

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



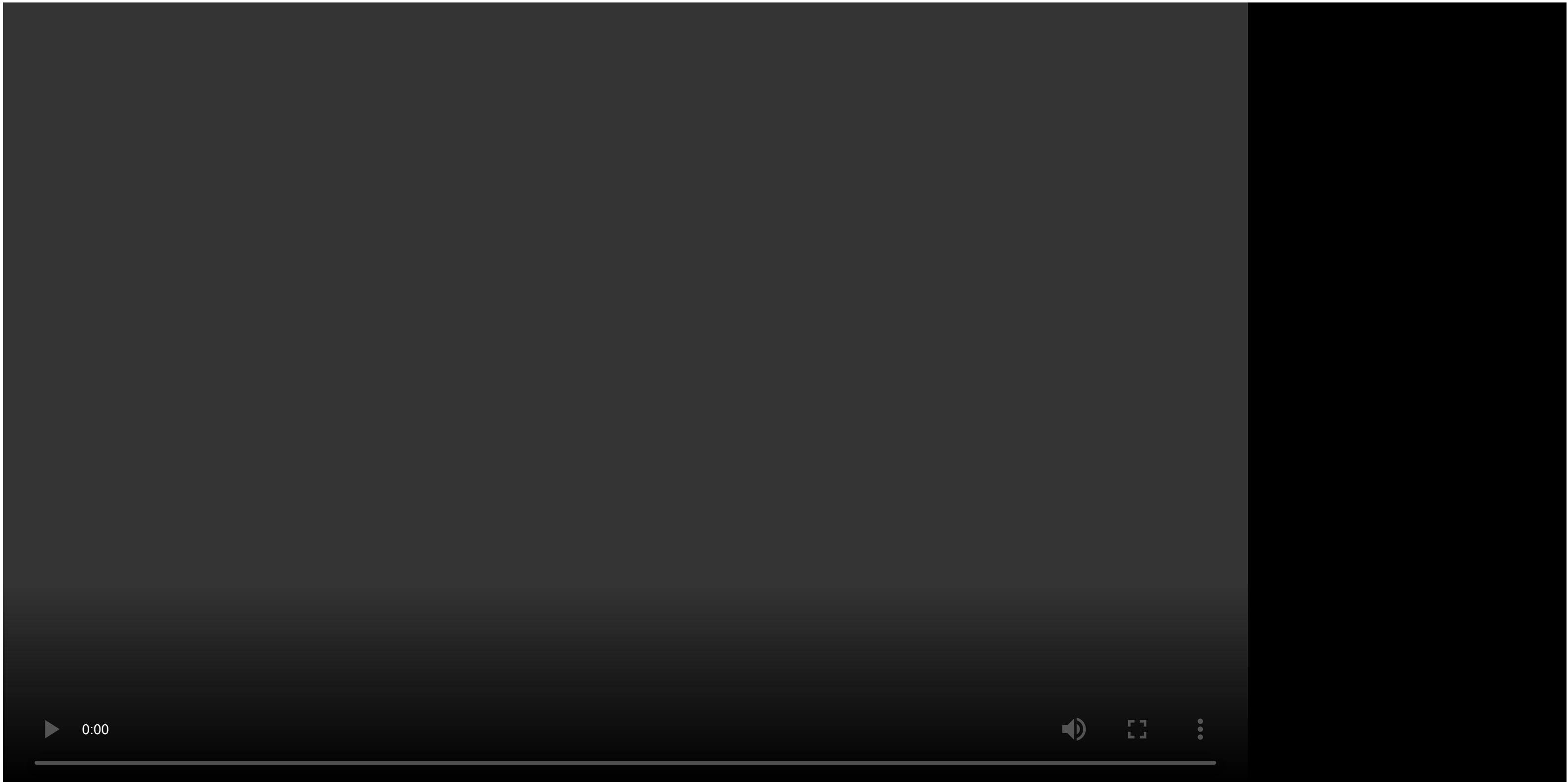
Colloque international de la Société des Neurosciences 2019, 23/5/2019

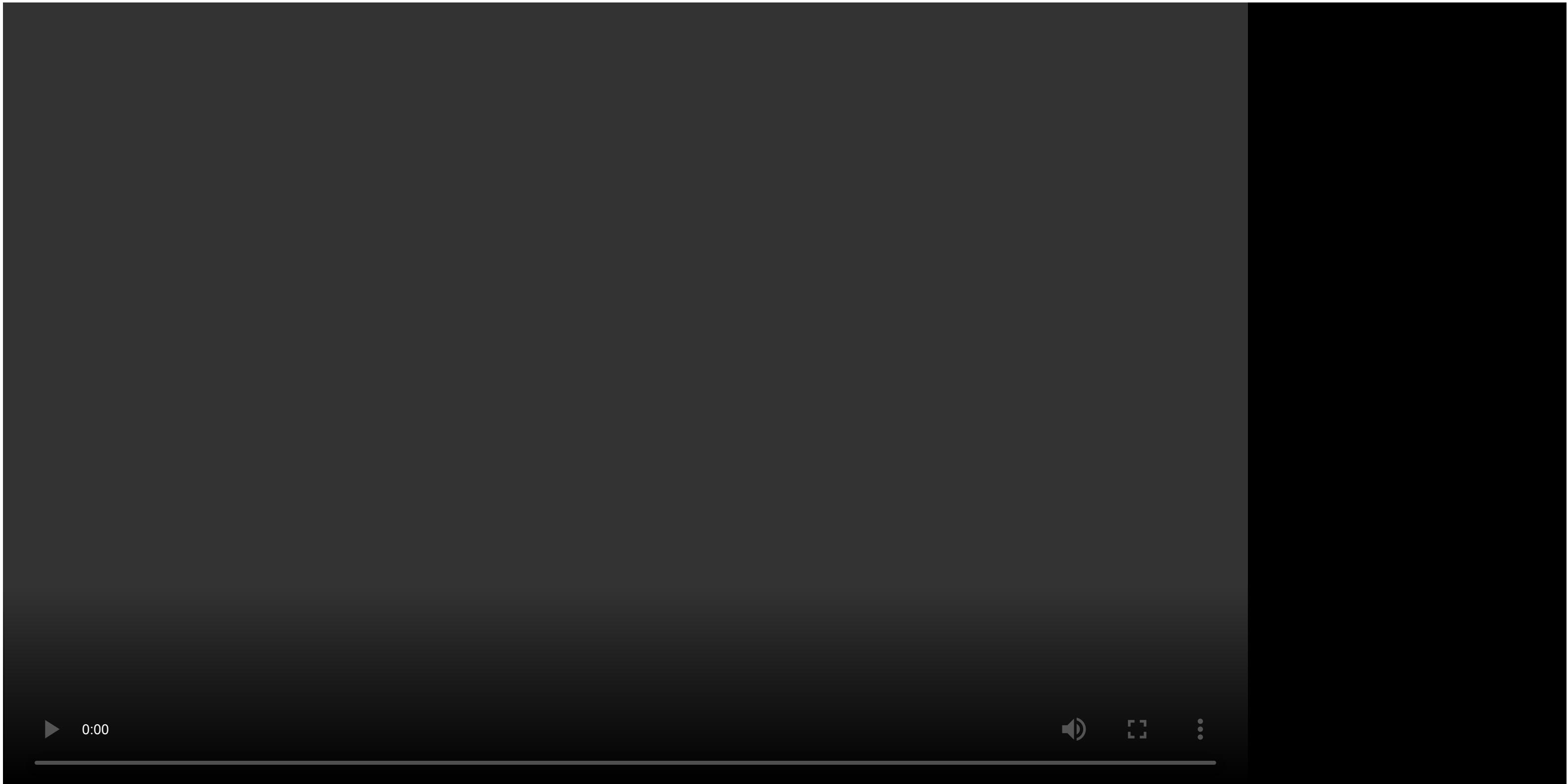
Acknowledgements:

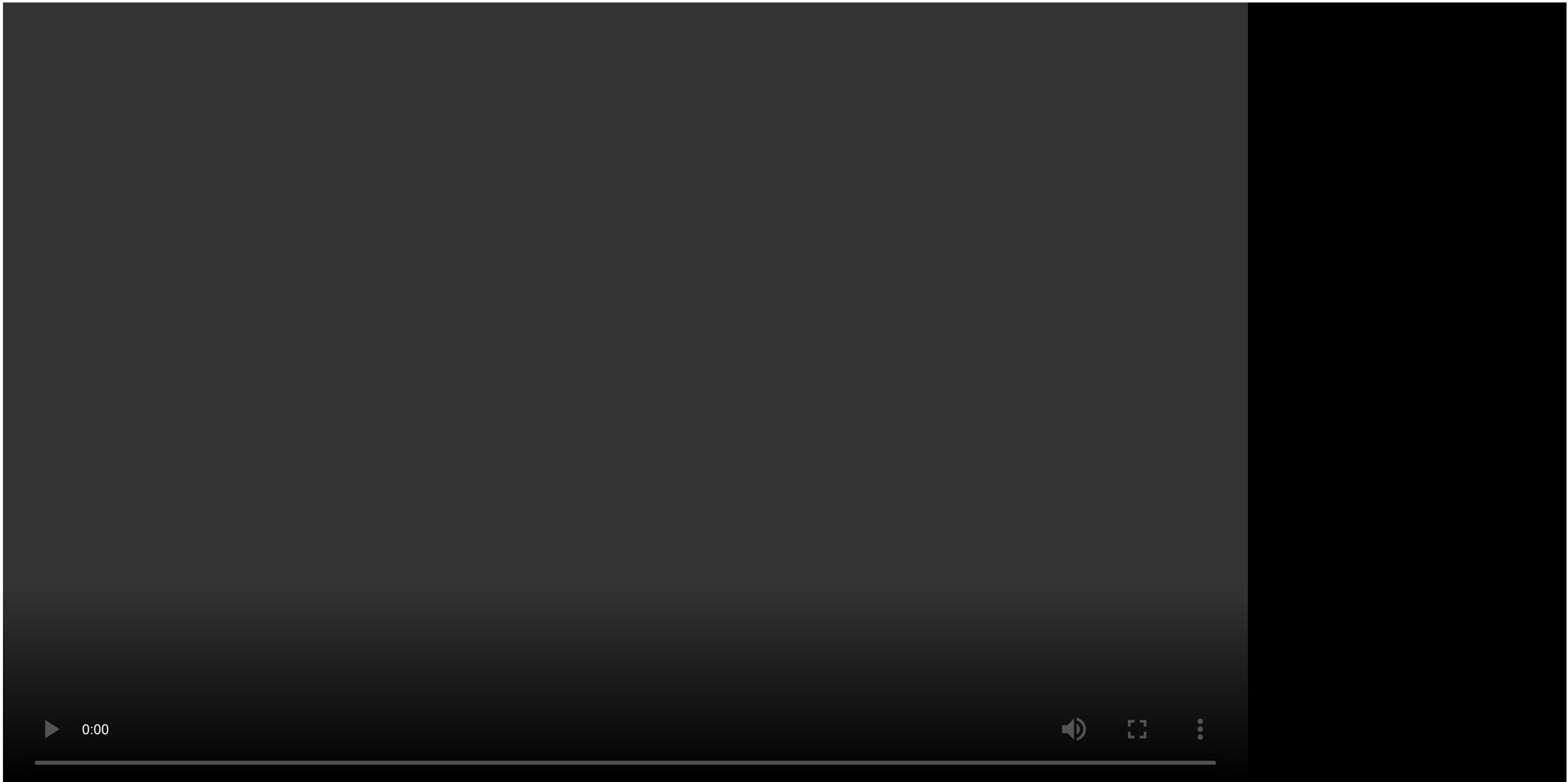
- Rick Adams and Karl Friston @ UCL - Wellcome Trust Centre for Neuroimaging
- Jean-Bernard Damasse, Laurent Madelain and Anna Montagnini - ANR REM
- Frédéric Chavane - INT



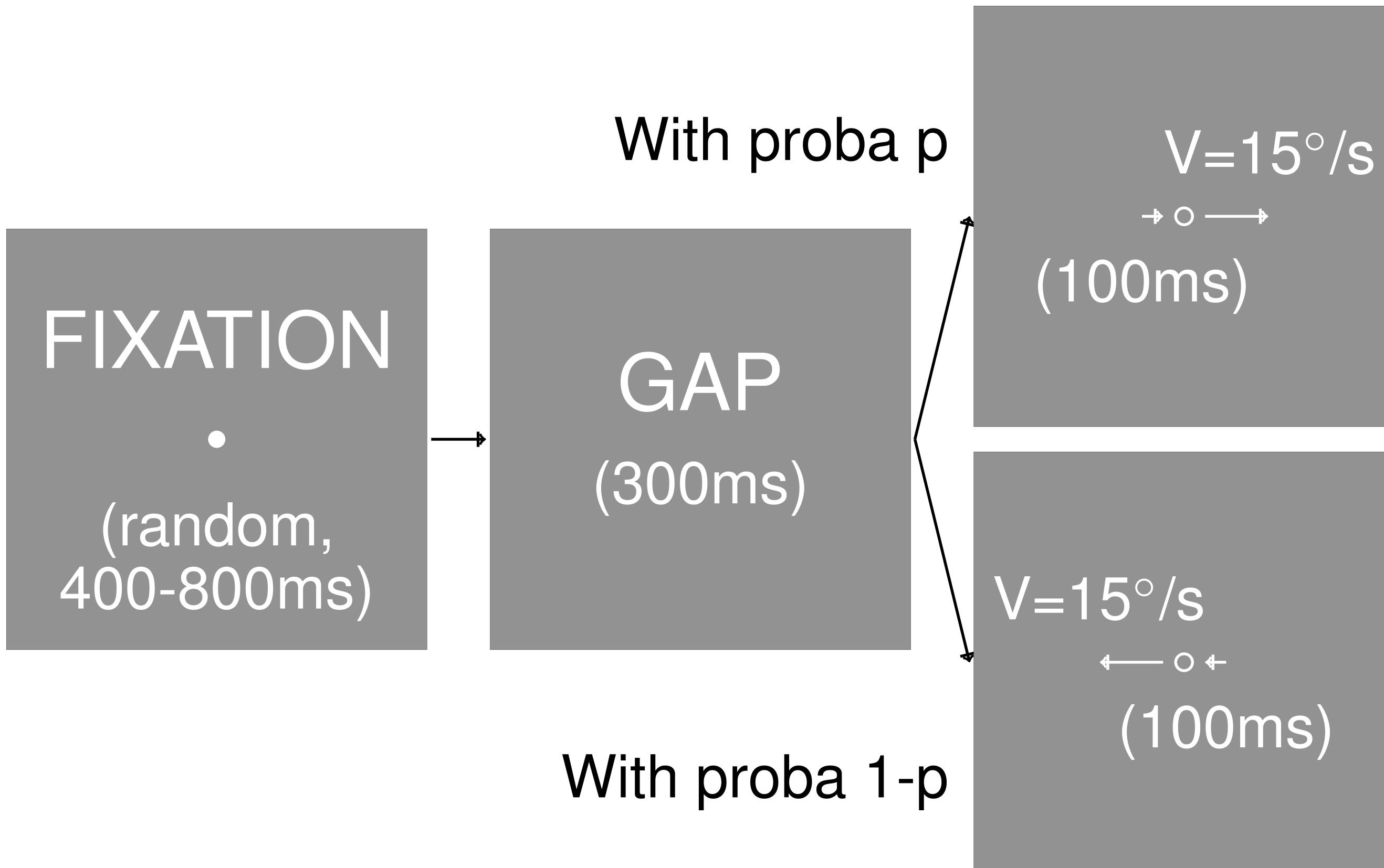
This work was supported by the PACE-ITN Project.



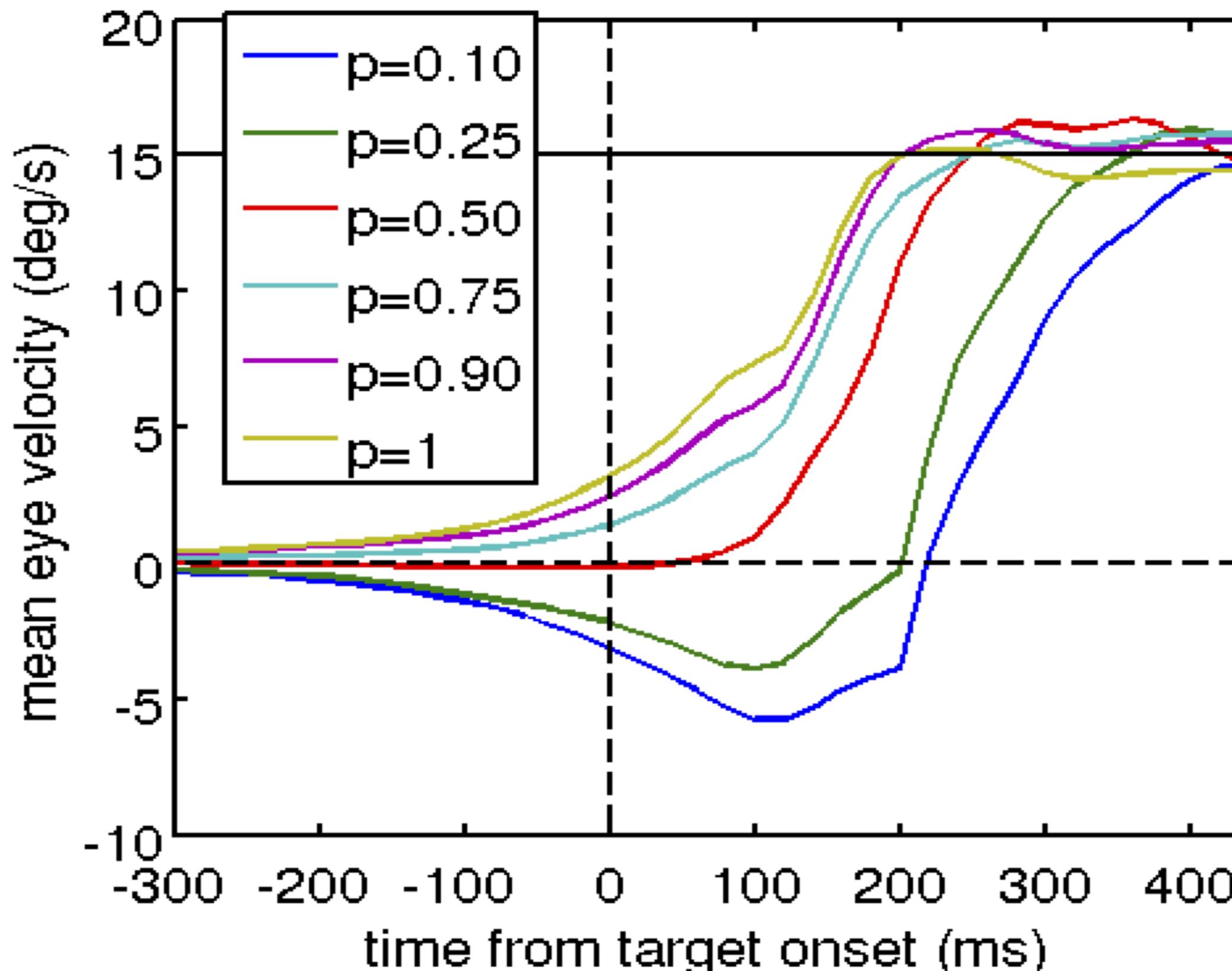




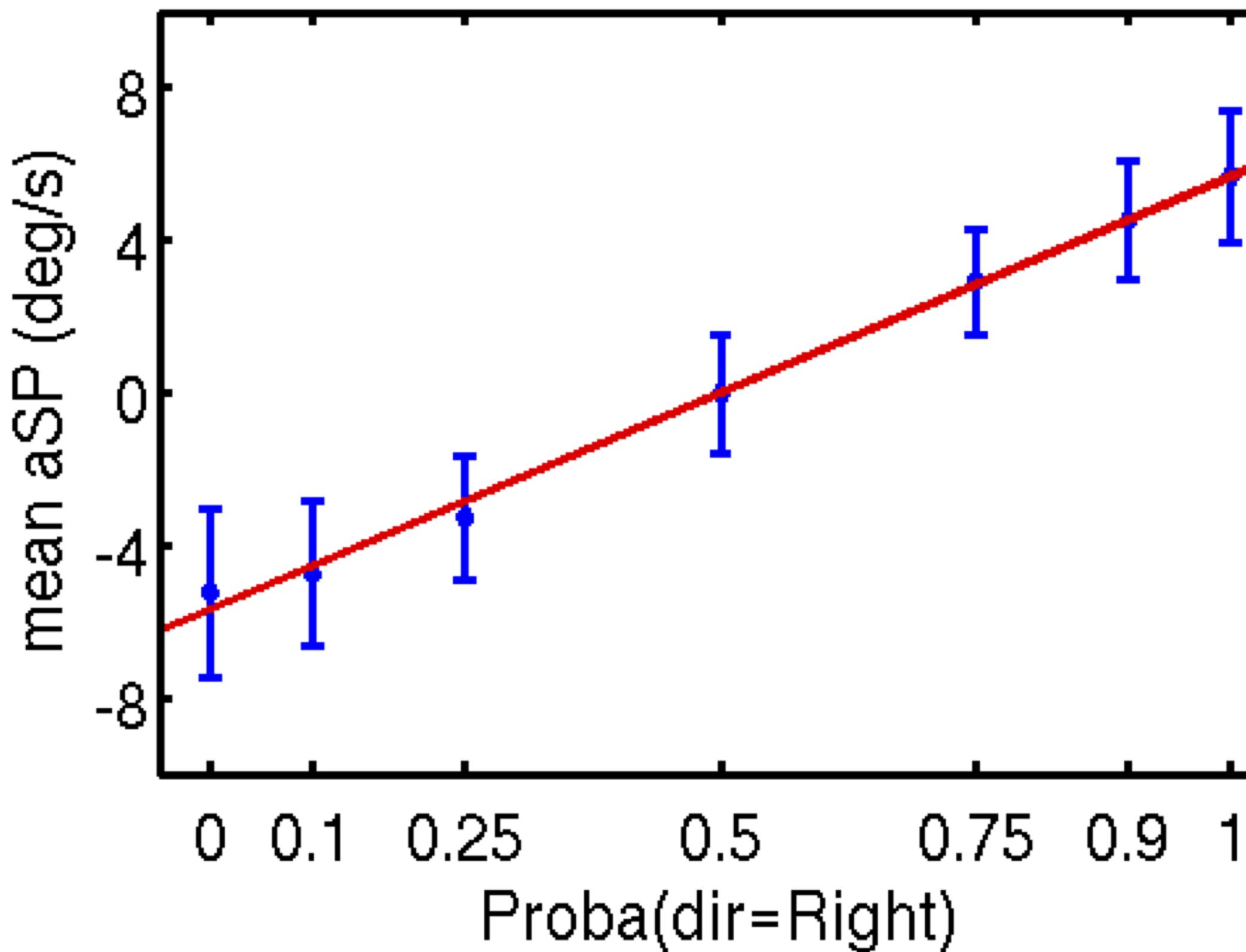
Should I stay or should I go? - Eye Movements

