SSRTs

# Outline

- Stop-signal paradigm
  - Existing methods for estimating SSRTs
- Bayesian parametric approach (BPA) for estimating SSRT distributions
- Parameter recovery study
- Fitting real data
- Future directions

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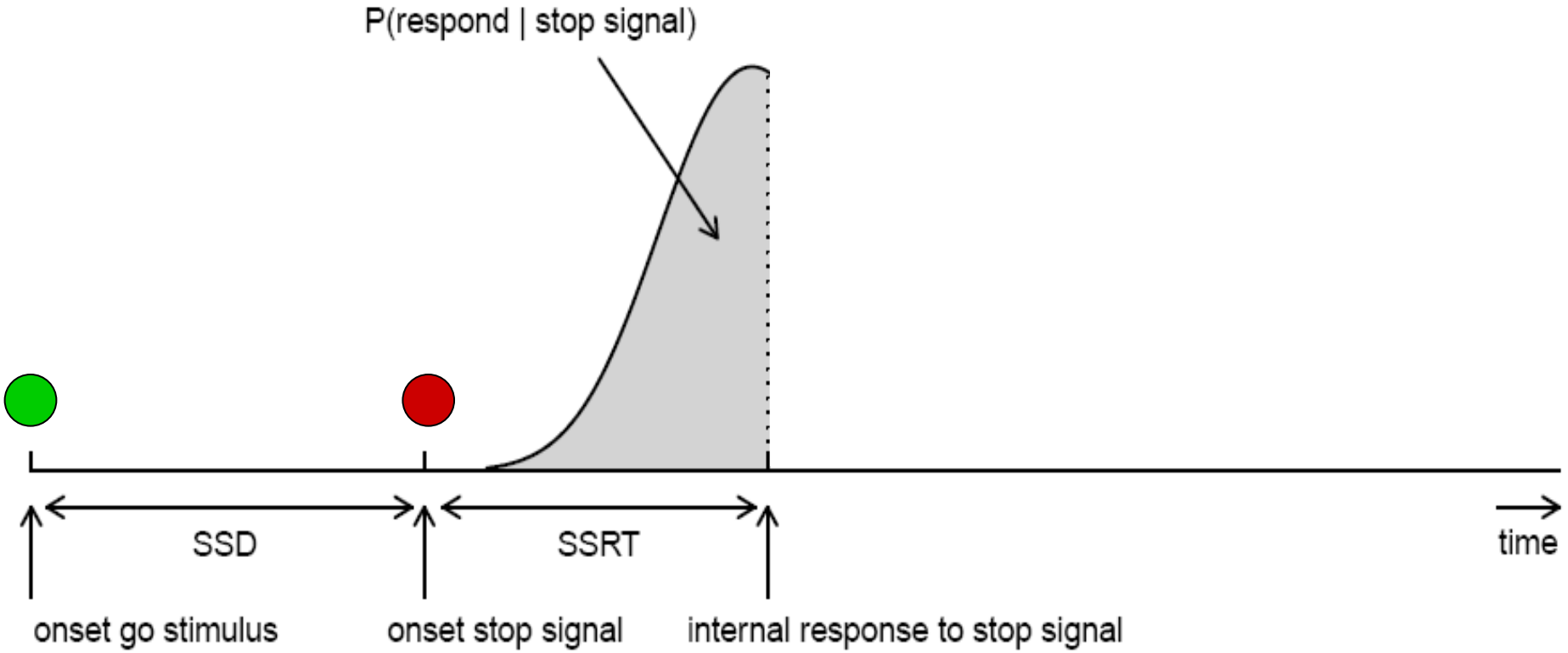
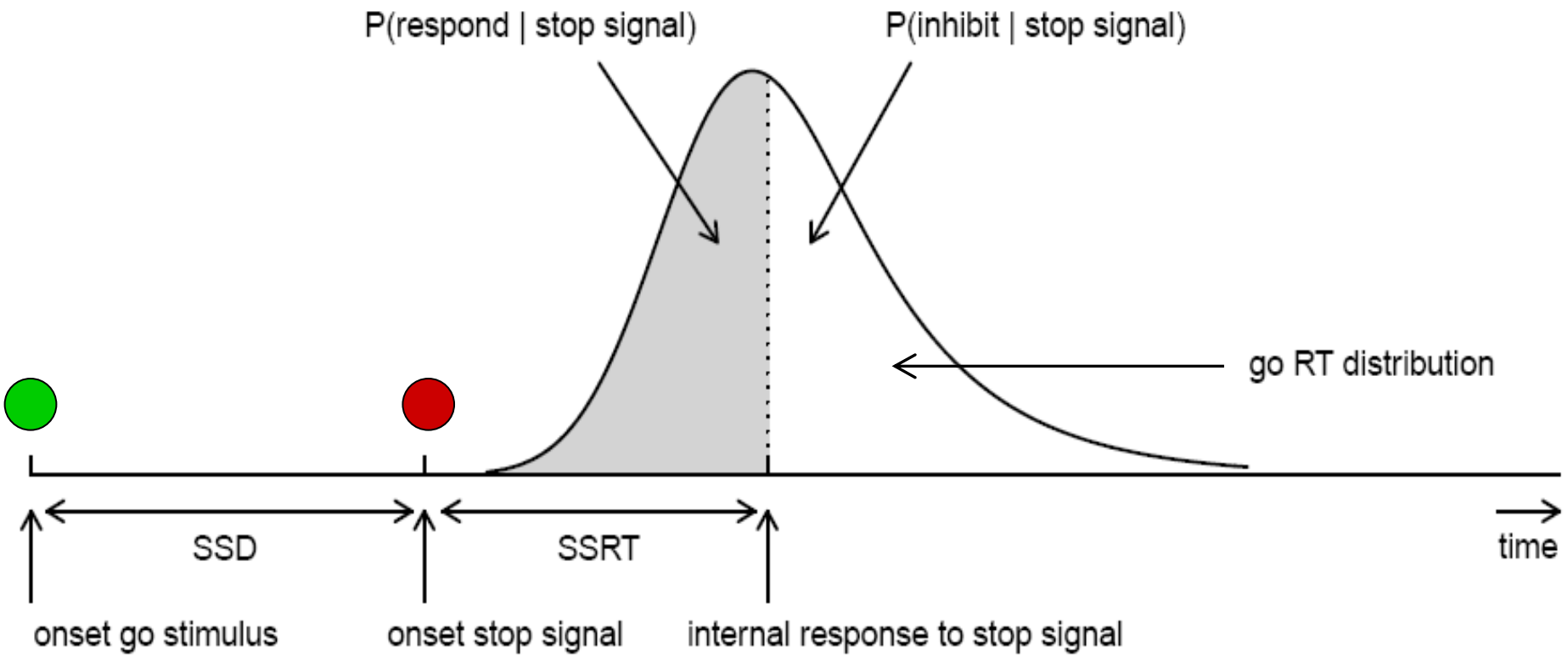
# Stop-Signal Paradigm

