

# Should I stay or should I go? Humans adapt to the volatility of visual motion properties, and know about it

Laurent Perrinet, Chloé Pasturel & Anna Montagnini



Colloque international de la Société des Neurosciences 2019, 23/5/2019

Acknowledgements:

- Rick Adams and Karl Friston @ UCL - Wellcome Trust Centre for Neuroimaging
- Jean-Bernard Damasse and Laurent Madelain - ANR REM
- Frédéric Chavane - INT



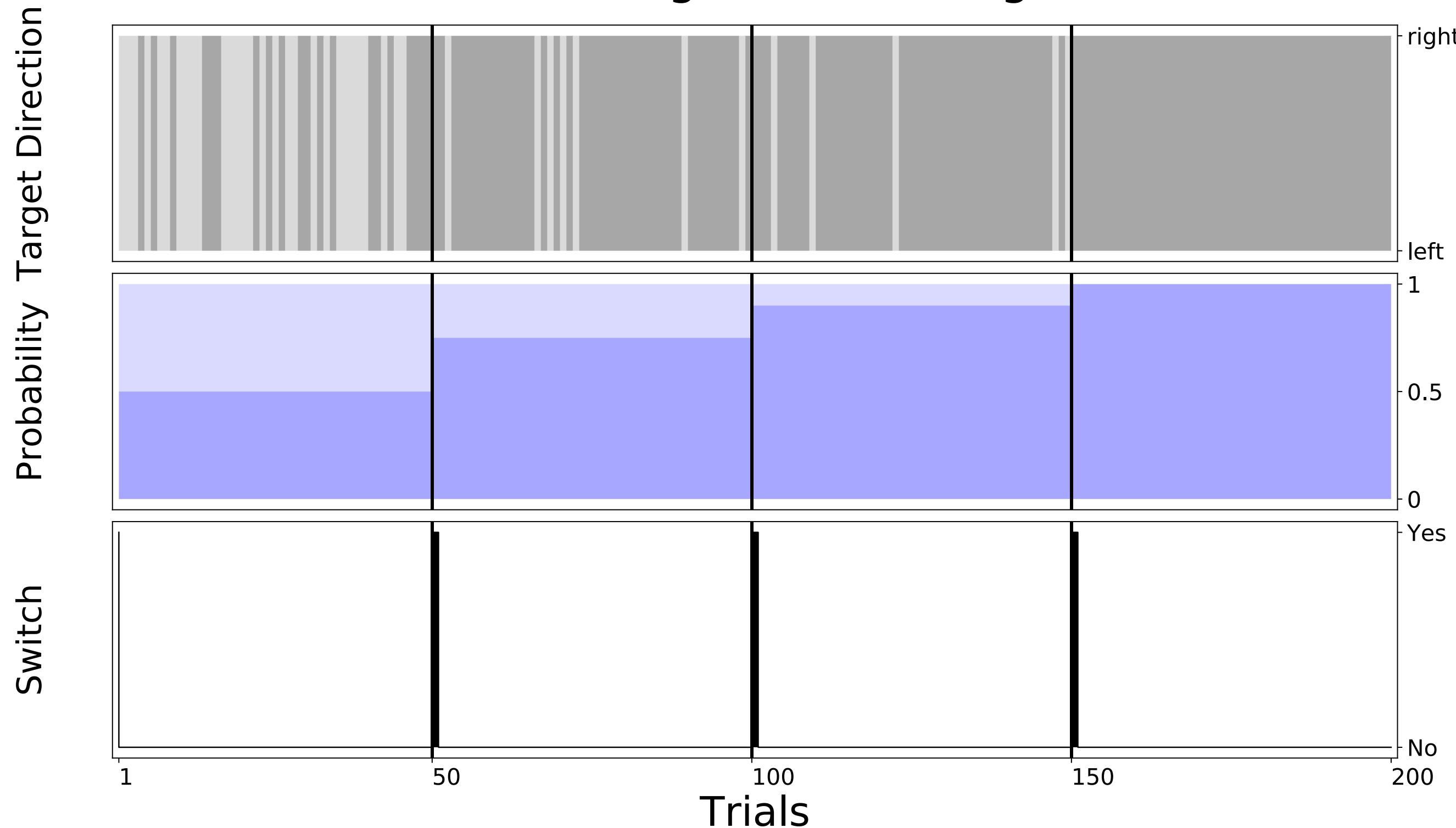
This work was supported by the PACE-ITN Project.



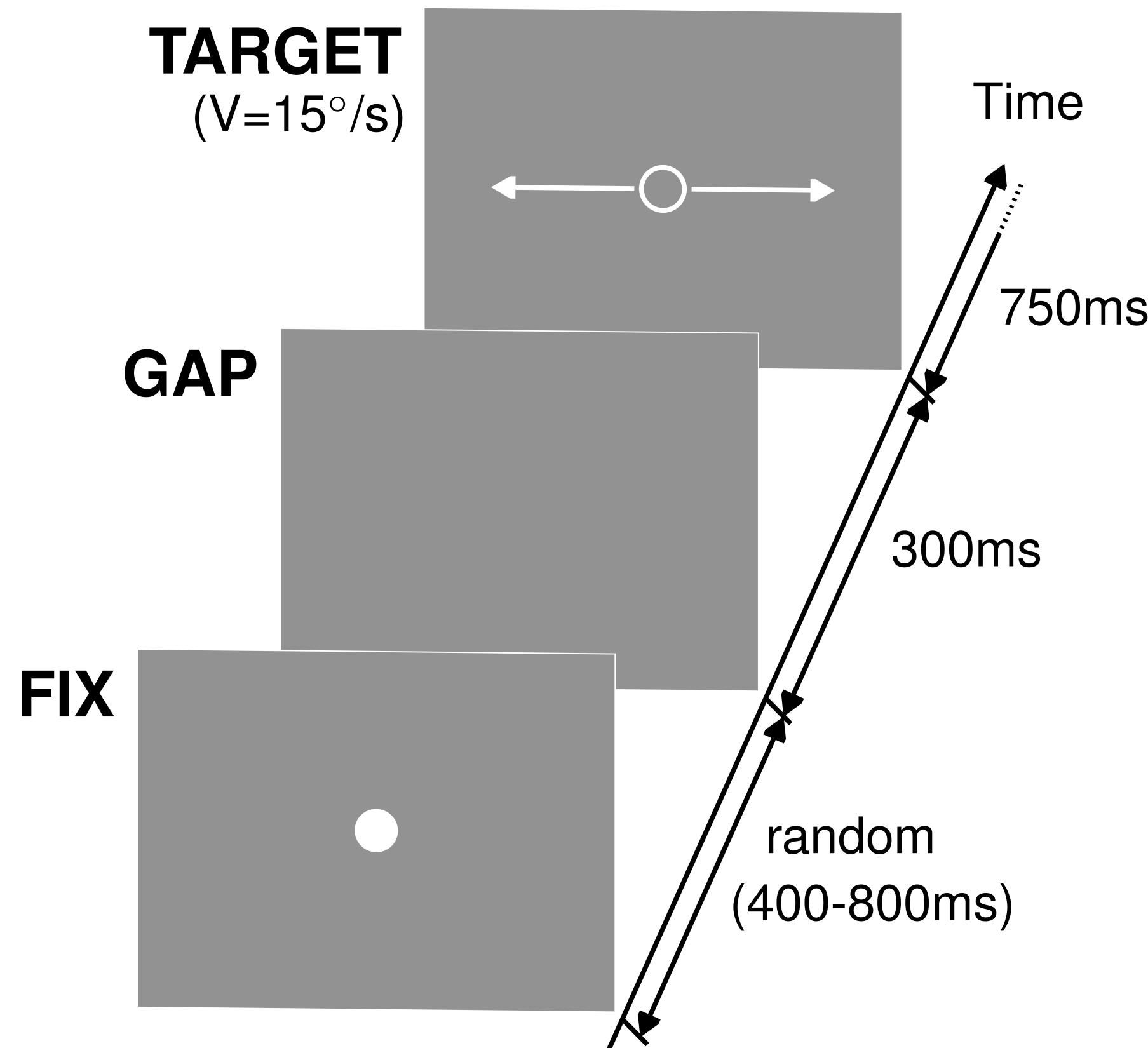


# Motivation: Should I stay or should I go? - Probability bias

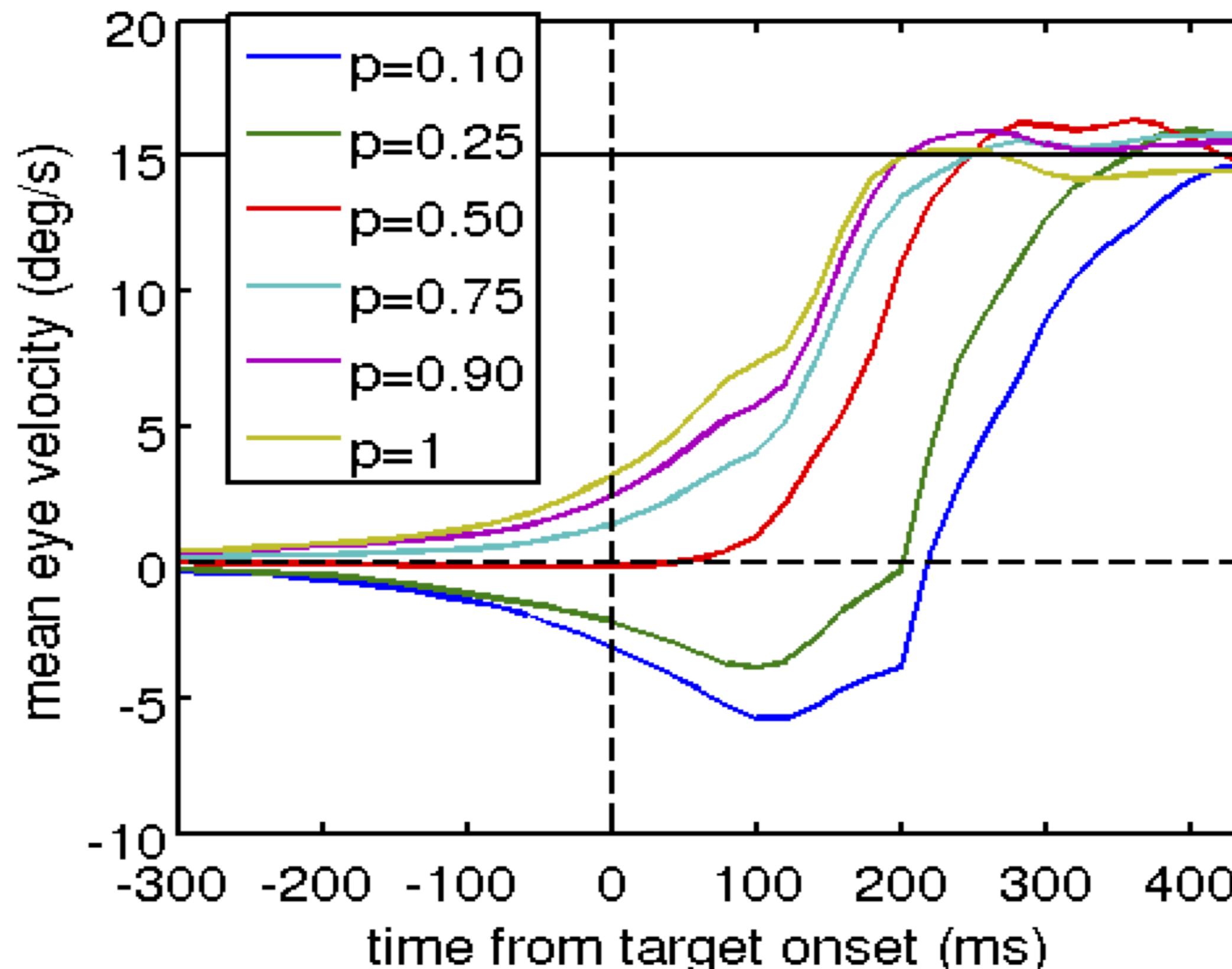
Fixed-length block design



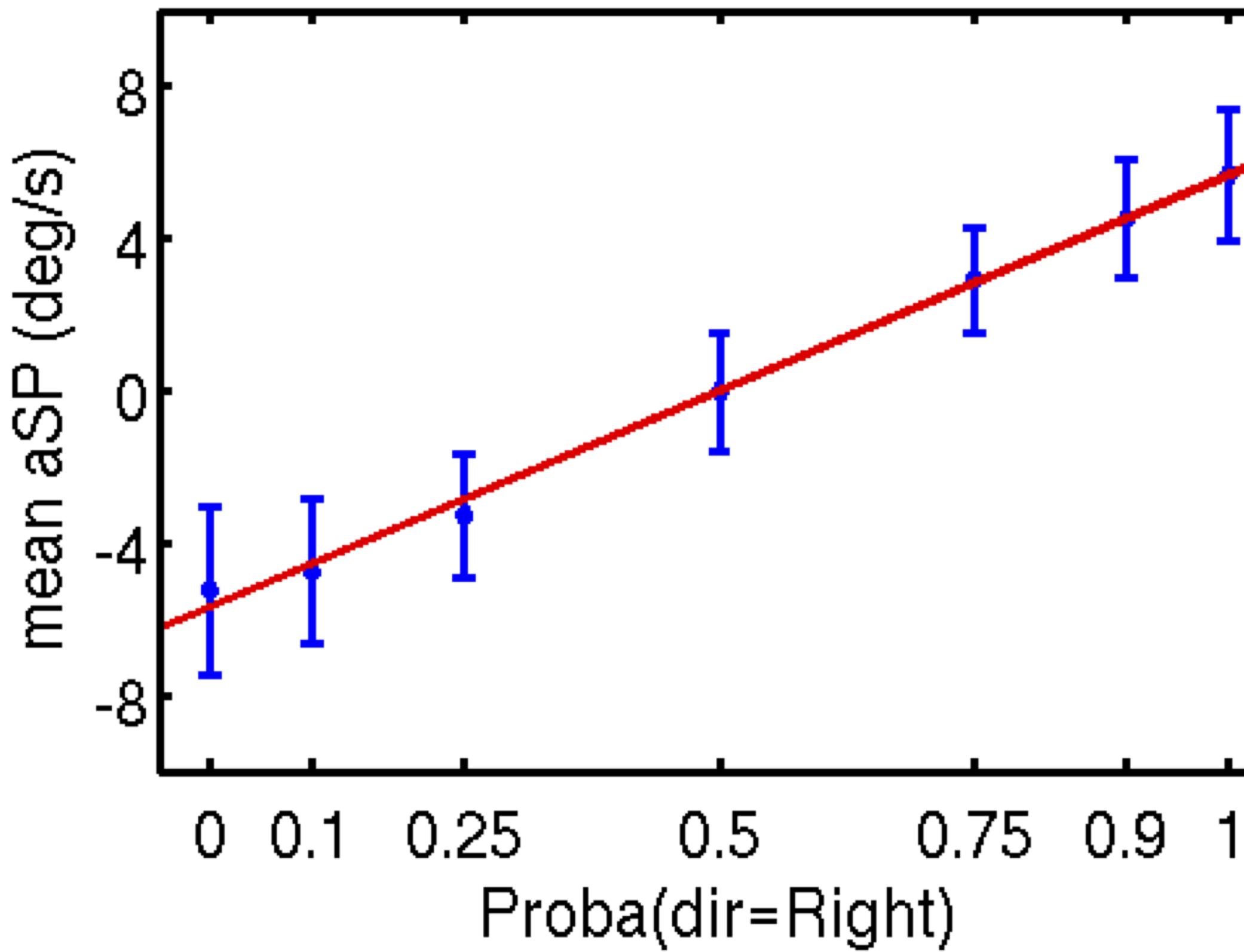
# Motivation: Should I stay or should I go? - Eye Movements



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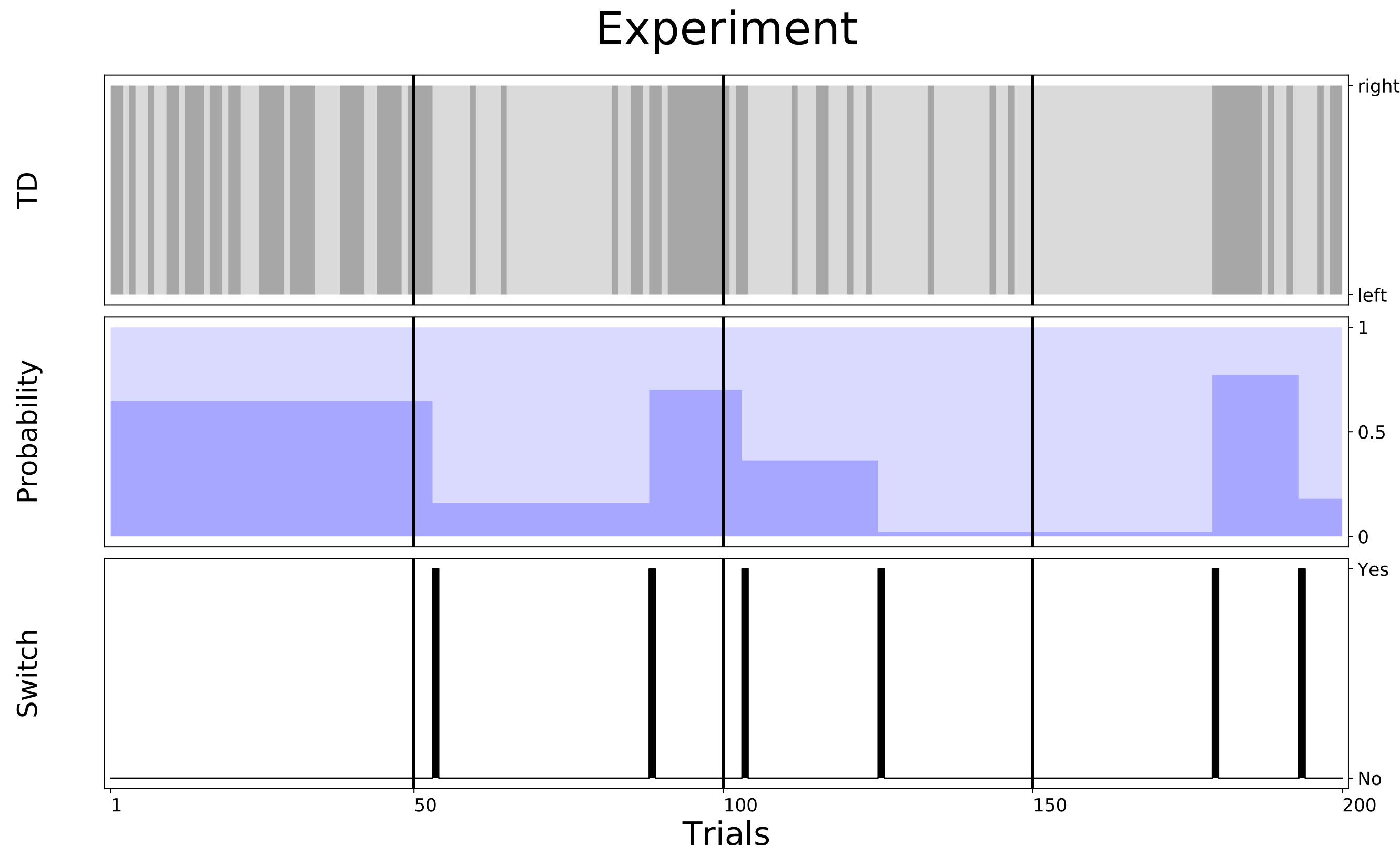