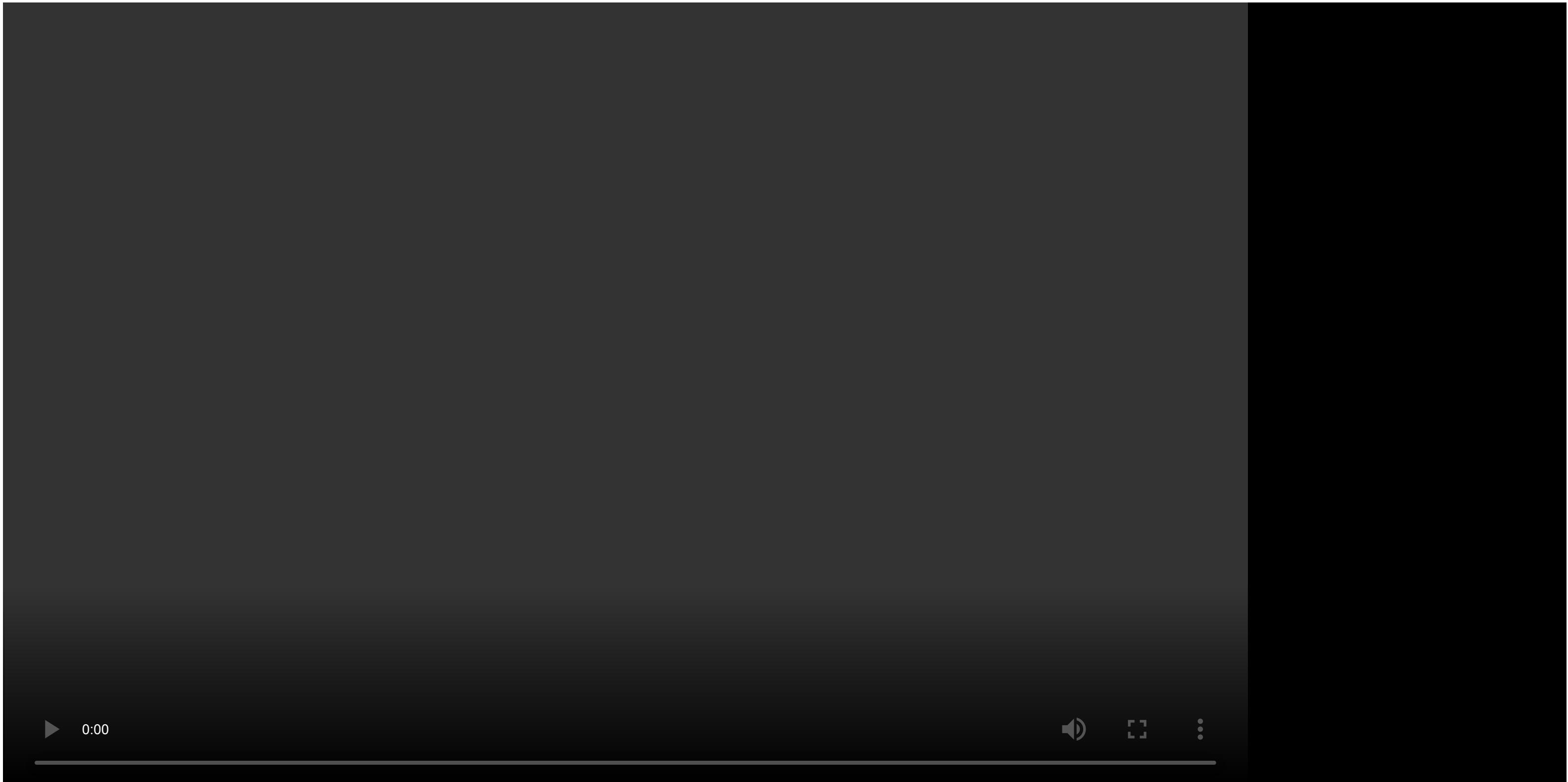


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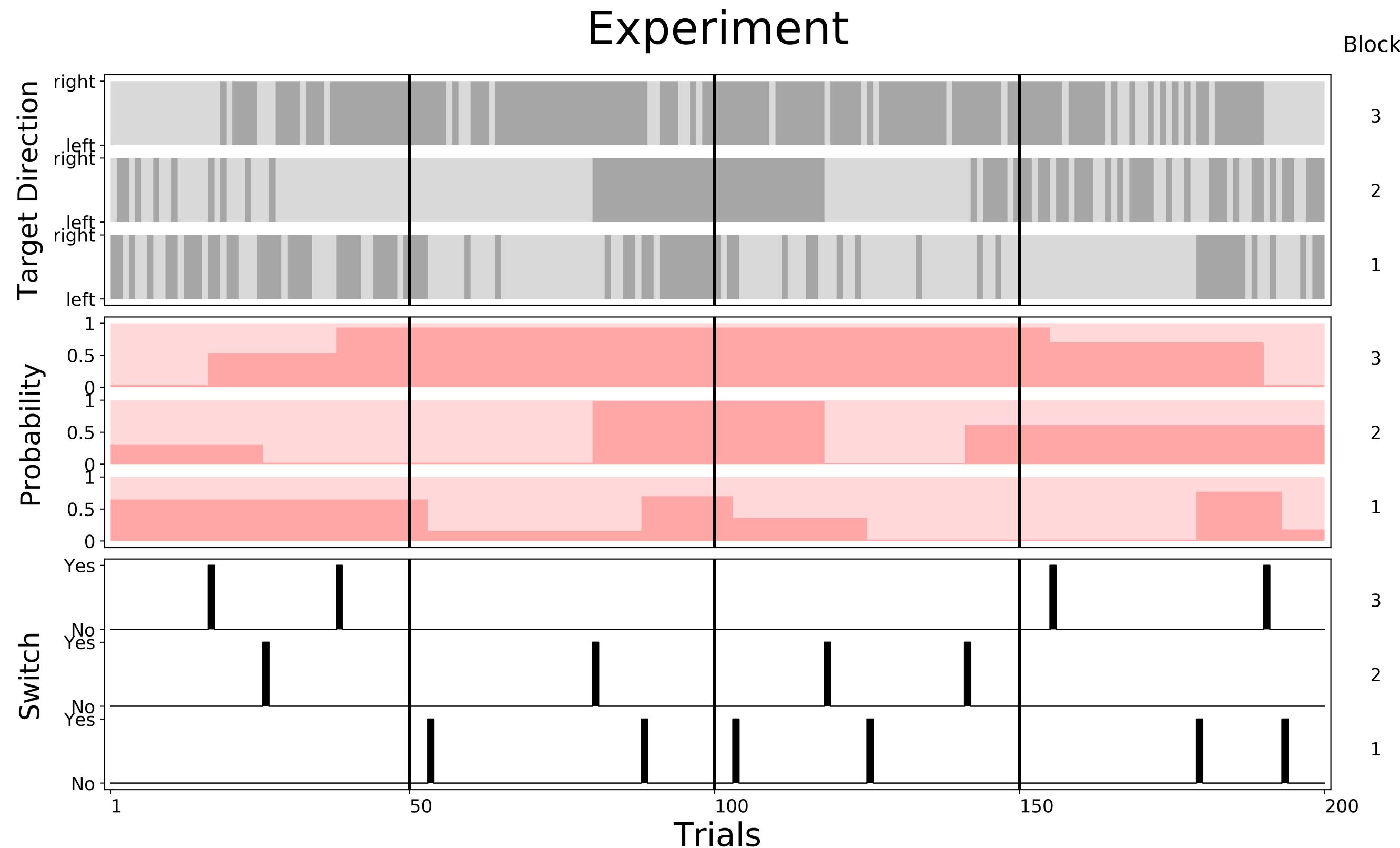


Should I stay or should I go? - Eye Movements





Should I stay or should I go? - Random-length block design



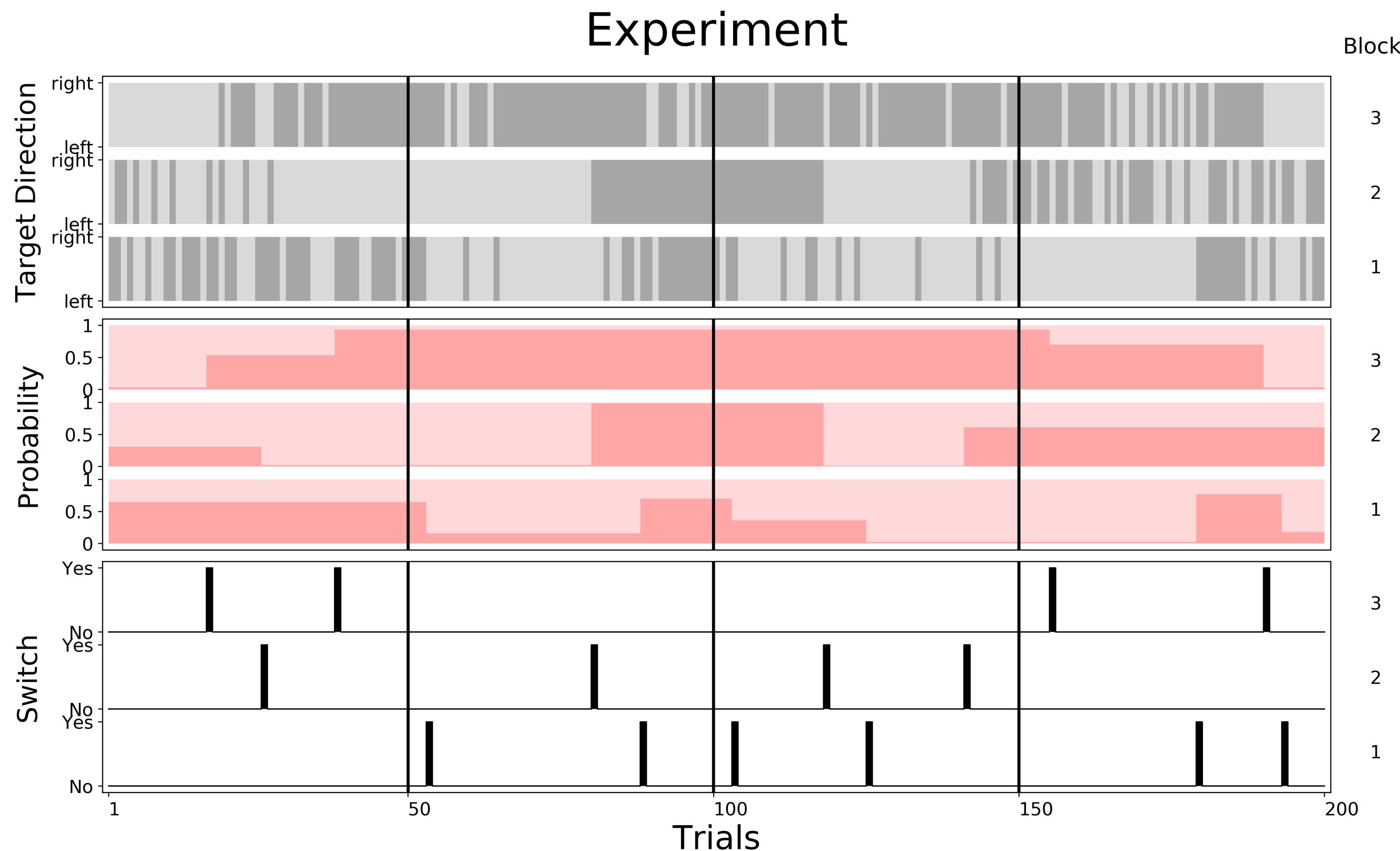
Outline

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

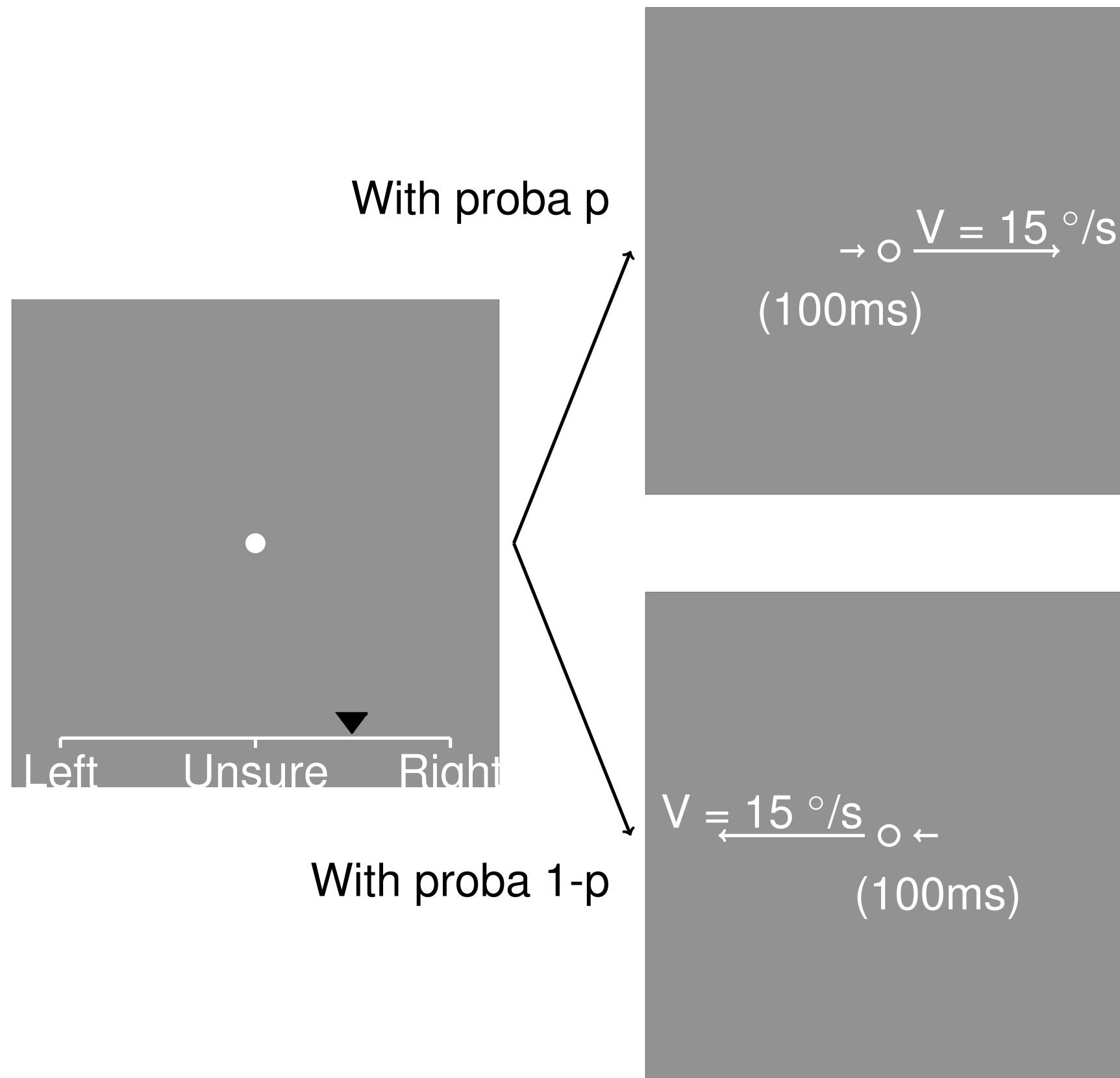
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Experimental protocol - Random-length block design