- 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



# Estimating SSRT

- Various methods are available
  - Nonparametric
  - Only summary measure of SSRT
- But we want to estimate the entire distribution of SSRTs
- Previously: Colonius (1990) method

# Goal

- Develop an efficient method to estimate SSRT distributions
- Parametric approach
- Individual and hierarchical data structures
- Bayesian parameter estimation

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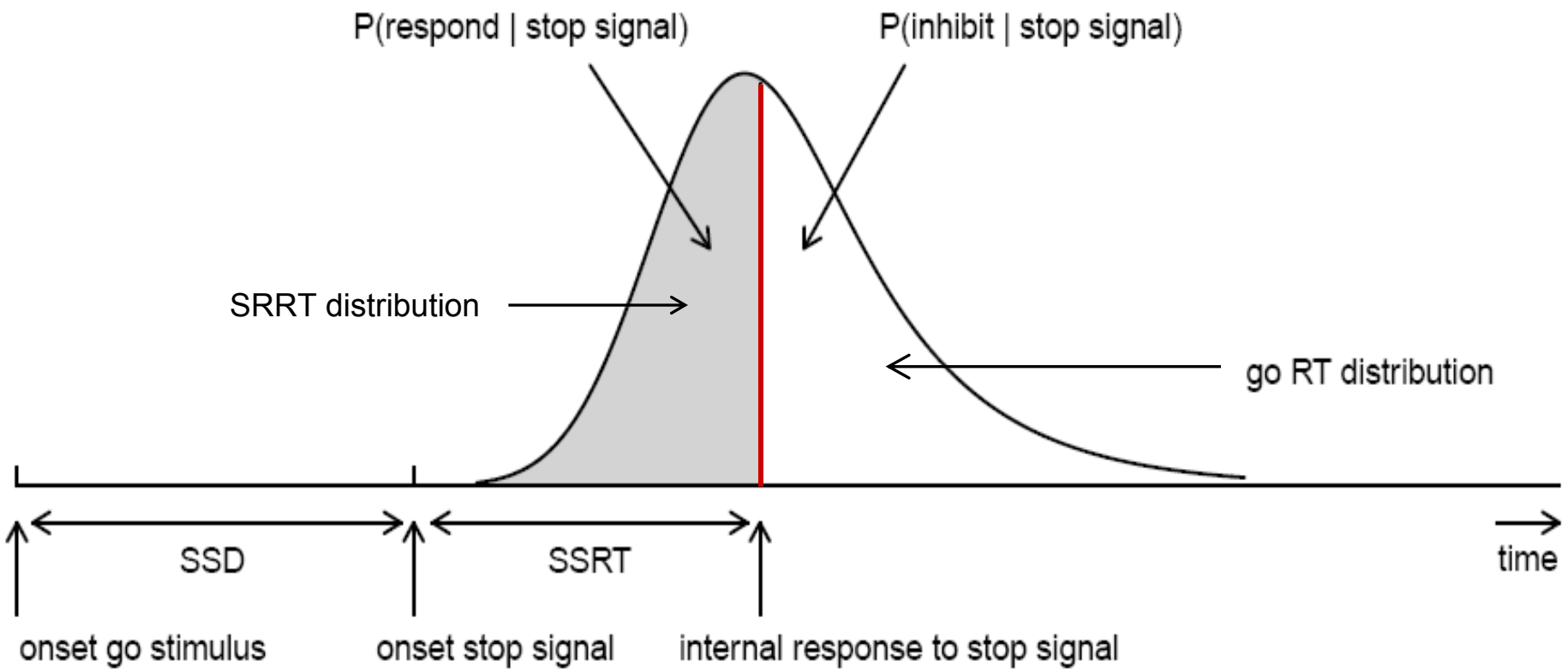
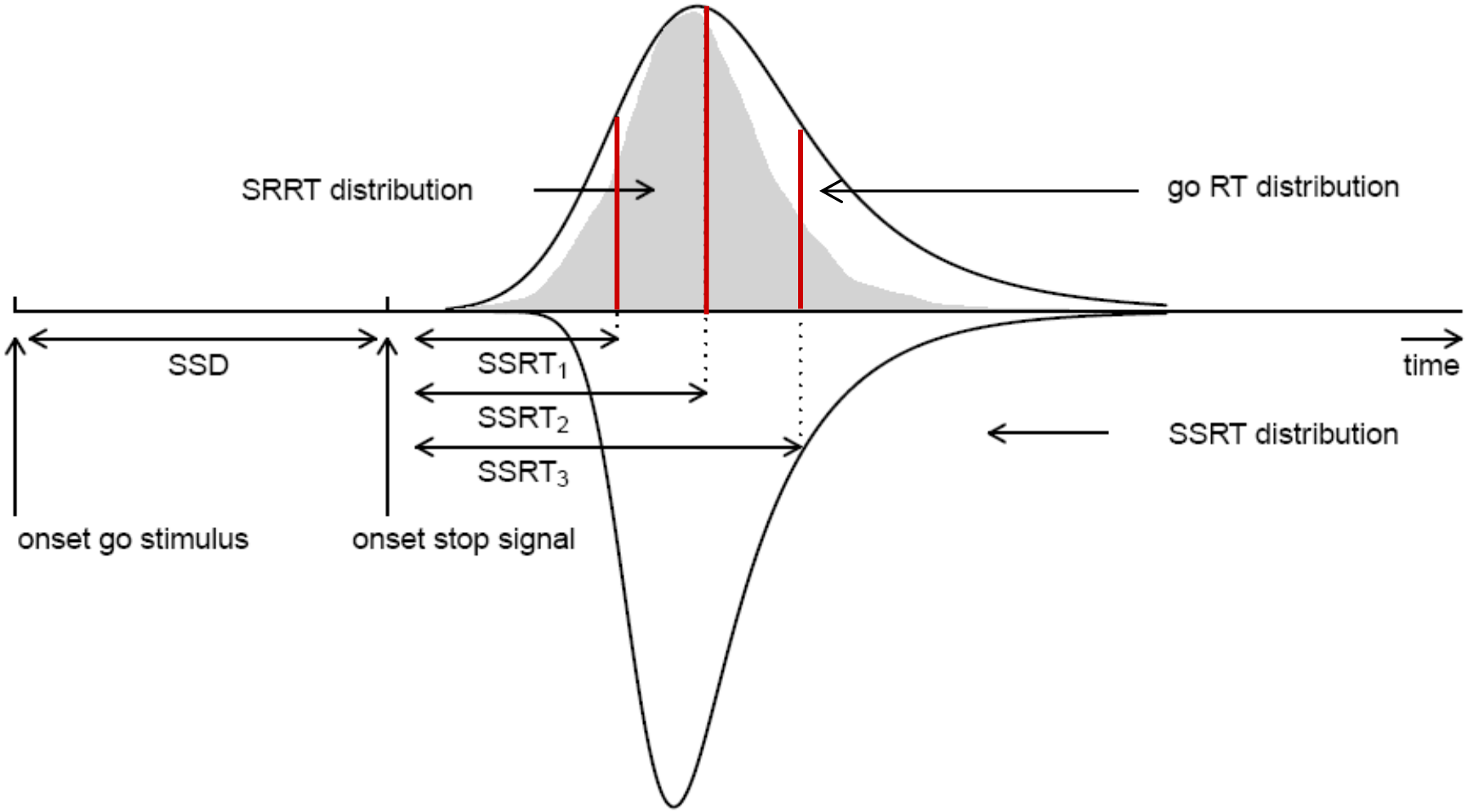
# Horse-race model