# Motivation: Should I stay or should I go? - Eye Movements





# Motivation: Should I stay or should I go? - Switching model



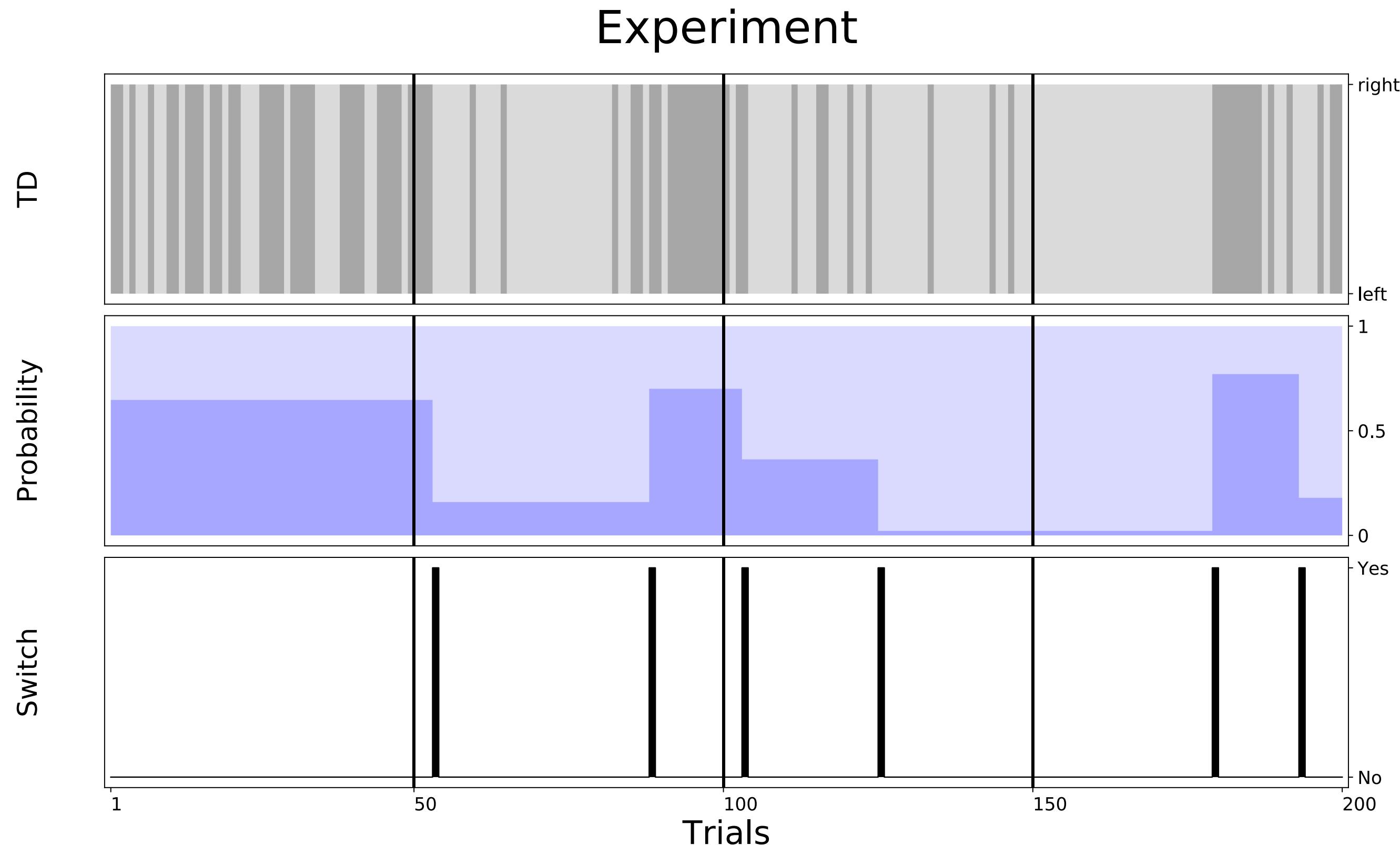
# Outline

1. Motivation: Should I stay or should I go?
2. Methods: Experimental protocol
3. Results: The Bayesian Changepoint Detector
4. Results: Matching Behavioral data
5. Results: Analyzing inter-individual differences

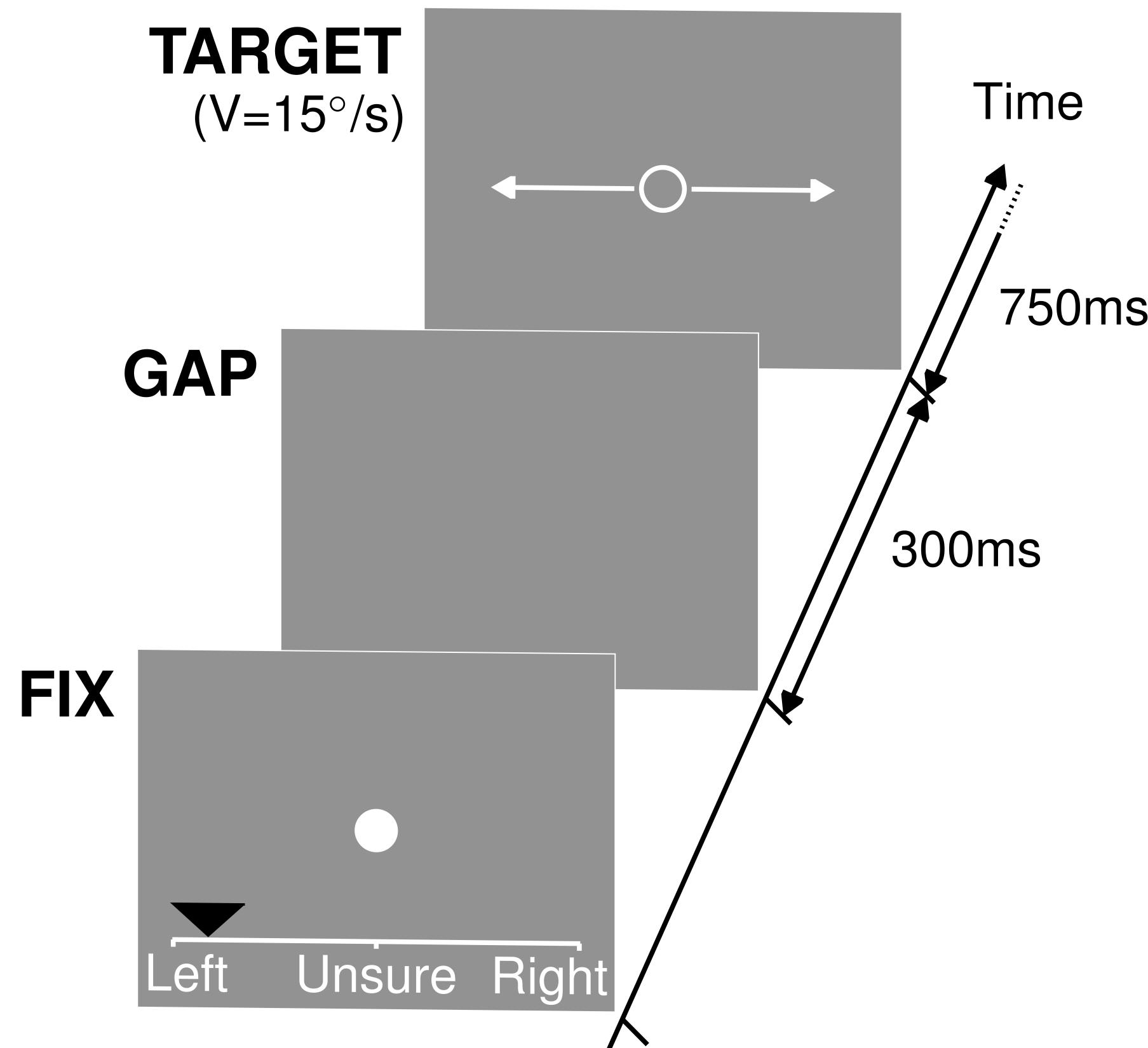
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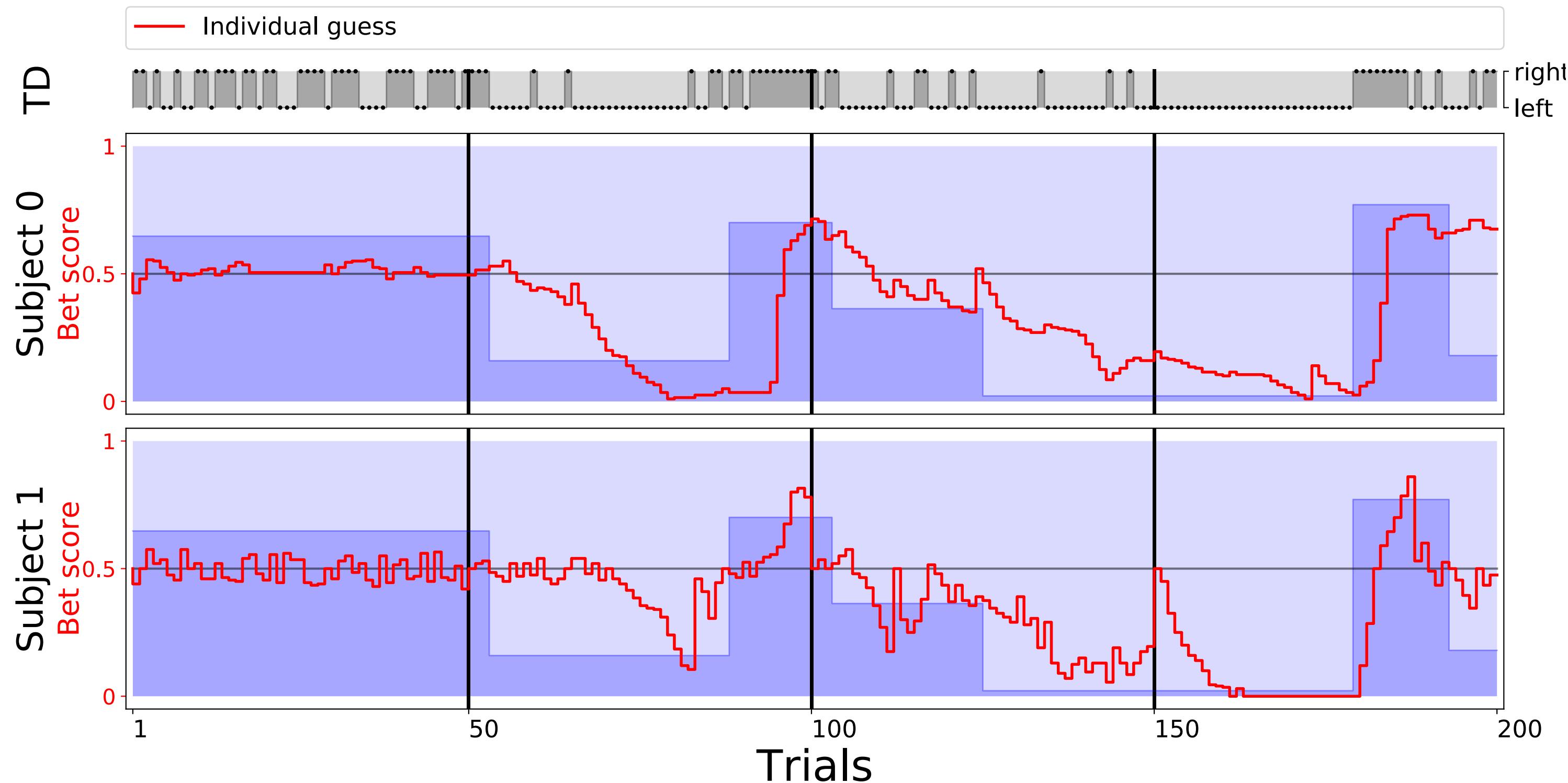
# Methods: Experimental protocol - Switching model



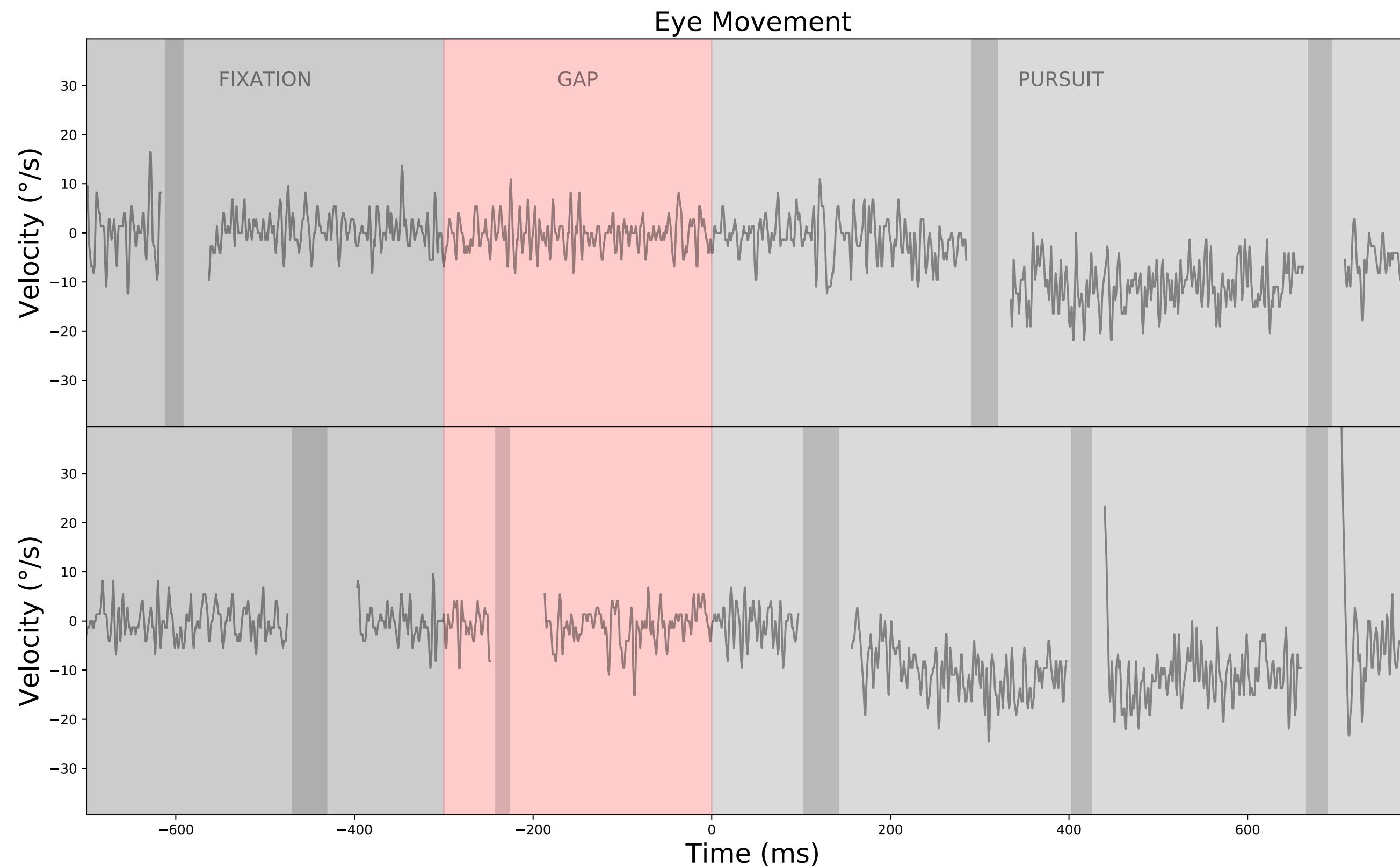
# Methods: Experimental protocol - Rating scale



