

Should I stay or should I go? Adaption of human observers to the volatility of visual inputs

Laurent Perrinet



LACONEU 2019: 5th Latin-American Summer School in Computational Neuroscience, 18/1/2019

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



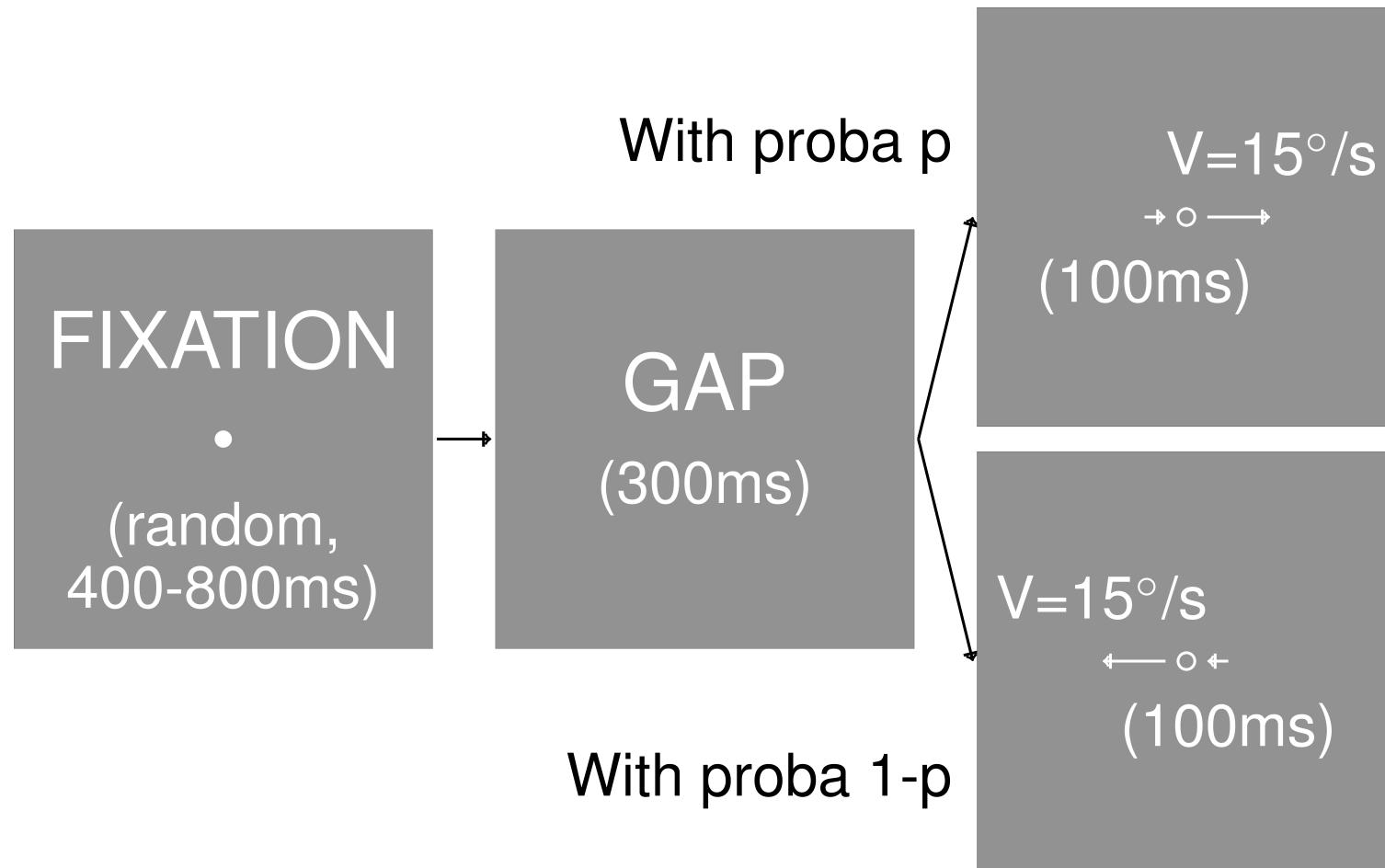
Outline

1. Motivation
2. What psychophysical results tell us
3. The Bayesian Changepoint Detector
4. Results using the BCP

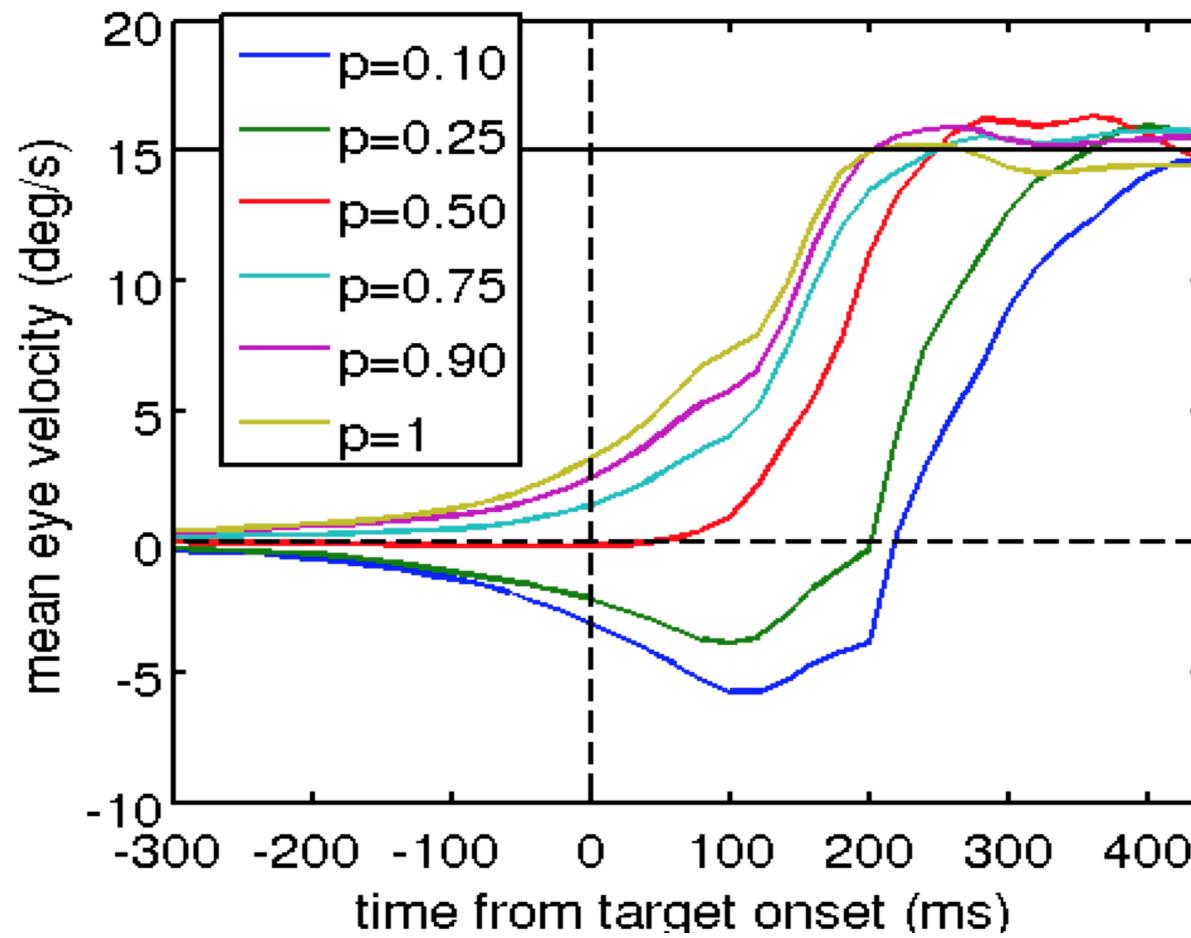
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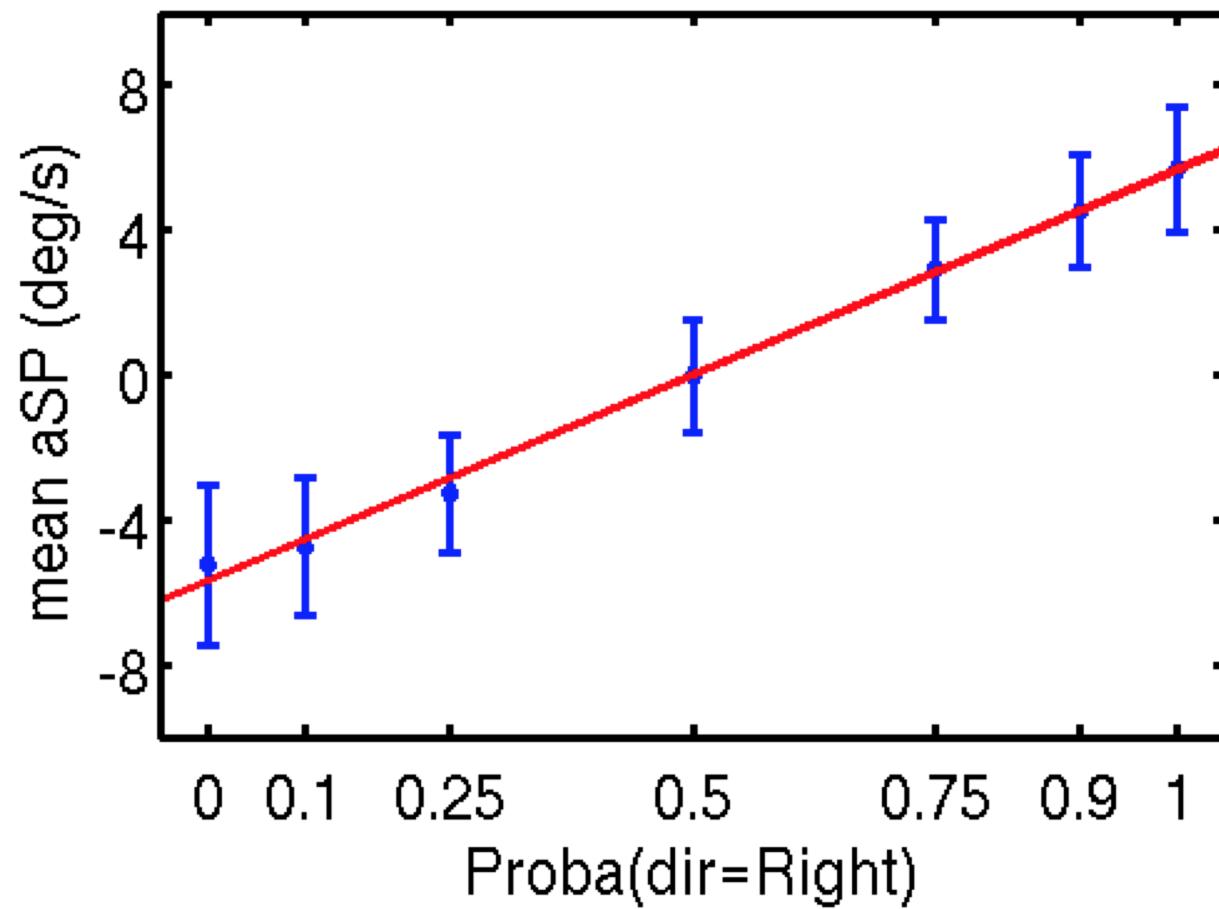
Motivation - Eye Movements