- Let's assume that SSRT is constant→ censoring



# Bayesian Parametric Approach

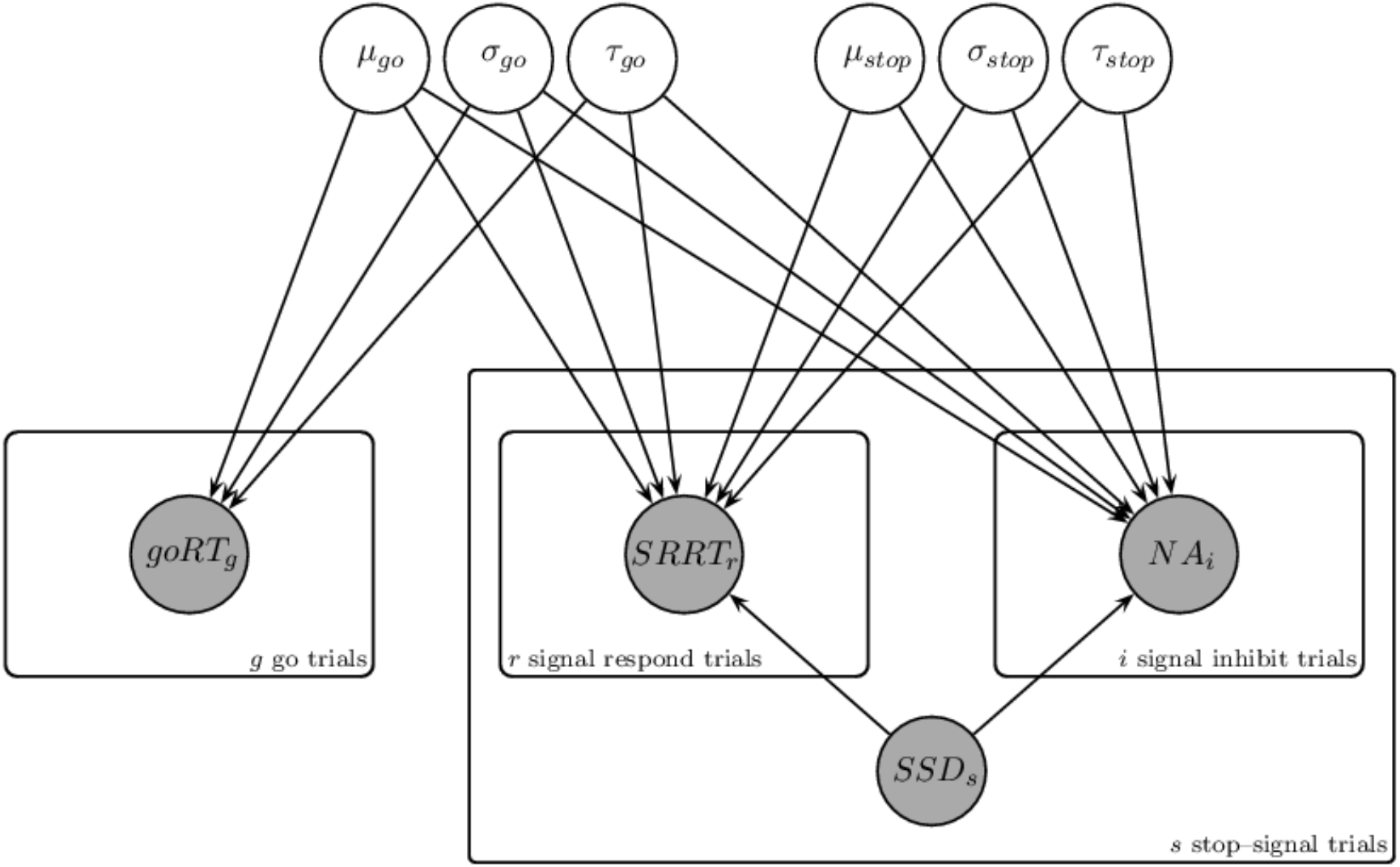
- Let's assume that SSRT is variable→ random censoring



# Assumptions

- Go RT and SSRT are independent random variables
- Go-RTs and SSRTs are ex-Gaussian distributed
  - μ, σ, and τ

# Graphical Model



# Implementation

- Bayesian parameter estimation
  - Posterior $\propto$ likelihood × prior
- Likelihood: implemented in WBDev
- Prior: independent uniform across a plausible range
- Use WinBUGS to sample from the posterior distribution of the parameters