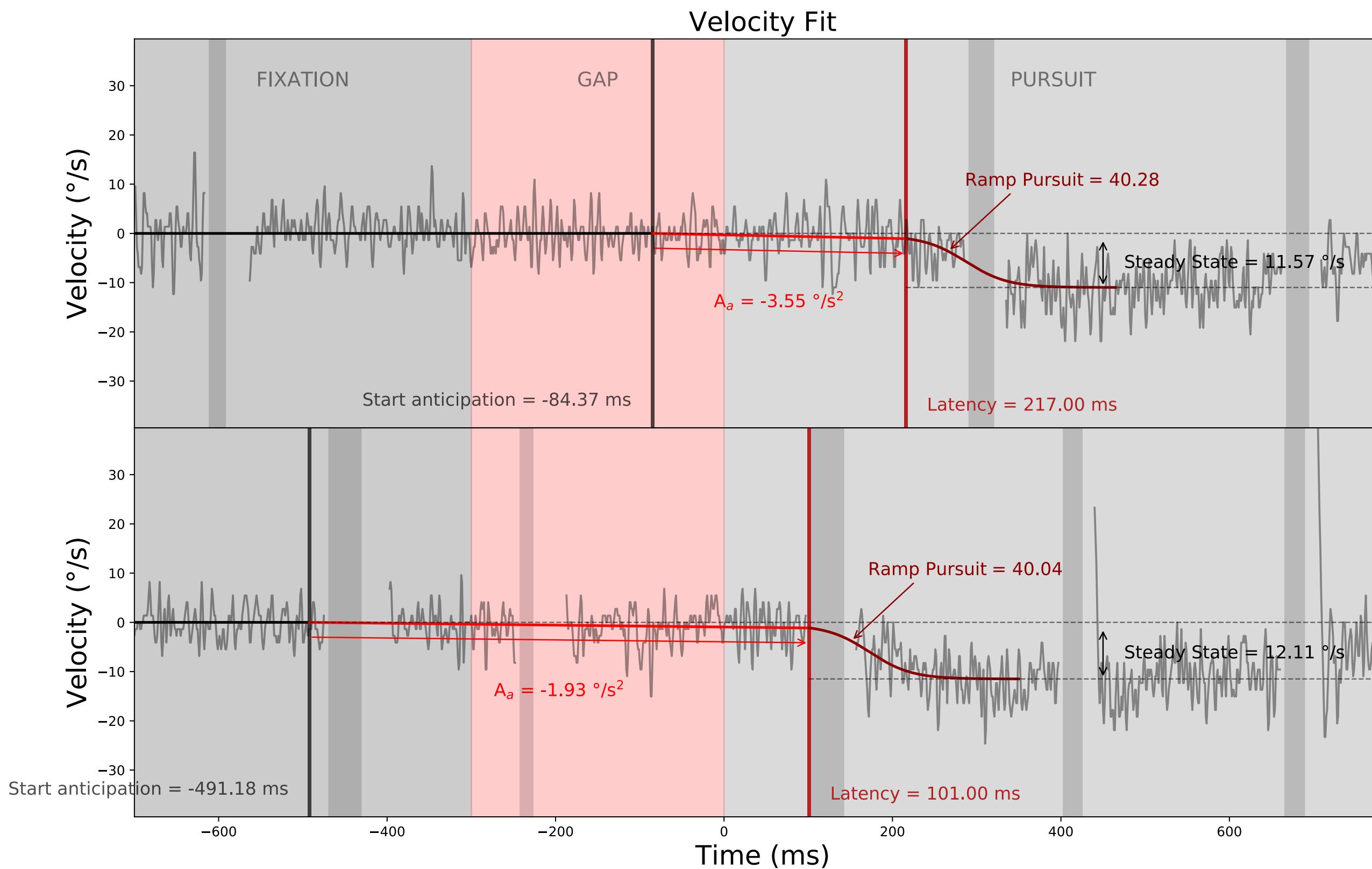
# Methods: Experimental protocol - Rating scale



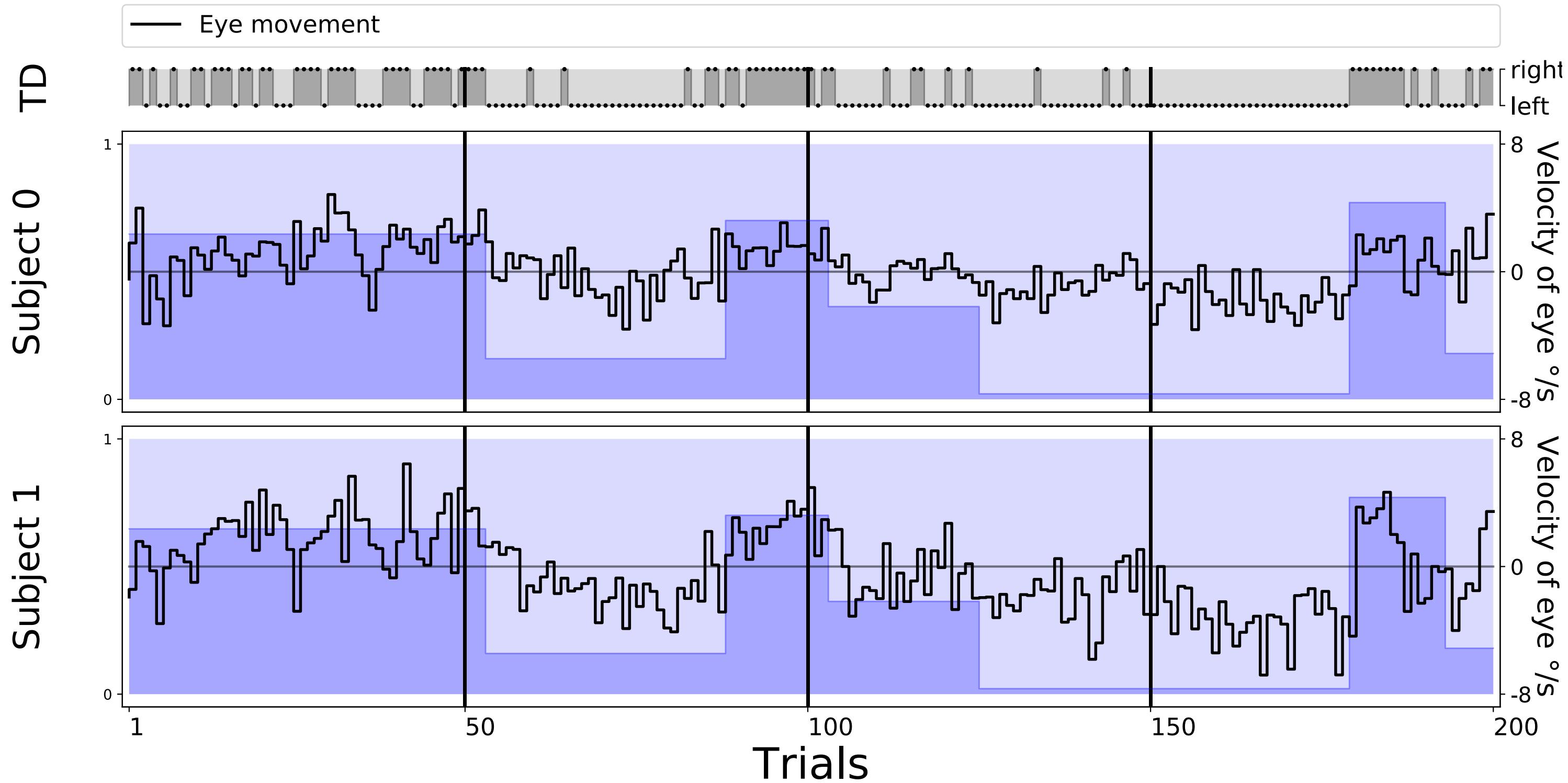
# Methods: Experimental protocol - Fitting eye movements



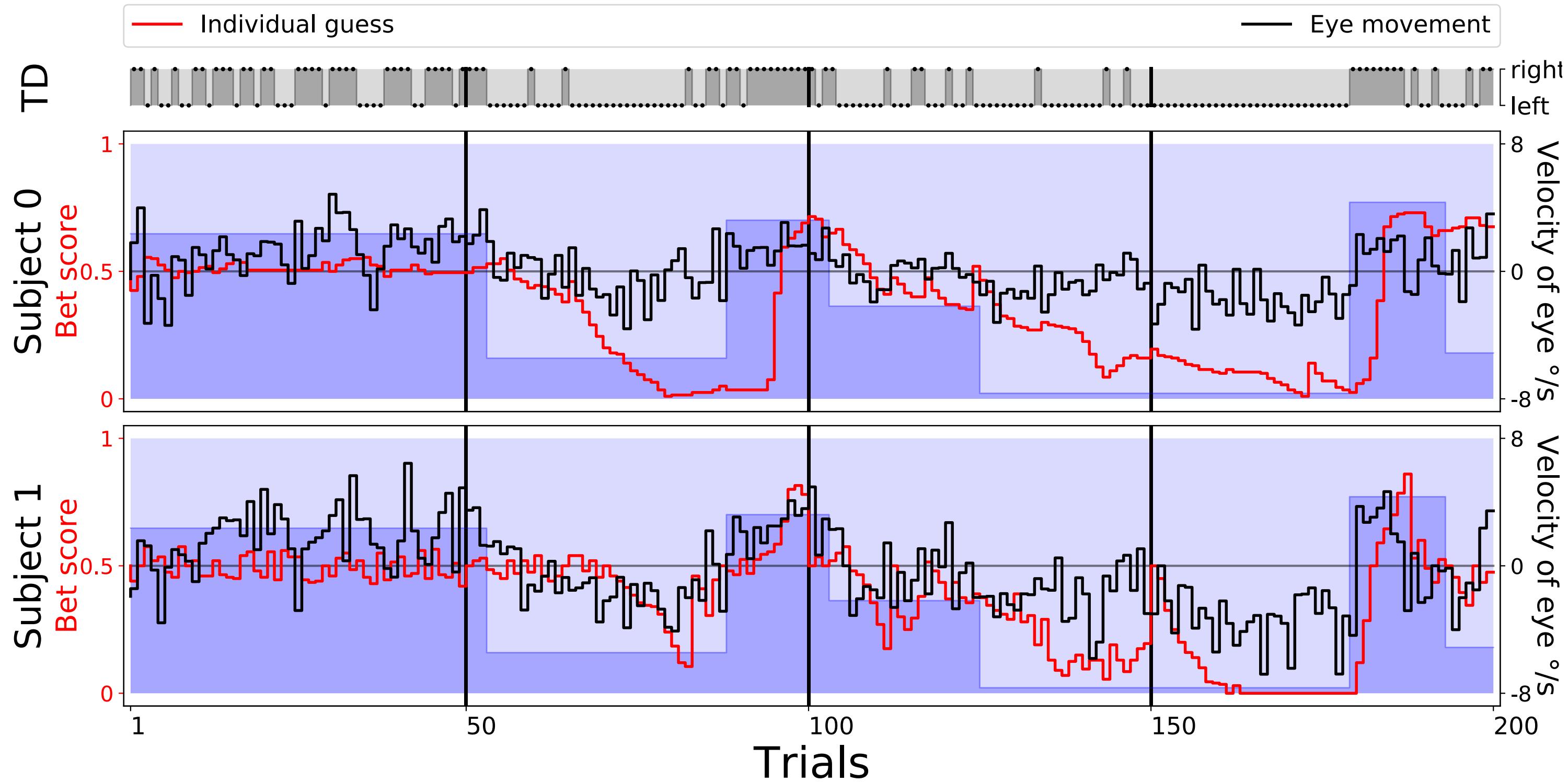
# Methods: Experimental protocol - Fitting eye movements



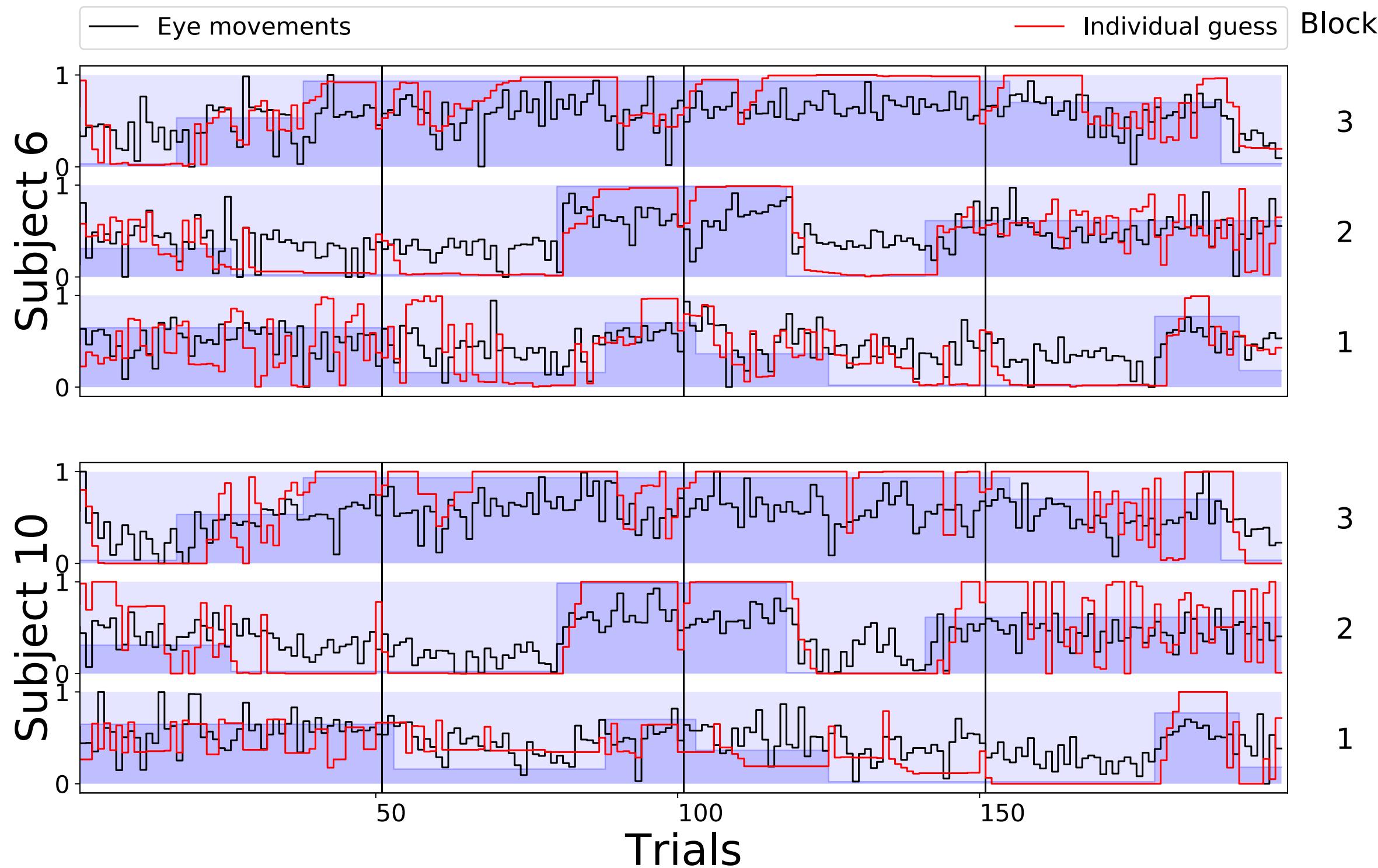
# Methods: Experimental protocol - Eye Movements



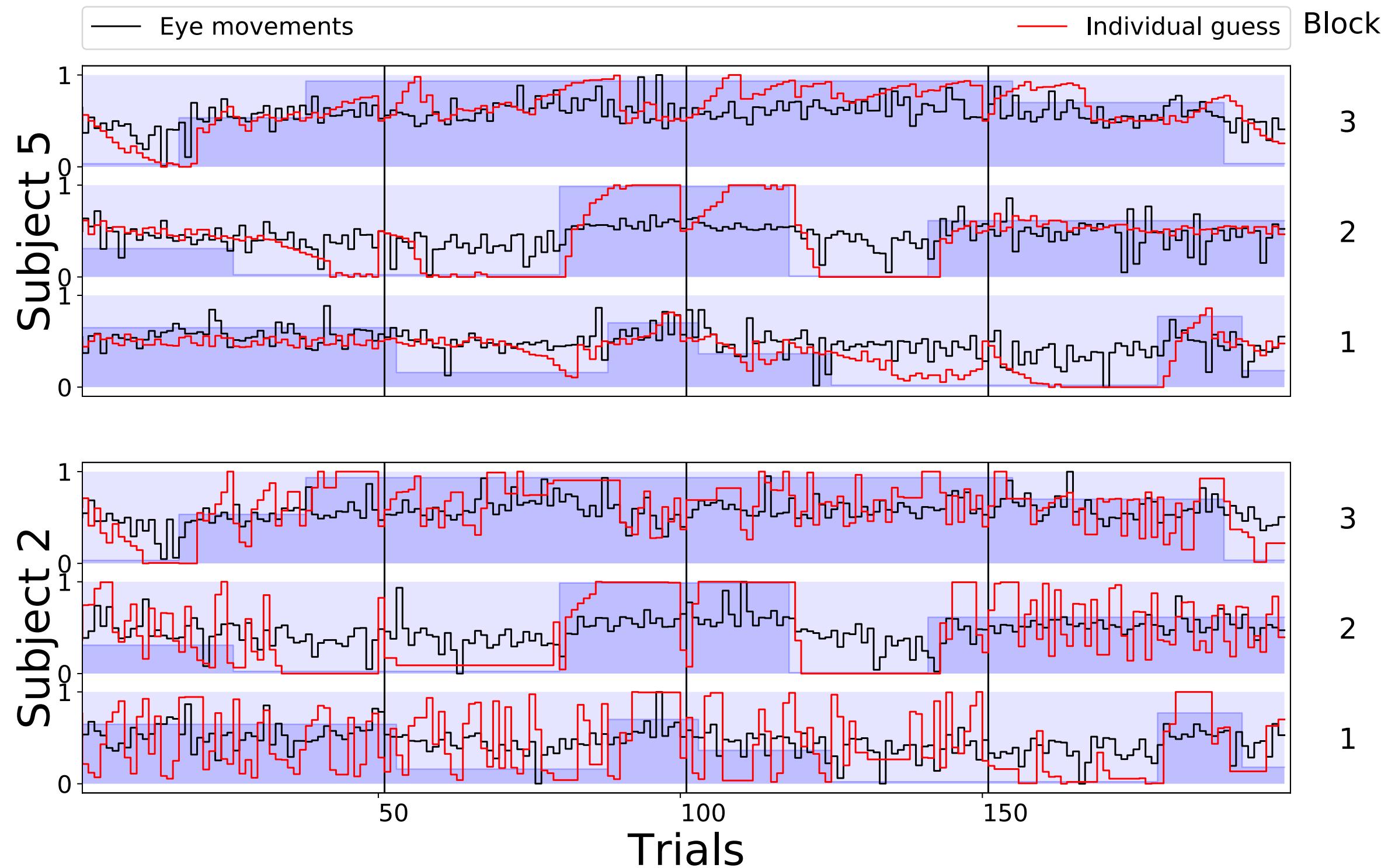
# Methods: Experimental protocol - Behaviour