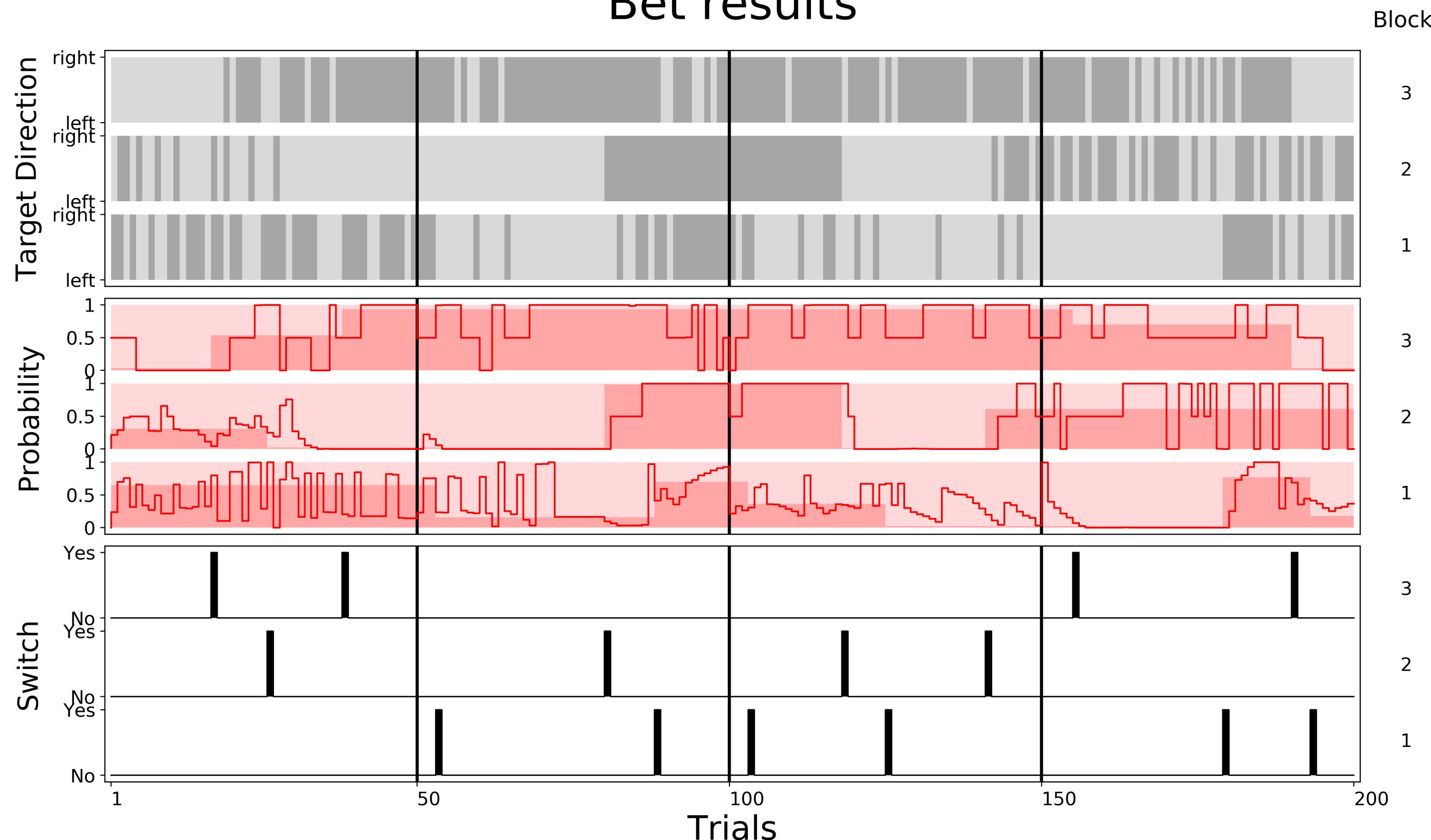


Experimental protocol - Random-length block design

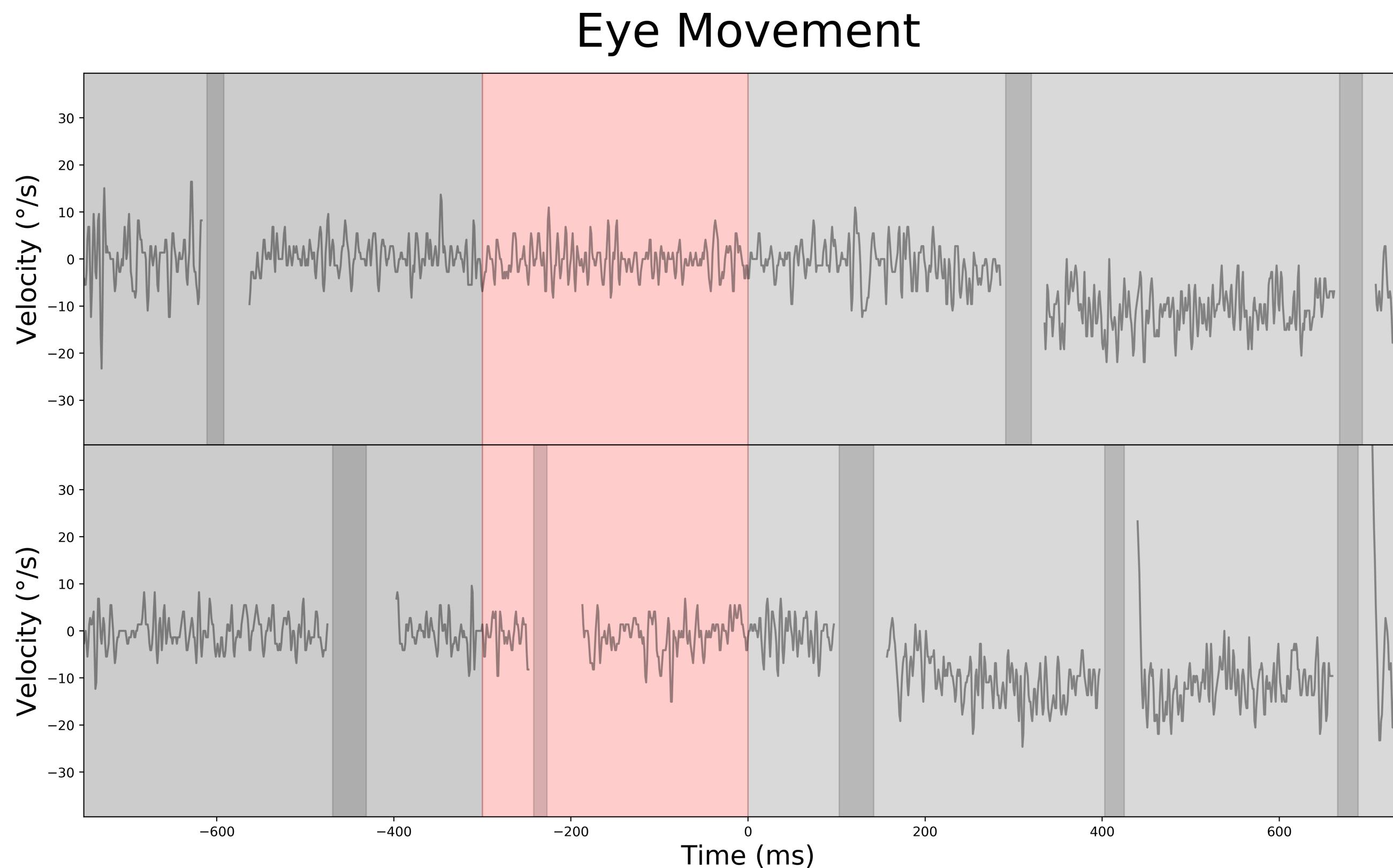


Experimental protocol

Bet results

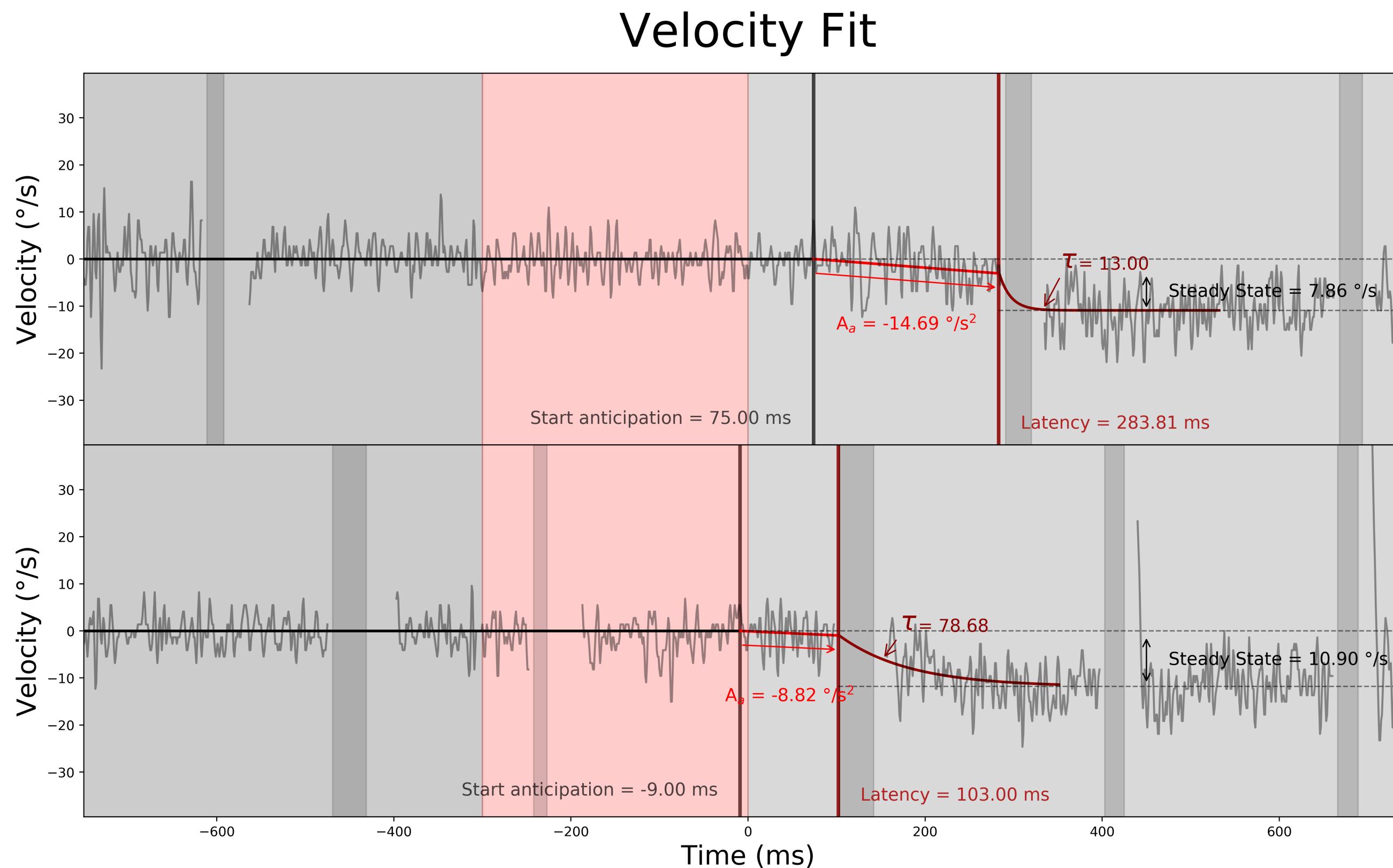


Experimental protocol - Fitting eye movements



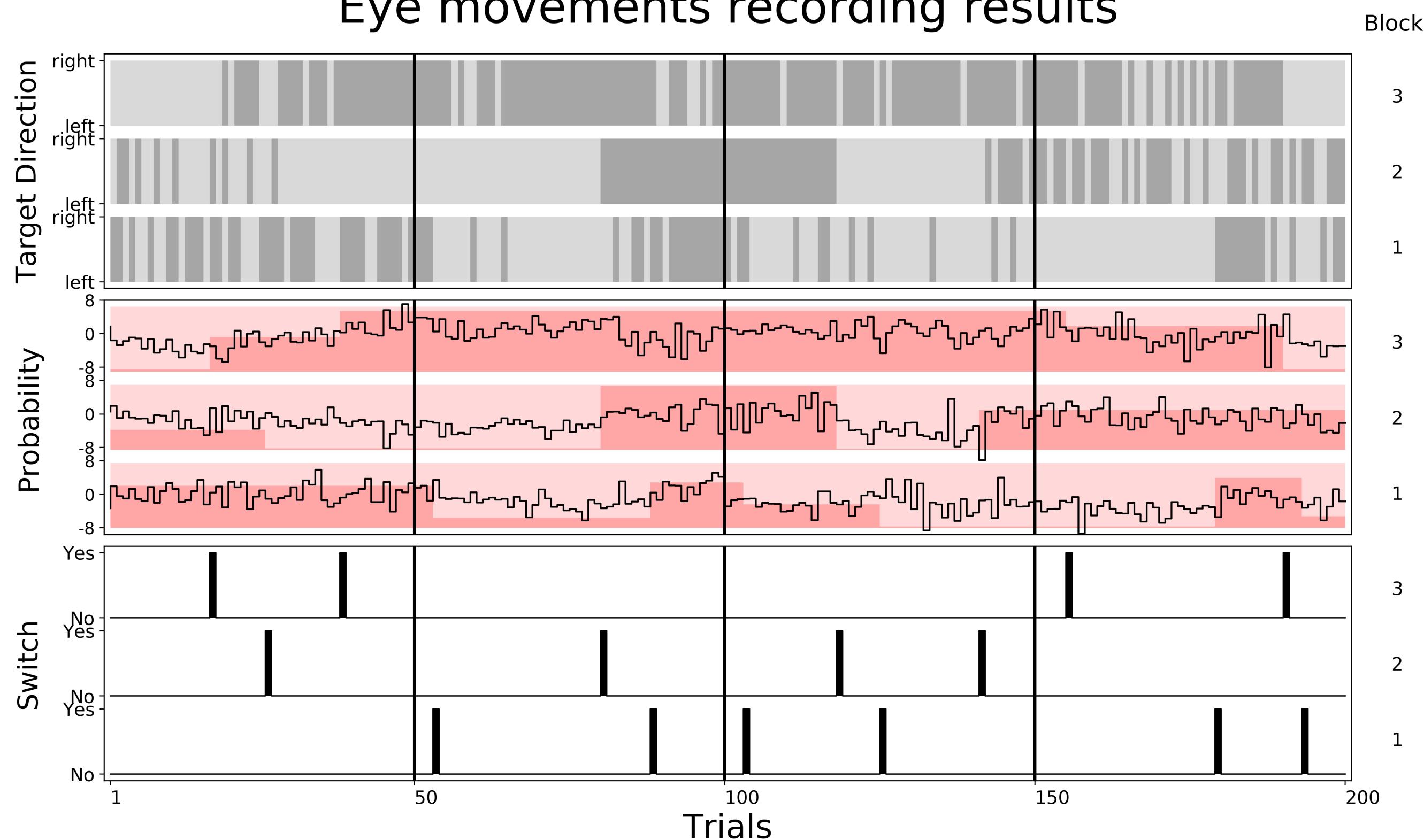
full code @ github.com/chloepasturel/AnticipatorySPEM