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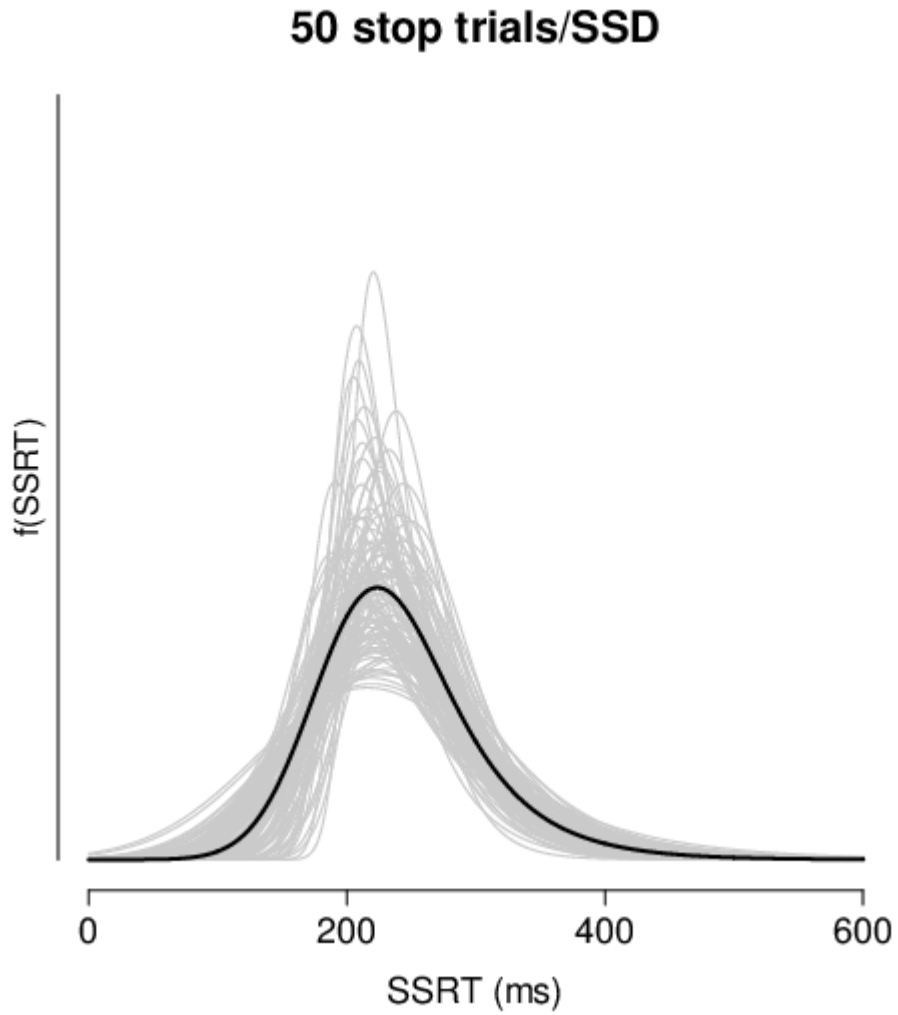
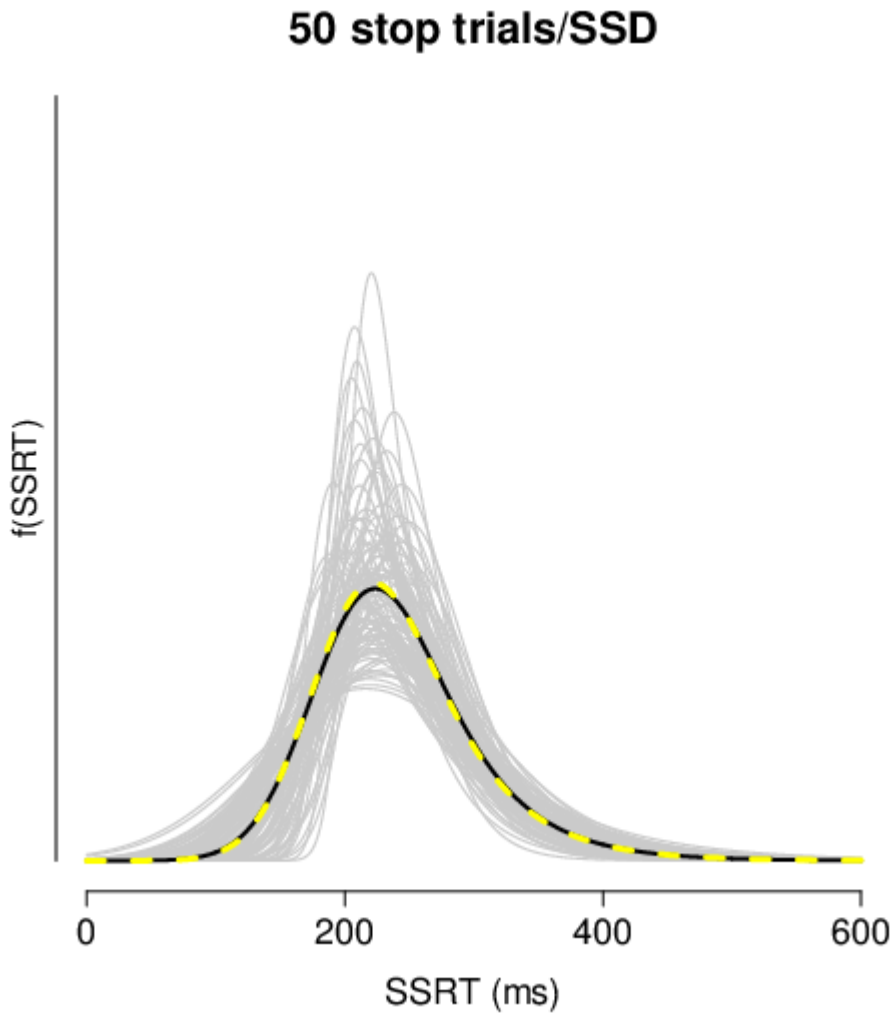
# Recovery Study



# Recovery Study



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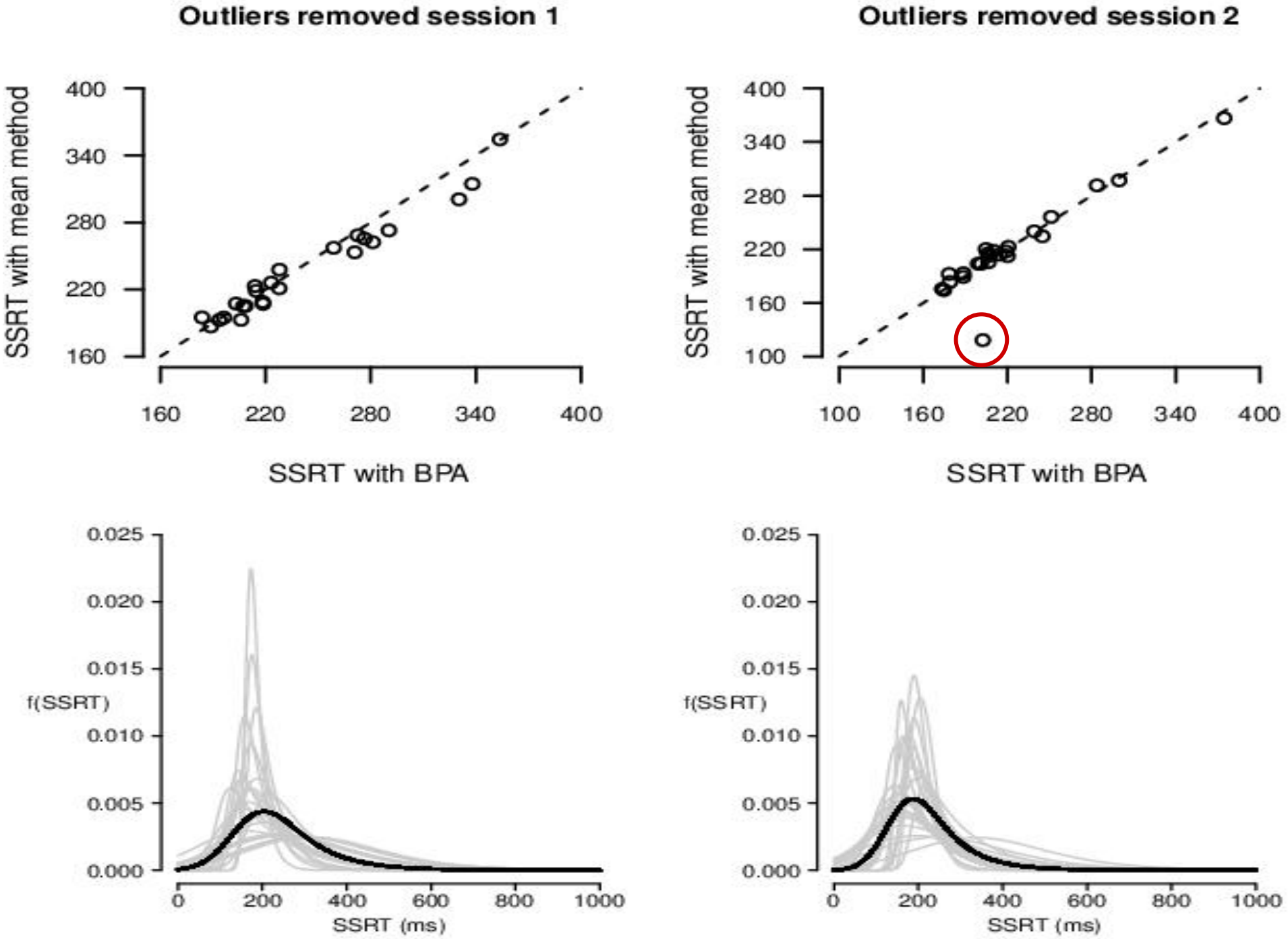
# Fitting Real Data: Bissett & Logan (2011)