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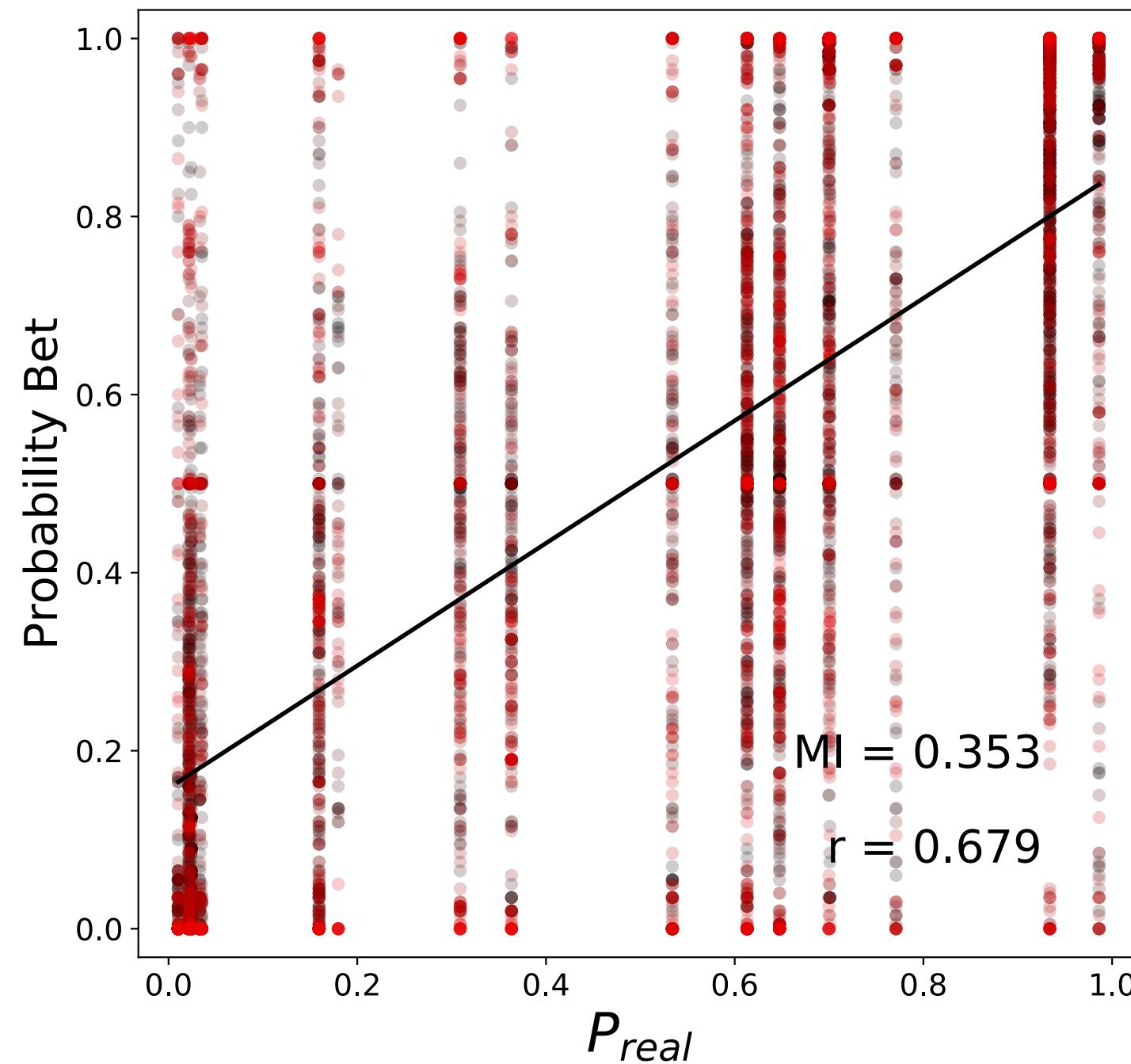


# Methods: Experimental protocol - Behaviour

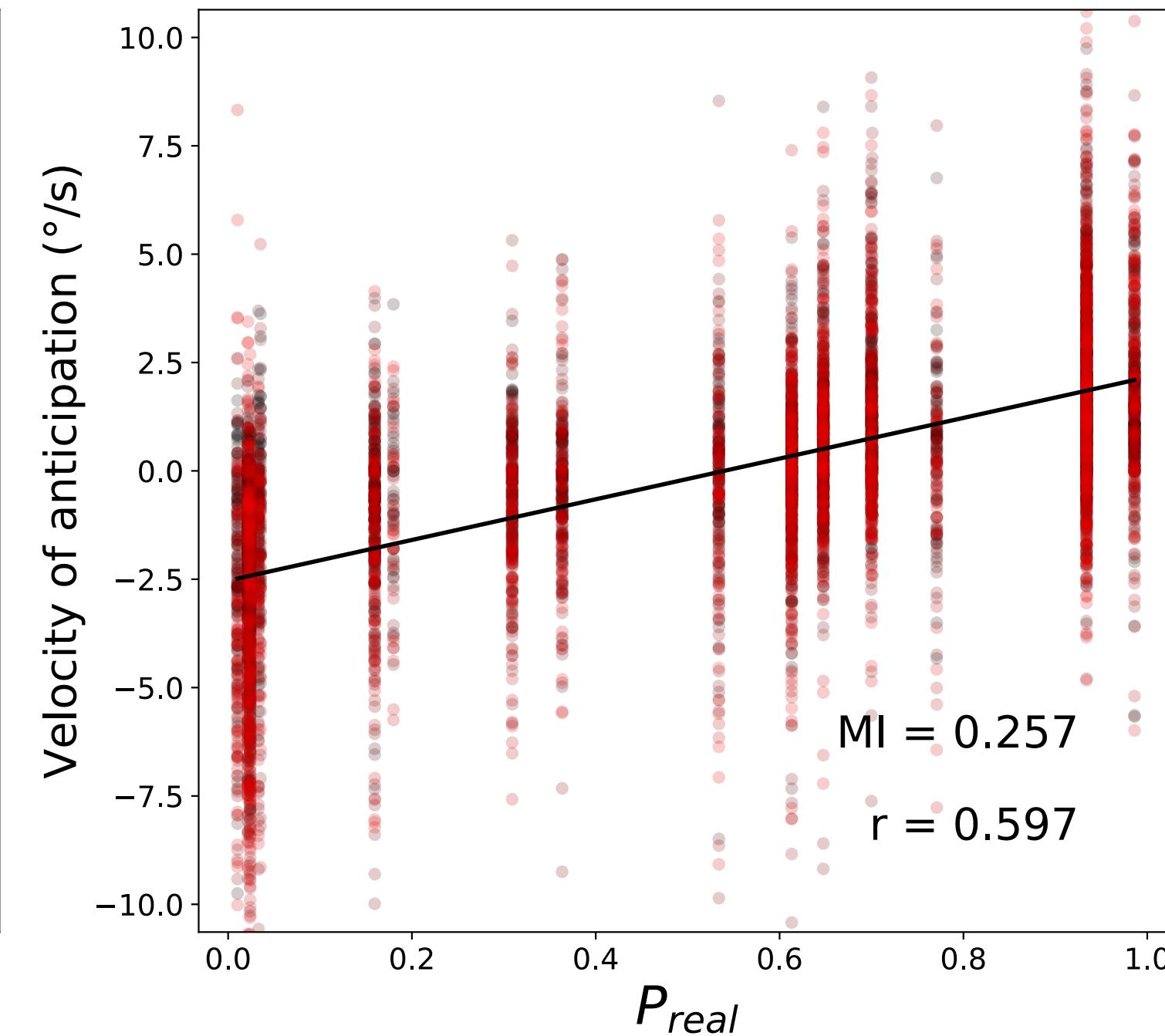


# Methods: Experimental protocol

Probability Bet



Velocity



full code @ [github.com/chloepasturel/AnticipatorySPEM](https://github.com/chloepasturel/AnticipatorySPEM)

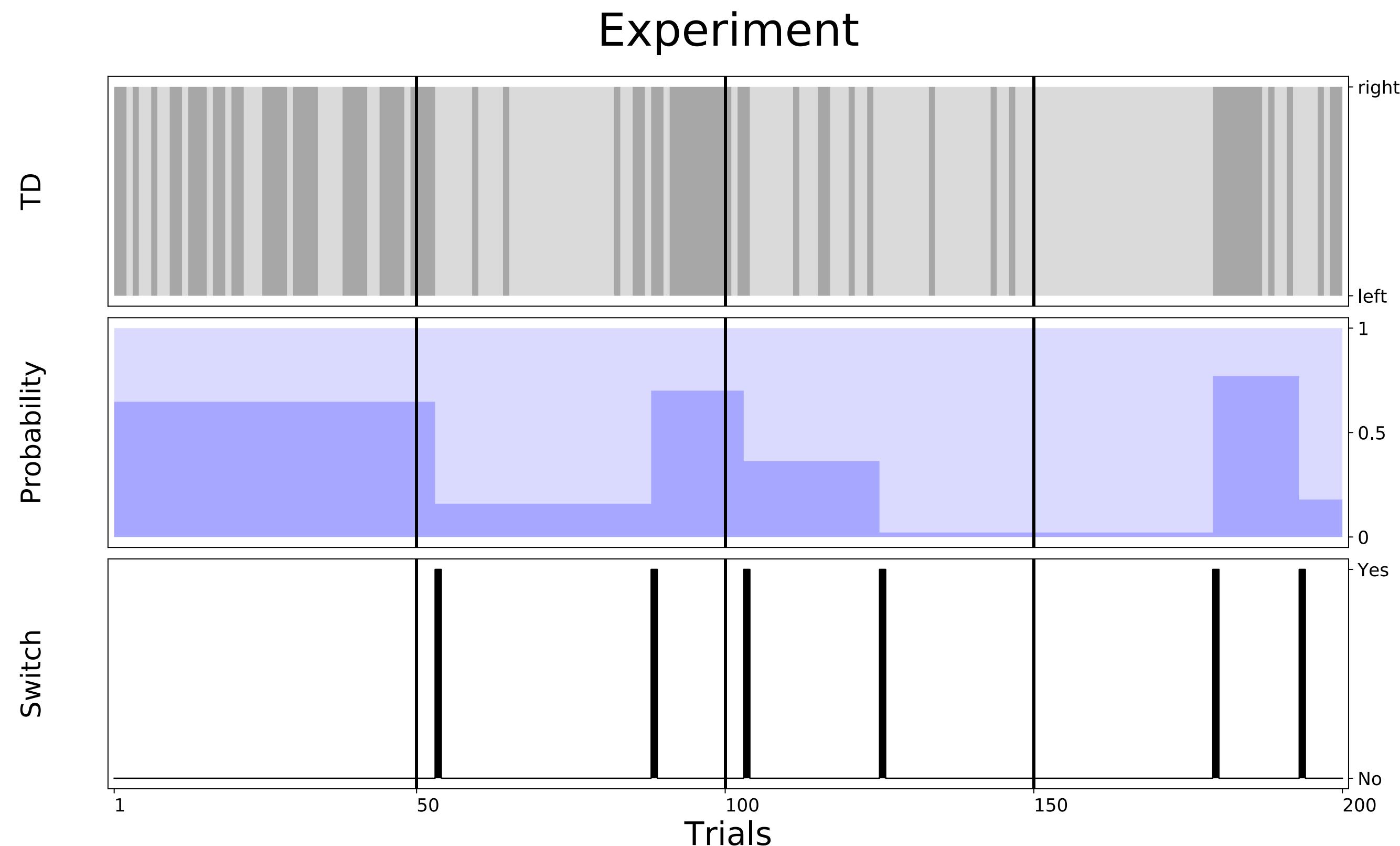
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# Results: The Bayesian Changepoint Detector - Switching model



# Bayesian Online Changepoint Detector

- an implementation of Adams & MacKay 2007 "Bayesian Online Changepoint Detection" in Python.

```
@TECHREPORT{ adams-mackay-2007,
  AUTHOR = "Ryan Prescott Adams and David J.C. MacKay",
  TITLE  = "Bayesian Online Changepoint Detection",
  INSTITUTION = "University of Cambridge",
  ADDRESS = "Cambridge, UK",
  YEAR   = "2007",
  NOTE   = "arXiv:0710.3742v1 [stat.ML]",
  URL    = "http://arxiv.org/abs/0710.3742"
}
```

- adapted from <https://github.com/JackKelly/bayesianchangepoint> by Jack Kelly (2013) for a binomial input.
- This code is based on the MATLAB implementation provided by Ryan Adam. Was available at <http://hips.seas.harvard.edu/content/bayesian-online-changepoint-detection>
- full code @ <https://github.com/laurentperrinet/bayesianchangepoint>

# Bayesian Changepoint Detector

## 1. Initialize

- $P(r_0 = 0) = 1$  and
- $\nu_1^{(0)} = \nu_{prior}$  and  $\chi_1^{(0)} = \chi_{prior}$

## 2. cycle over data from $t = 0$ until $t = T - 1$ :

1. Observe New Datum  $x_t$

2. Evaluate Predictive Probability  $\pi_{0:t} = P(x_t | \nu_t^{(r)}, \chi_t^{(r)})$

3. Calculate Growth Probabilities  $P(r_t = r_{t-1} + 1, x_{0:t}) = P(r_{t-1}, x_{0:t-1}) \cdot \pi_t^{(r)} \cdot (1 - h)$

4. Calculate Changepoint Probabilities  $P(r_t = 0, x_{0:t}) = \sum_{r_{t-1}} P(r_{t-1}, x_{0:t-1}) \cdot \pi_t^{(r)} \cdot h$

5. Calculate Evidence  $P(x_{0:t}) = \sum_{r_{t-1}} P(r_t, x_{0:t})$

6. Determine Run Length Distribution  $P(r_t | x_{0:t}) = P(r_t, x_{0:t}) / P(x_{0:t})$

7. Update Sufficient Statistics :

- $\nu_{t+1}^{(0)} = \nu_{prior}, \chi_{t+1}^{(0)} = \chi_{prior}$
- $\nu_{t+1}^{(r+1)} = \nu_t^{(r)} + 1, \chi_{t+1}^{(r+1)} = \chi_t^{(r)} + u(x_t)$

8. Perform Prediction  $P(x_{t+1} | x_{0:t}) = \sum_{r_t} P(x_{t+1} | x_{0:t}, r_t) \cdot P(r_t | x_{0:t})$  for the next datum

# Results: The Bayesian Changepoint Detector

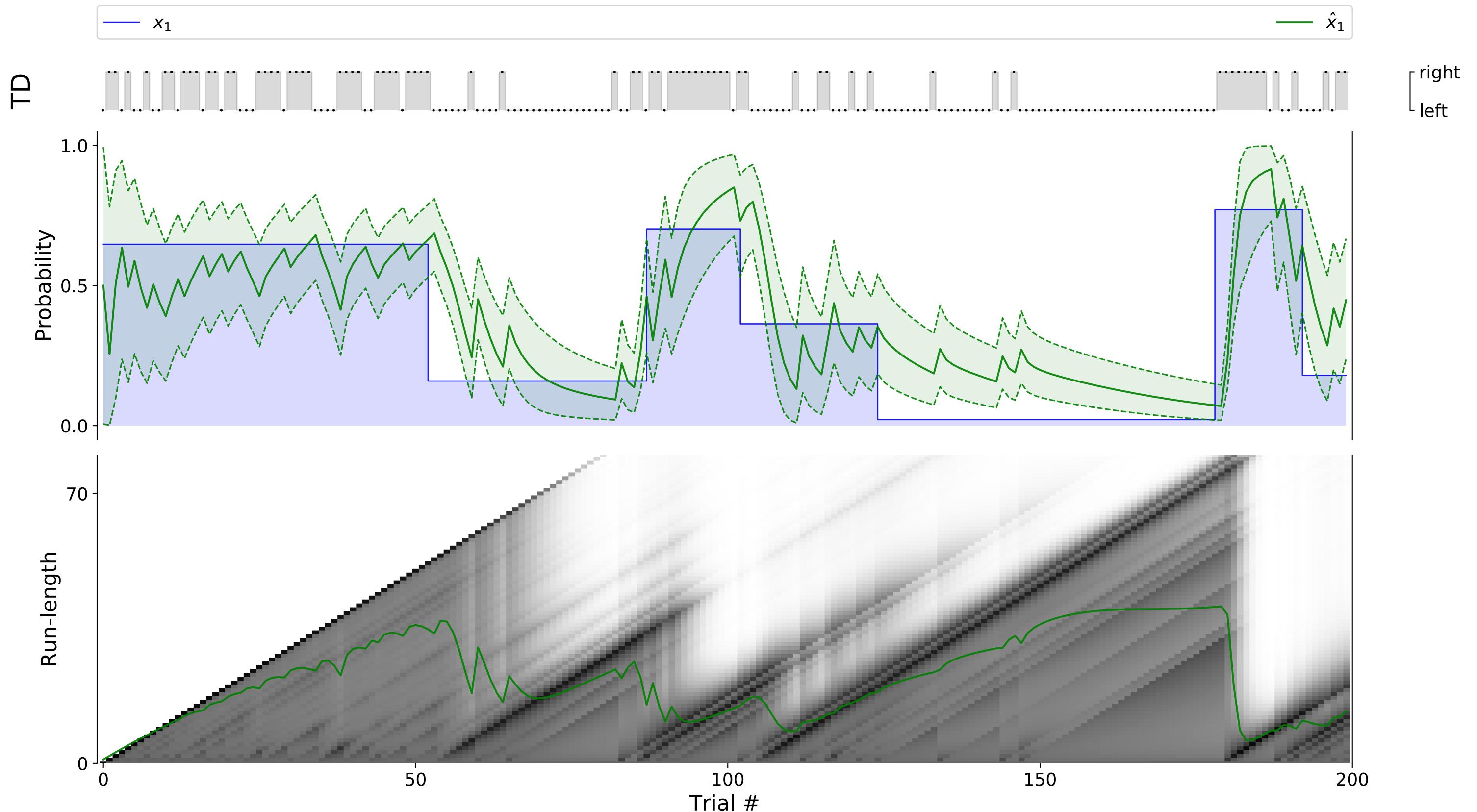
The screenshot shows the GitHub repository page for `laurentperrinet/bayesianchangepoint`. The page includes the repository name, a fork from `JackKelly/bayesianchangepoint`, and statistics like 84 commits, 1 branch, 0 releases, 4 contributors, and an Apache-2.0 license. It also shows a list of recent commits and a green "Clone or download" button.