Experimental protocol - Fitting eye movements



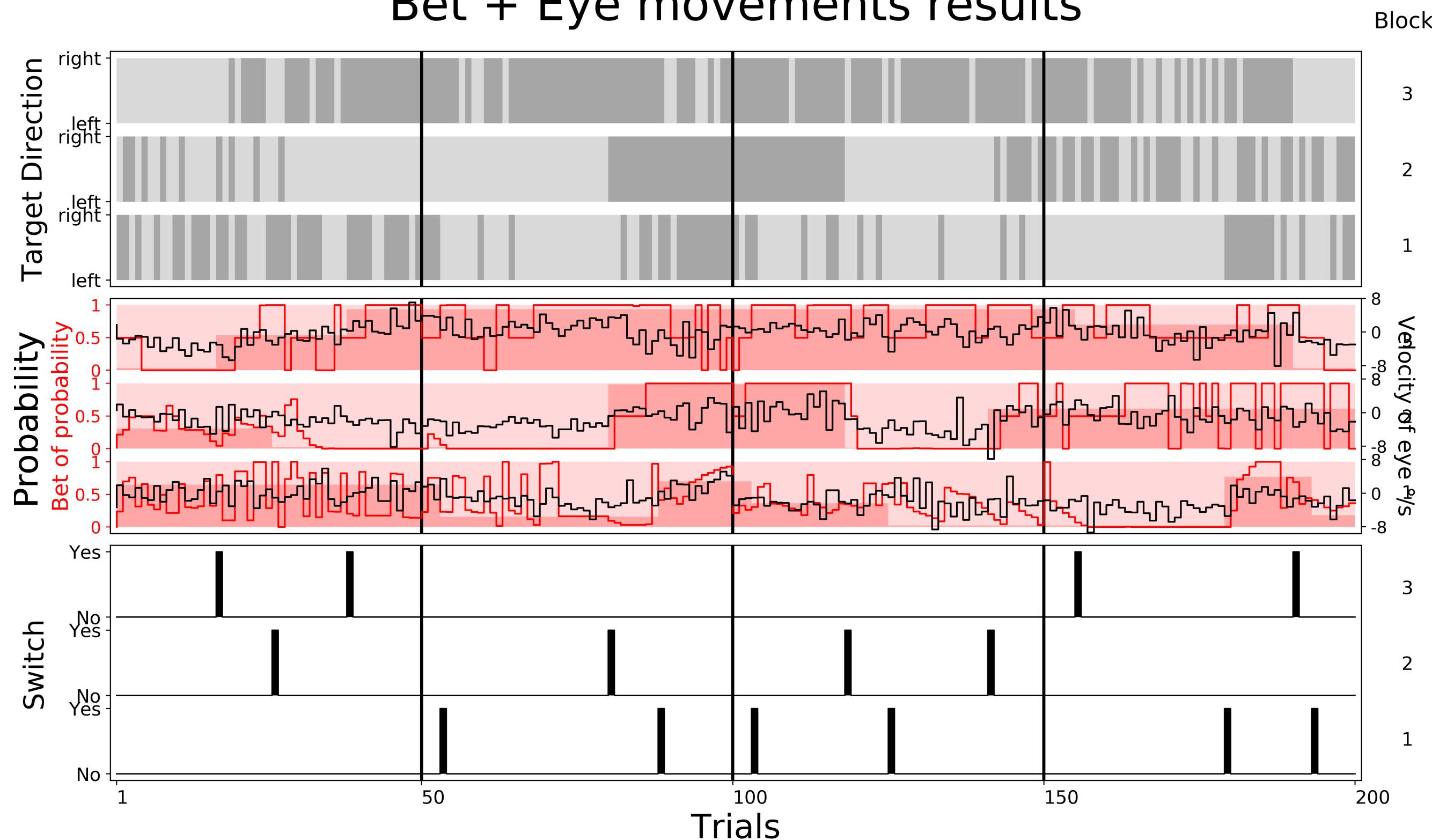
Experimental protocol

Eye movements recording results



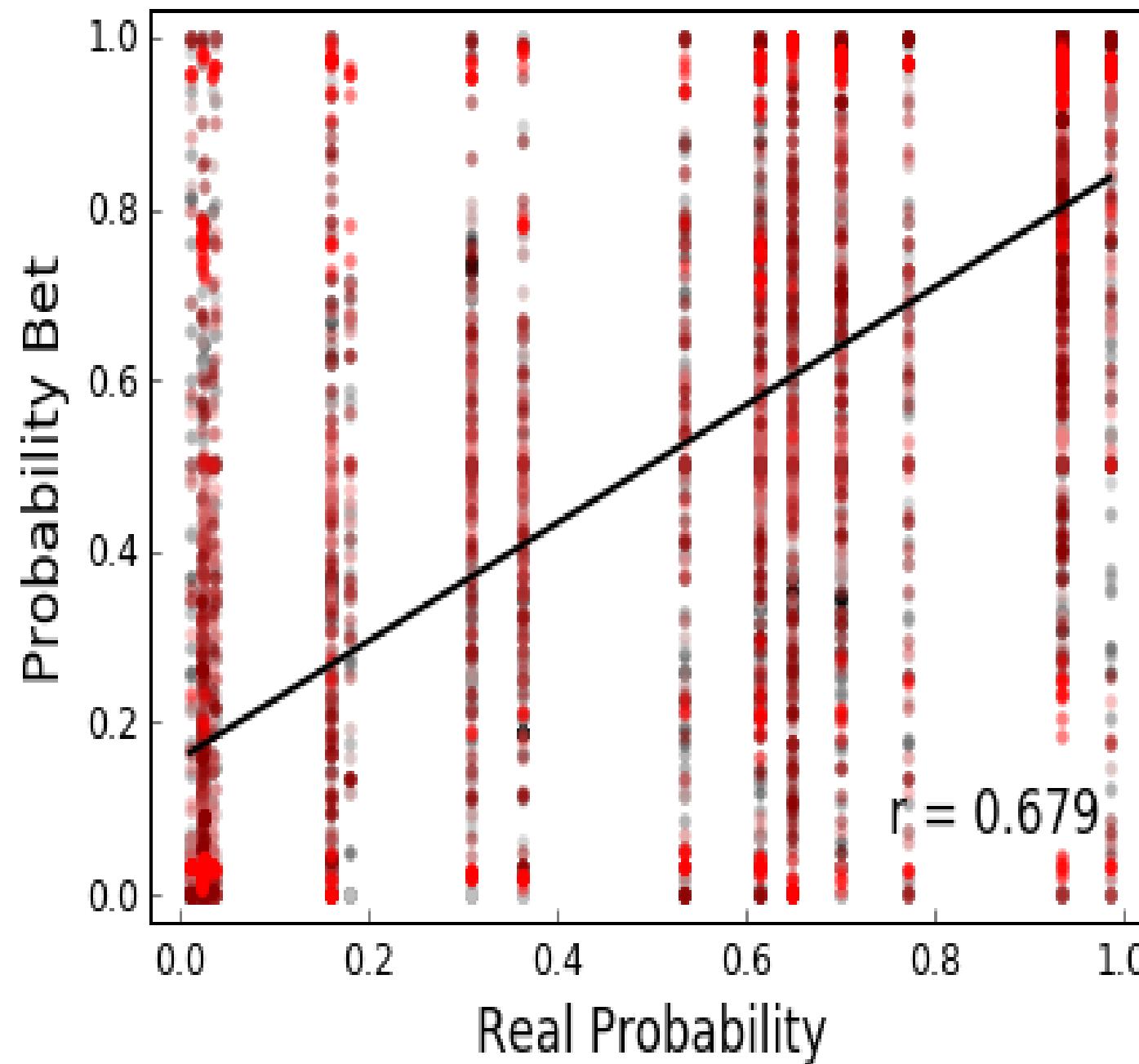
Experimental protocol

Bet + Eye movements results

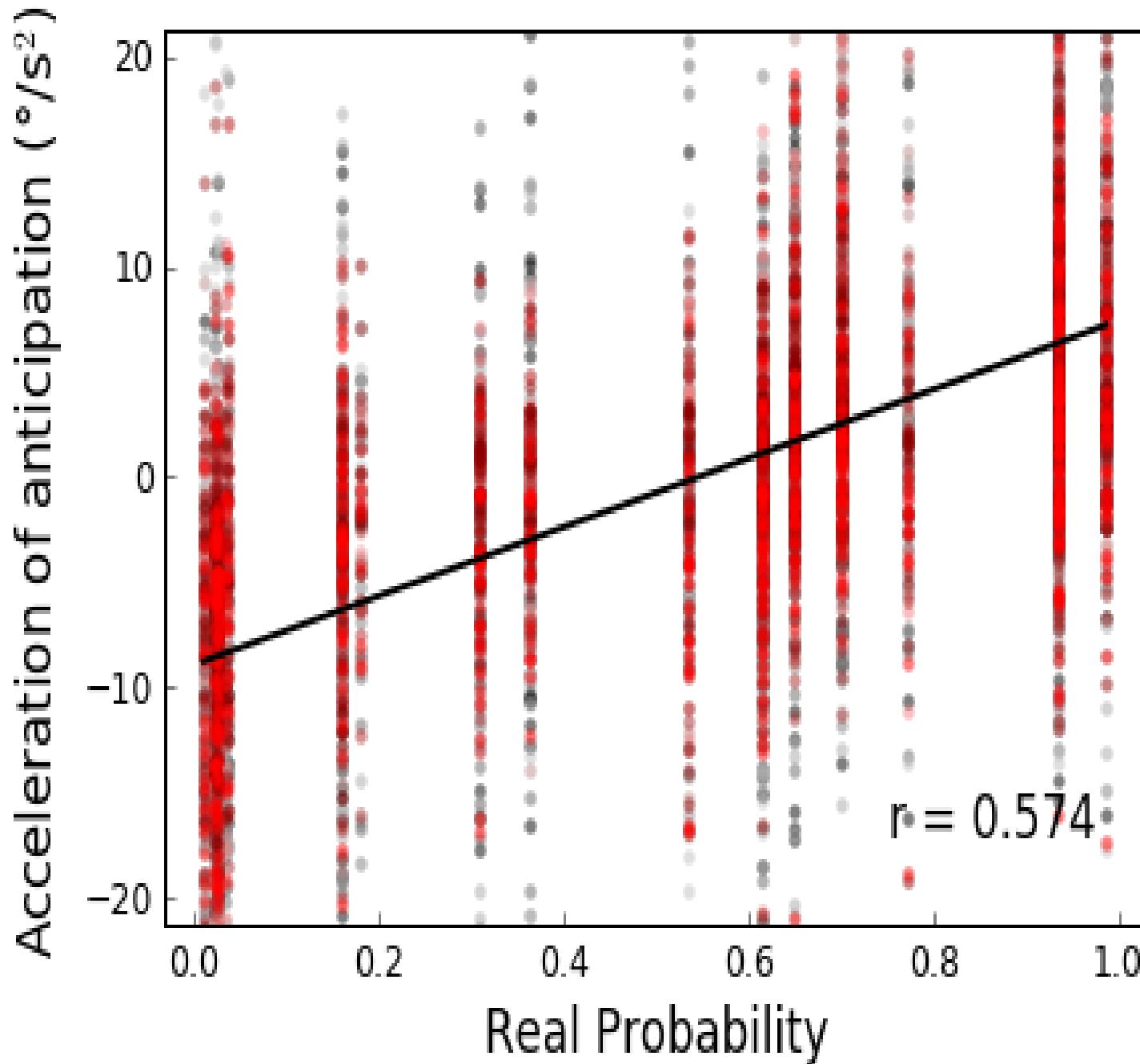


Experimental protocol

Probability Bet



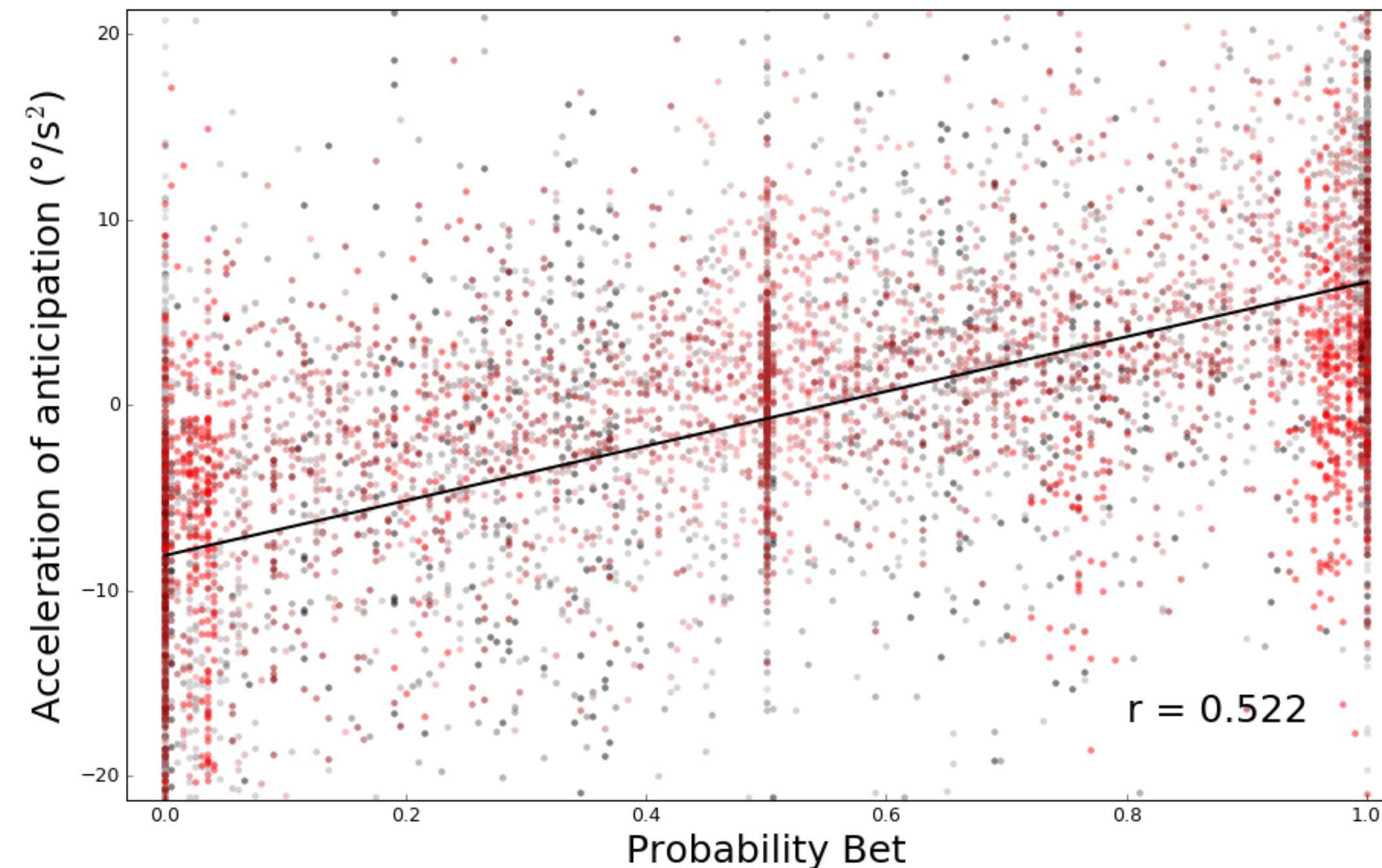
Acceleration



full code @ github.com/chloepasturel/AnticipatorySPEM

Experimental protocol

Probability Bet vs Acceleration



full code @ github.com/chloepasturel/AnticipatorySPEM

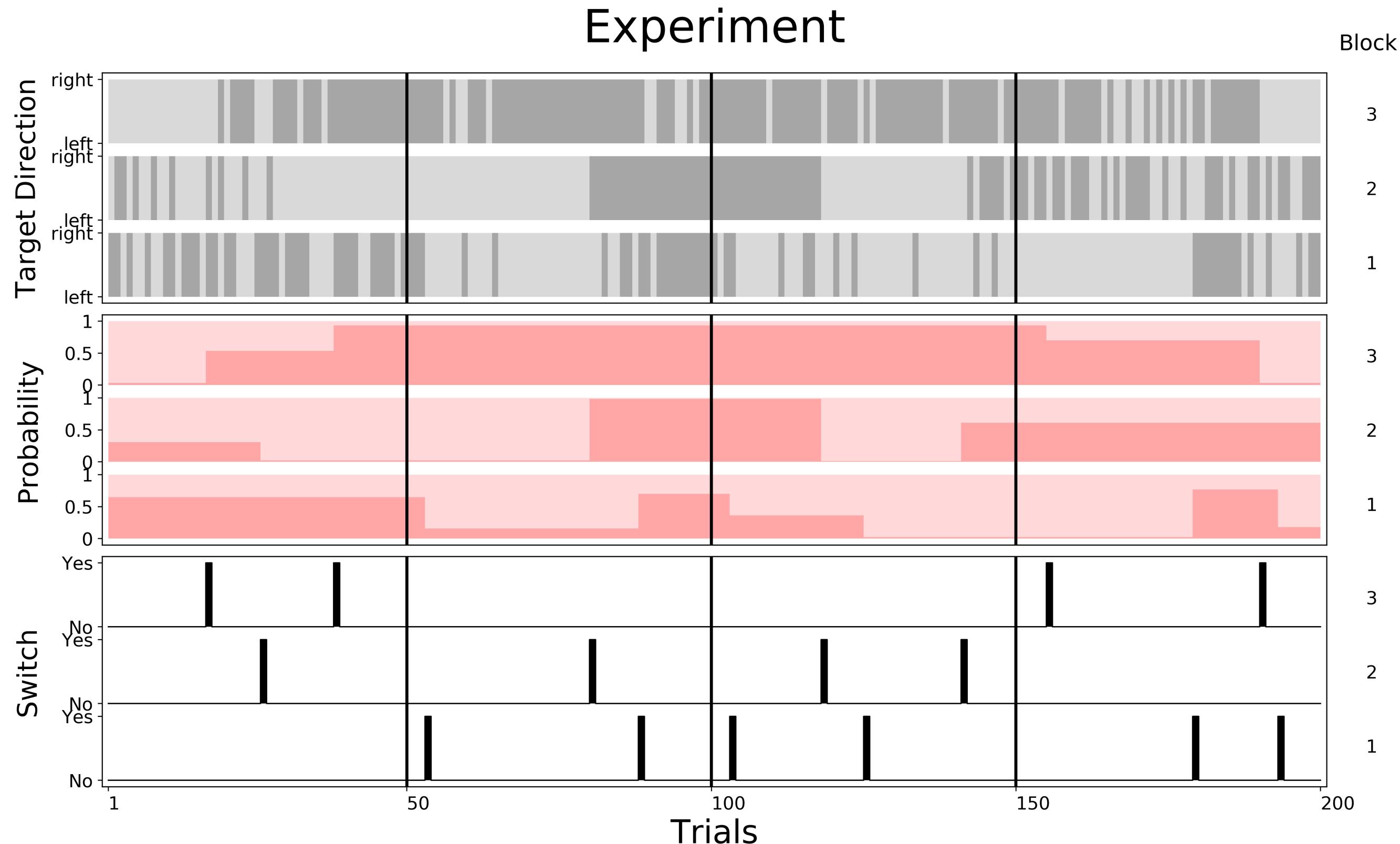
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Results: The Bayesian Changepoint Detector - Random-length block design



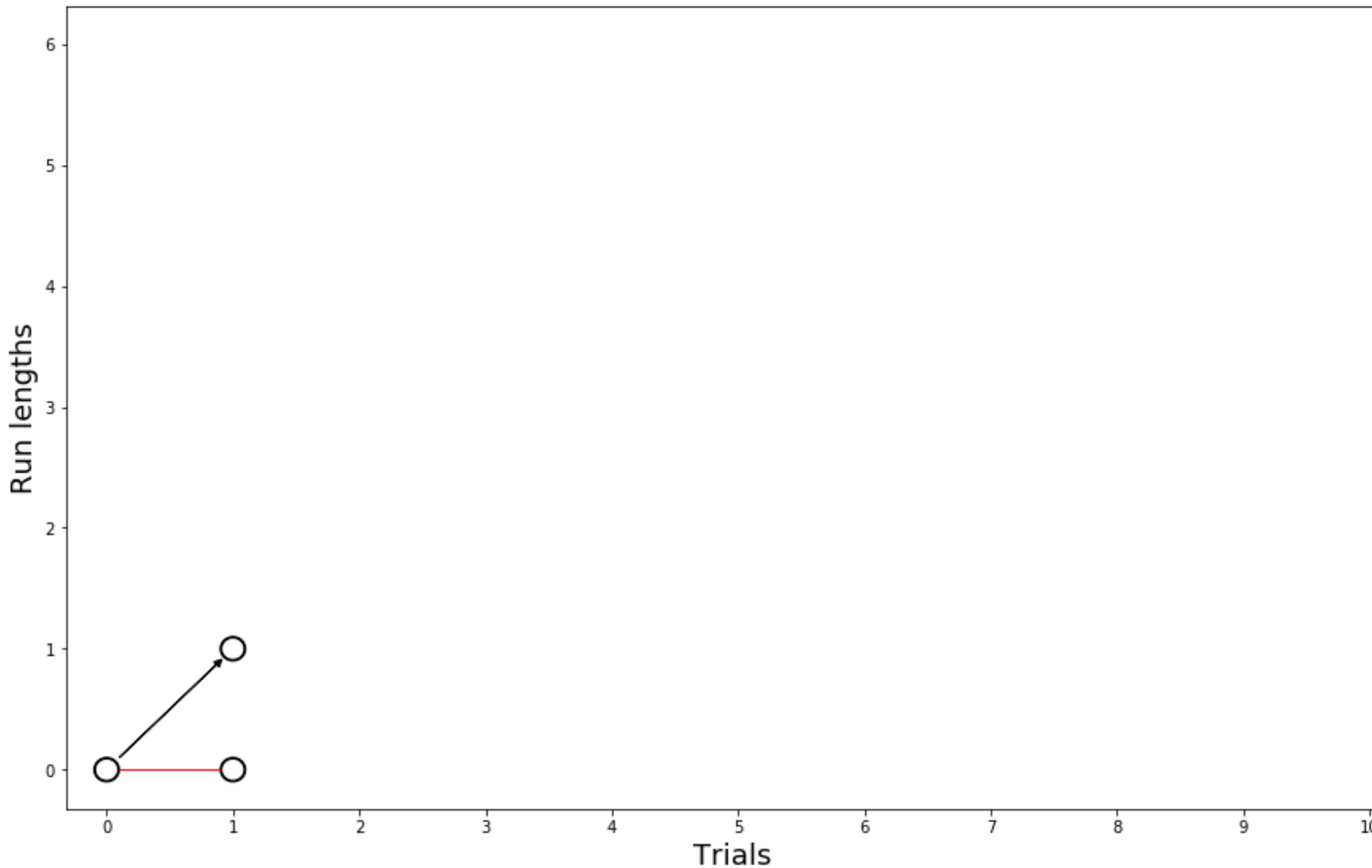
Bayesian Online Changepoint Detector

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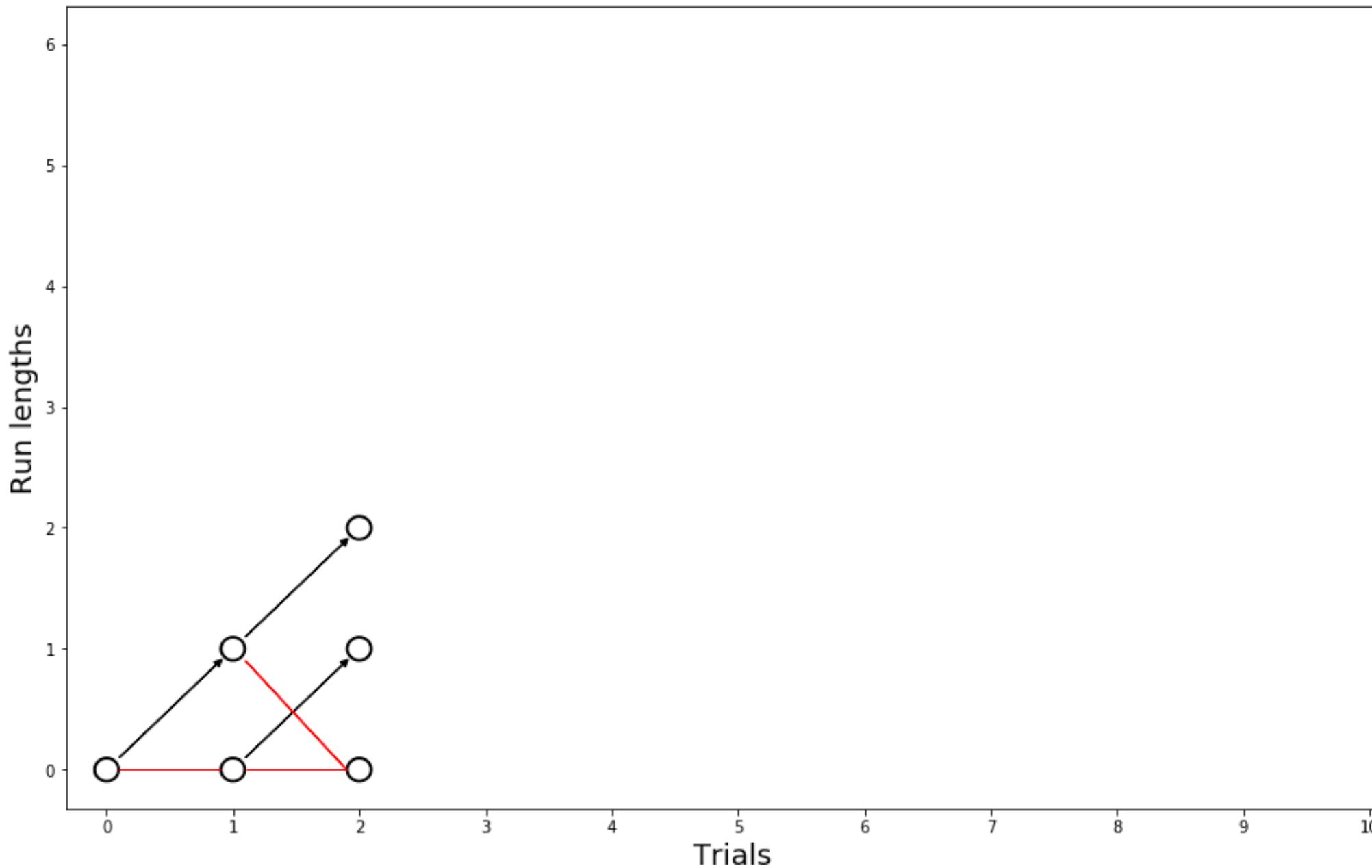
- adapted from <https://github.com/JackKelly/bayesianchangepoint> by Jack Kelly (2013) for a binomial input.
- This code is based on the MATLAB implementation provided by Ryan Adam. Was available at <http://hips.seas.harvard.edu/content/bayesian-online-changepoint-detection>
- full code @ <https://github.com/laurentperrinet/bayesianchangepoint>