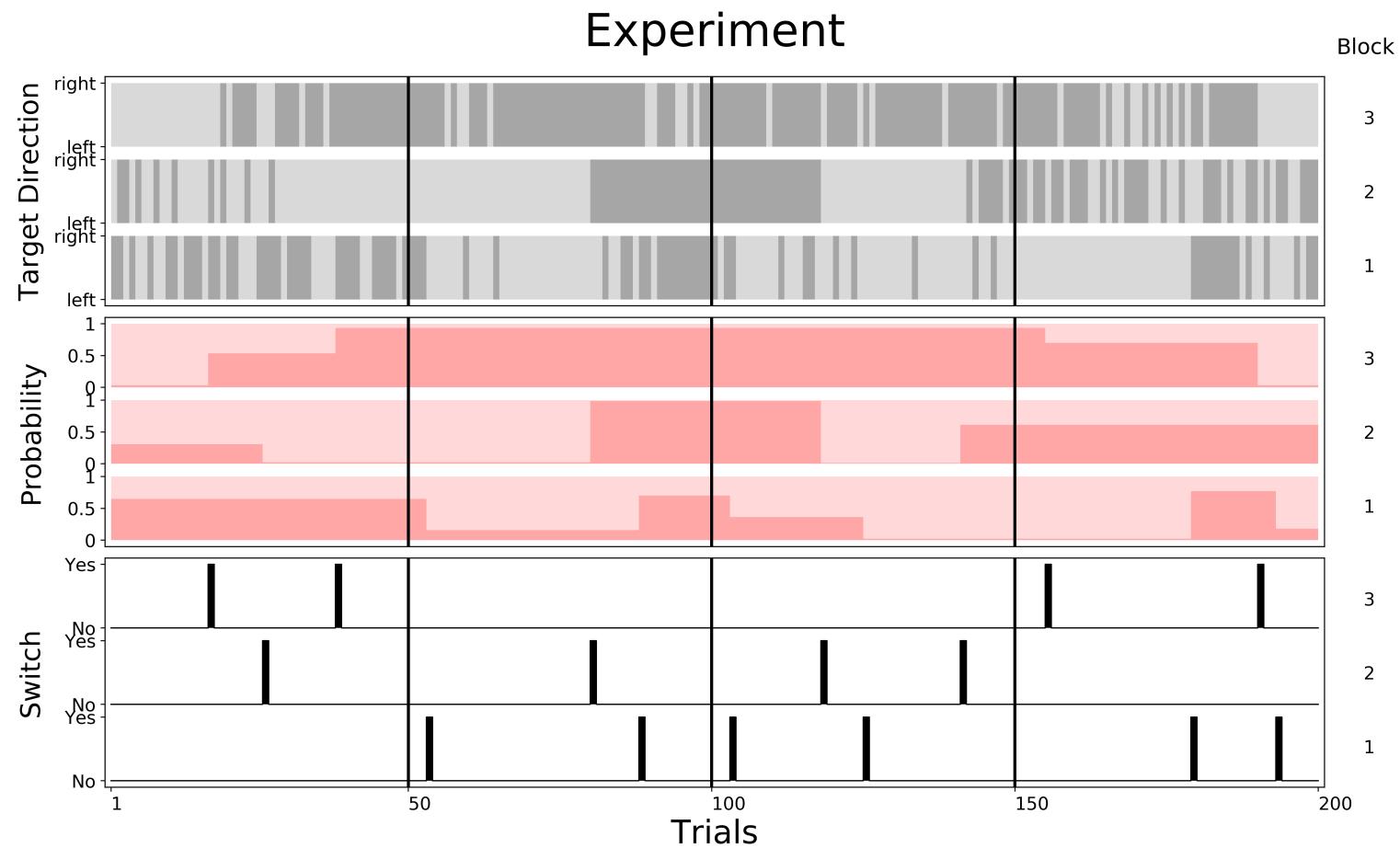
Motivation - Eye Movements



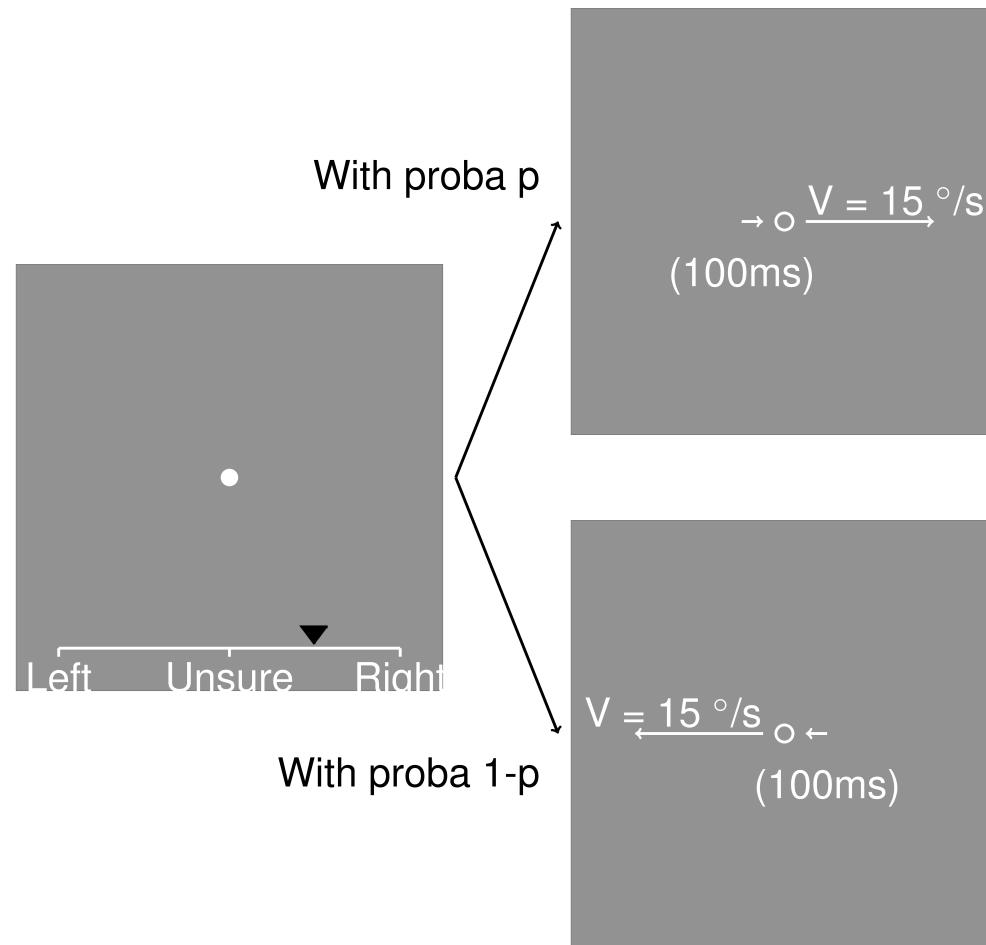
Motivation - Eye Movements



Motivation - Random-length block design



Motivation - Random-length block design



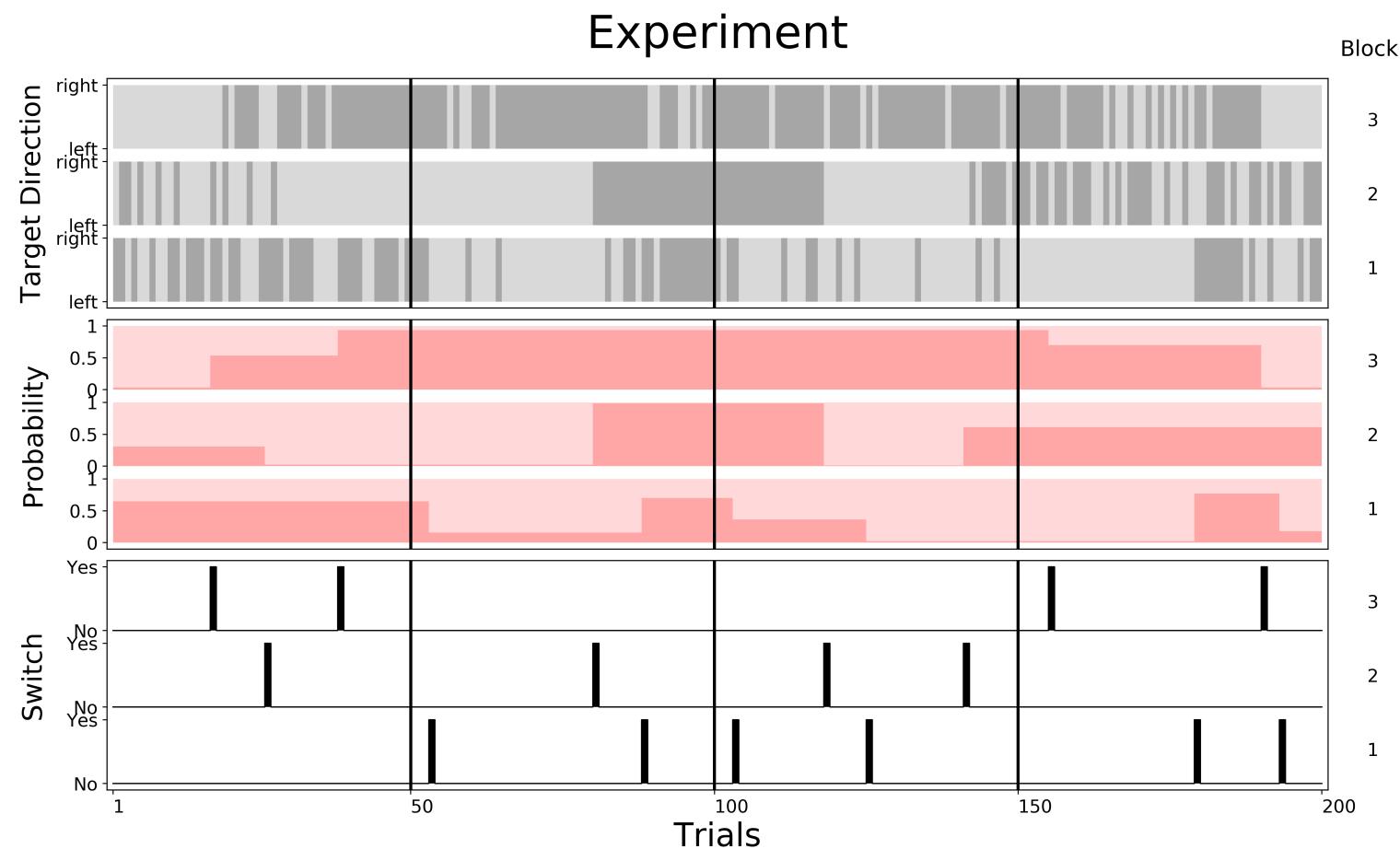
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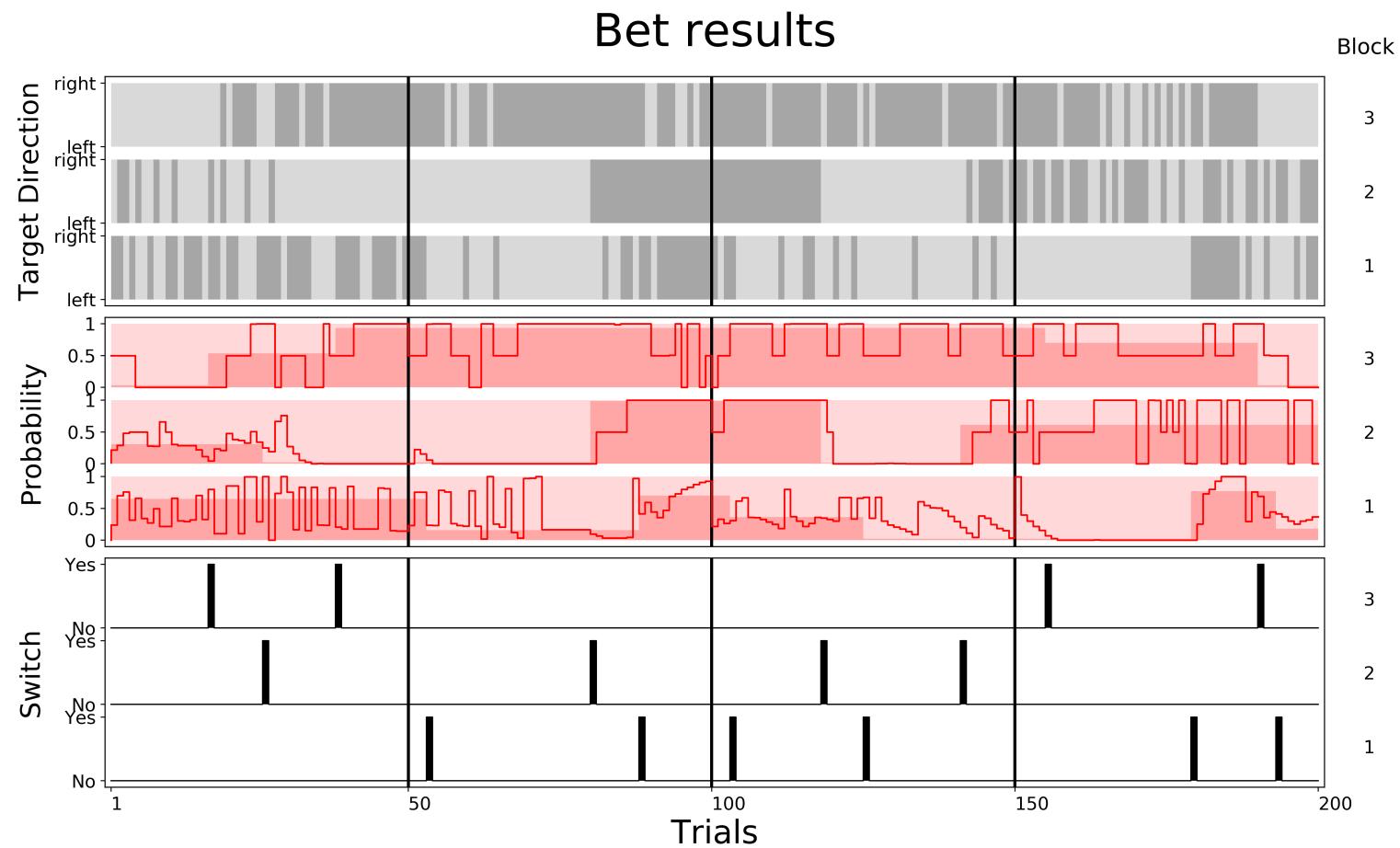
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What psychophysical results tell us - Random-length block design