An implementation of Adams & MacKay 2007 "Bayesian Online Changepoint Detection"

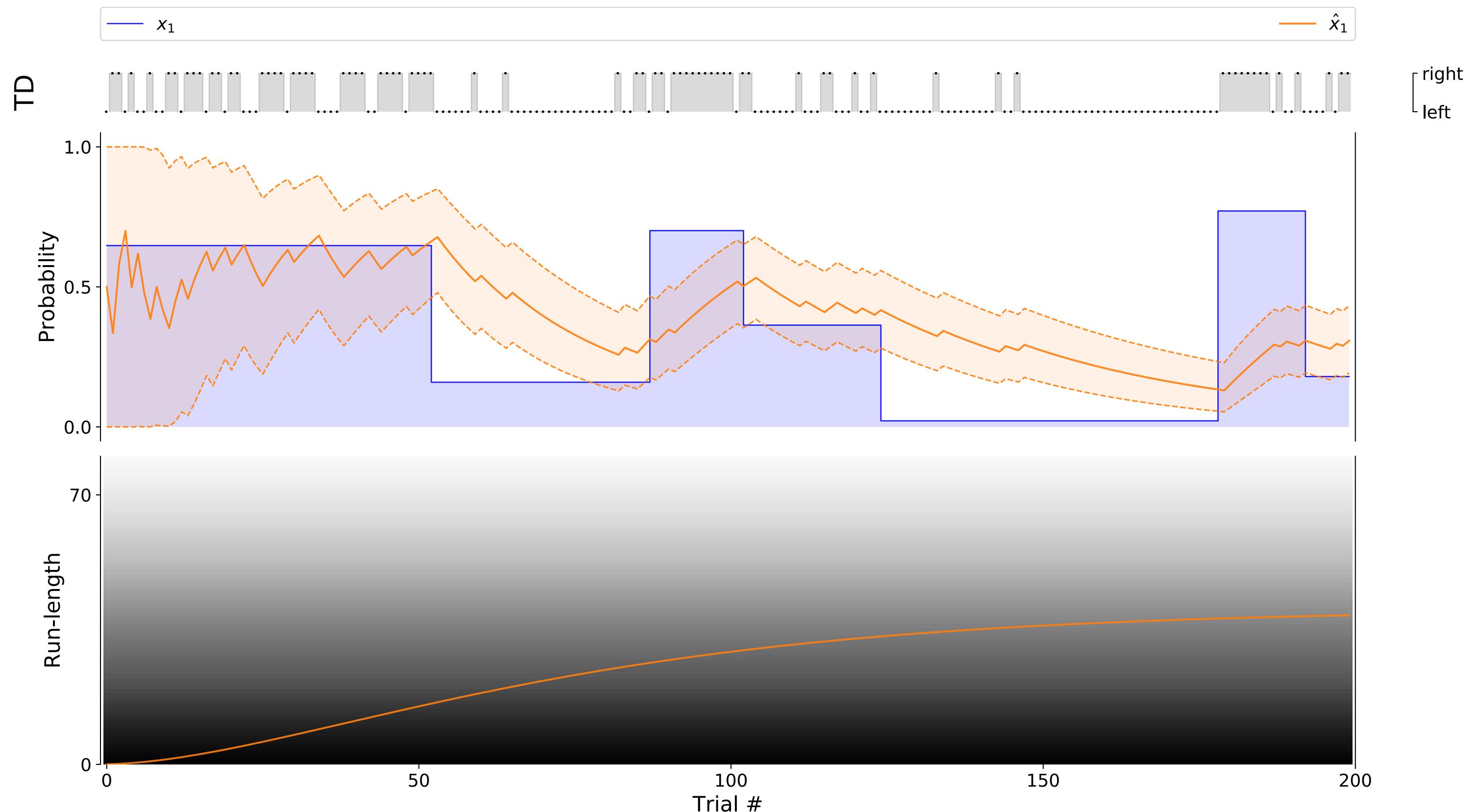
Branch: master	New pull request	Find File	Clone or download
This branch is 75 commits ahead of JackKelly:master.			
<b>laurentperrinet</b> fine tuning installation			Latest commit eb459e2 on Jan 17
<b>bayesianchangepoint</b>	setting mean readout as default		6 months ago
<b>notebooks</b>	better method for fitting data with different hypothesis : clean-up		5 months ago
<b>.gitignore</b>	re-running notebooks		a year ago
<b>LICENSE</b>	Initial commit		6 years ago
<b>README.md</b>	post-talk		a year ago
<b>requirements.txt</b>	fine tuning installation		4 months ago

full code @ [github.com/laurentperrinet/bayesianchangepoint](https://github.com/laurentperrinet/bayesianchangepoint)

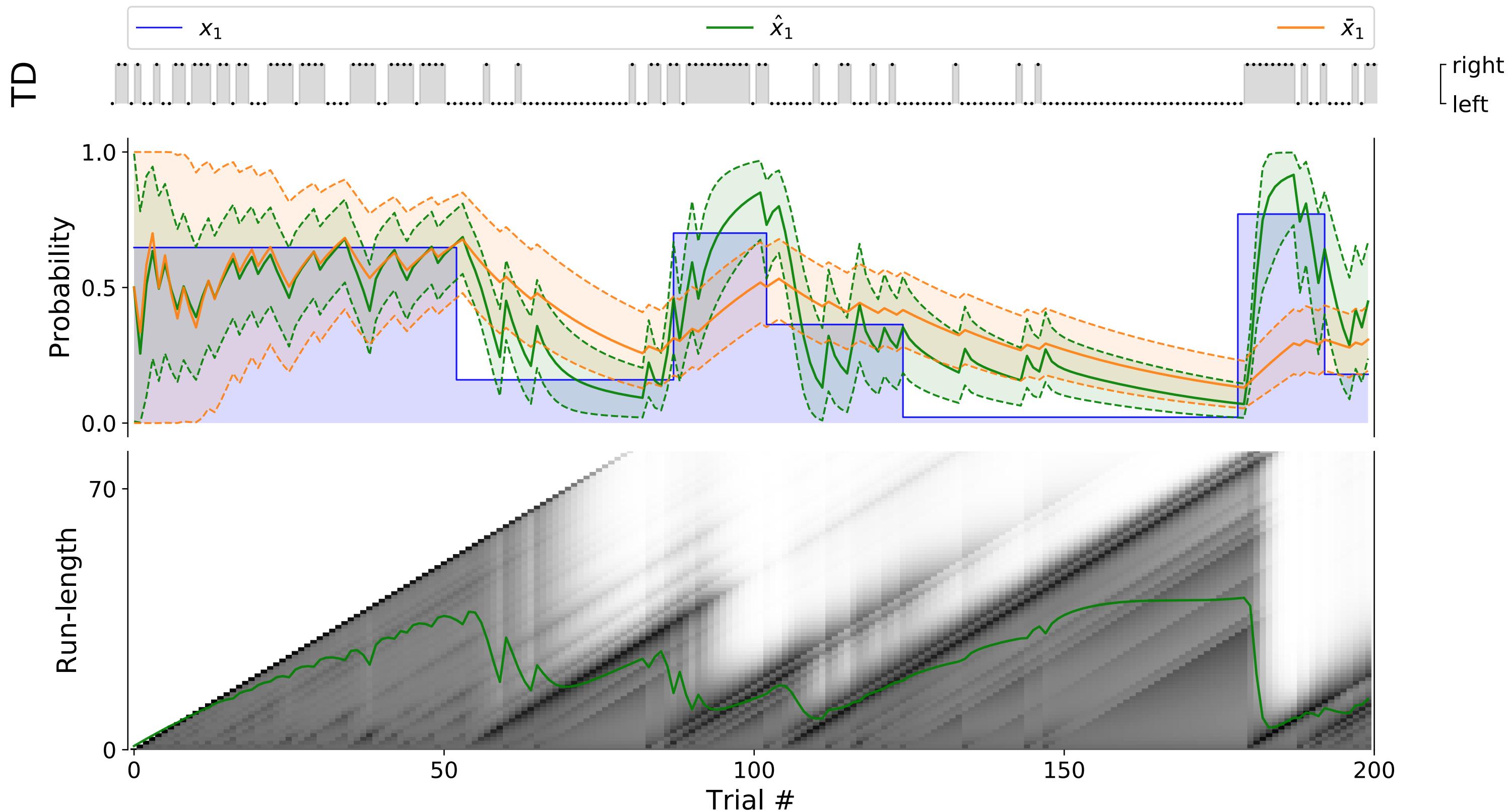
# Results: The Bayesian Changepoint Detector - Leaky vs BBCP



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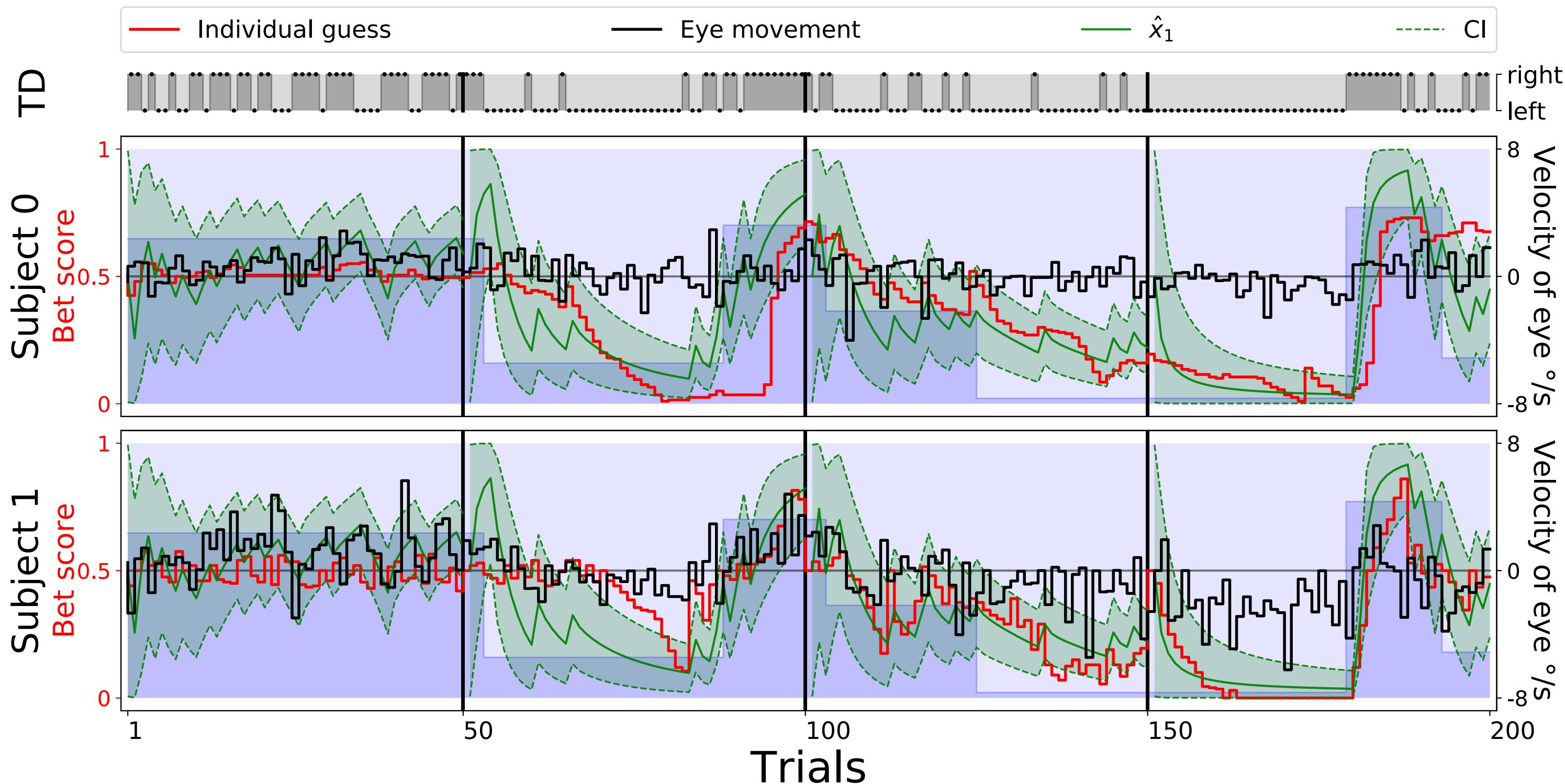
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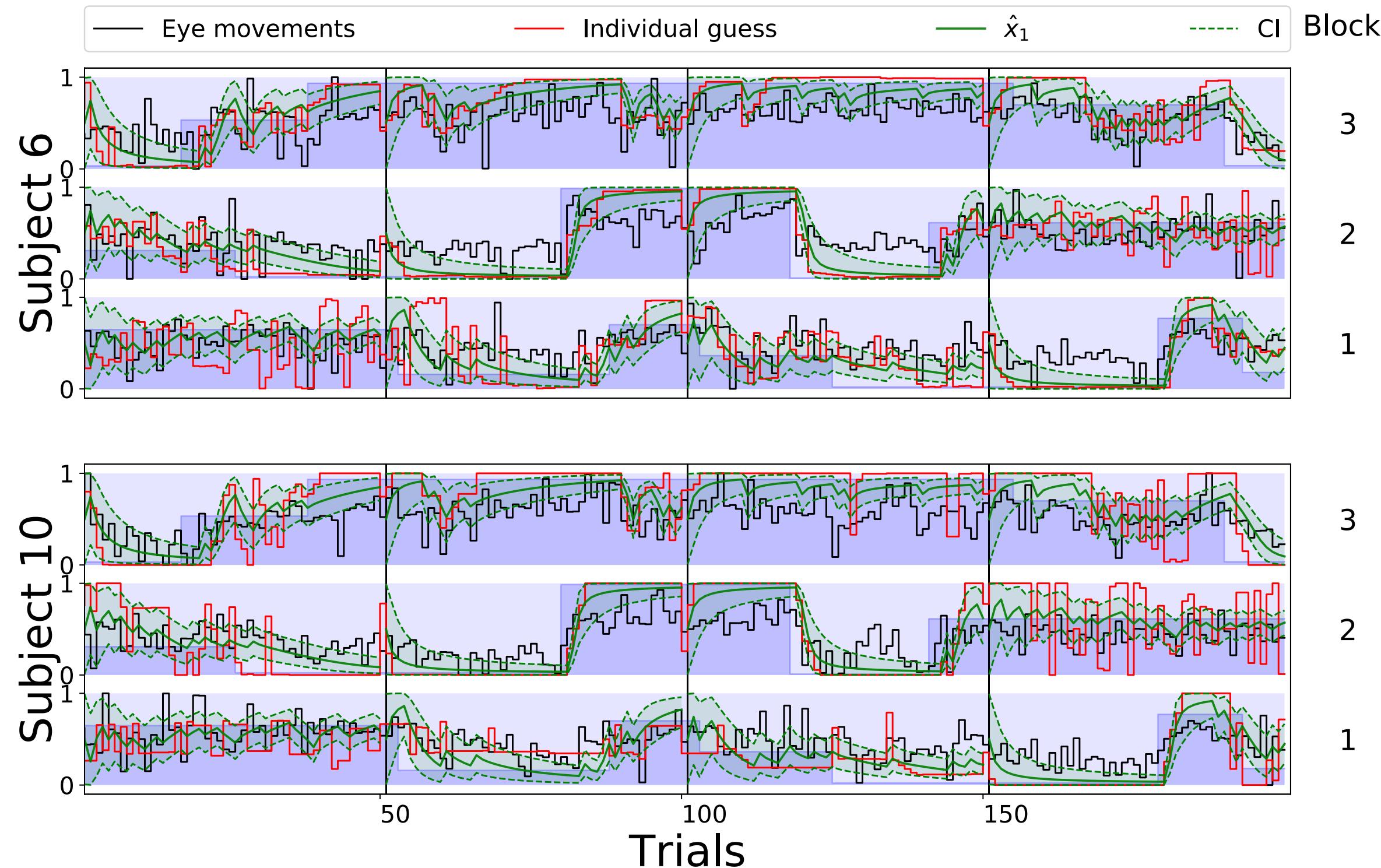
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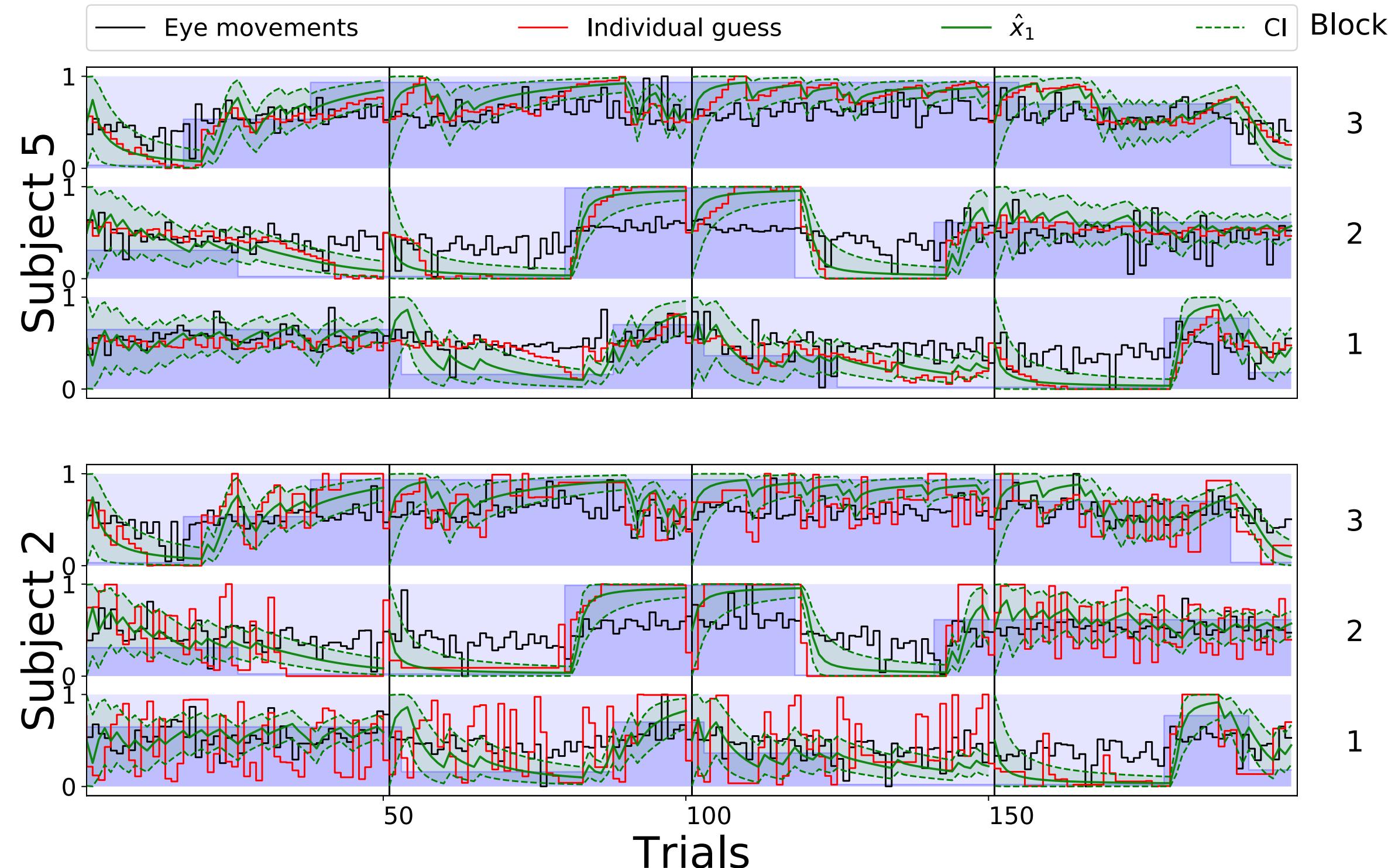
# Results: Matching Behavioral data - Compiling results