Results: The Bayesian Changepoint Detector



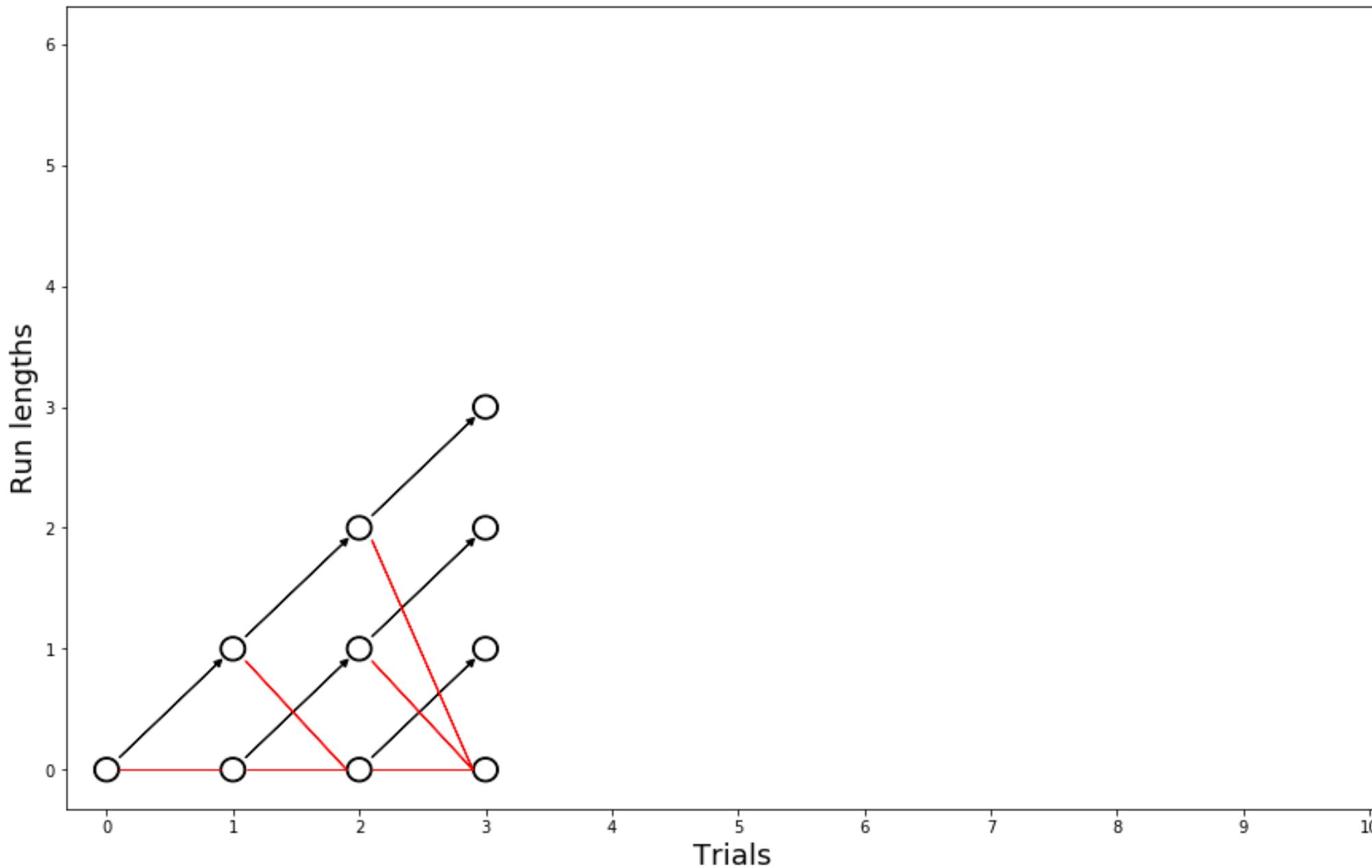
Initialize $P(r_0=0)=1$ and $v^{(0)}_1 = v_{\text{prior}}$ and $\chi^{(0)}_1 = \chi_{\text{prior}}$

Results: The Bayesian Changepoint Detector



Observe New Datum x_{t+1} and Perform Prediction $P(x_{t+1} | x_{1:t}) = P(x_{t+1}|x_{1:t}, r_t) \cdot P(r_t|x_{1:t})$

Results: The Bayesian Changepoint Detector



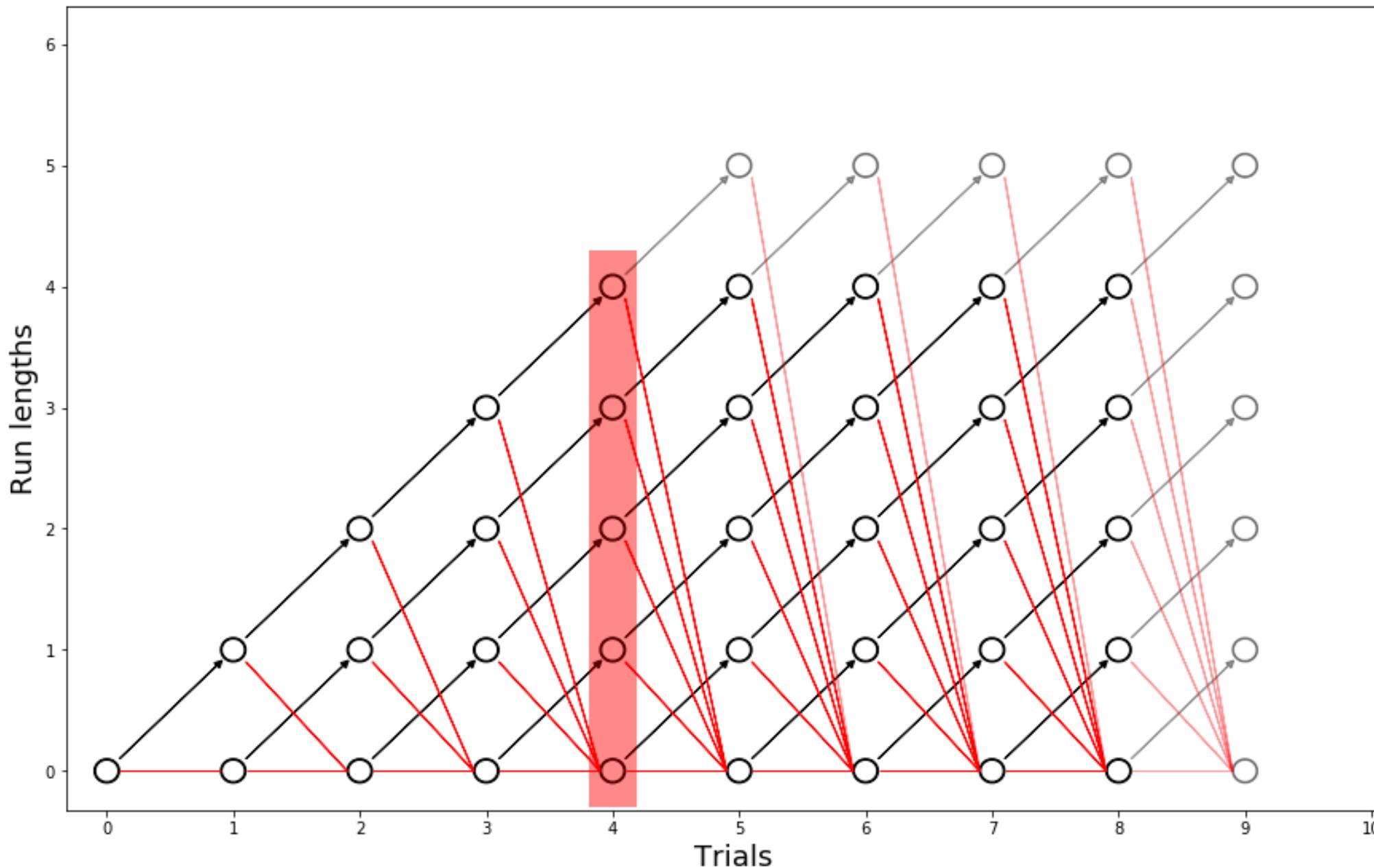
Evaluate (likelihood) Predictive Probability $\pi_{1:t} = P(x_t | v^{(r)}_t, \chi^{(r)}_t)$

Calculate Growth Probabilities $P(r_t=r_{t-1}+1, x_{1:t}) = P(r_{t-1}, x_{1:t-1}) \cdot \pi^{(r)}_t$

$$\cdot (1-h)$$

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

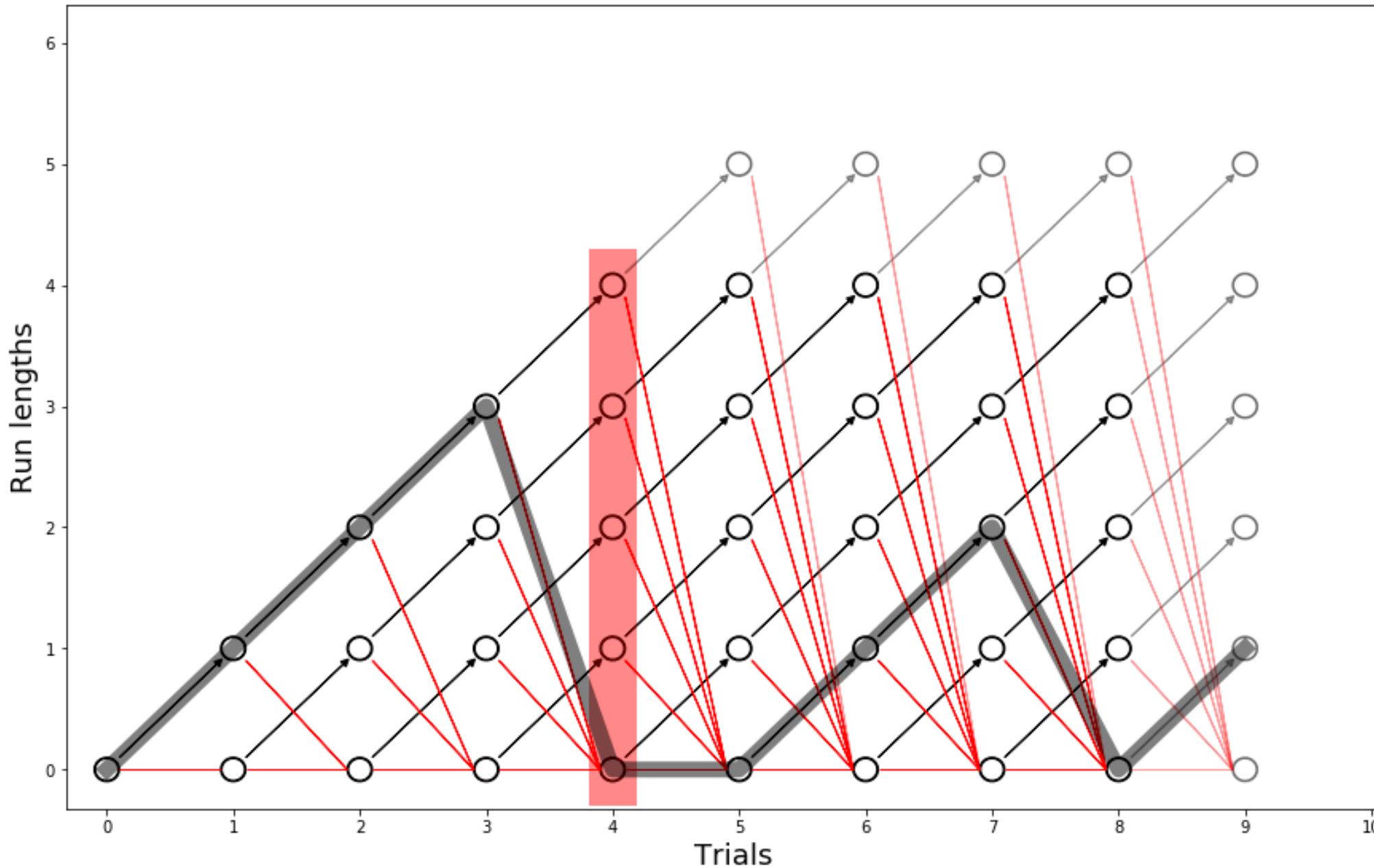
Results: The Bayesian Changepoint Detector



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

Determine Run Length Distribution $P(r_t | x_{1:t}) = P(r_t, x_{1:t}) / P(x_{1:t})$

Results: The Bayesian Changepoint Detector



Update Sufficient Statistics :

$$v^{(r+1)}_{t+1} = v^{(r)}_t + 1, \quad x^{(r+1)}_{t+1} = x^{(r)}_t + u(x_t)$$

Bayesian Changepoint Detector

1. Initialize

- $P(r_0=0)=1$ and
- $v^{(0)}_1 = v_{\text{prior}}$ and $x^{(0)}_1 = x_{\text{prior}}$

2. Observe New Datum x_t

3. Evaluate Predictive Probability $\pi_{1:t} = P(x_t | v^{(r)}_t, x^{(r)}_t)$

4. Calculate Growth Probabilities $P(r_t=r_{t-1}+1, x_{1:t}) = P(r_{t-1}, x_{1:t-1}) \cdot \pi^{(r)}_t \cdot (1 - H(r^{(r)}_{t-1}))$

5. Calculate Changepoint Probabilities $P(r_t=0, x_{1:t}) = \sum_{r_{t-1}} P(r_{t-1}, x_{1:t-1}) \cdot \pi^{(r)}_t \cdot H(r^{(r)}_{t-1})$

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

7. Determine Run Length Distribution $P(r_t | x_{1:t}) = P(r_t, x_{1:t}) / P(x_{1:t})$

8. Update Sufficient Statistics :

- $v^{(0)}_{t+1} = v_{\text{prior}}$, $x^{(0)}_{t+1} = x_{\text{prior}}$
- $v^{(r+1)}_{t+1} = v^{(r)}_t + 1$, $x^{(r+1)}_{t+1} = x^{(r)}_t + u(x_t)$

9. Perform Prediction $P(x_{t+1} | x_{1:t}) = P(x_{t+1} | x_{1:t}, r_t) \cdot P(r_t | x_{1:t})$

10. go to (2)

Results: The Bayesian Changepoint Detector

The screenshot shows the GitHub repository page for 'laurentperrinet/bayesianchangepoint'. The repository is a fork from 'JackKelly/bayesianchangepoint'. It has 20 commits, 1 branch, 0 releases, and 3 contributors. The latest commit was on Oct 27, 2017. The repository description is "An implementation of Adams & MacKay 2007 'Bayesian Online Changepoint Detection'".

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

20 commits | 1 branch | 0 releases | 3 contributors

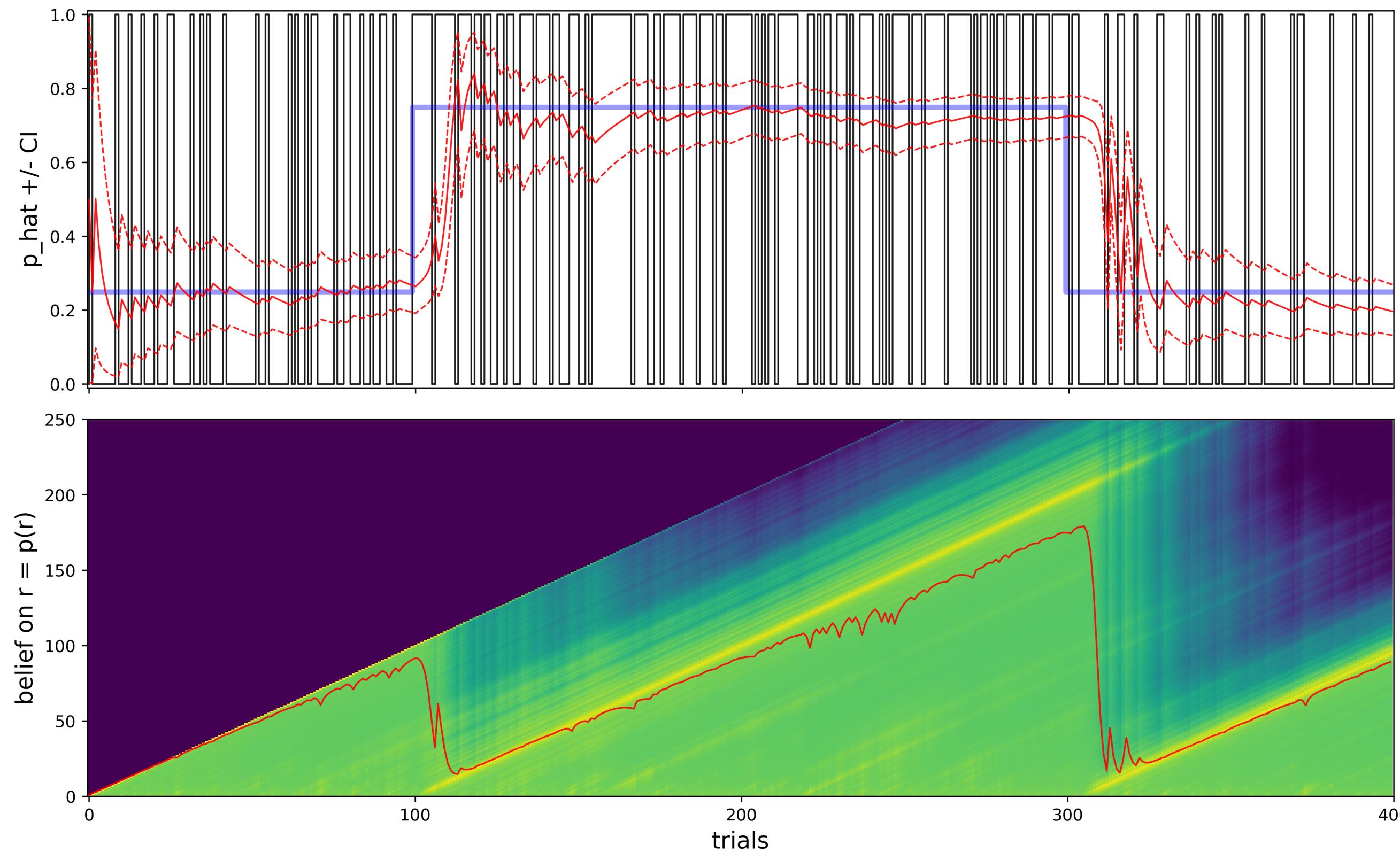
Branch: master | New pull request | Create new file | Upload files | Find file | Clone or download

This branch is 11 commits ahead of JackKelly:master.

| File | Commit Message | Date |
|---------------------|---|--------------|
| bayesianchangepoint | testing scoring method with the likelihood to find an optimal hazard... | Oct 26, 2017 |
| notebooks | testing scoring method with the likelihood to find an optimal hazard... | Oct 27, 2017 |
| .gitignore | small fixes | Oct 26, 2017 |
| LICENSE | Initial commit | Oct 23, 2013 |
| README.md | importing functions from notebook | Oct 26, 2017 |
| setup.py | small fixes | Oct 26, 2017 |

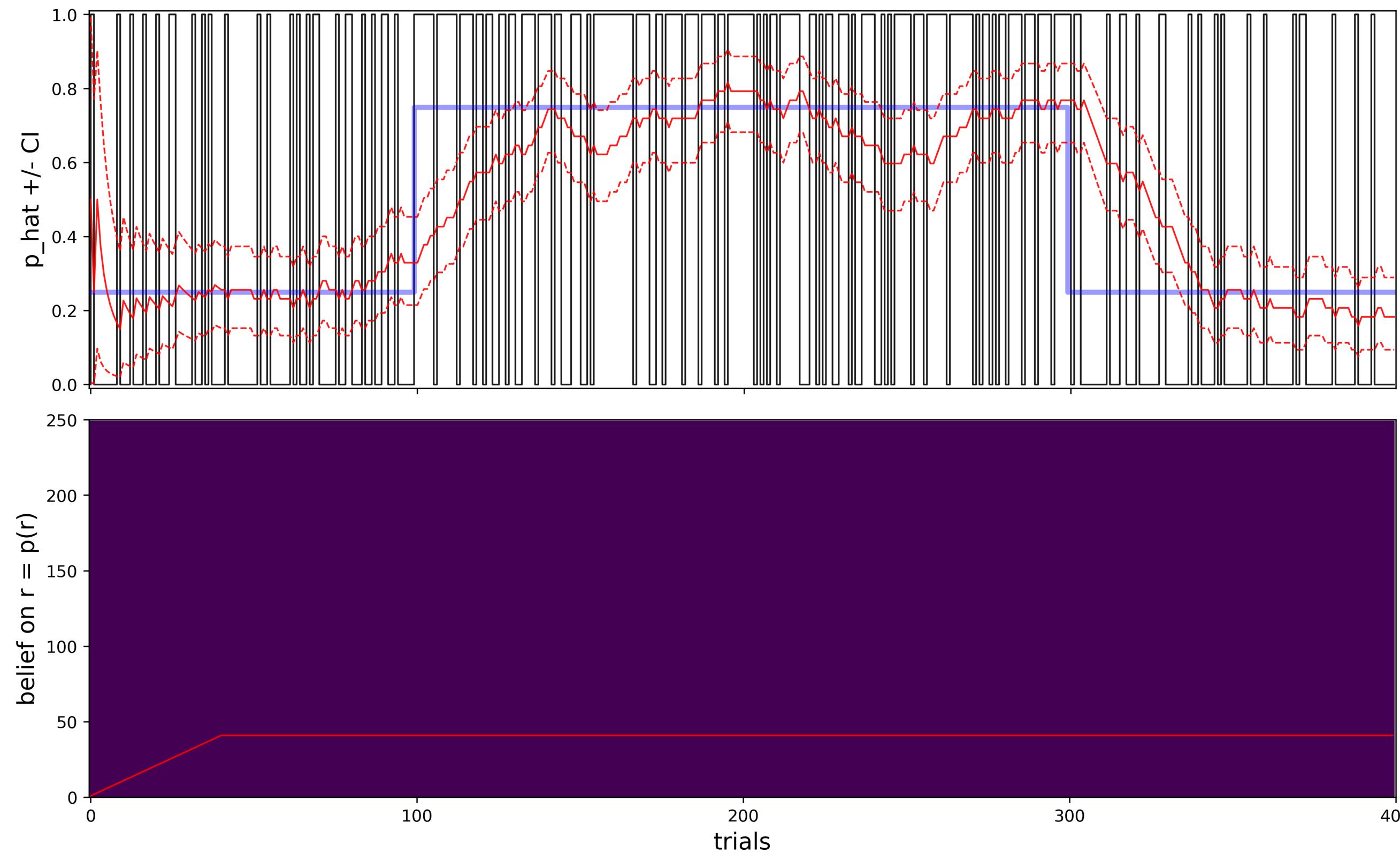
full code @ github.com/laurentperrinet/bayesianchangepoint