full code @ github.com/chloepasturel/AnticipatorySPEM

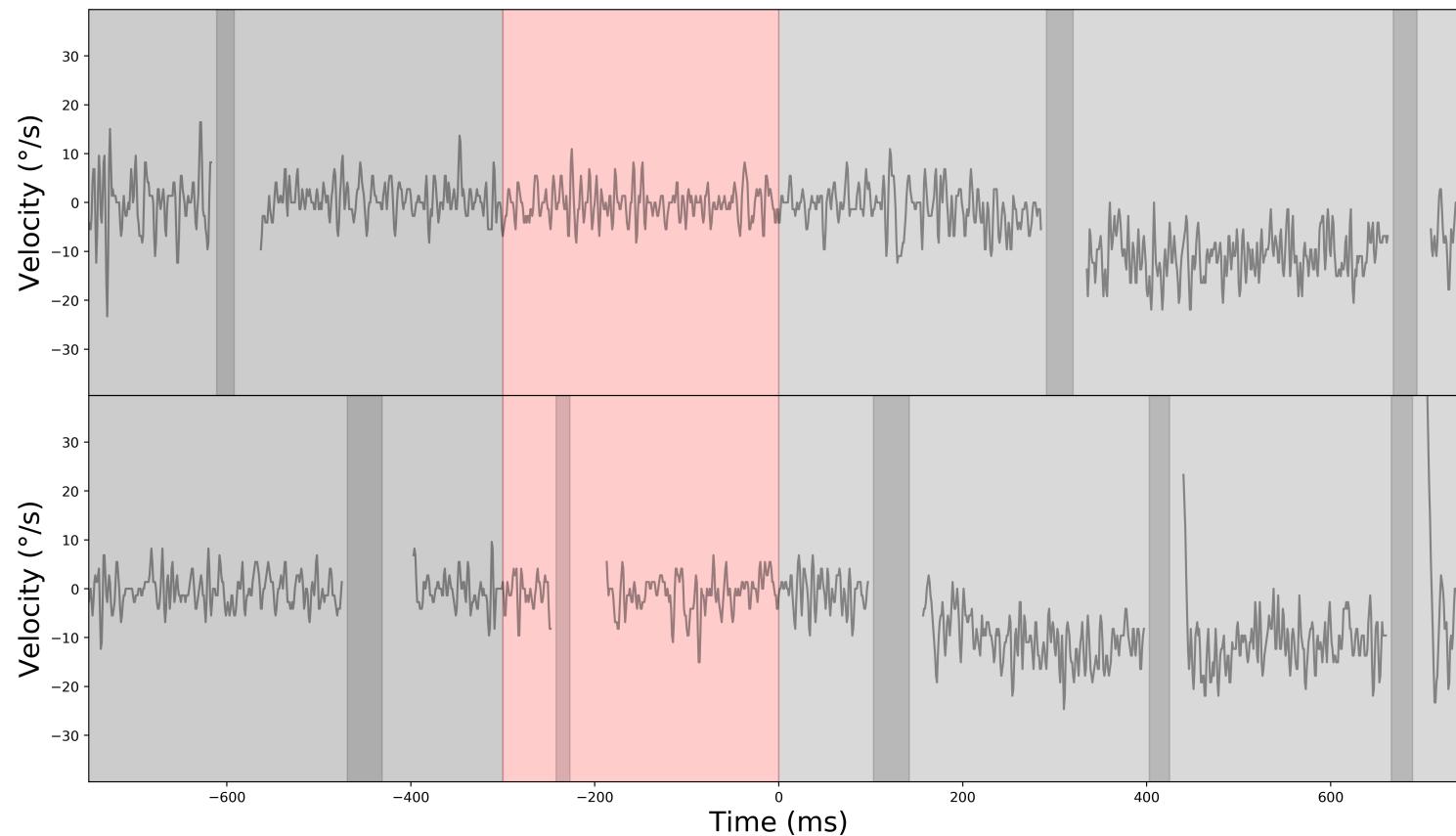
What psychophysical results tell us



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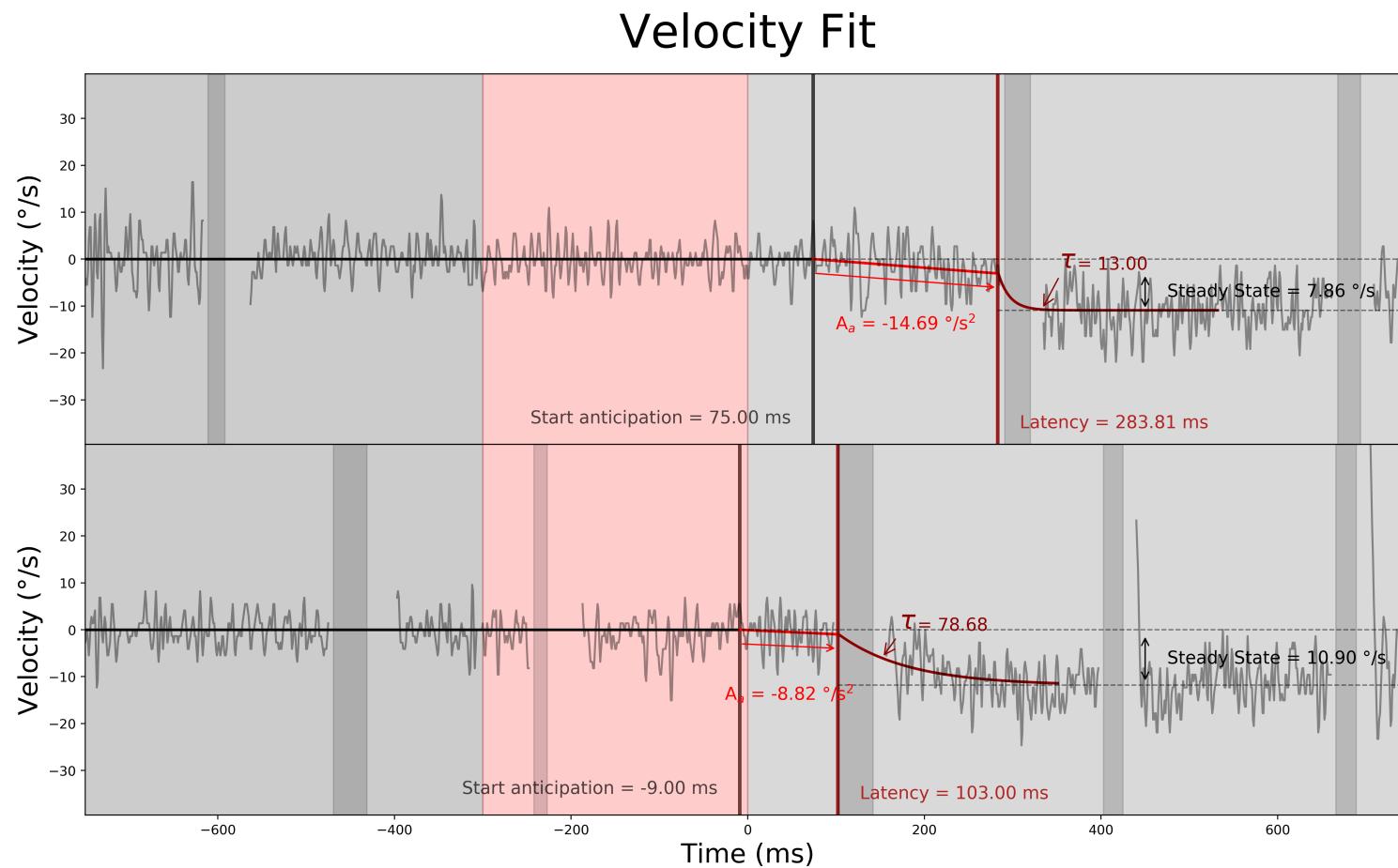
What psychophysical results tell us - Fitting eye movements