# Results: Matching Behavioral data - fit with BCP

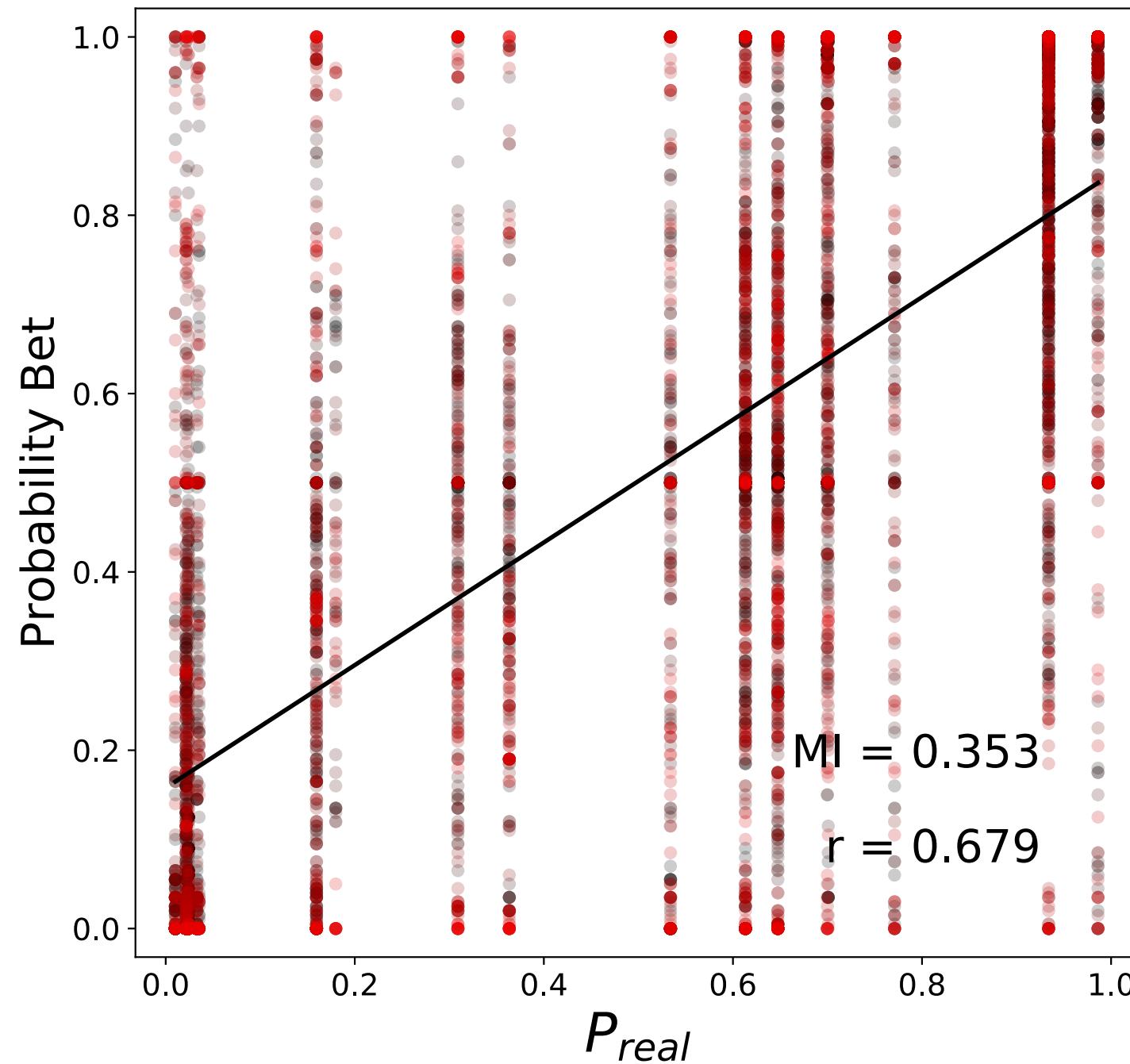


# Results: Matching Behavioral data - fit with BCP

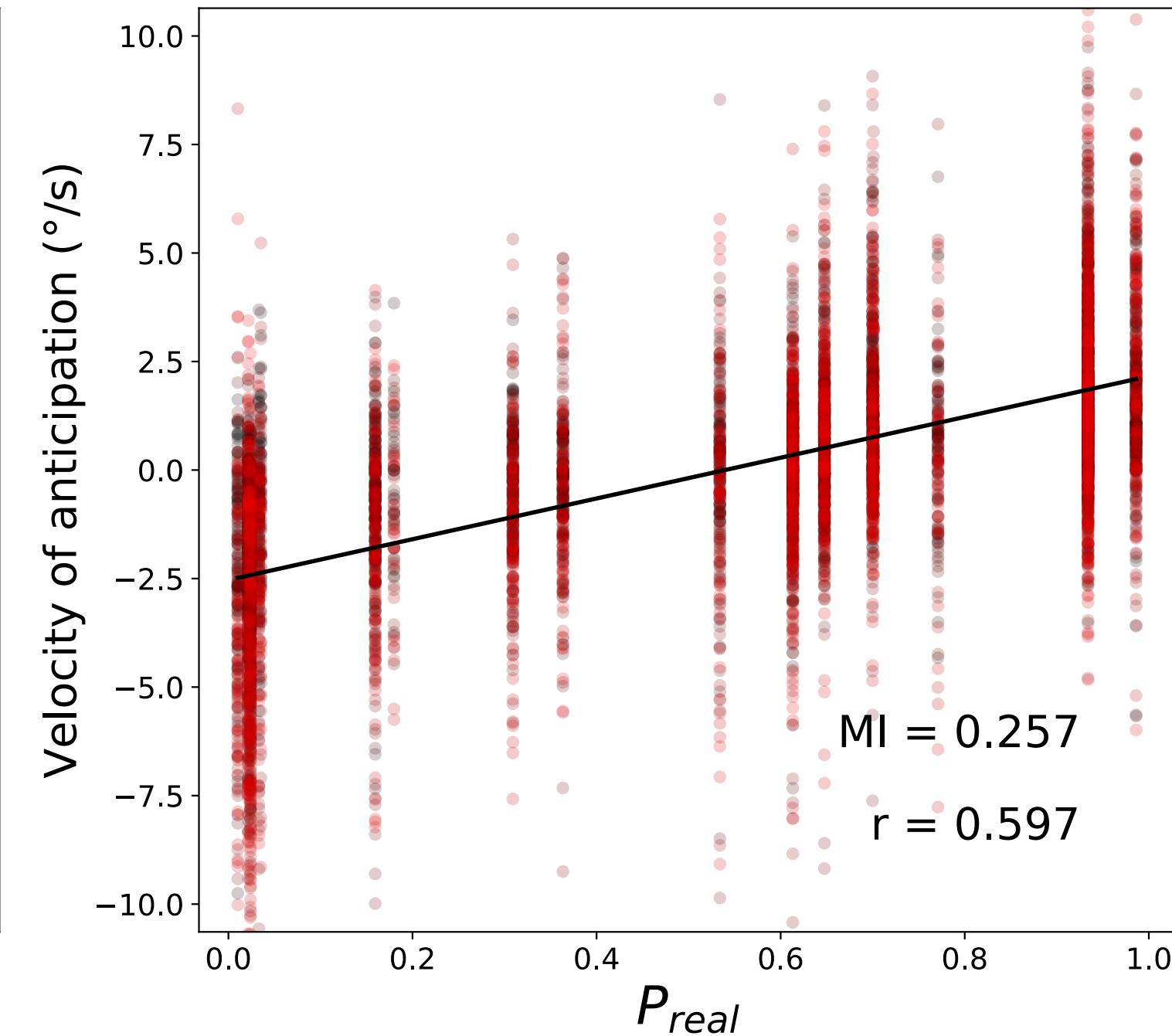


# Results: Matching Behavioral data

Probability Bet



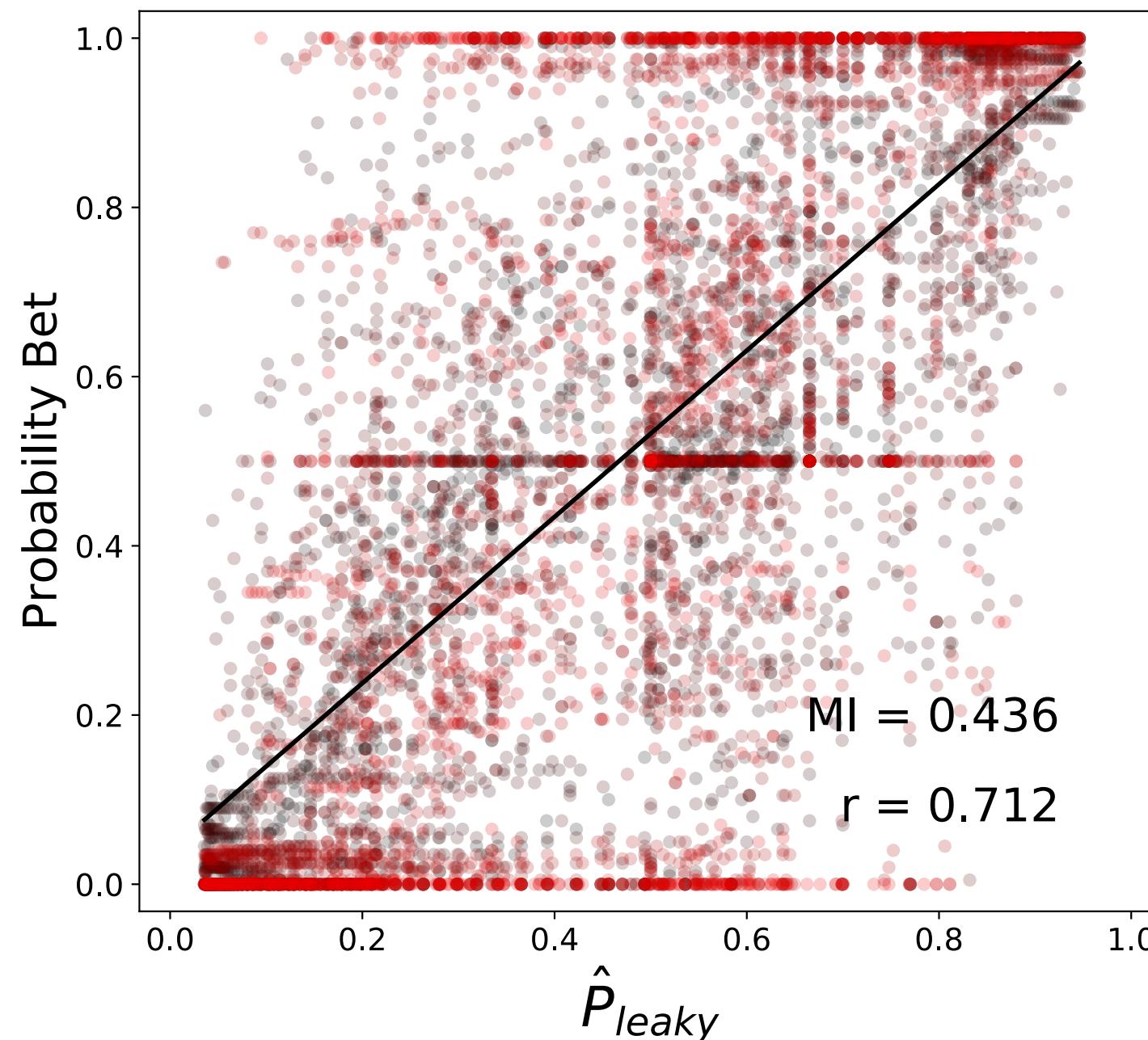
Velocity



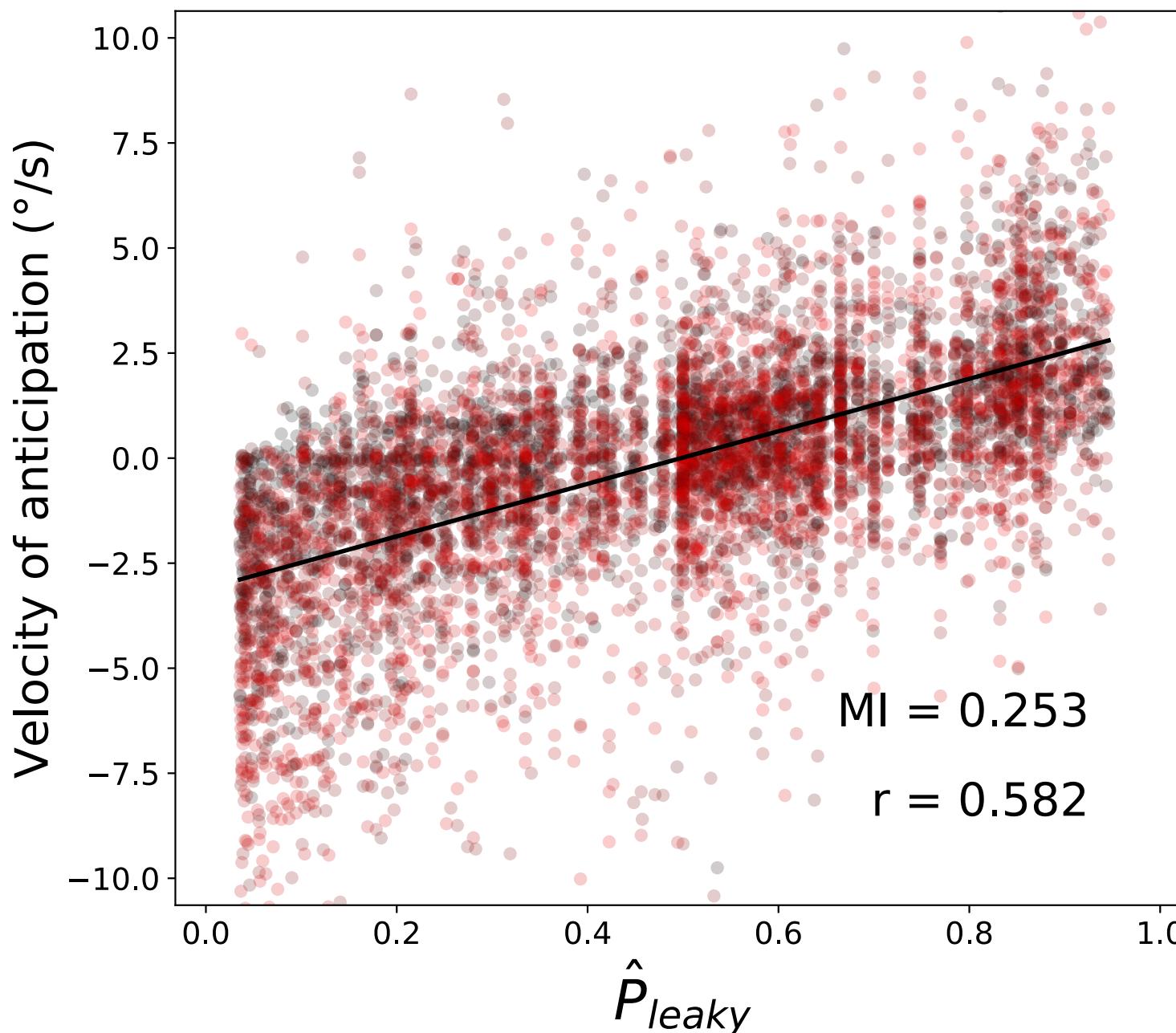
full code @ [github.com/laurentperrinet/bayesianchangepoint](https://github.com/laurentperrinet/bayesianchangepoint)