Results: The Bayesian Changepoint Detector - Full model



full code @ github.com/laurentperrinet/bayesianchangepoint

Results: The Bayesian Changepoint Detector - Fixed window



full code @ github.com/laurentperrinet/bayesianchangepoint

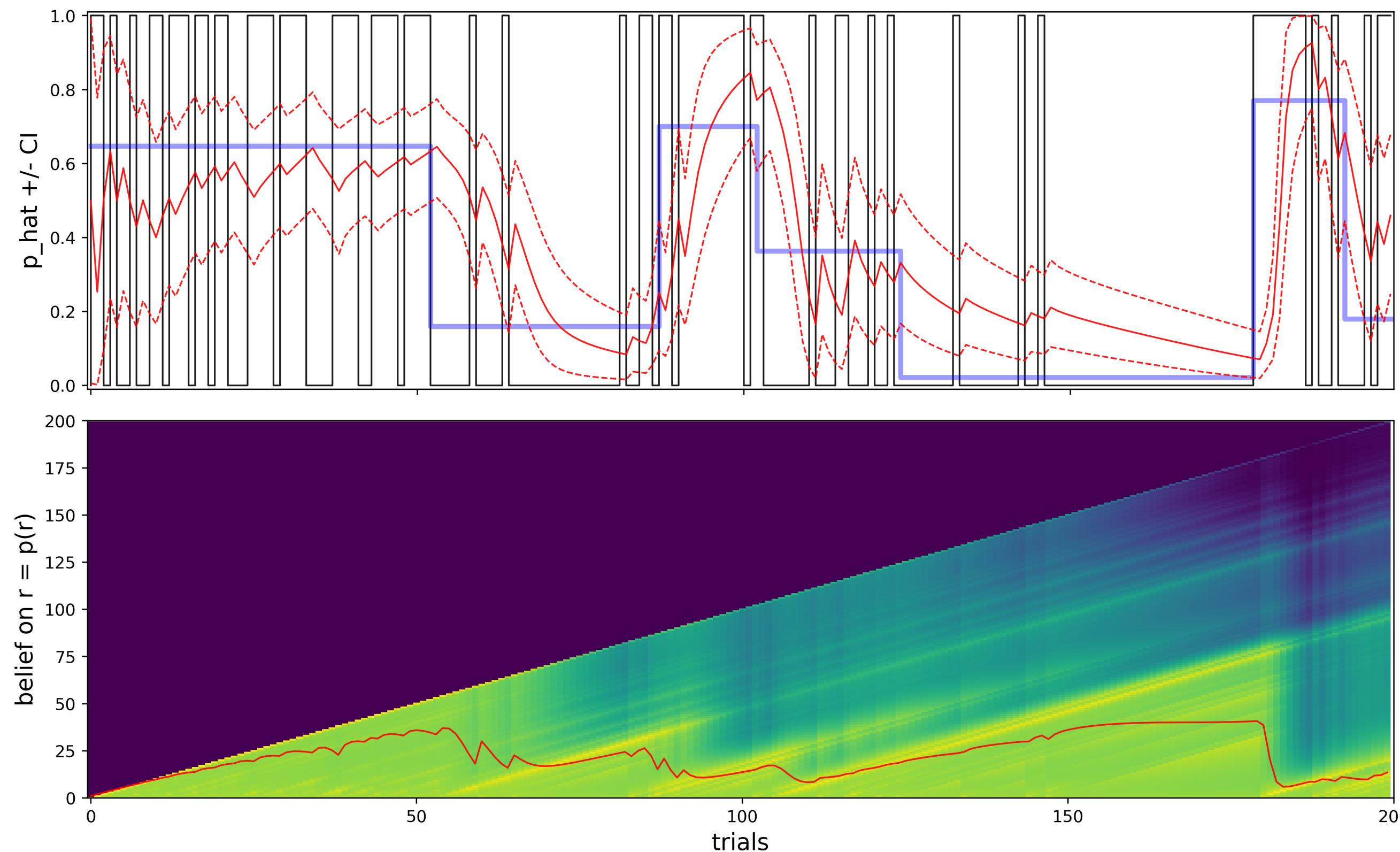
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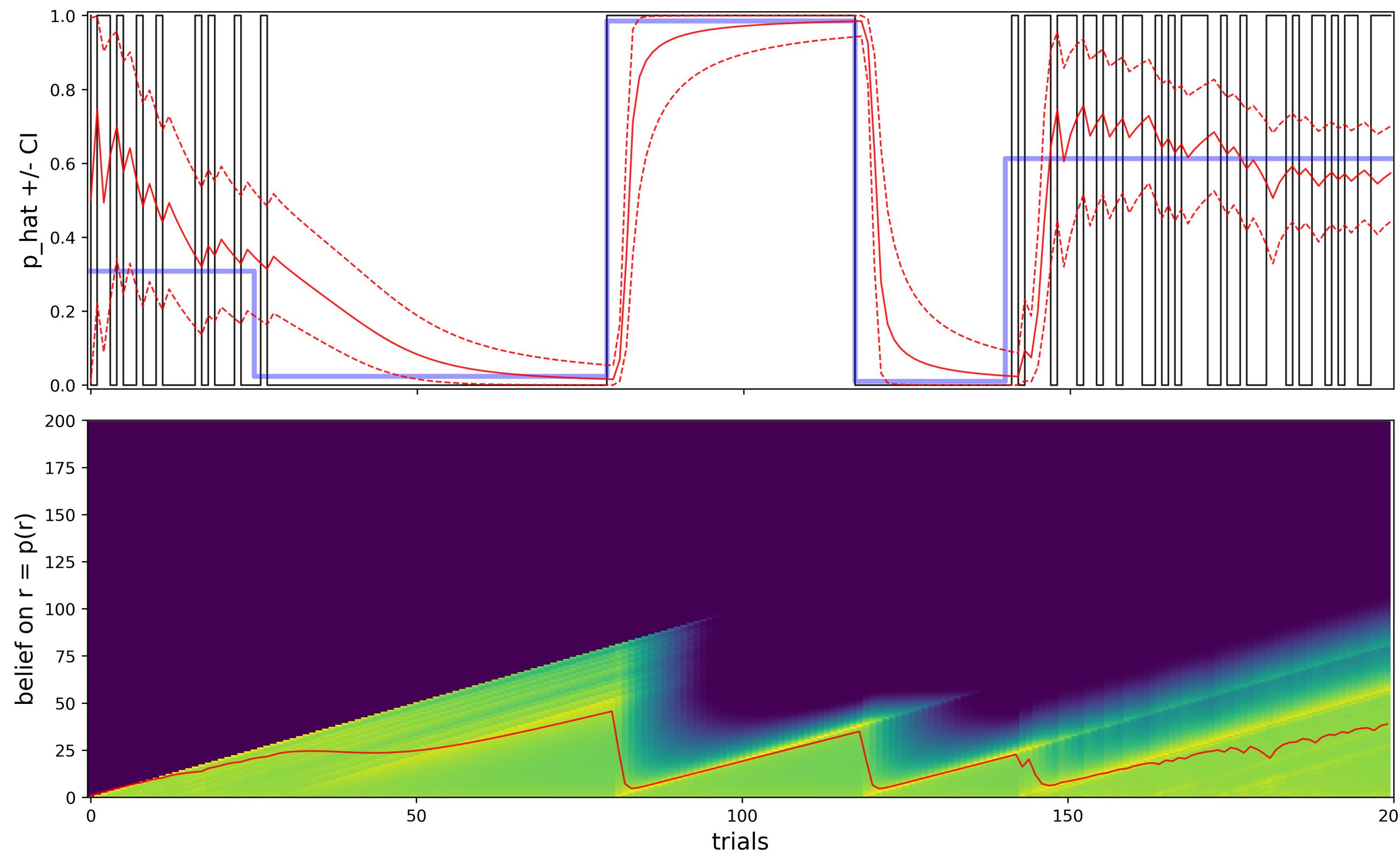
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Results: Matching Behavioral data - Full model



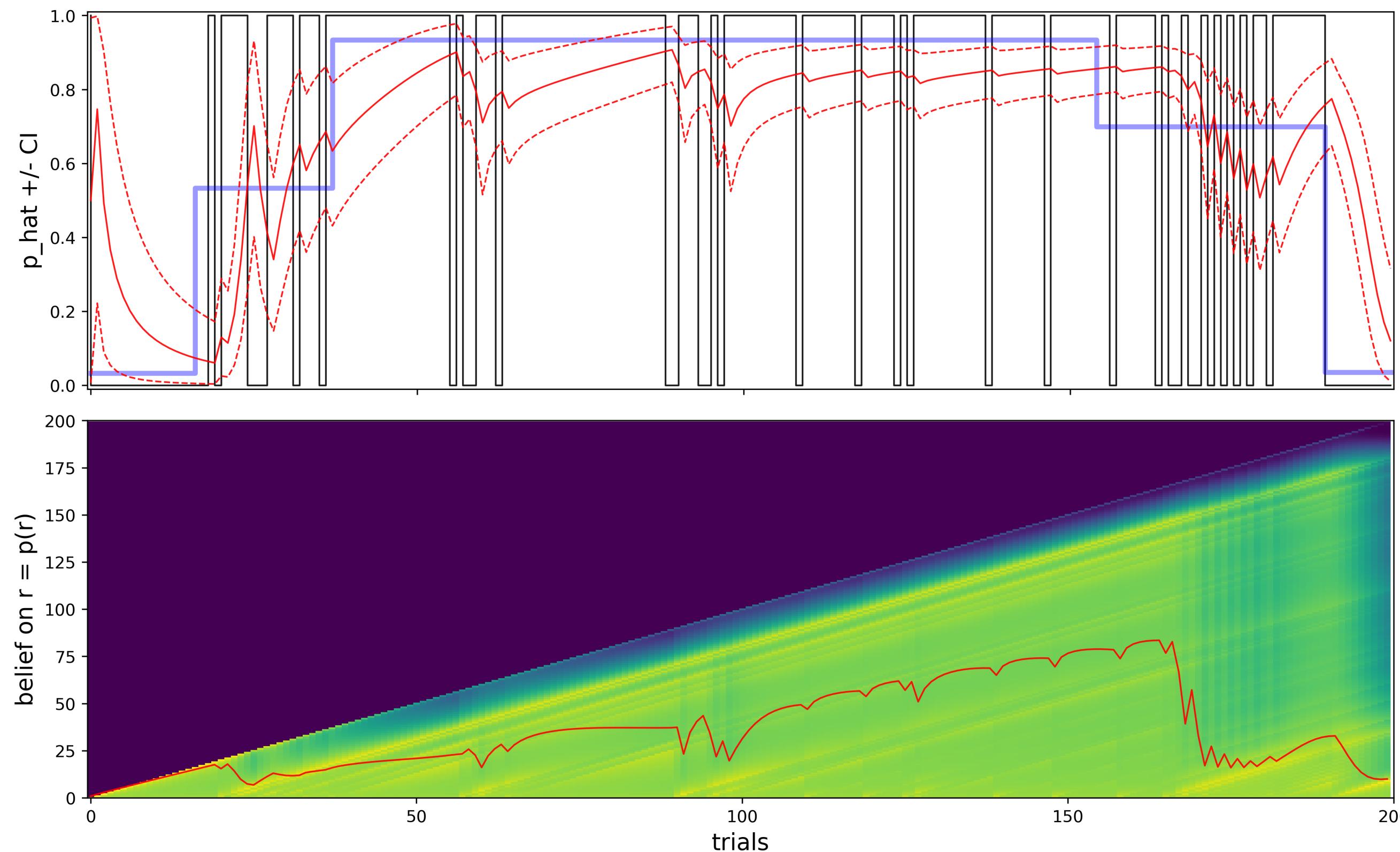
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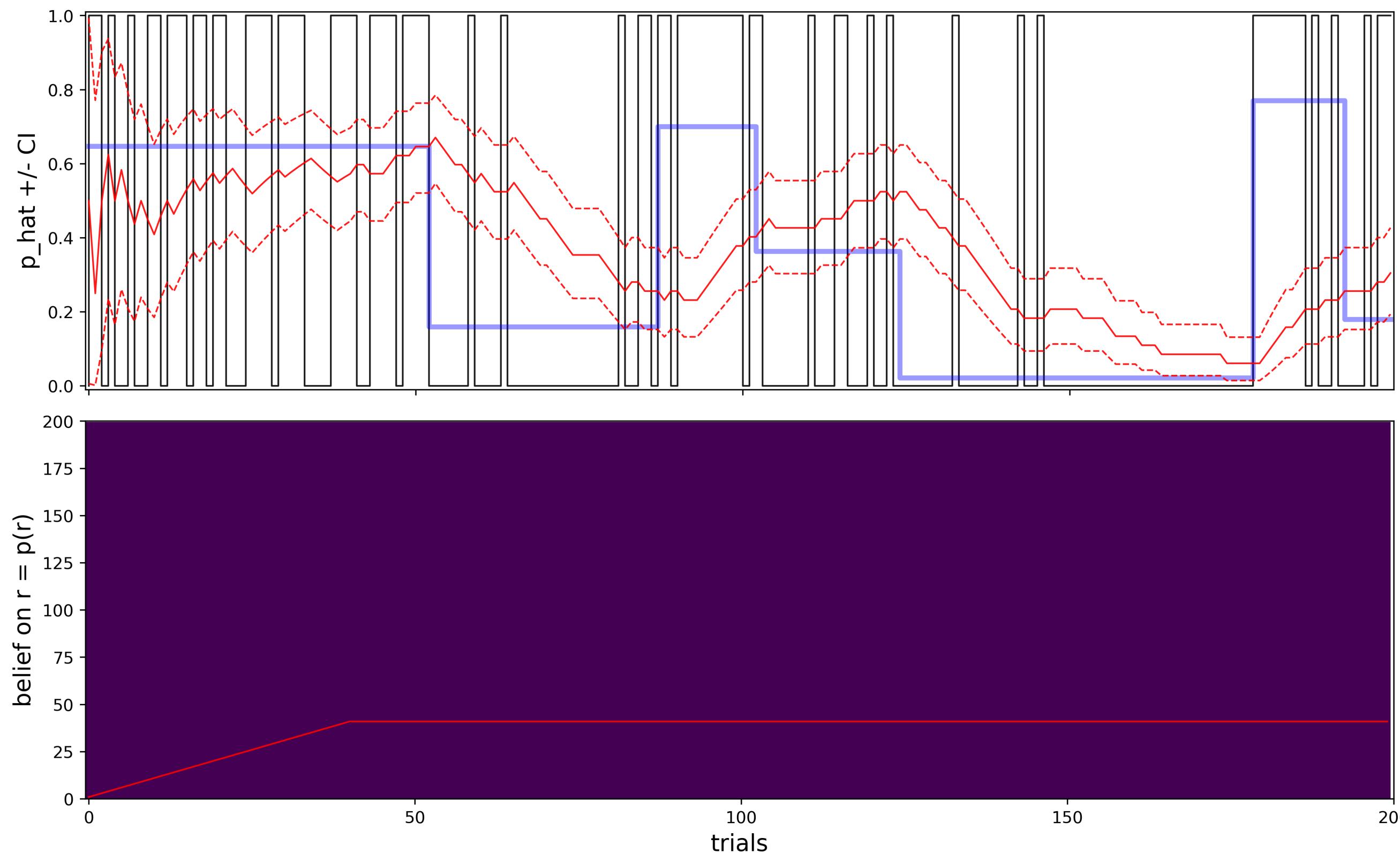
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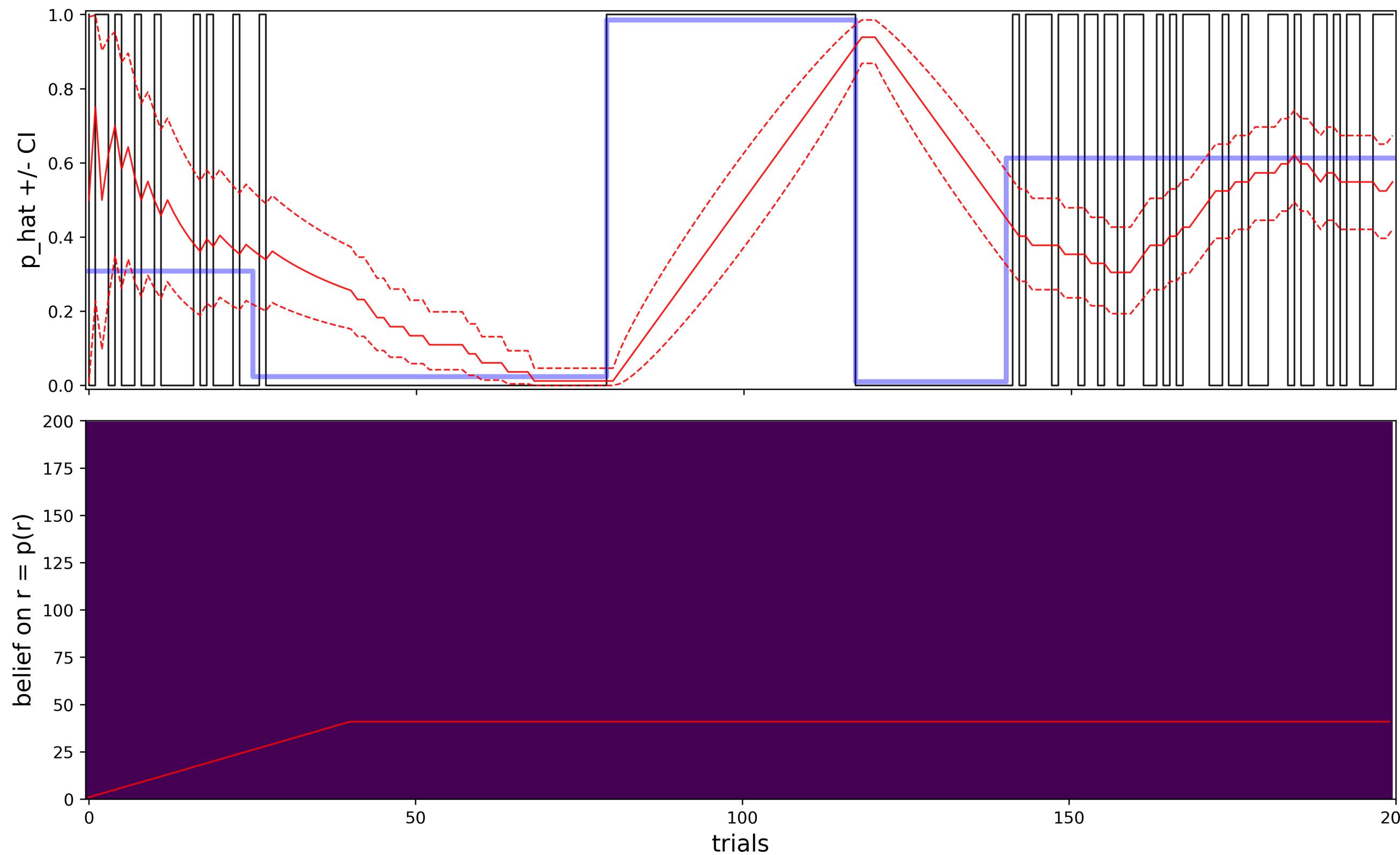
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Results: Matching Behavioral data - Fixed window