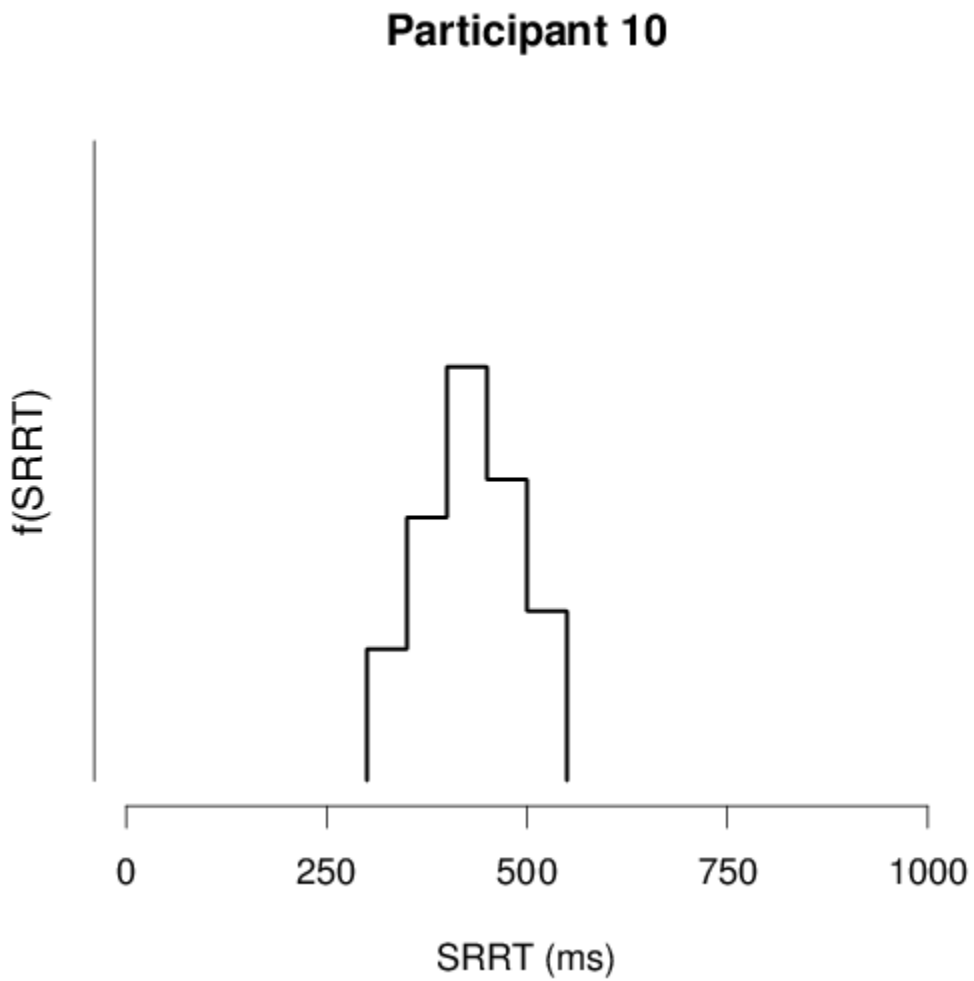
- N = 24
- Session 1: 960 go and 240 stop trials
- Session 2:  720 go and 480 stop trials
- SSD set using the staircase tracking procedure → P(respond|signal) = 0.50


Outliers removed session 1
SSRT with mean method
400
340
280
220
160
160
220
280
340
400
Outliers removed session 2
SSRT with mean method
400
340
280
220
160
100
100
160
220
280
340
400
SSRT with BPA
f(SSRT)
0.025
0.020
0.015
0.010
0.005
0.000
0
200
400
600
800
1000
SSRT (ms)
SSRT with BPA
f(SSRT)
0.025
0.020
0.015
0.010
0.005
0.000
0
200
400
600
800
1000
SSRT (ms)