# Results: Matching Behavioral data

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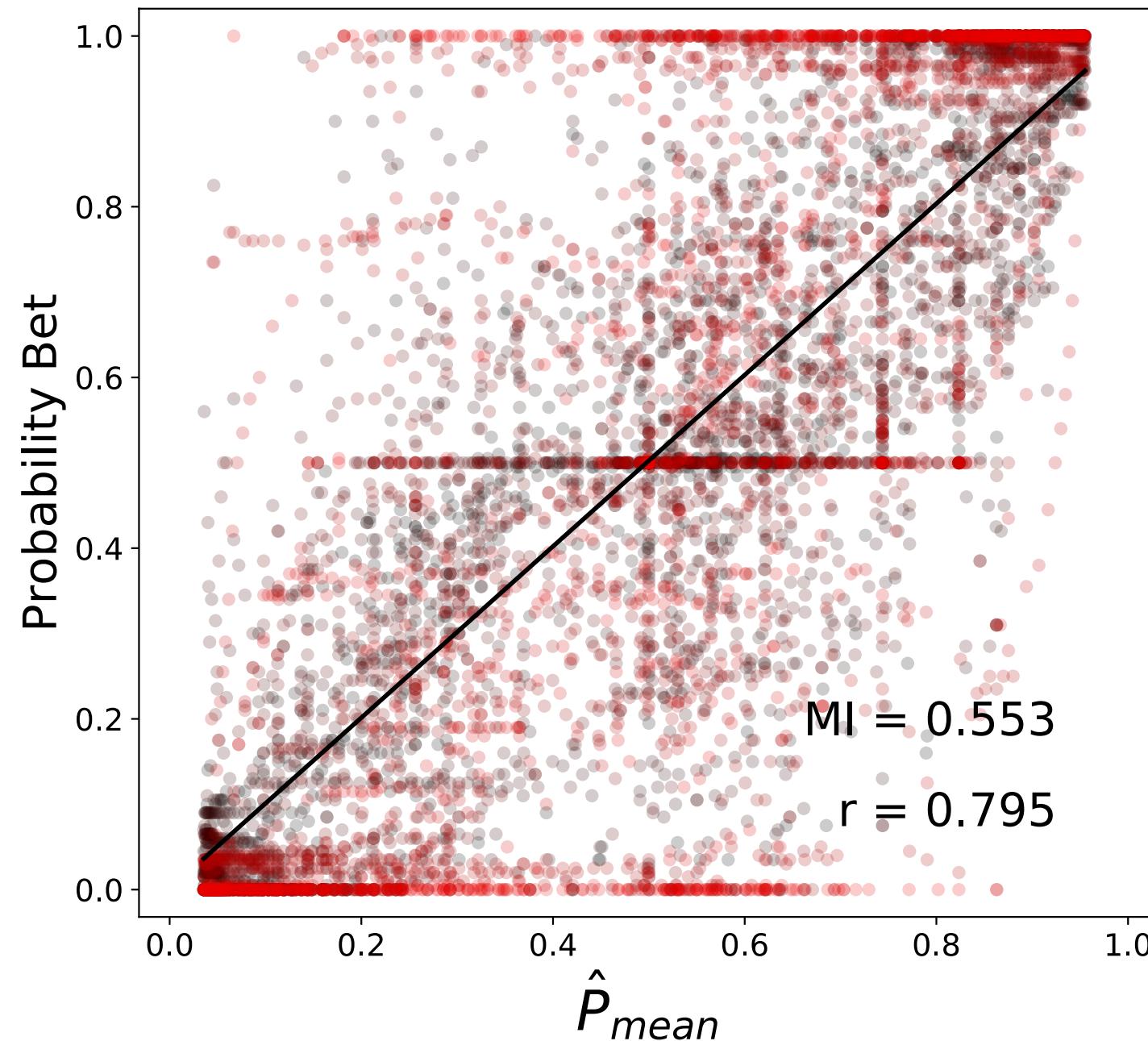
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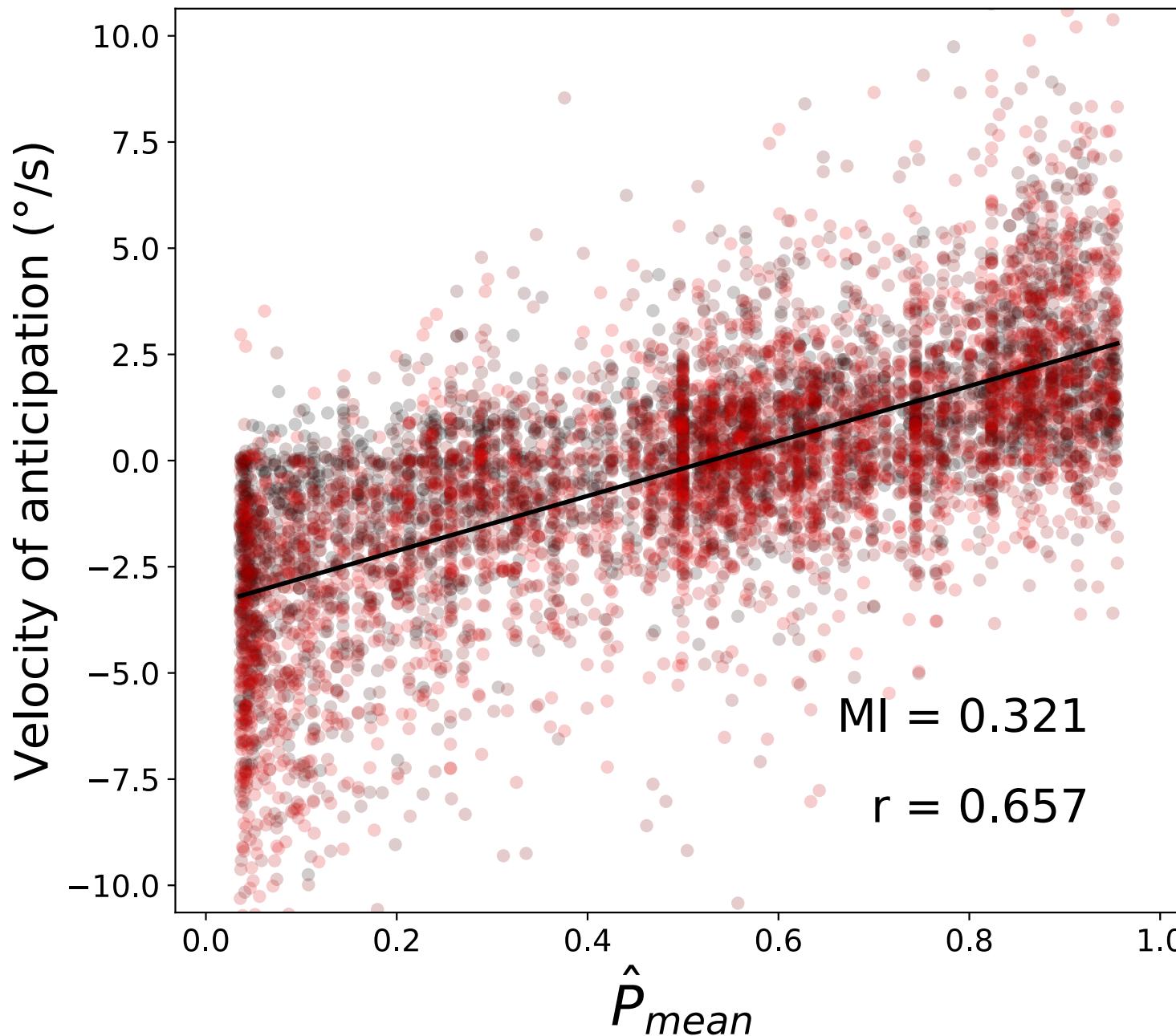
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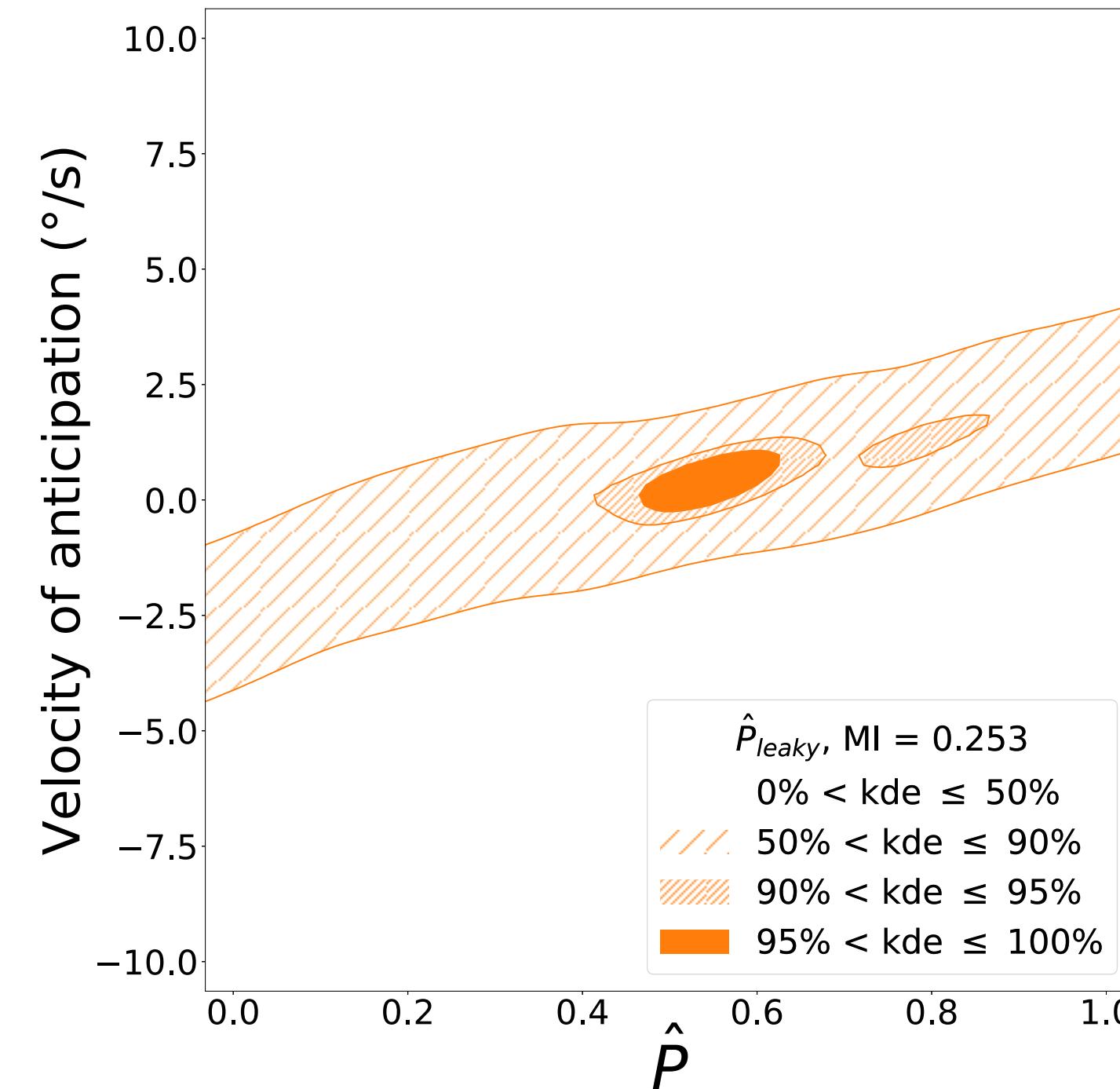
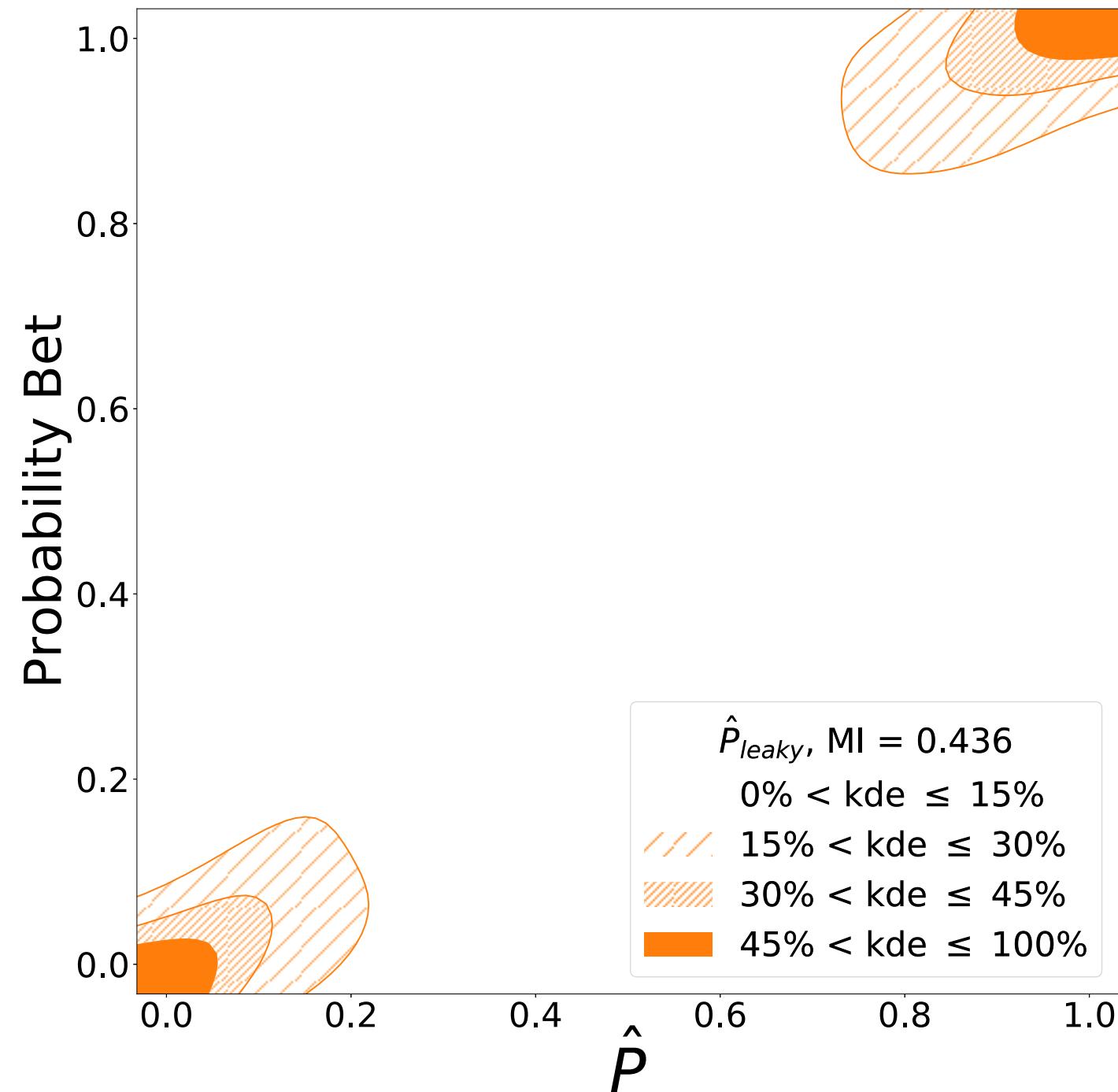