Eye Movement



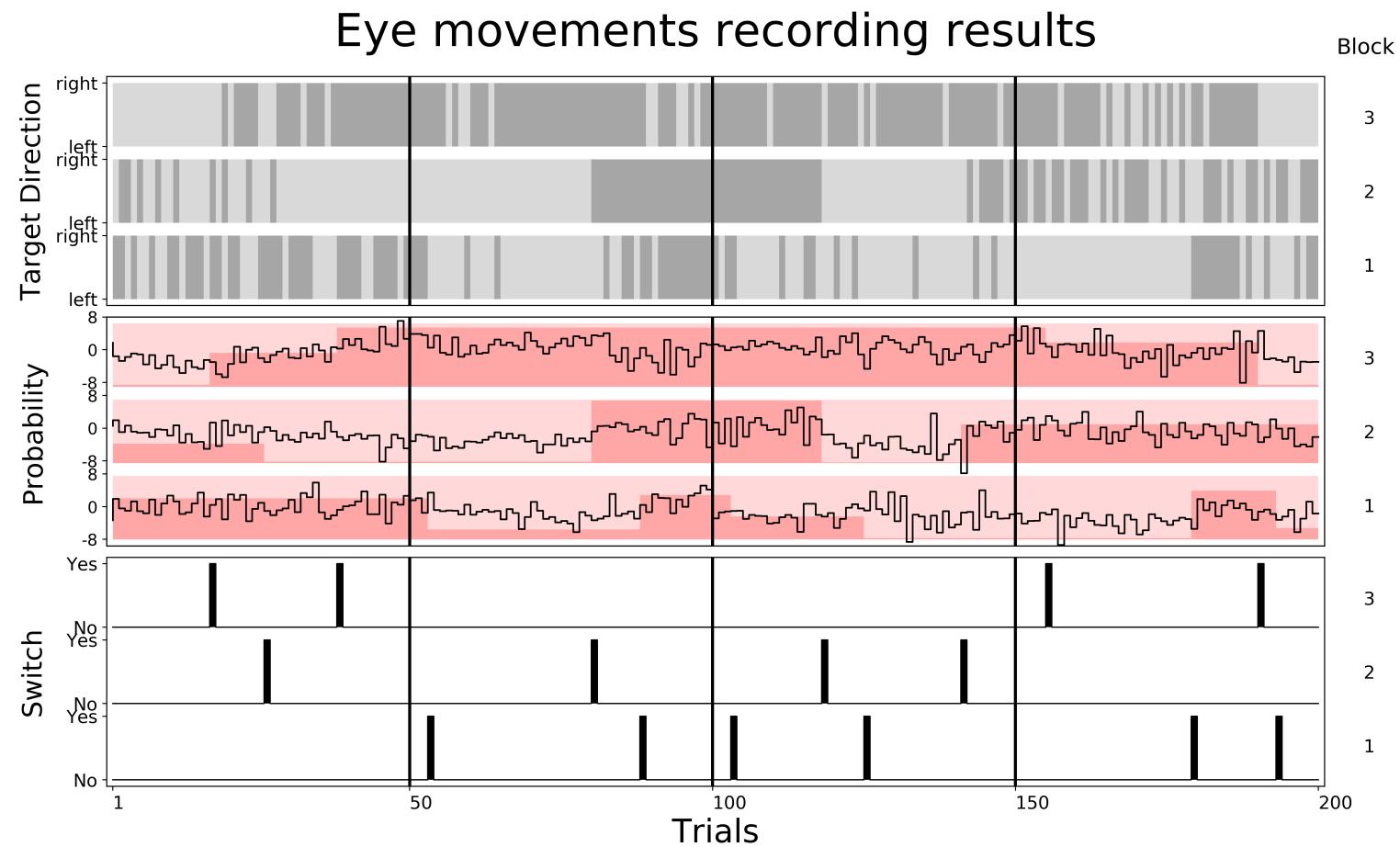
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What psychophysical results tell us - Fitting eye movements



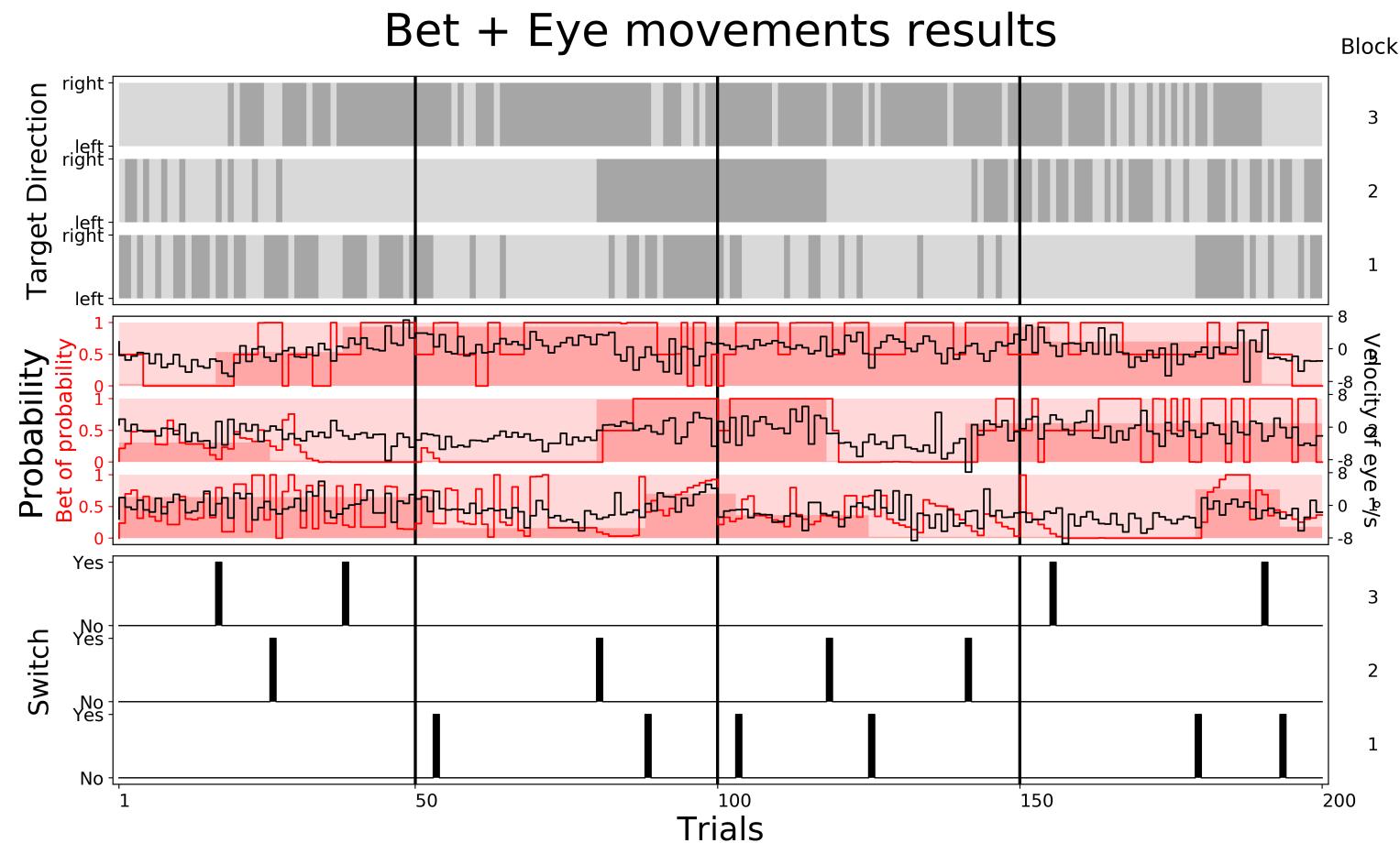
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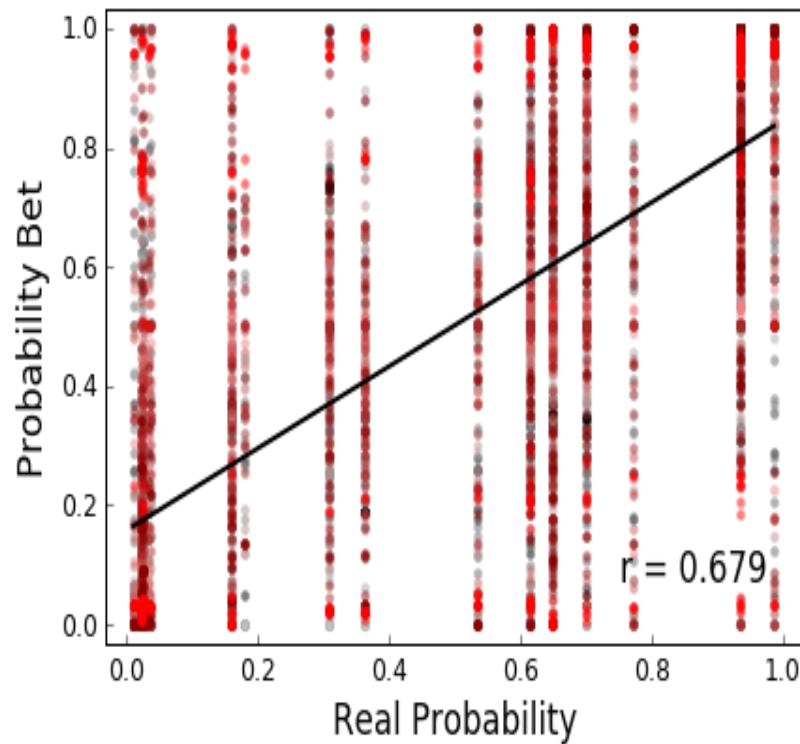
What psychophysical results tell us



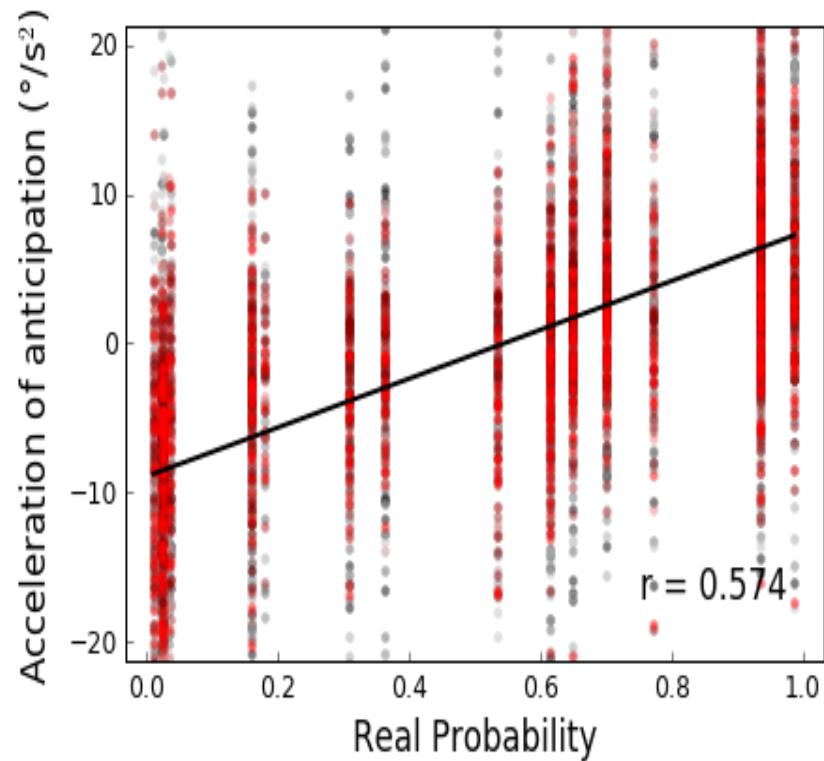
full code @ github.com/chloepasturel/AnticipatorySPEM