# Posterior Predictive Model Checks

- Observed SRRT distribution vs. predicted SRRT distributions

# Posterior Predictive Model Checks



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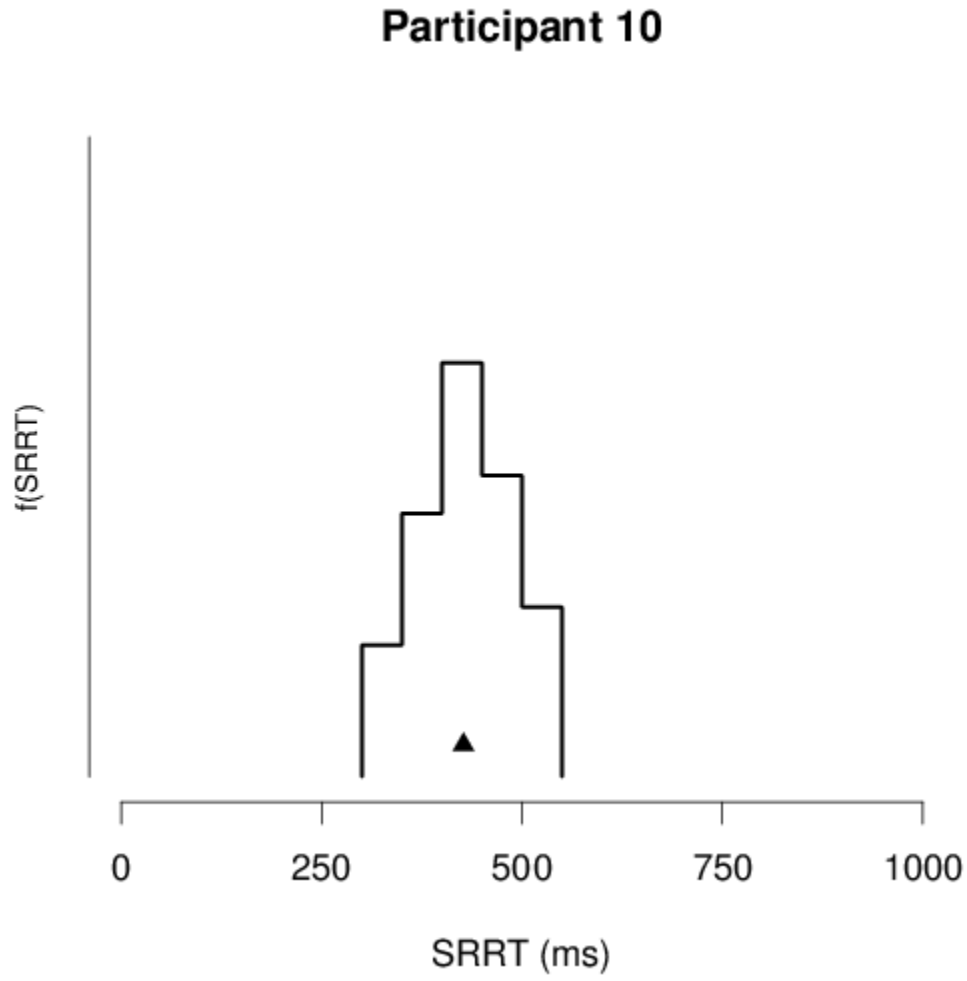

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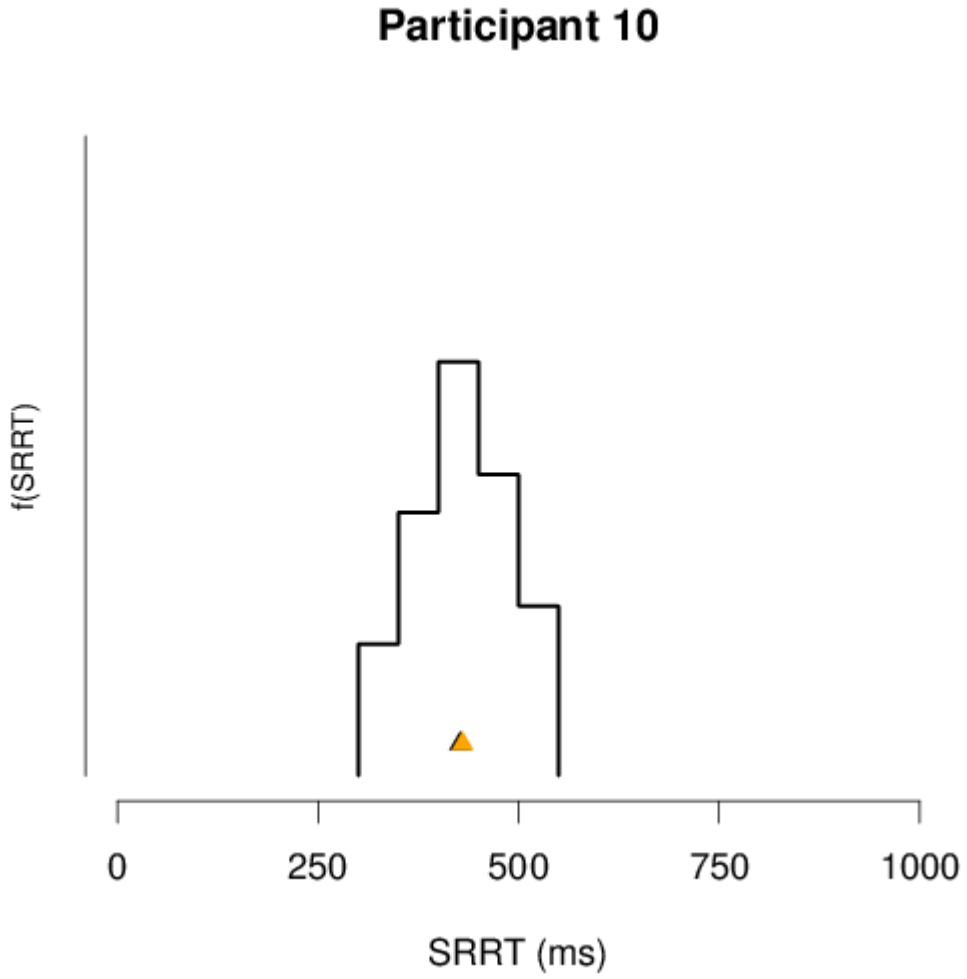

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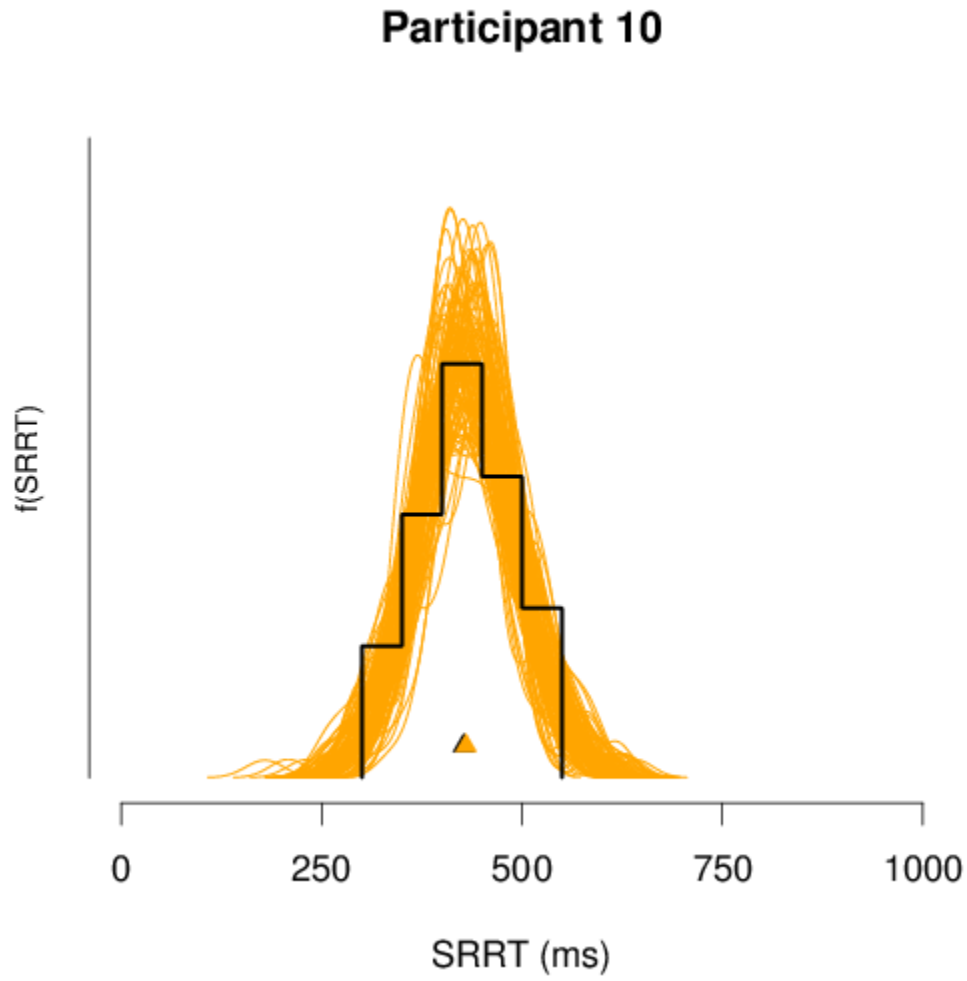