Velocity

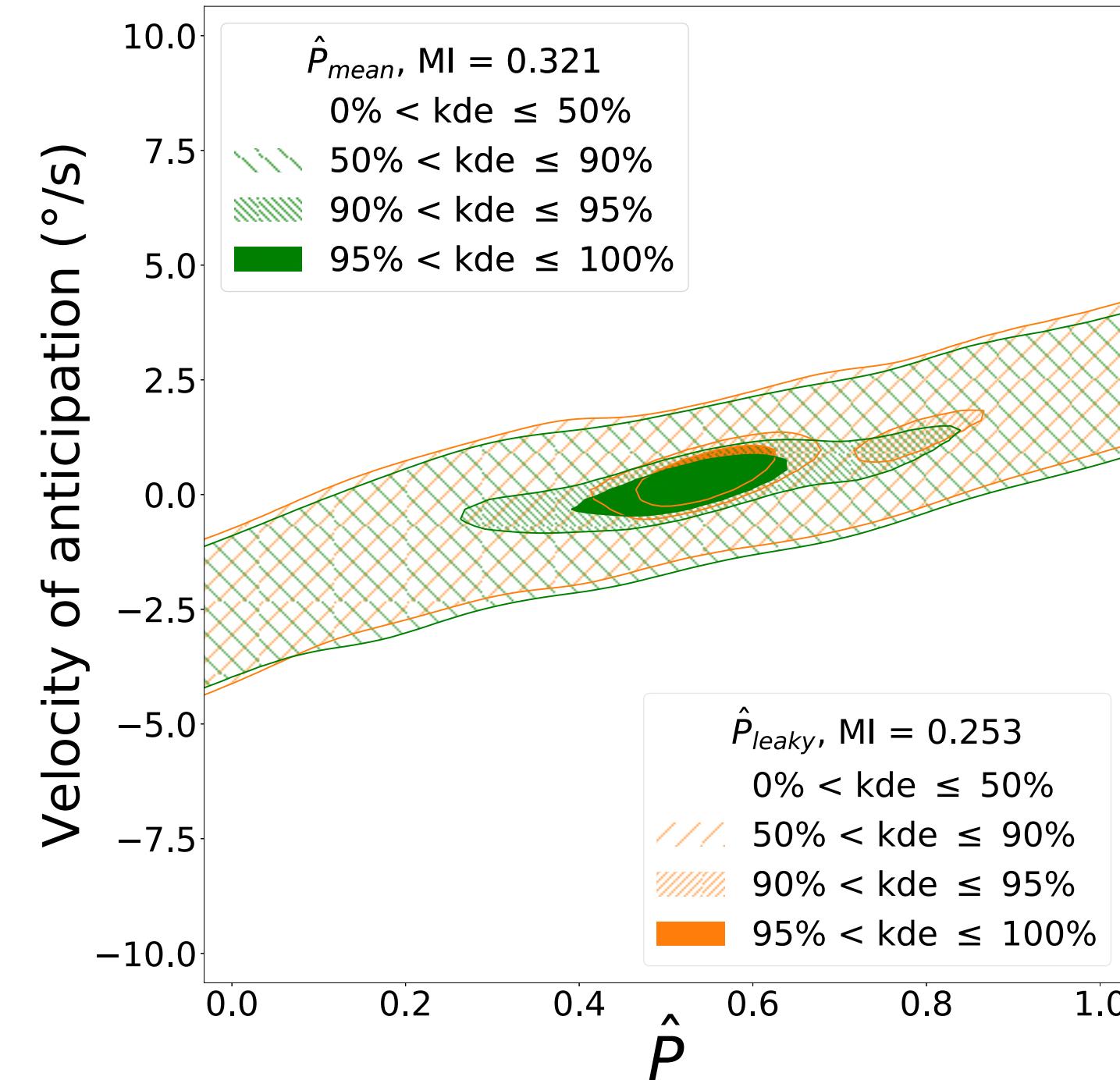
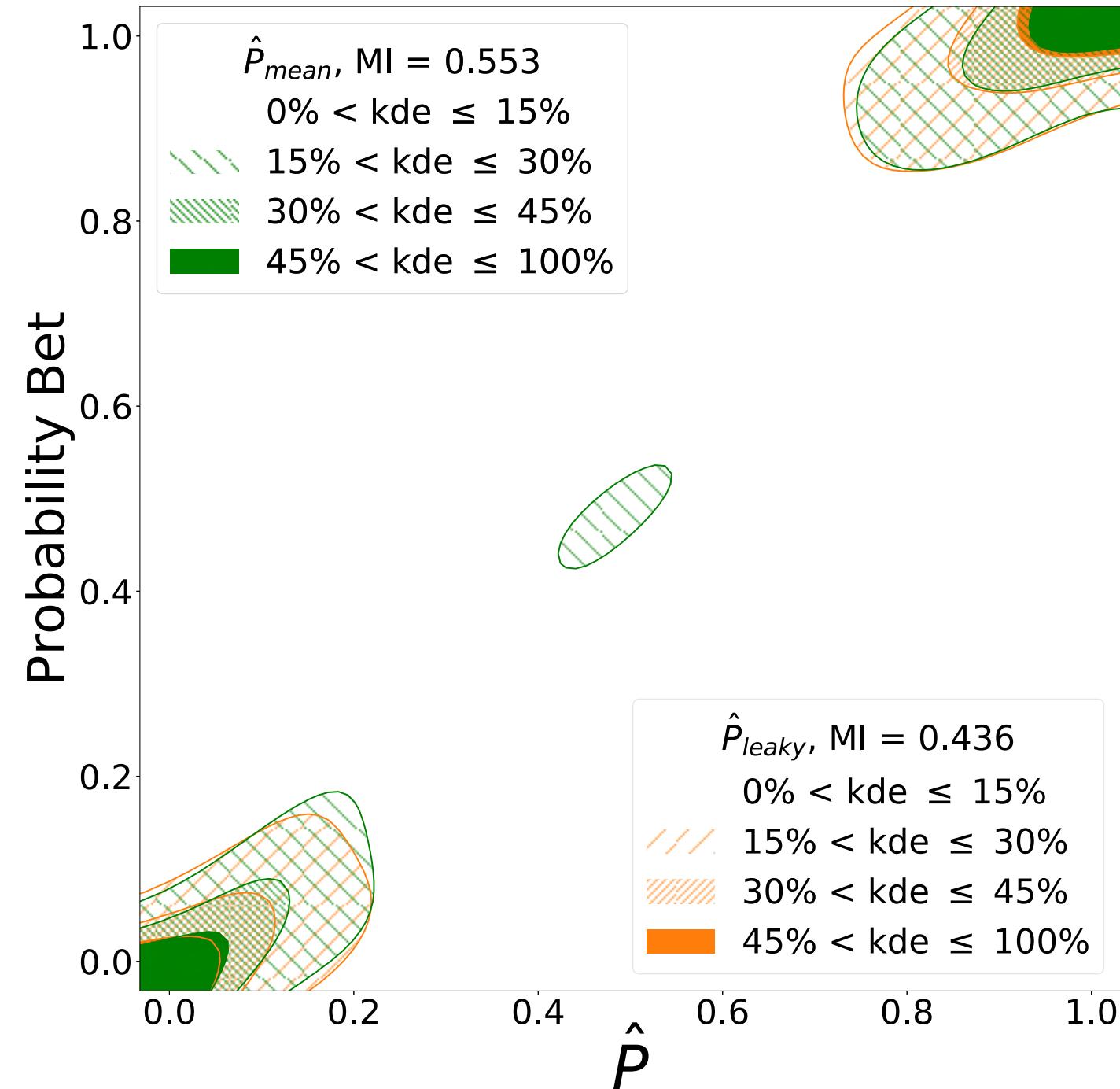


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# Results: Matching Behavioral data - Leaky integrator



# Results: Matching Behavioral data - BBCP



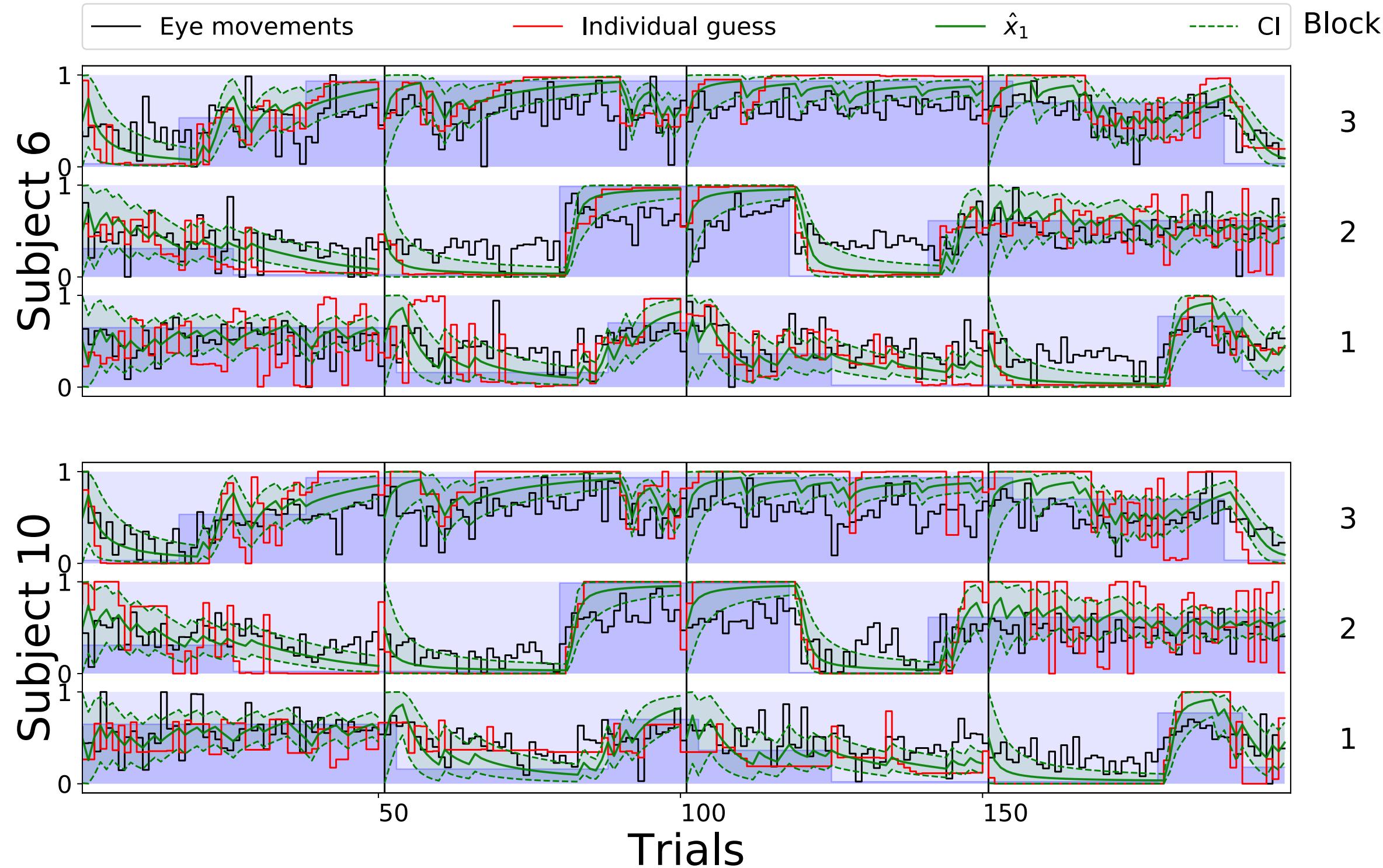
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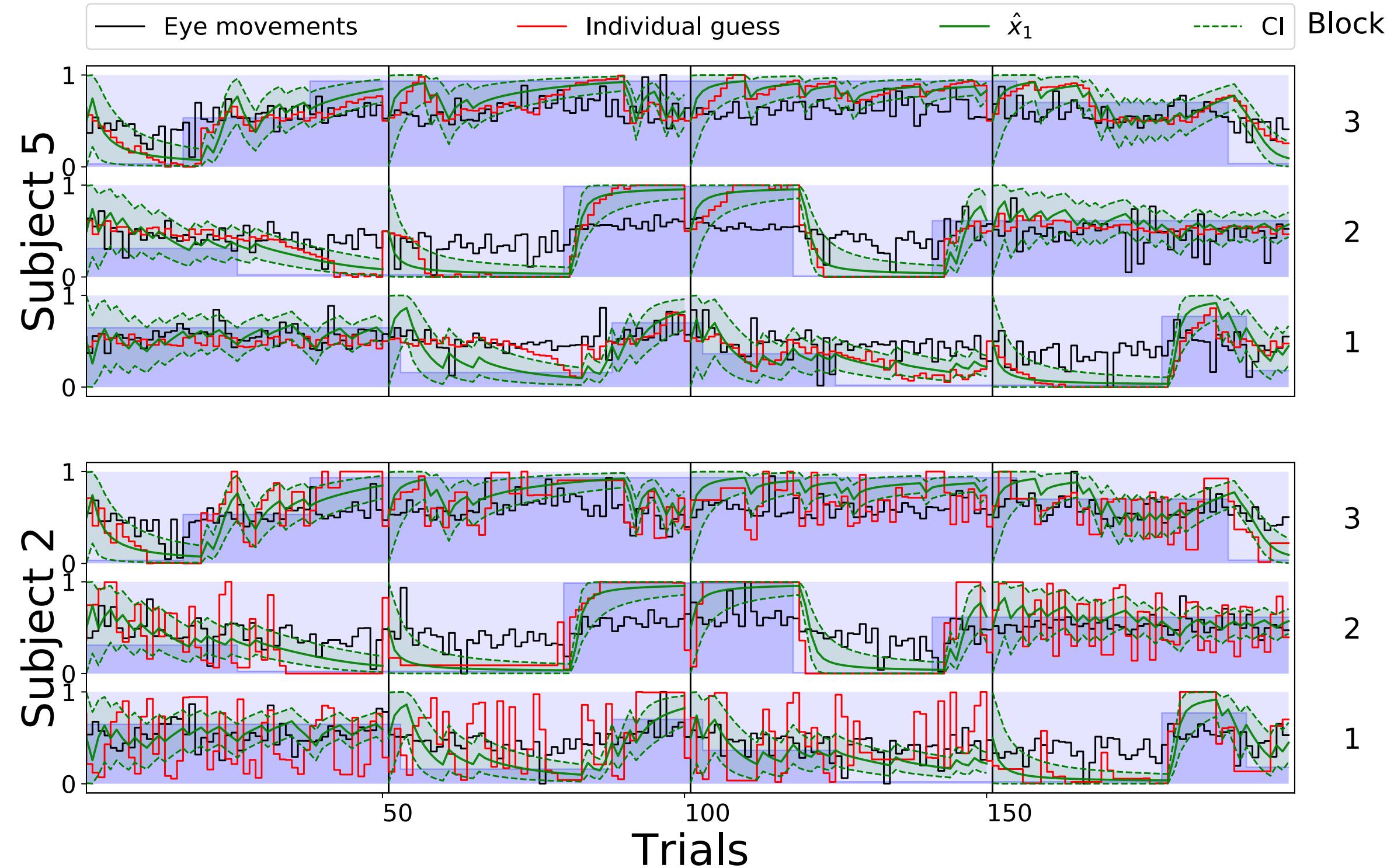
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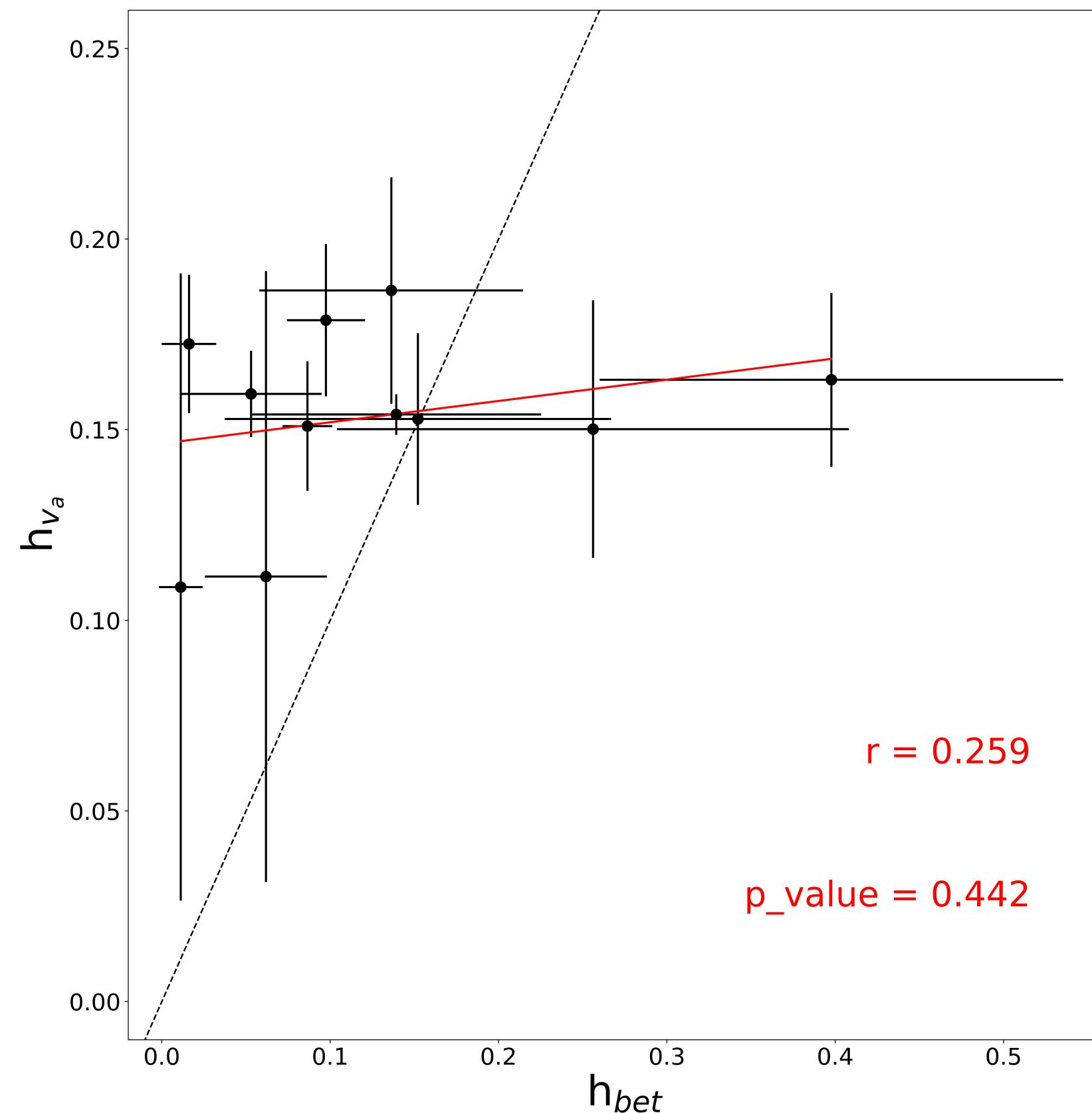
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<https://laurentperrinet.github.io/talk/2019-05-23-neurofrance>