What psychophysical results tell us

Probability Bet



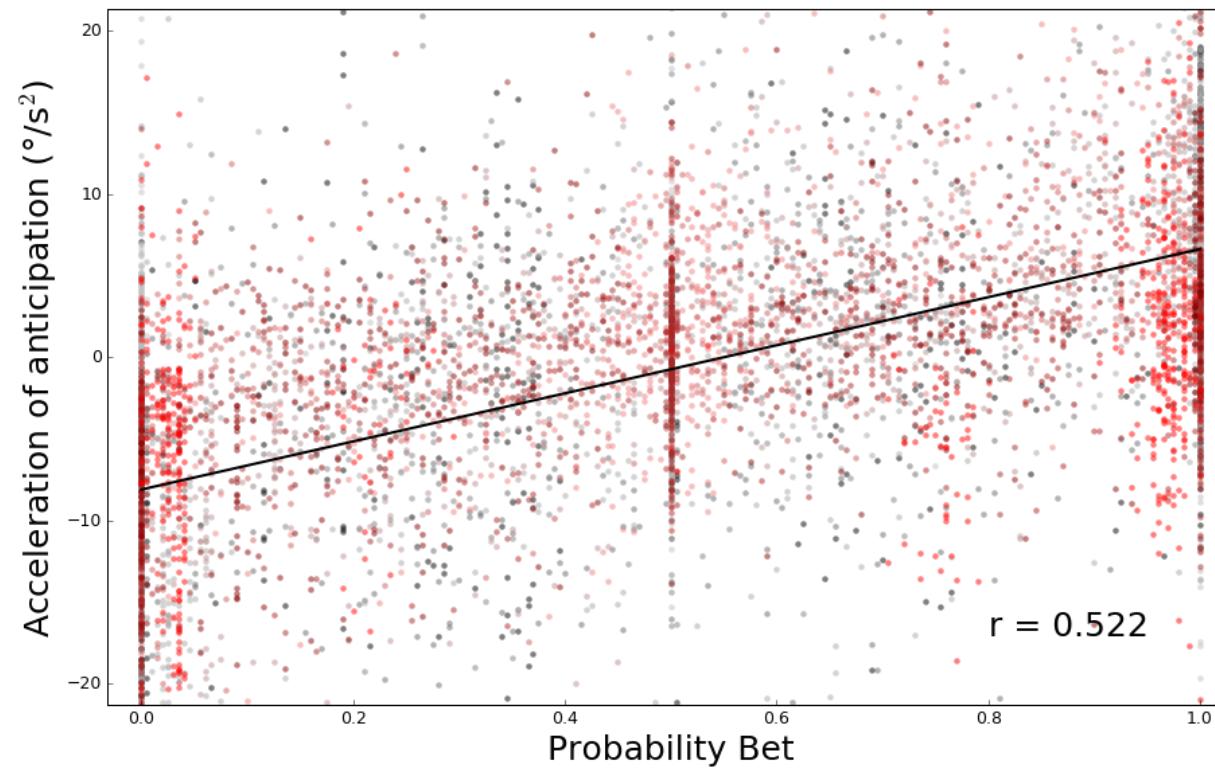
Acceleration



full code @ github.com/chloepasturel/AnticipatorySPEM

What psychophysical results tell us

Probability Bet vs Acceleration



full code @ github.com/chloepasturel/AnticipatorySPEM

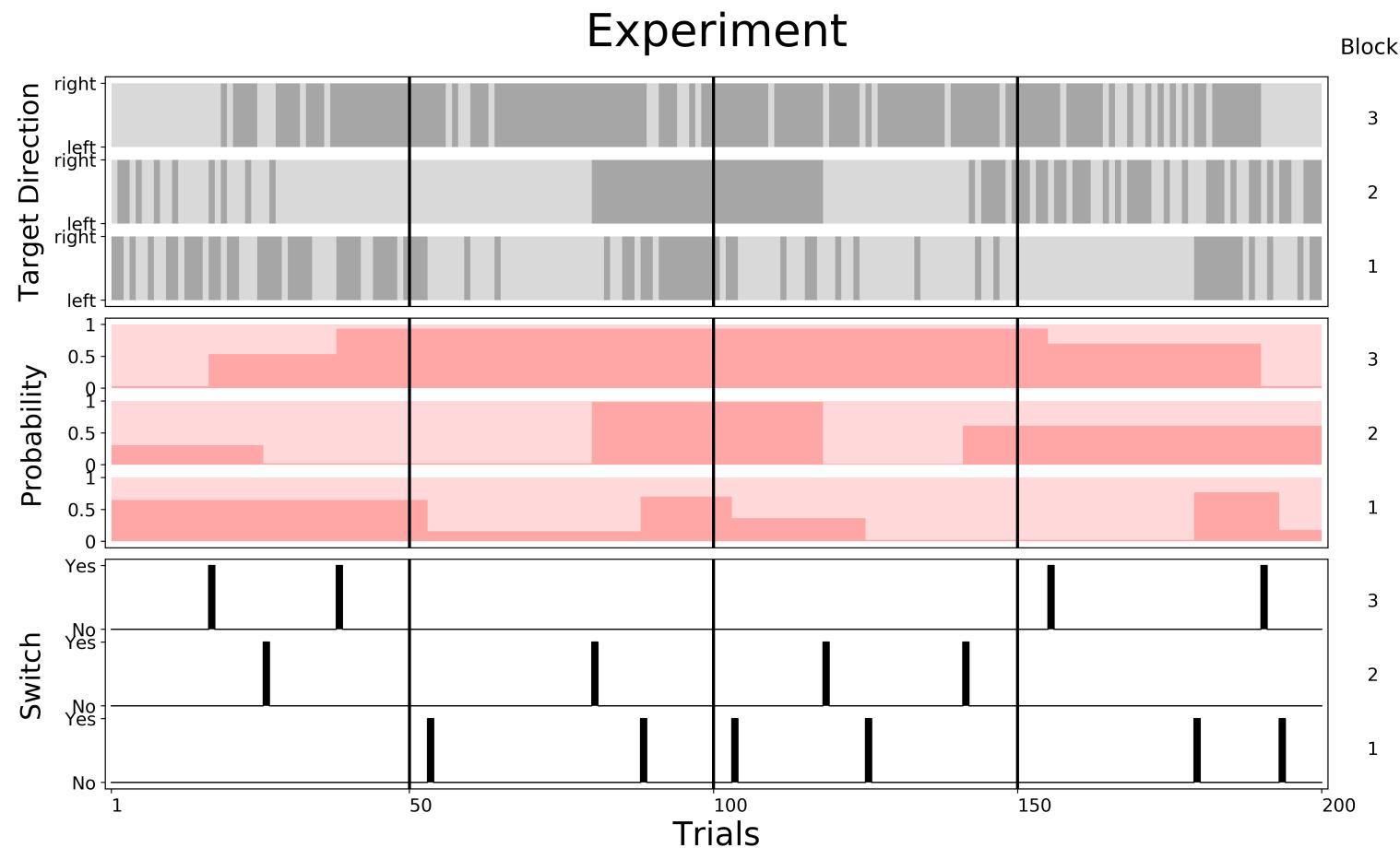
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The Bayesian Changepoint Detector - Random-length block design



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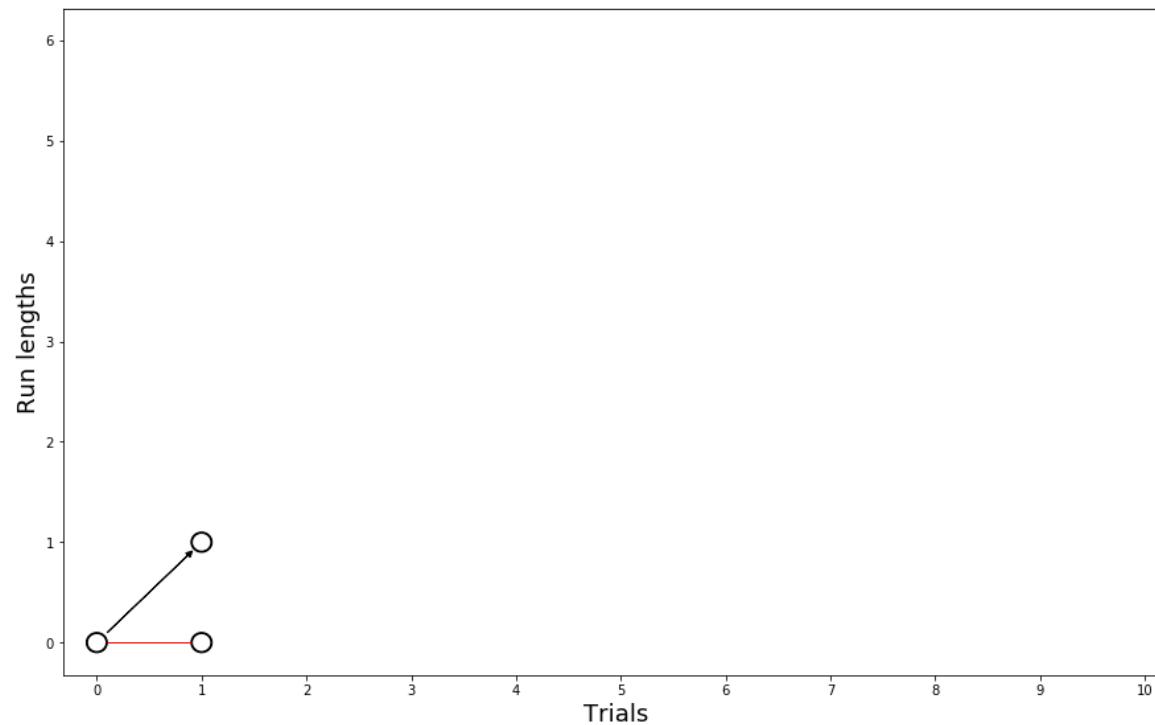
Bayesian Online Changepoint Detector