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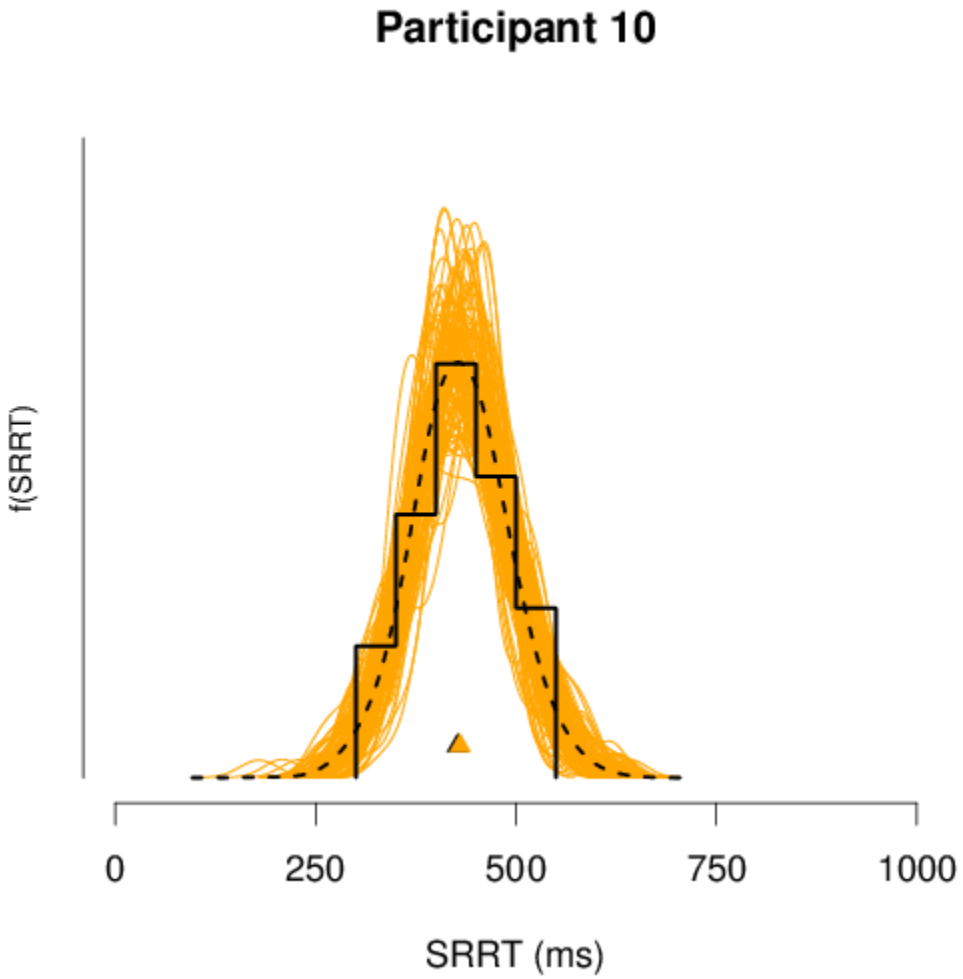

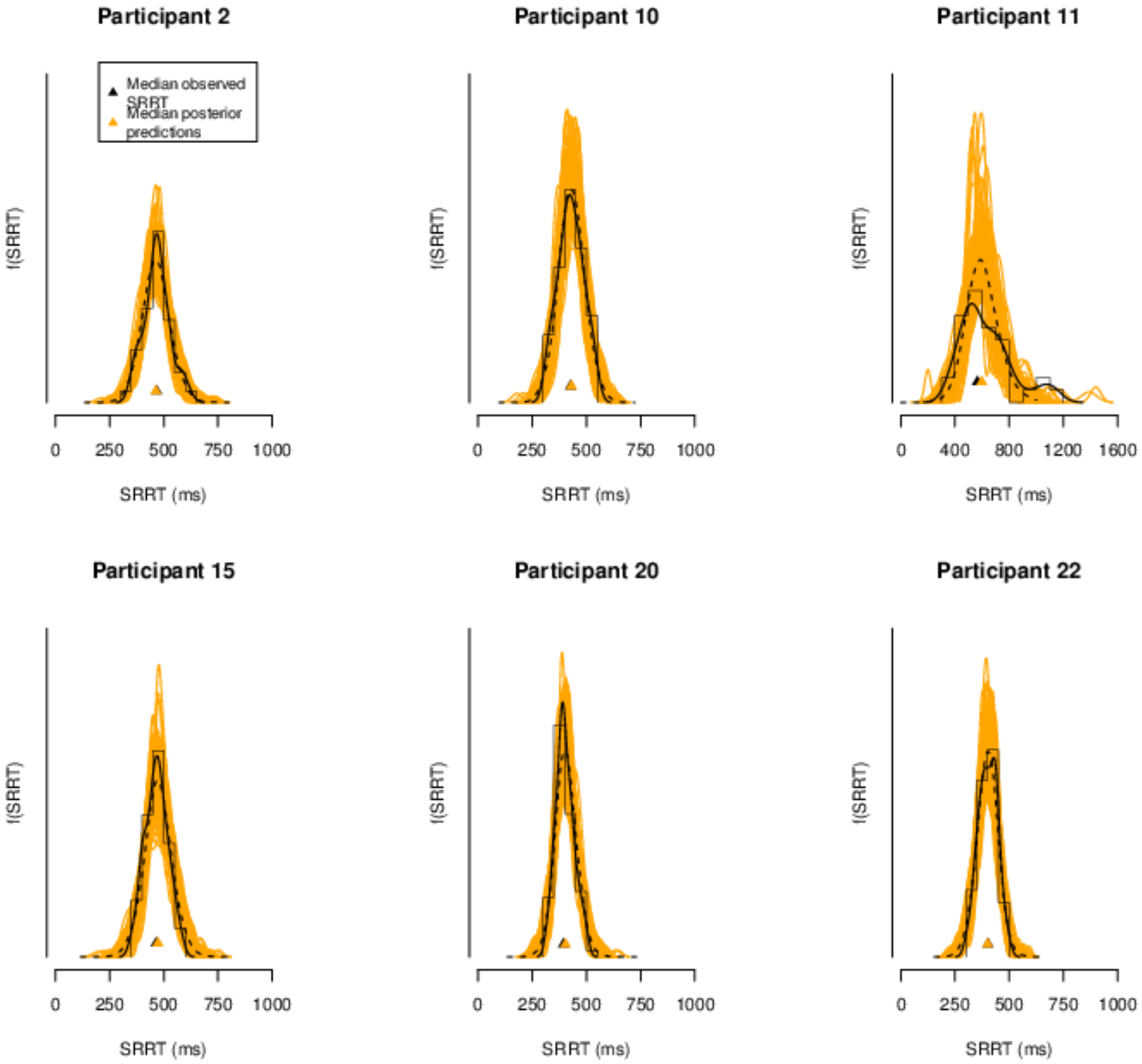
Participant 2
Median observed SRRT
Median posterior predictions
f(SRRT)
0
250
500
750
1000
SRRT (ms)
Participant 10
f(SRRT)
0
250
500
750
1000
SRRT (ms)
Participant 11
f(SRRT)
0
400
800
1200
1600
SRRT (ms)
Participant 15
f(SRRT)
0
250
500
750
1000
SRRT (ms)
Participant 20
f(SRRT)
0
250
500
750
1000
SRRT (ms)
Participant 22
f(SRRT)
0
250
500
750
1000
SRRT (ms)