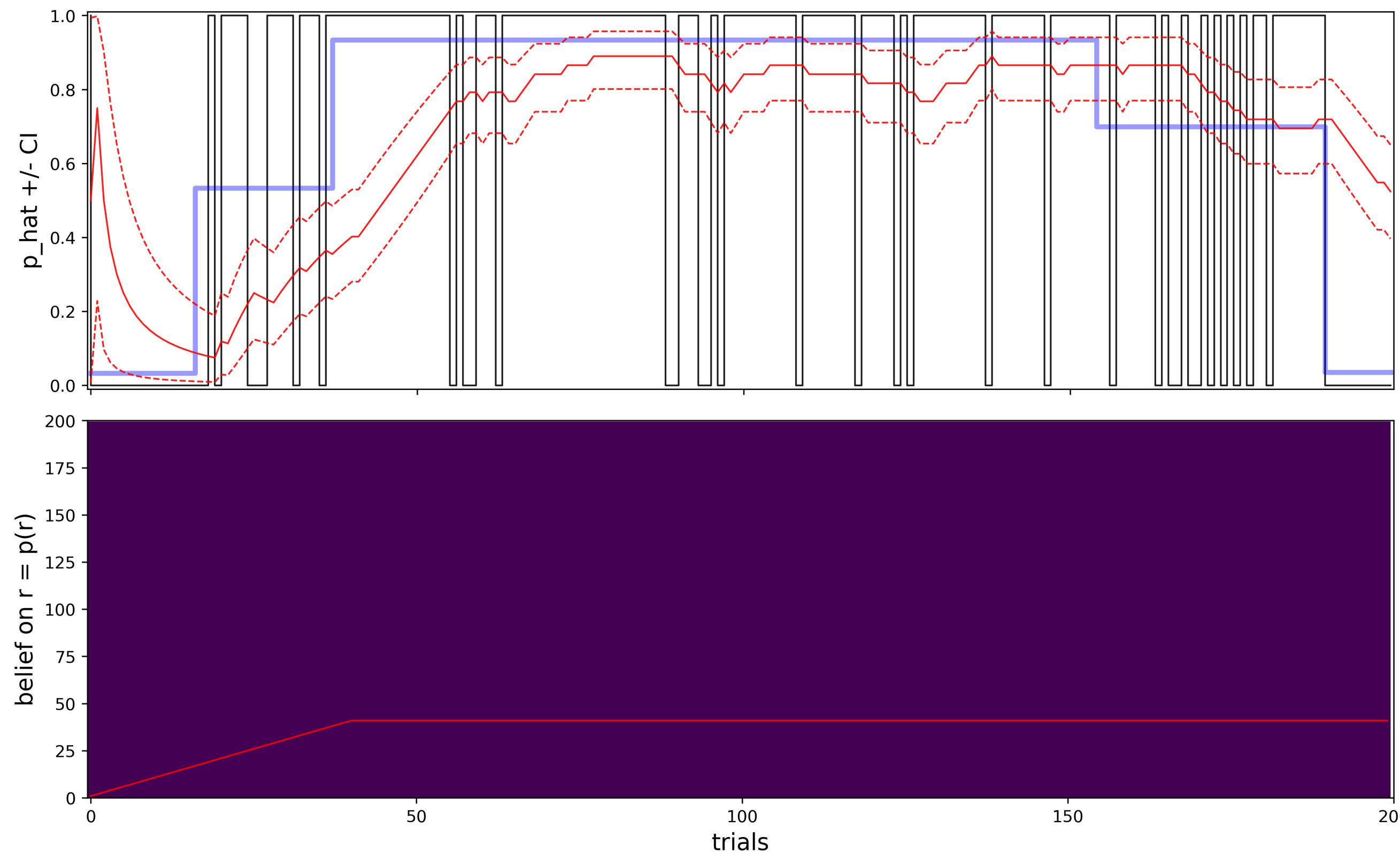
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Results: Matching Behavioral data - Fixed window



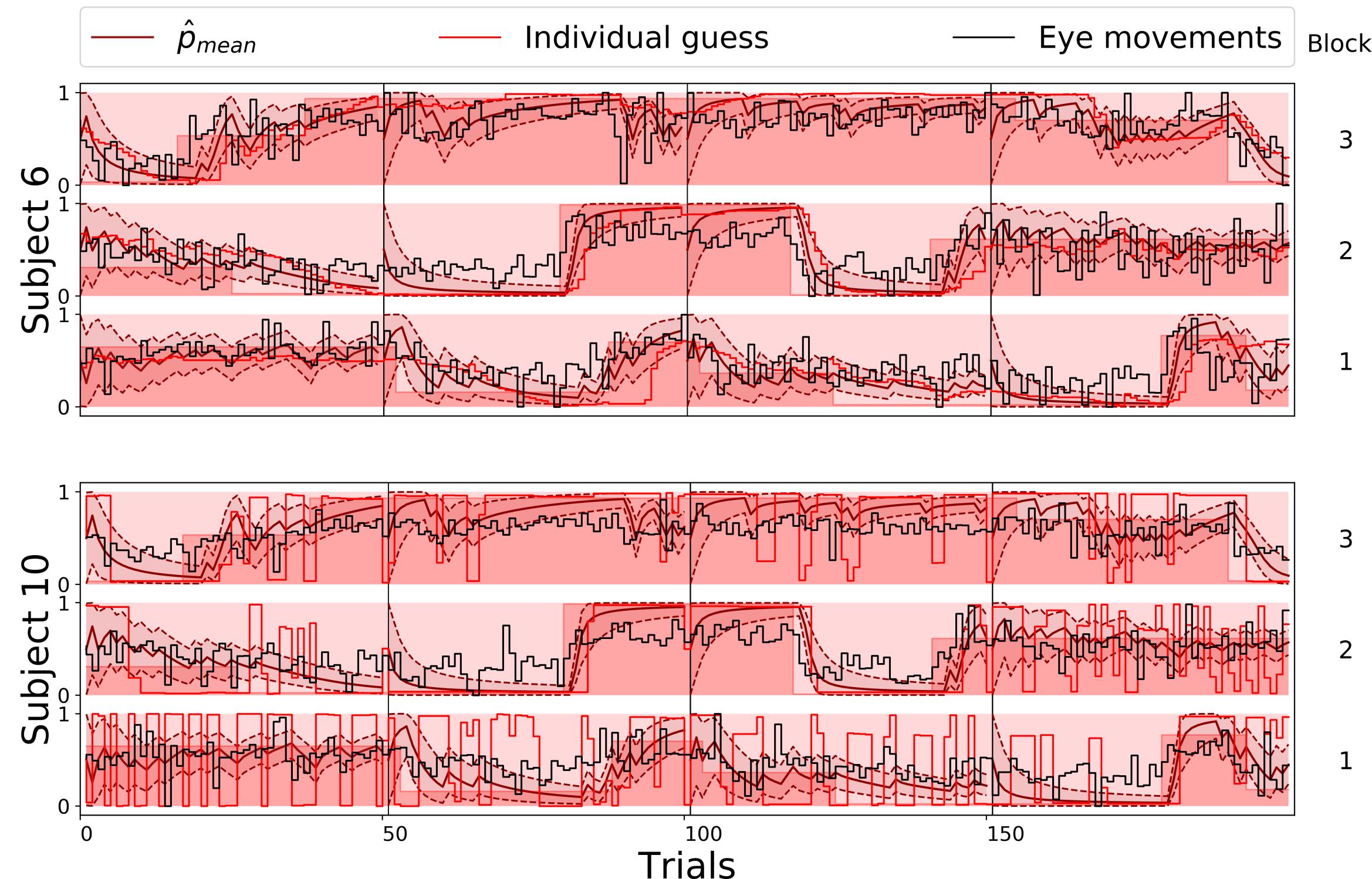
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Results: Matching Behavioral data - Fixed window