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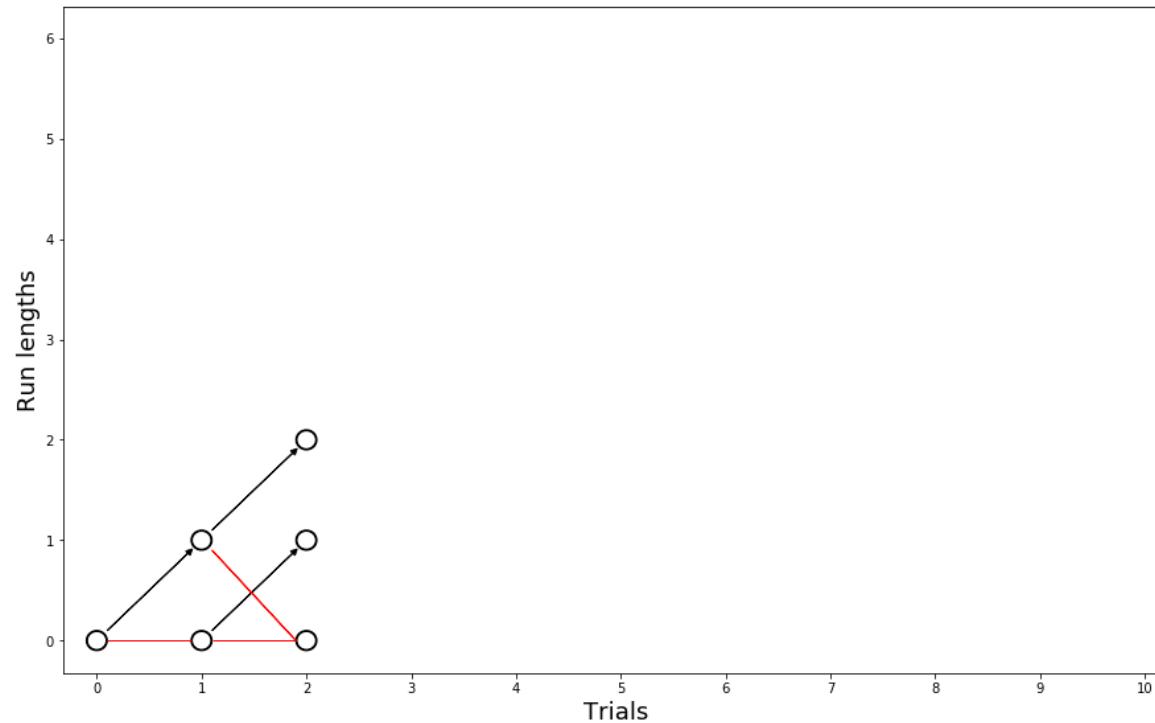
- adapted from <https://github.com/JackKelly/bayesianchangepoint> by Jack Kelly (2013) for a binomial input.
- This code is based on the [MATLAB implementation](#) provided by Ryan Adam. Was available at <http://hips.seas.harvard.edu/content/bayesian-online-changepoint-detection>
- full code @ <https://github.com/laurentperrinet/bayesianchangepoint>

The Bayesian Changepoint Detector



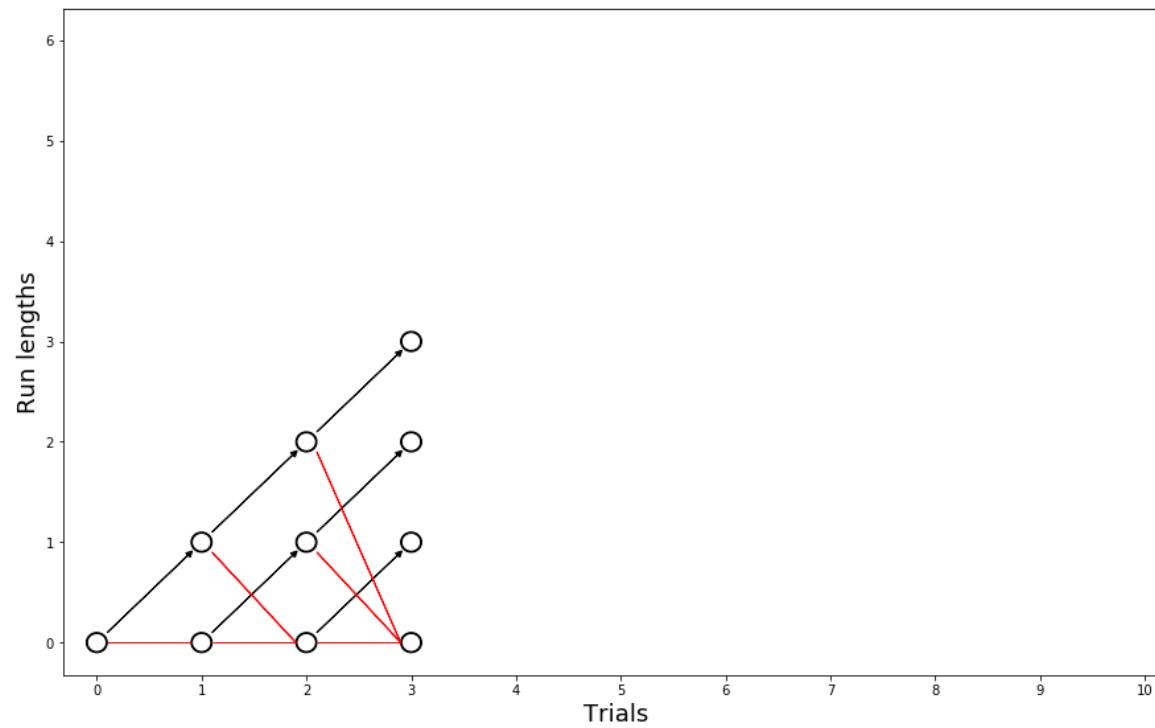
Initialize $P(r_0=0)=1$ and $v^{(0)}_1 = v_{\text{prior}}$ and $x^{(0)}_1 = x_{\text{prior}}$

The Bayesian Changepoint Detector



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

The Bayesian Changepoint Detector



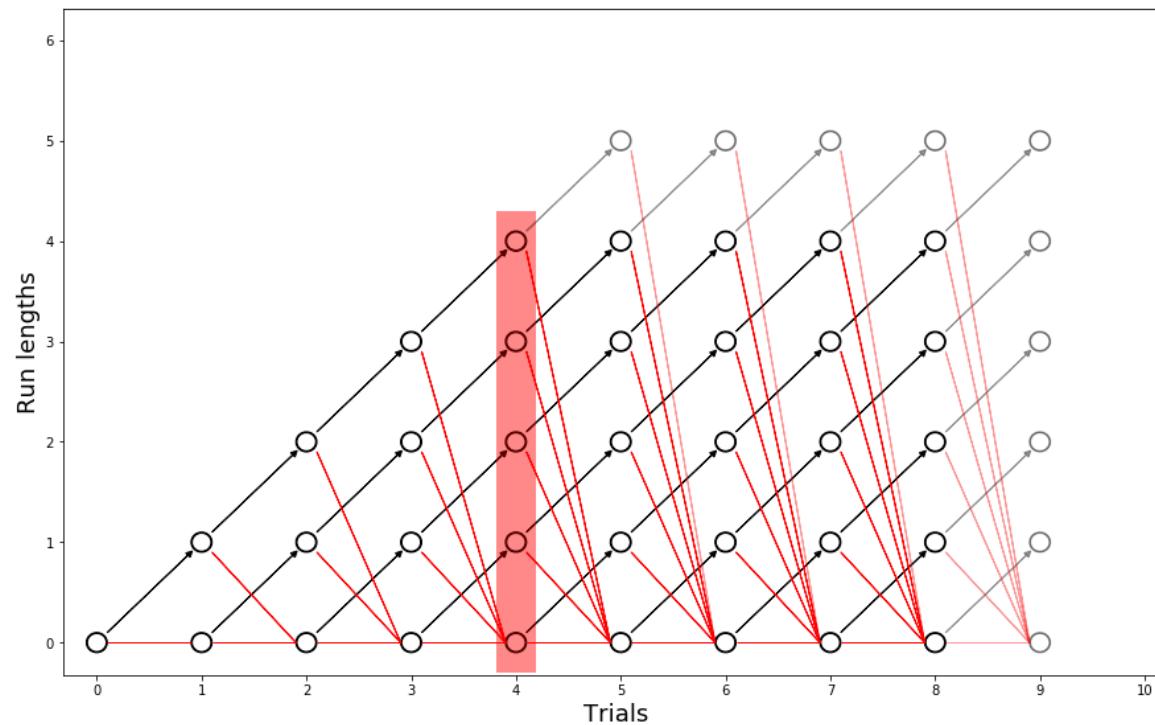
Evaluate (likelihood) Predictive Probability $\pi_{1:t} = P(x_t | v^{(r)}_t, x^{(r)}_t)$

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

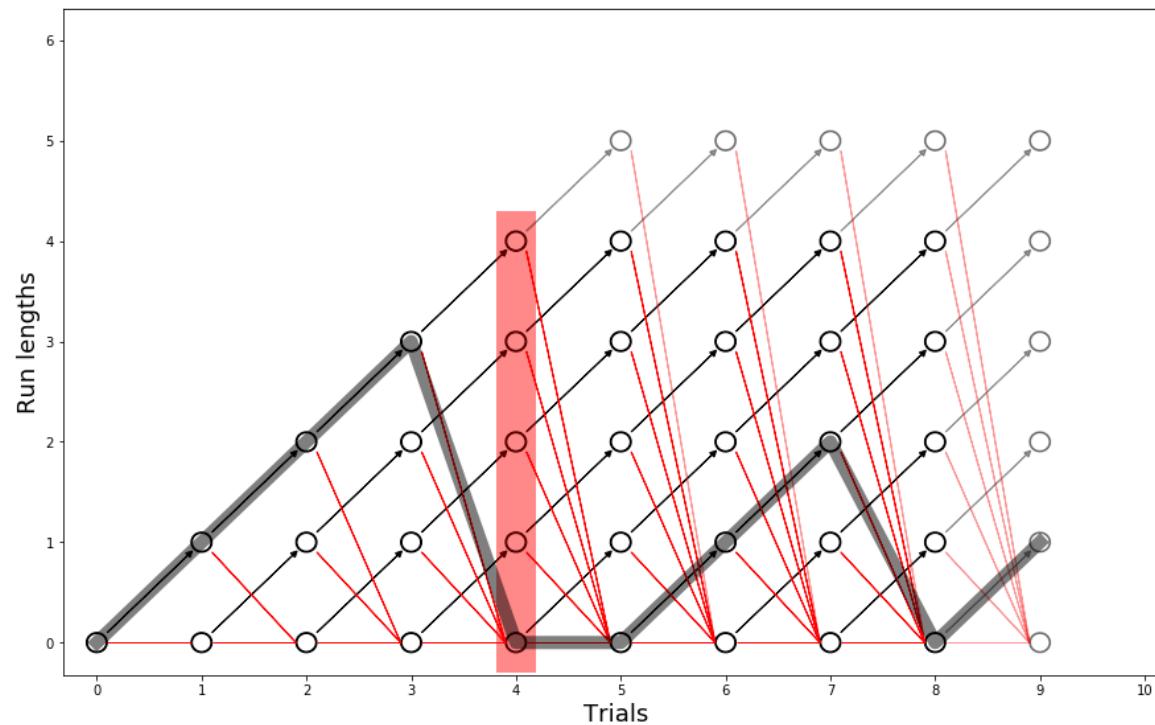
The Bayesian Changepoint Detector



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

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

The Bayesian Changepoint Detector



Update Sufficient Statistics :

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

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)