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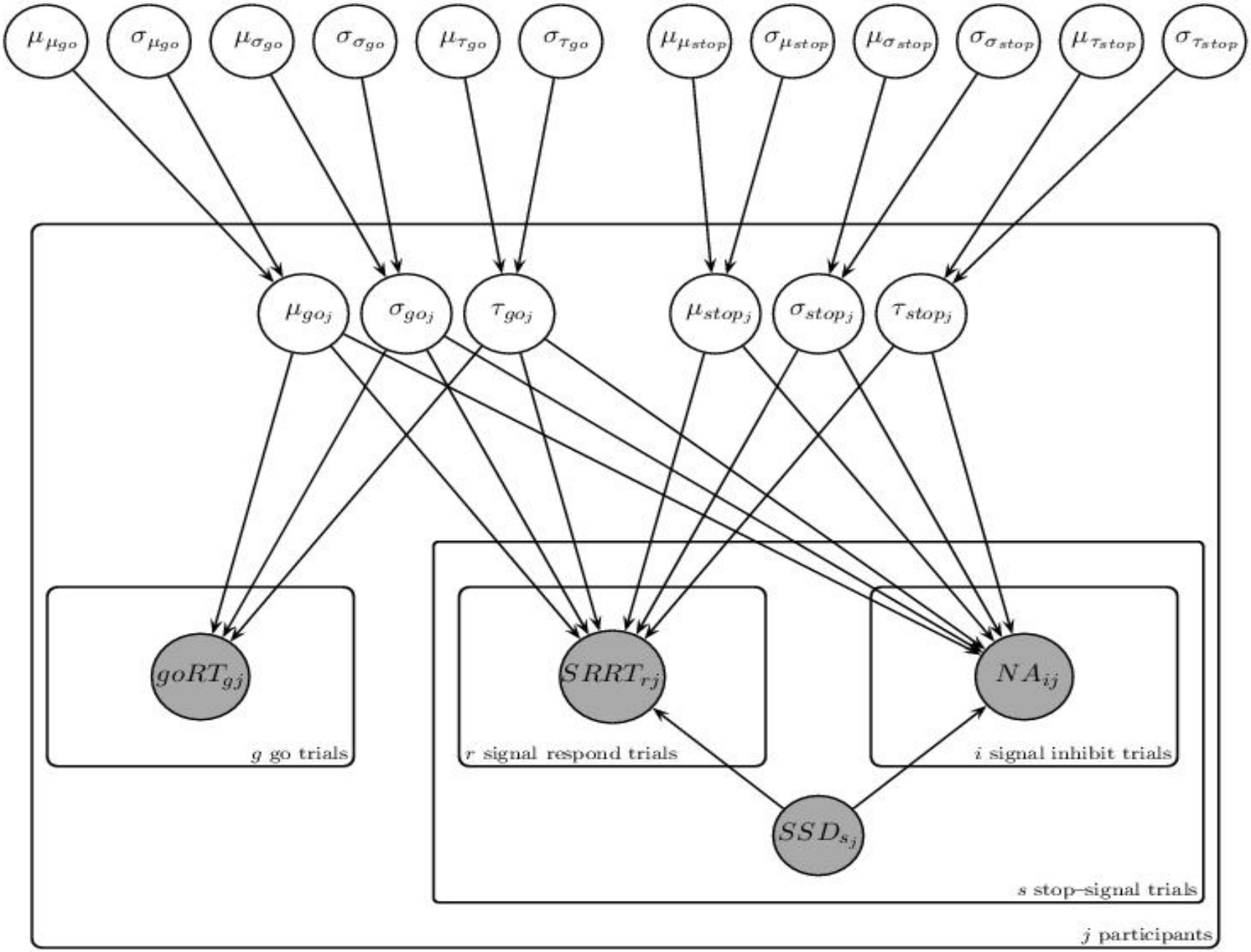
# To do list

- Hierarchical extension
  - To model between-subject variability in parameters
  - More realistic situation: lots of participants with few RTs
  - Individual parameters are assumed to be drawn from group-level distributions


$\mu_{\mu go}$
$\sigma_{\mu go}$
$\mu_{\sigma go}$
$\sigma_{\sigma go}$
$\mu_{\tau go}$
$\sigma_{\tau go}$
$\mu_{\mu stop}$
$\sigma_{\mu stop}$
$\mu_{\sigma stop}$
$\sigma_{\sigma stop}$
$\mu_{\tau stop}$
$\sigma_{\tau stop}$
$\mu_{go_j}$
$\sigma_{go_j}$
$\tau_{go_j}$
$\mu_{stop_j}$
$\sigma_{stop_j}$
$\tau_{stop_j}$
$goRT_{gj}$
$SRRT_{rj}$
$NA_{ij}$
$SSD_{s_j}$
$g$ go trials
$r$ signal respond trials
$i$ signal inhibit trials
$s$ stop–signal trials
$j$ participants

# To do list

- Hierarchical extension
  - To model between-subject variability in parameters
  - More realistic situation: lots of participants with few RTs
  - Individual parameters are assumed to be drawn from group-level distributions
- Easy-to-use R routine

# The End

Thanks for your attention!