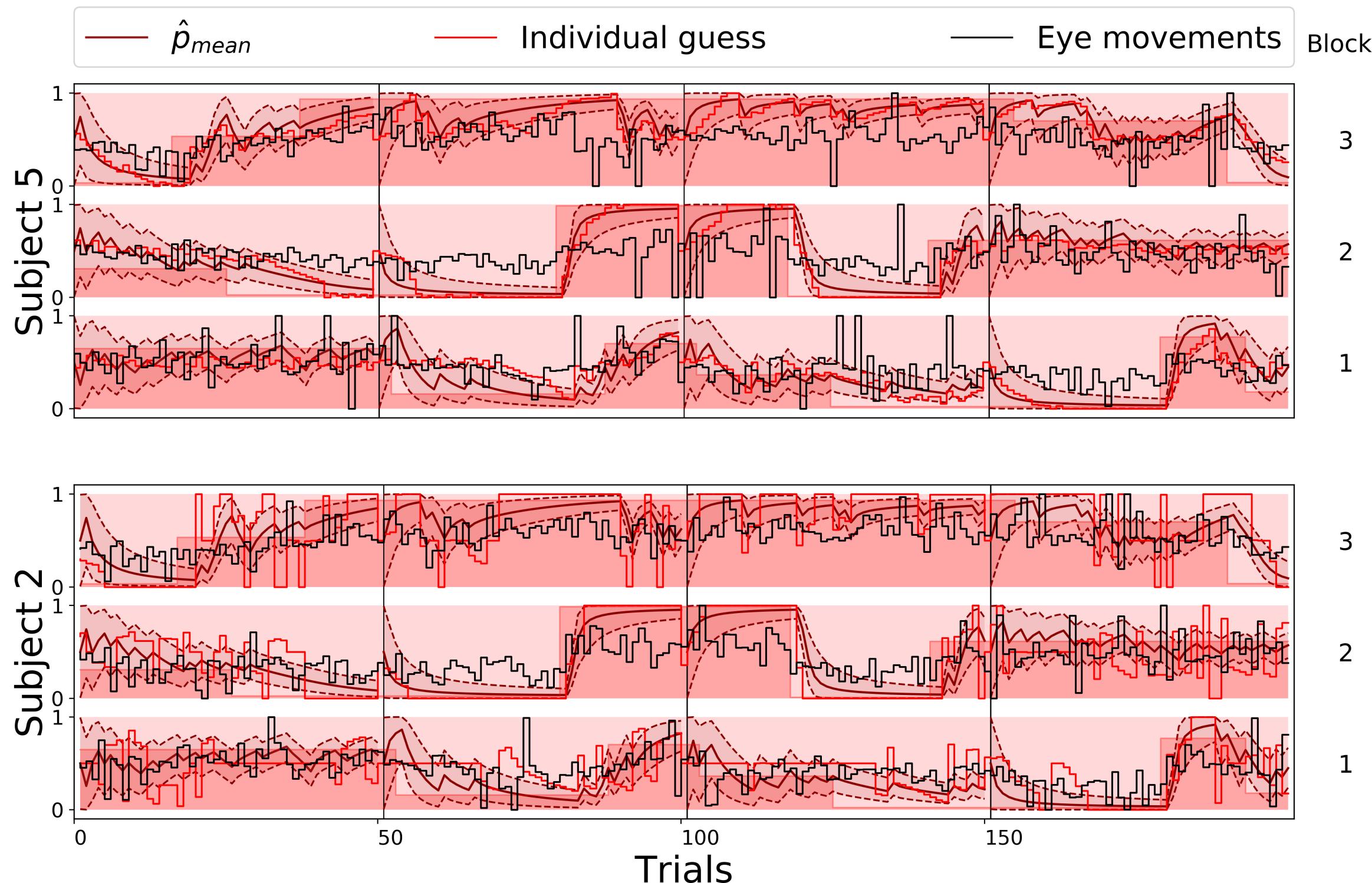


full code @ github.com/laurentperrinet/bayesianchangepoint

Results: Matching Behavioral data - fit with BCP

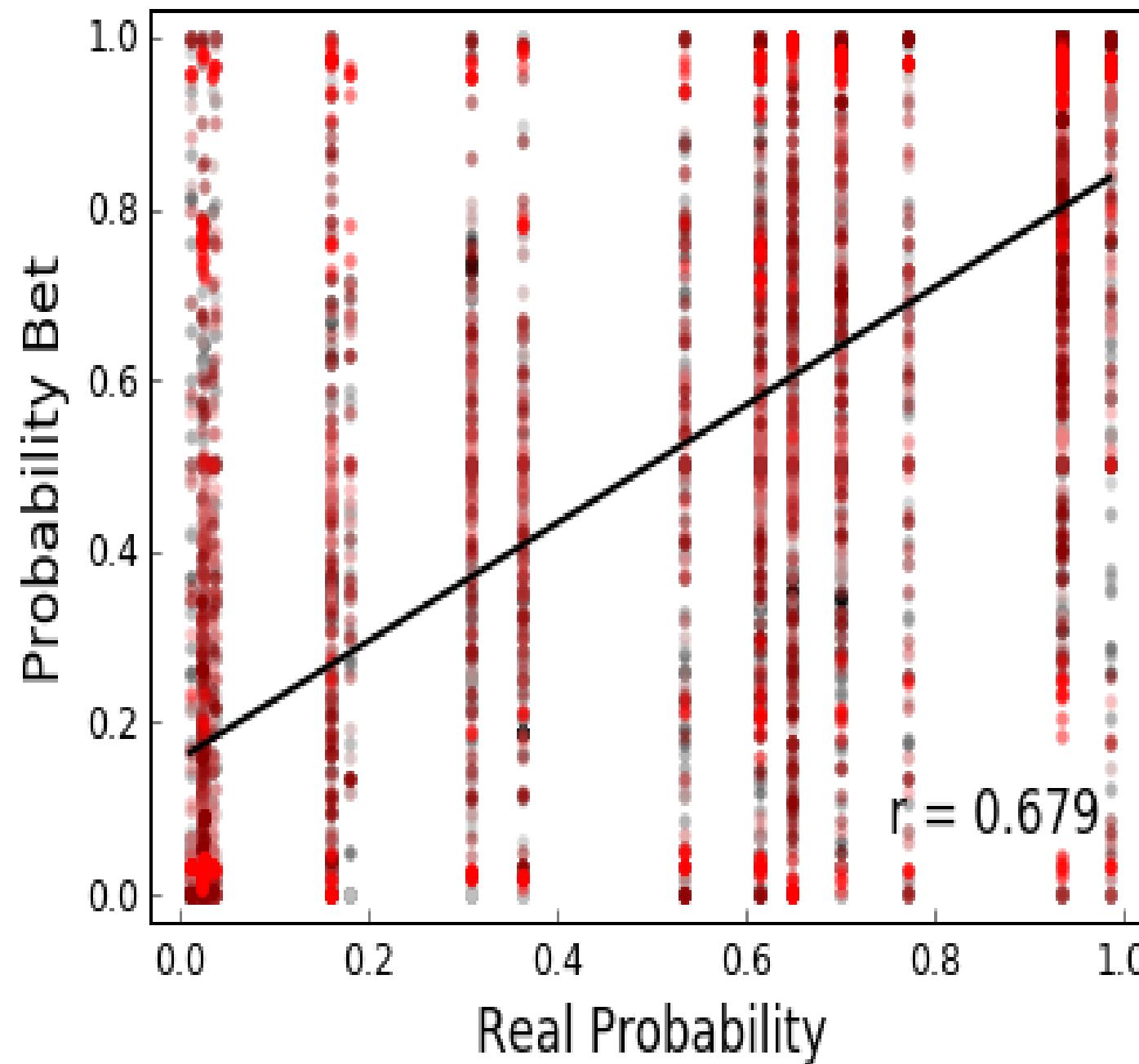


Results: Matching Behavioral data - fit with BCP

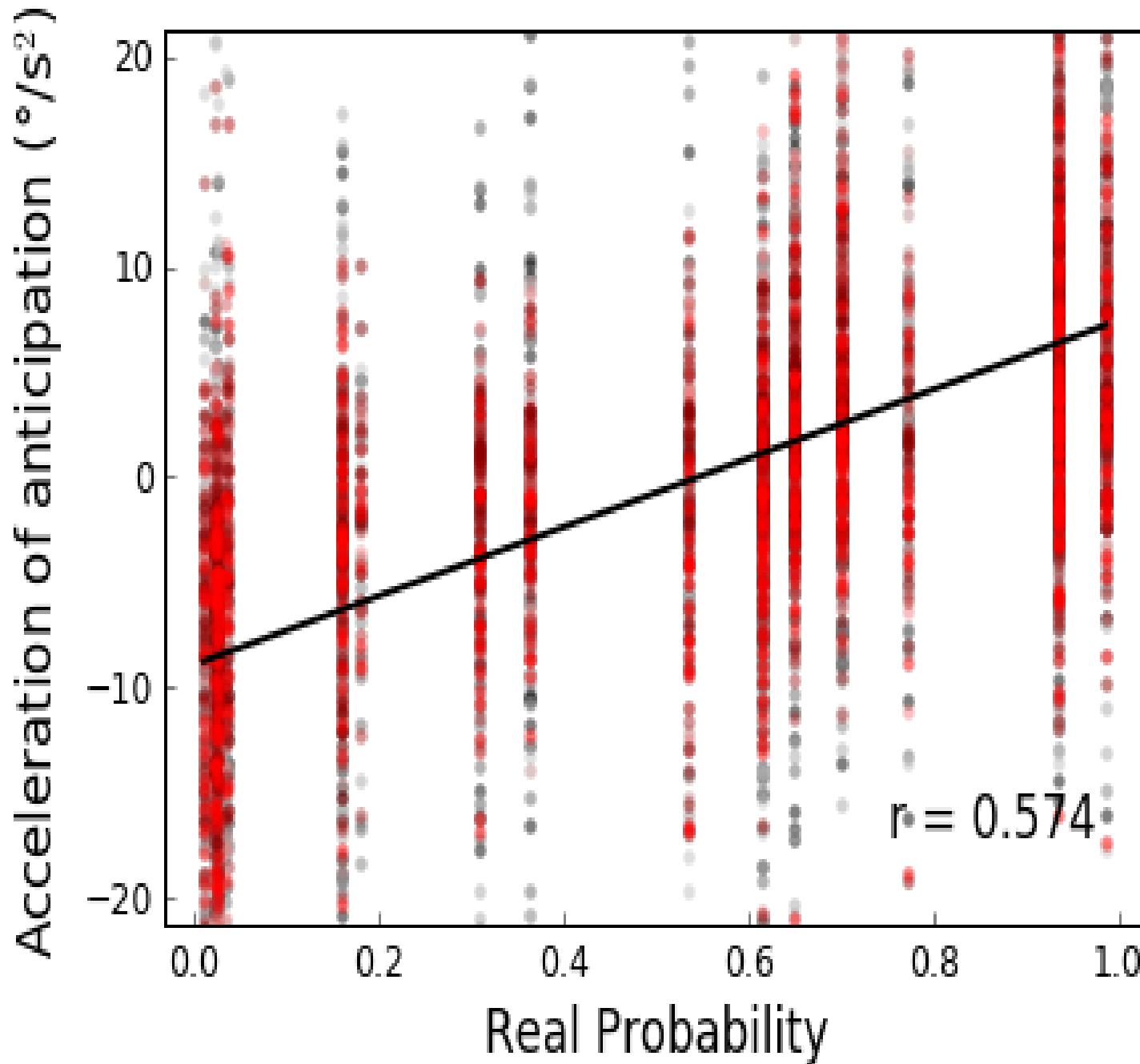


Results: Matching Behavioral data

Probability Bet

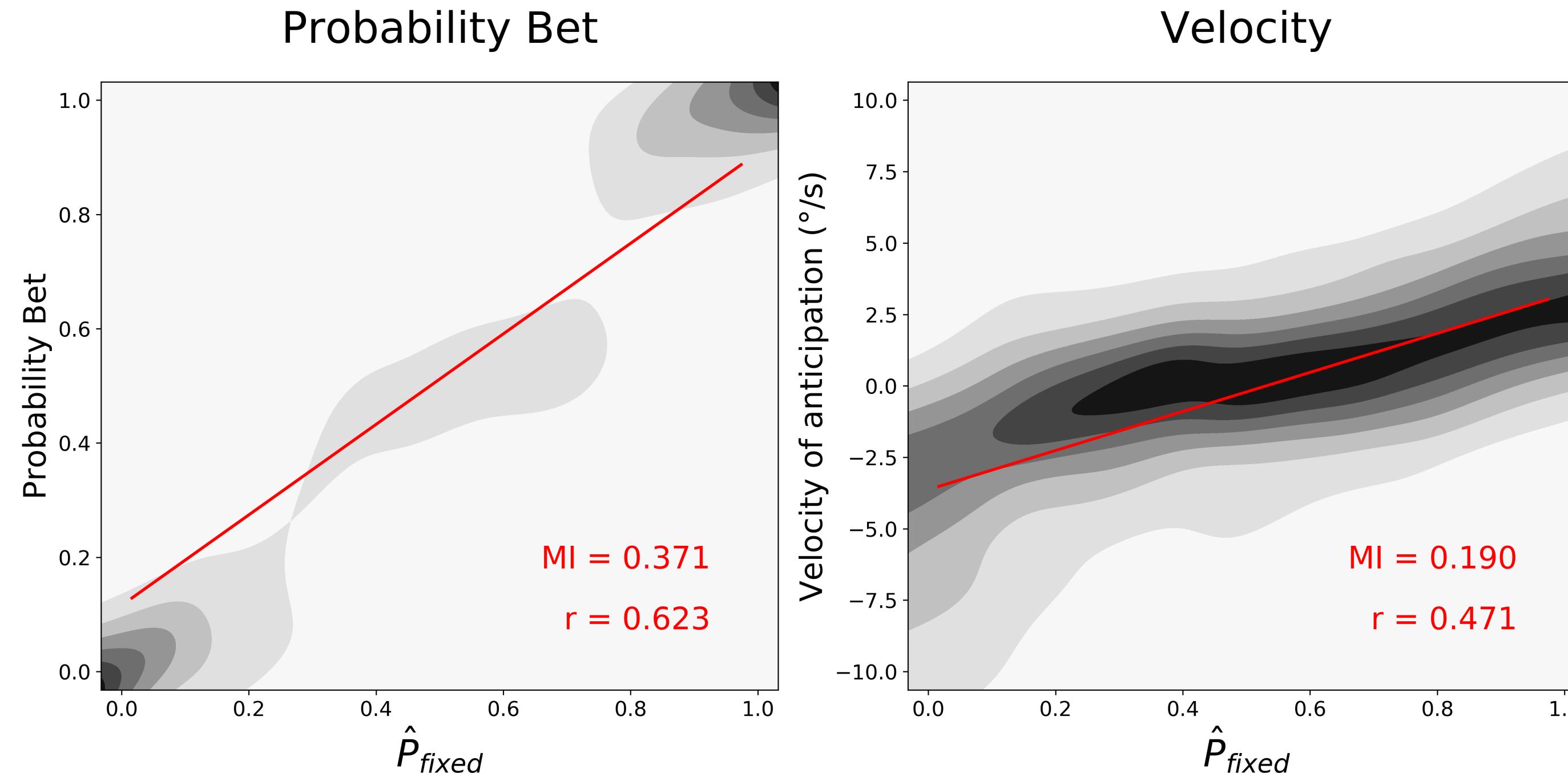


Acceleration



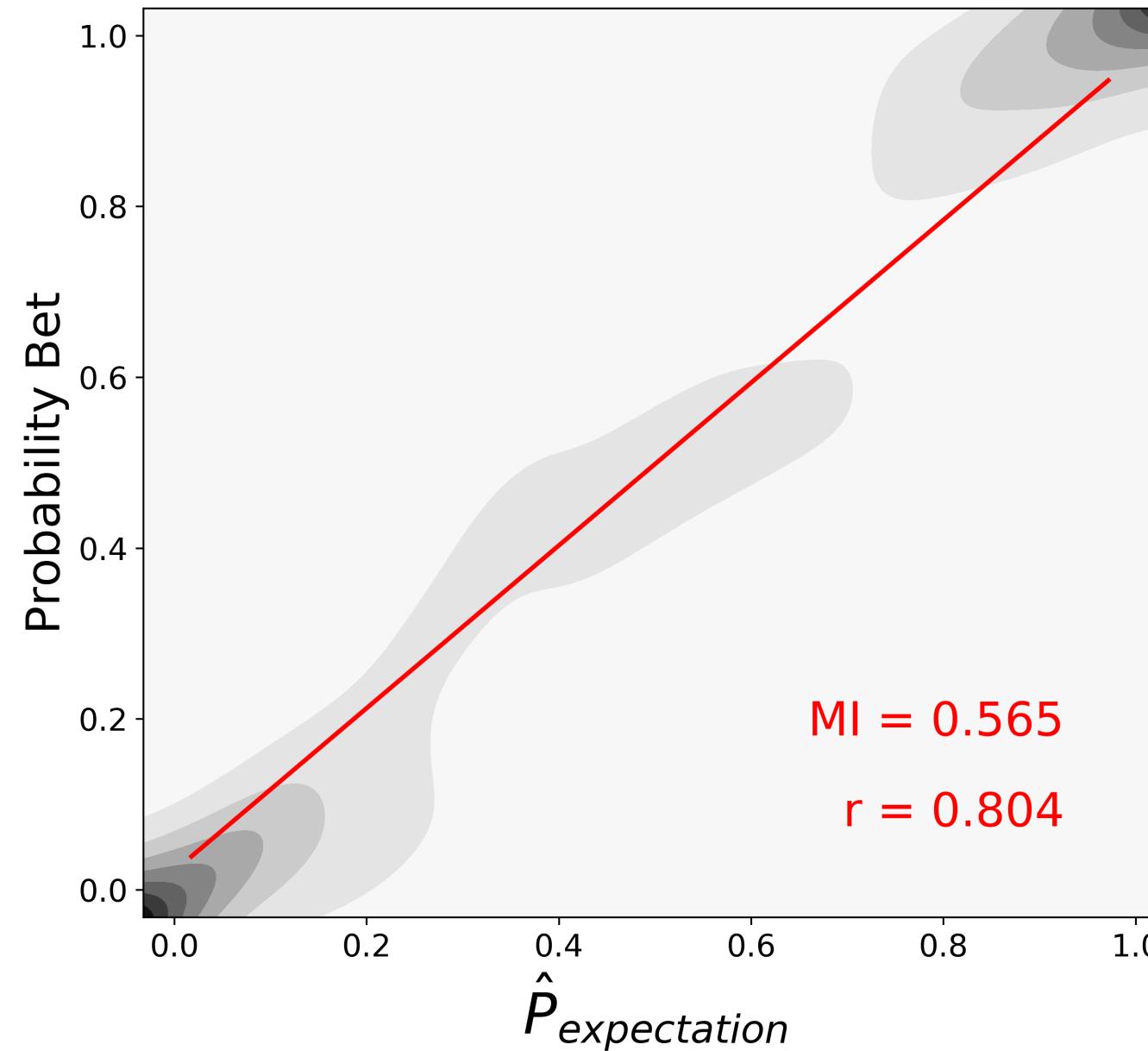
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Results: Matching Behavioral data - Fixed window

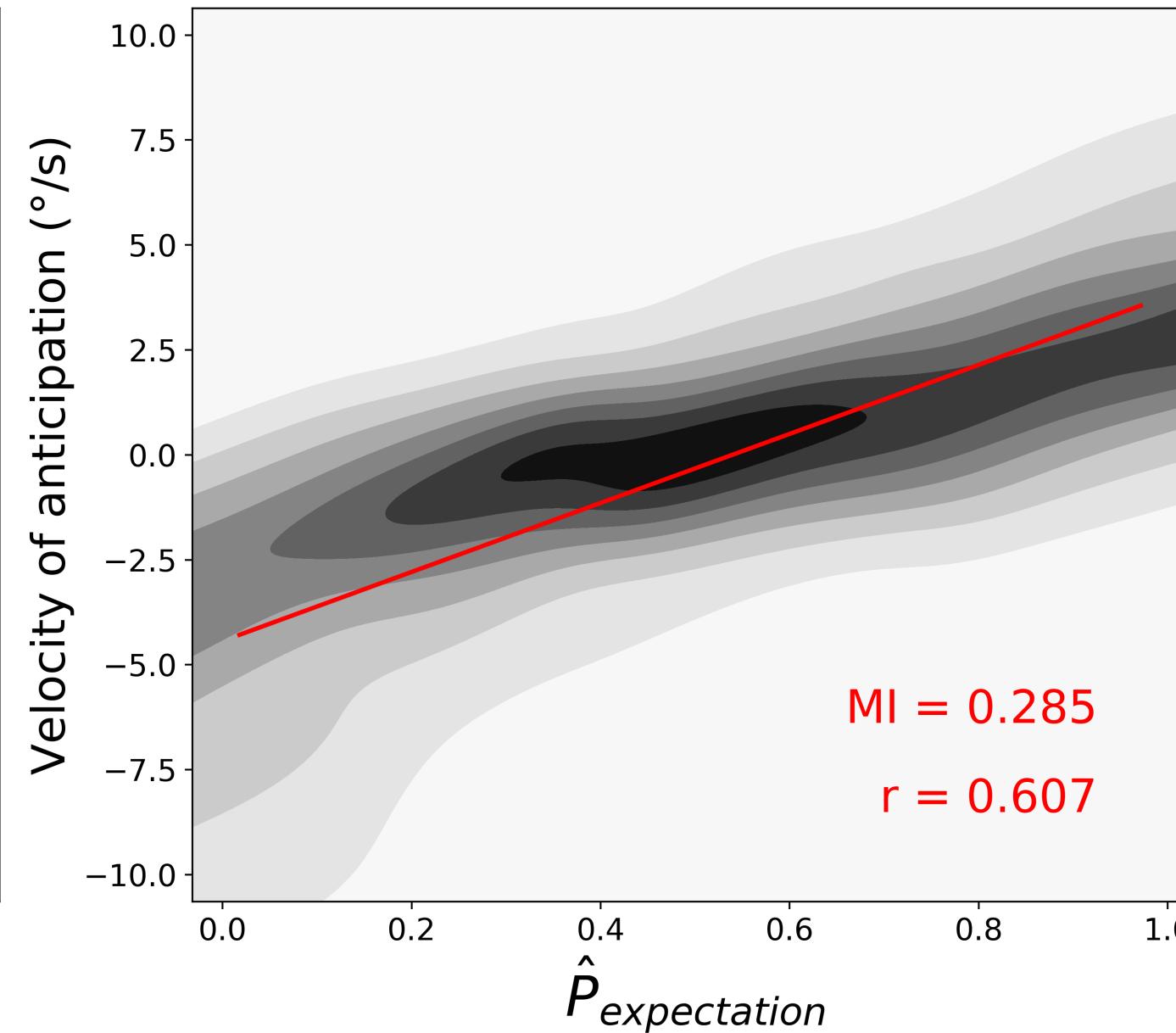


Results: Matching Behavioral data - Full model

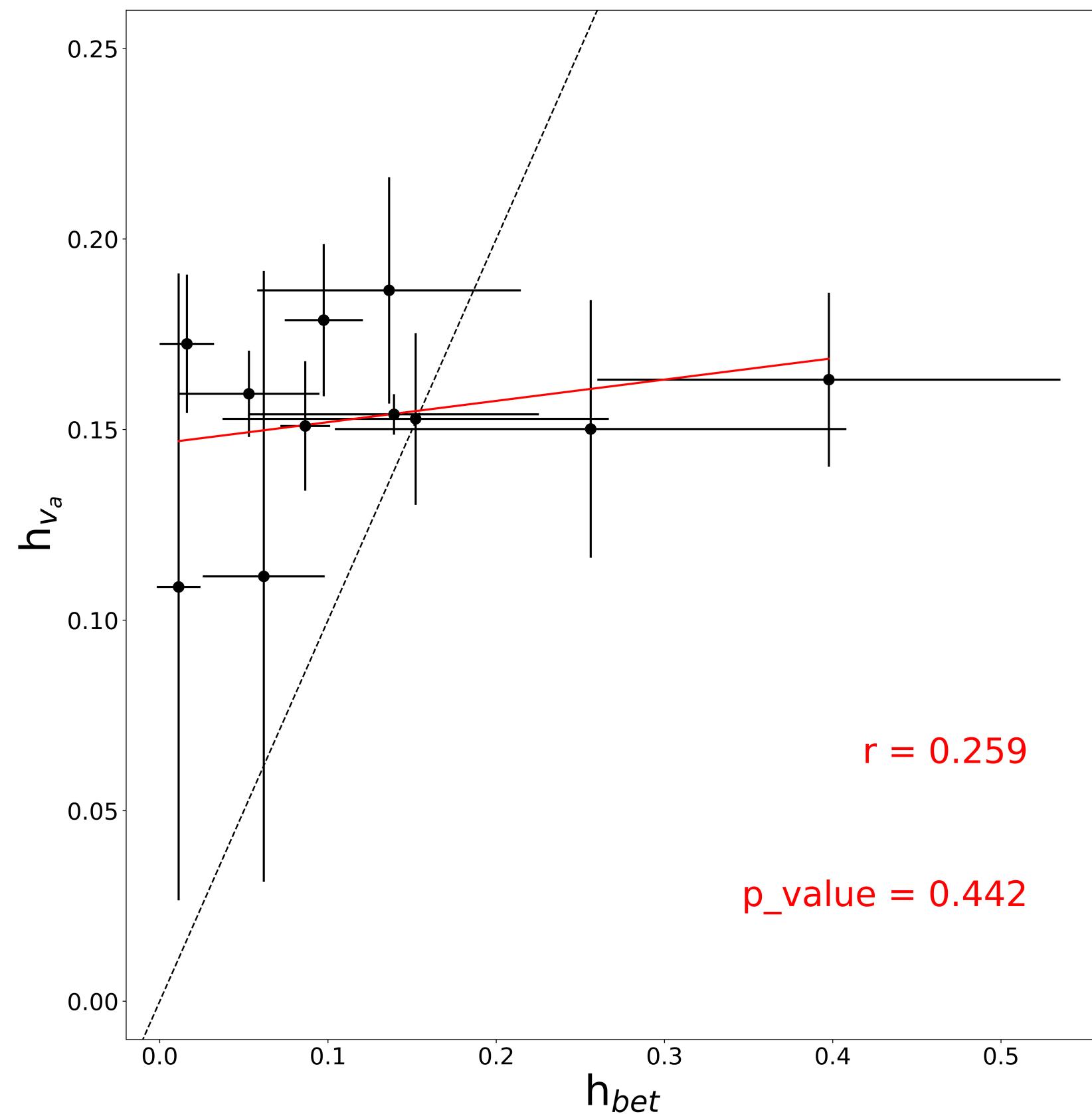
Probability Bet



Velocity



Results: Matching Behavioral data interindividual differences



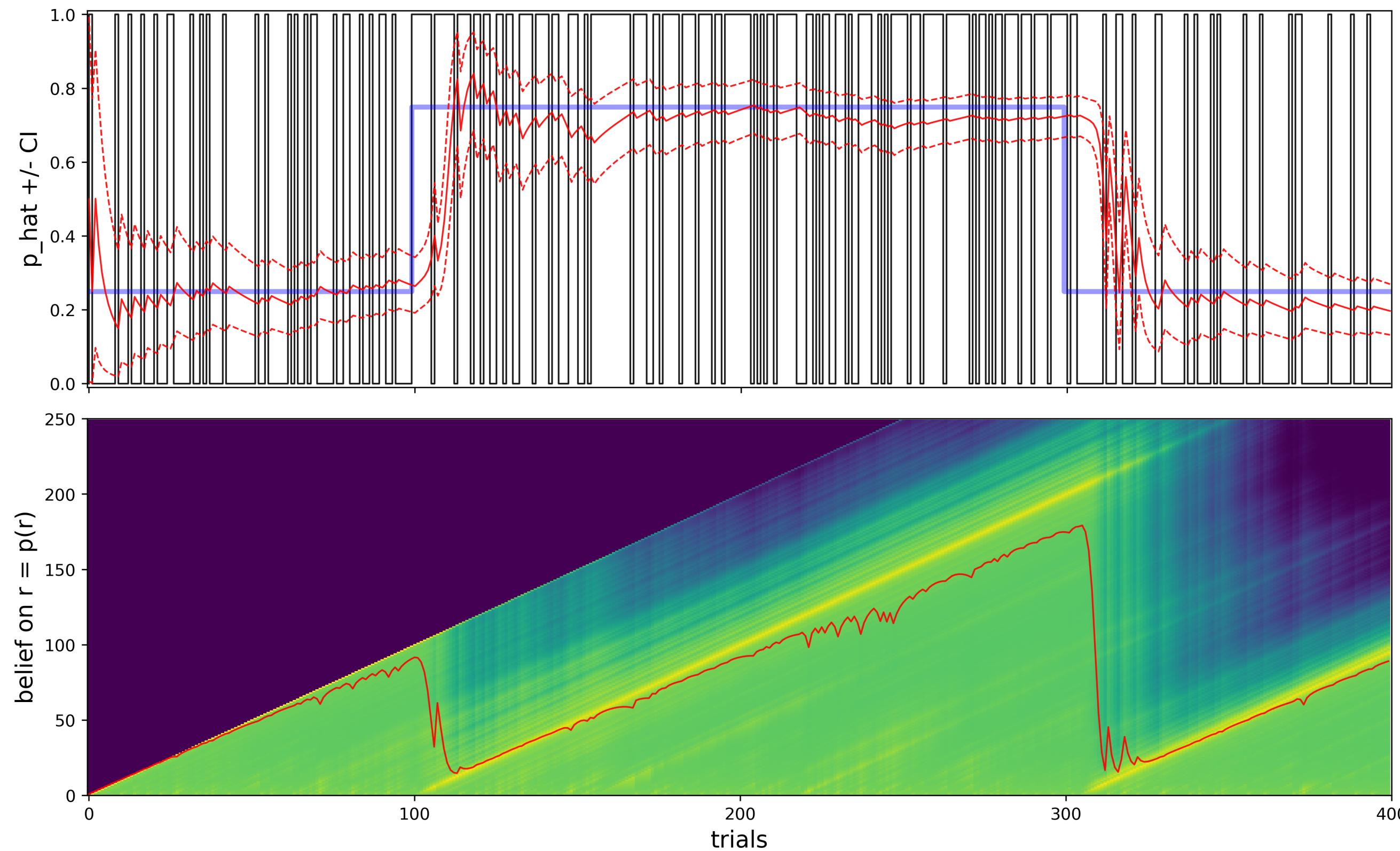
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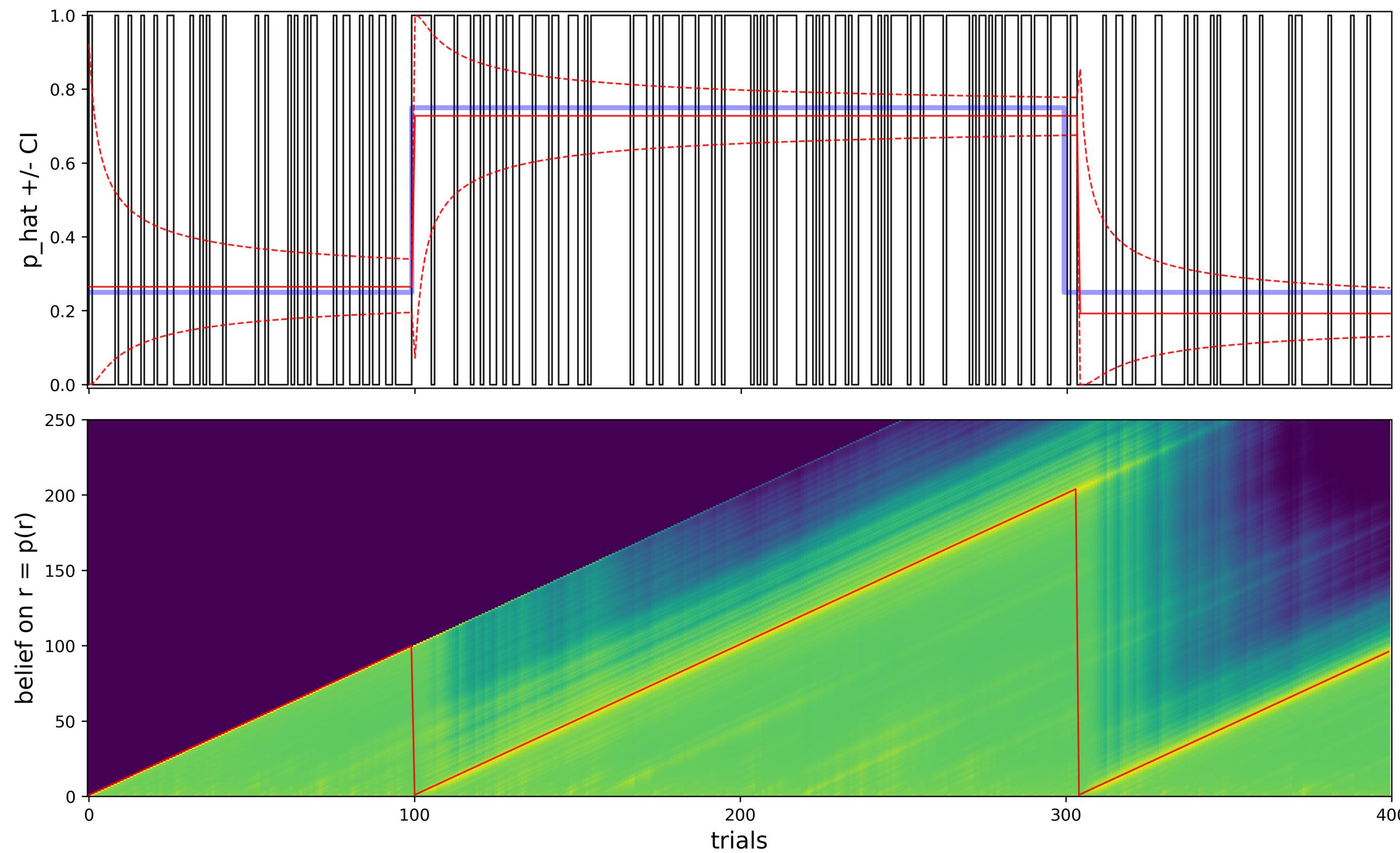
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Results: Analyzing inter-individual differences - Full model



full code @ github.com/laurentperrinet/bayesianchangepoint

Results: Analyzing inter-individual differences - With hindsight



full code @ github.com/laurentperrinet/bayesianchangepoint

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

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This work was supported by the PACE-ITN Project.



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