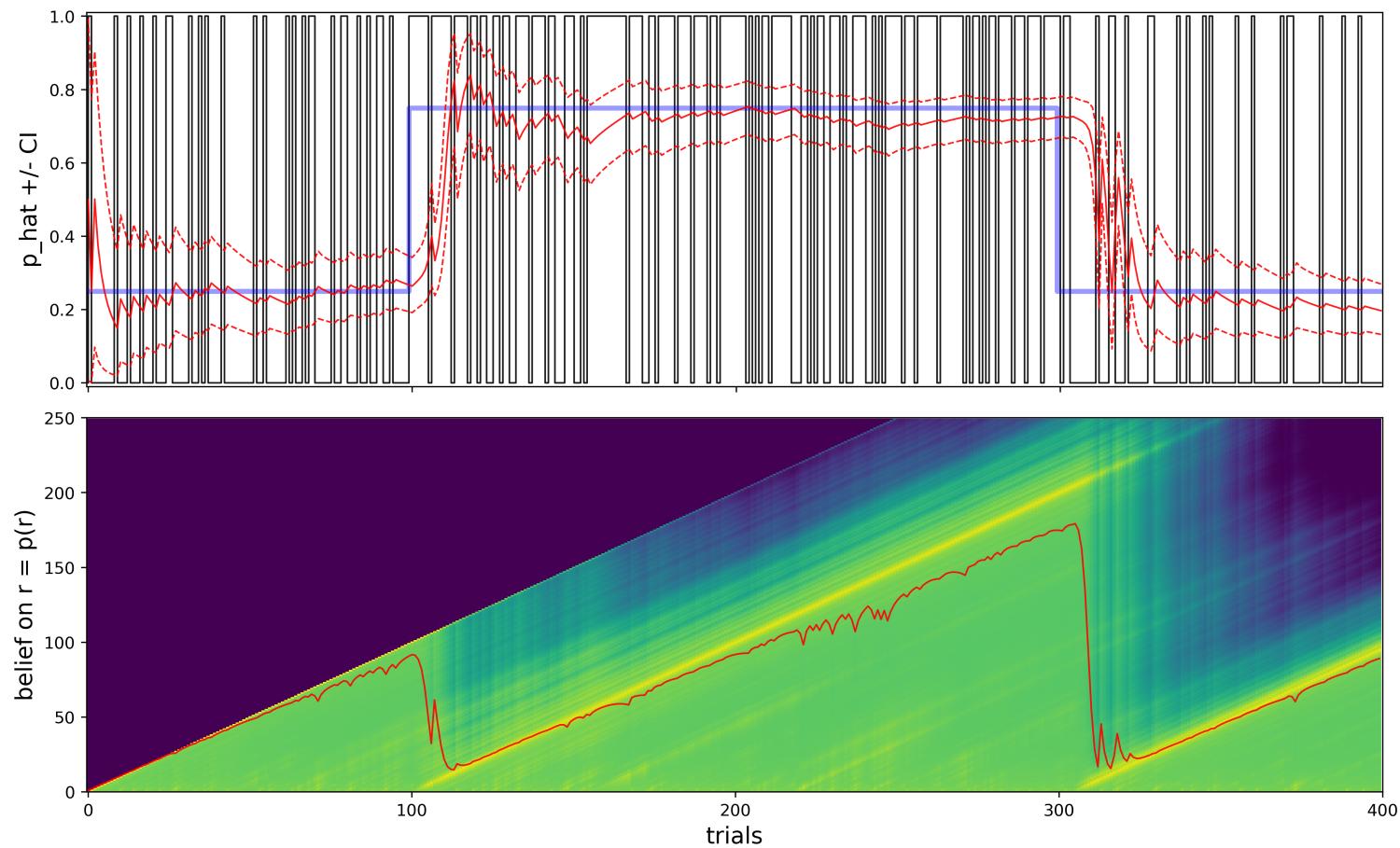
The Bayesian Changepoint Detector

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

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

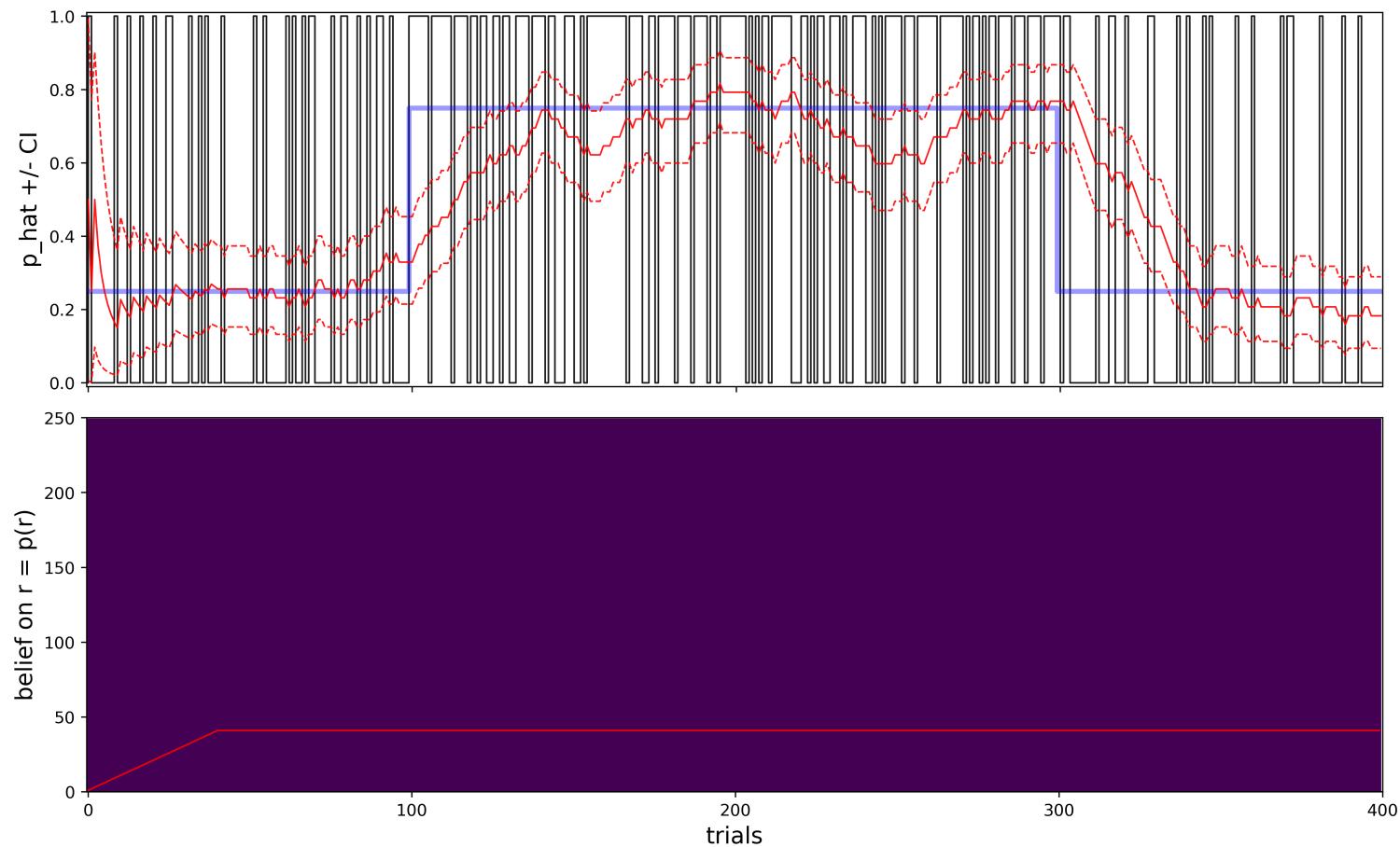
full code @ github.com/laurentperrinet/bayesianchangepoint

The Bayesian Changepoint Detector - Full model



full code @ github.com/laurentperrinet/bayesianchangepoint

The Bayesian Changepoint Detector - Fixed window



full code @ github.com/laurentperrinet/bayesianchangepoint

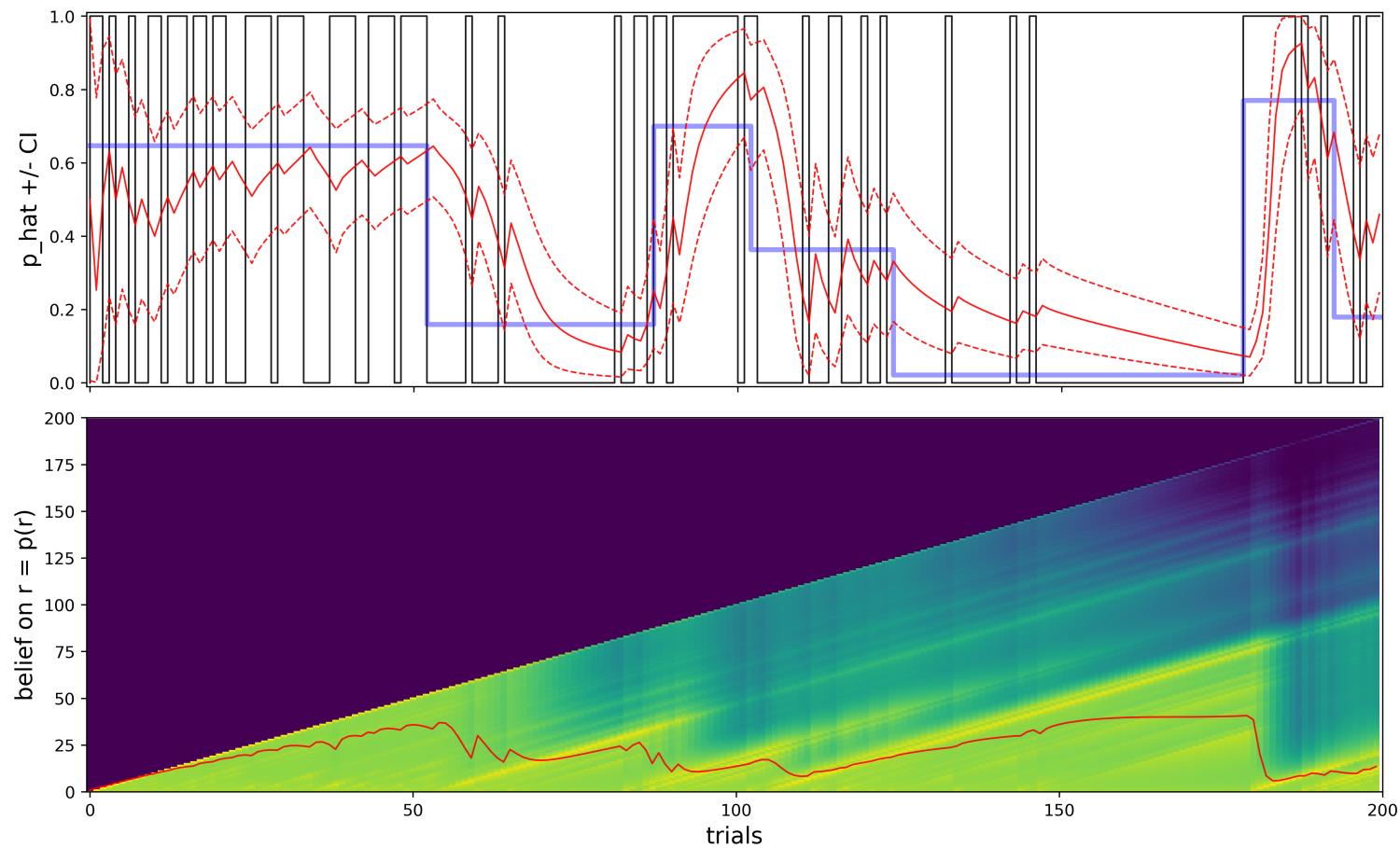
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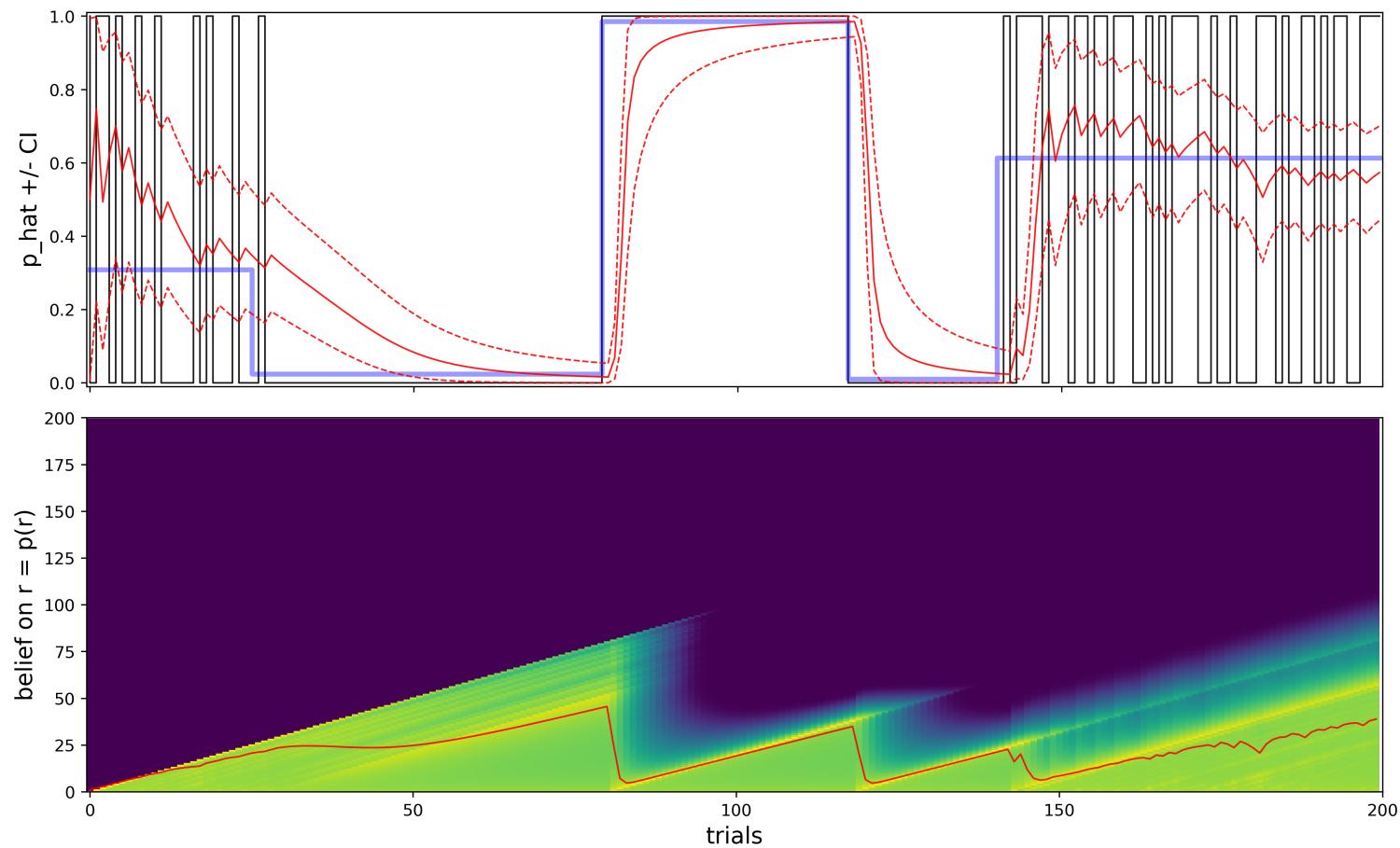
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Results using the BCP - Full model



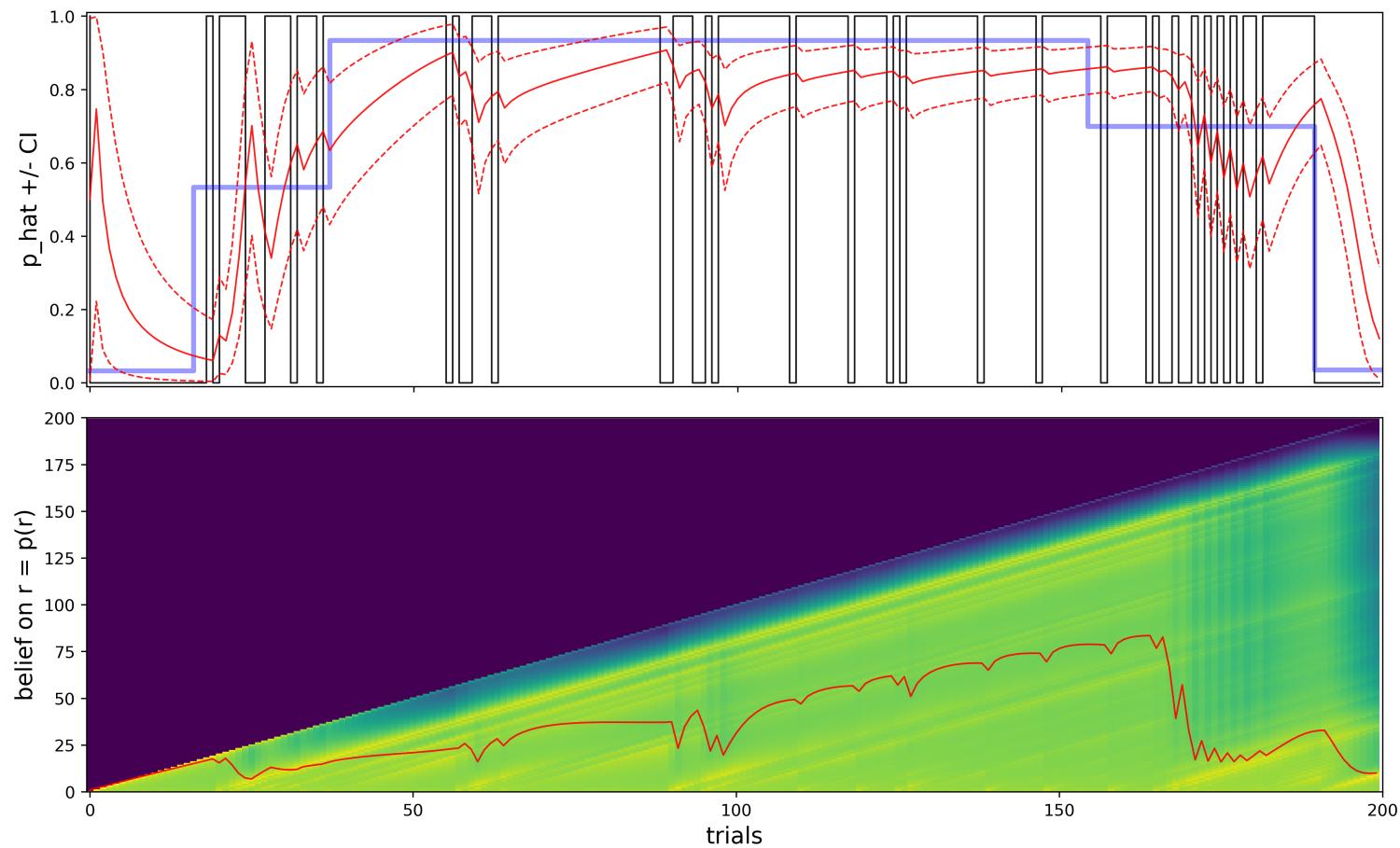
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Results using the BCP - Full model



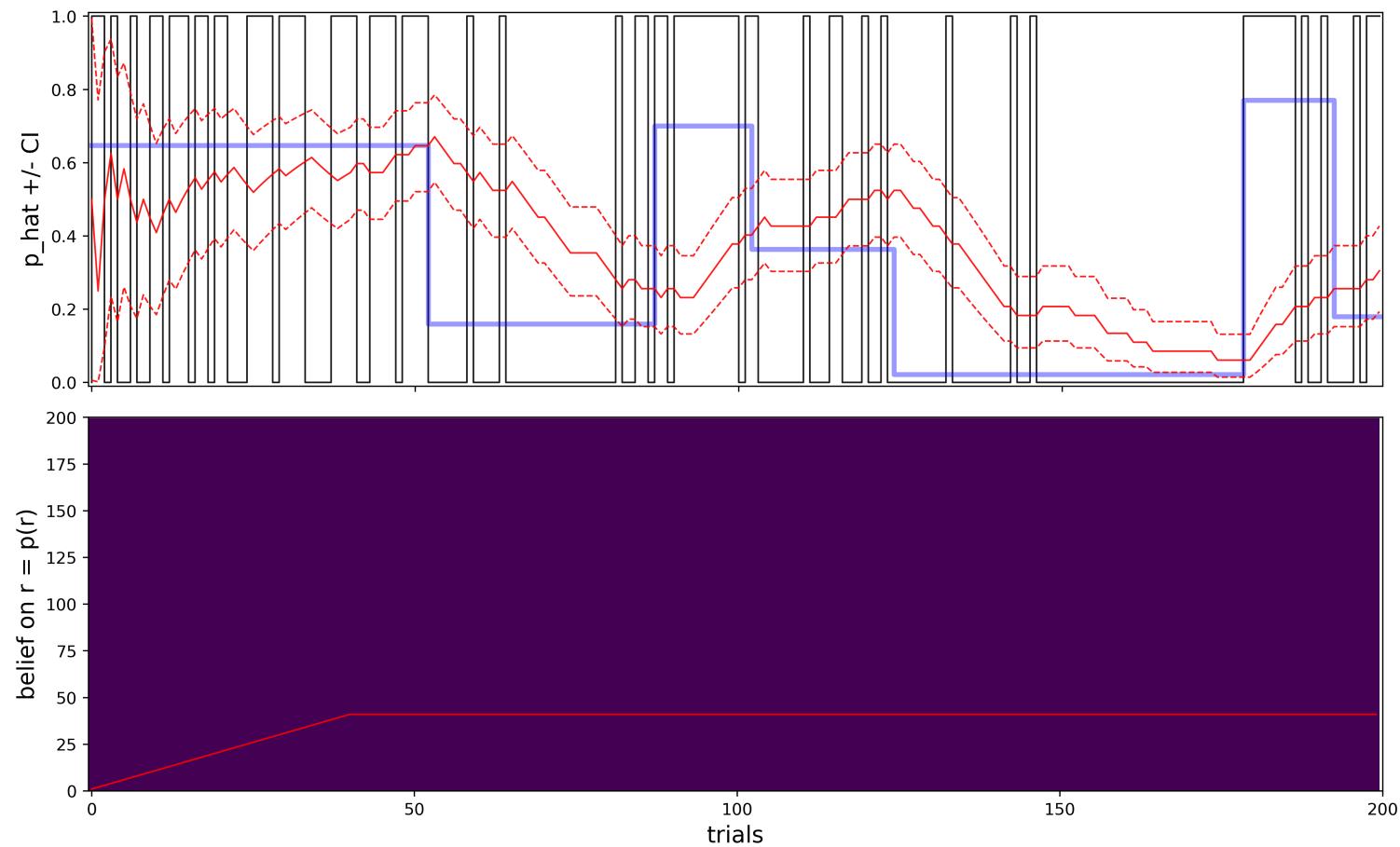
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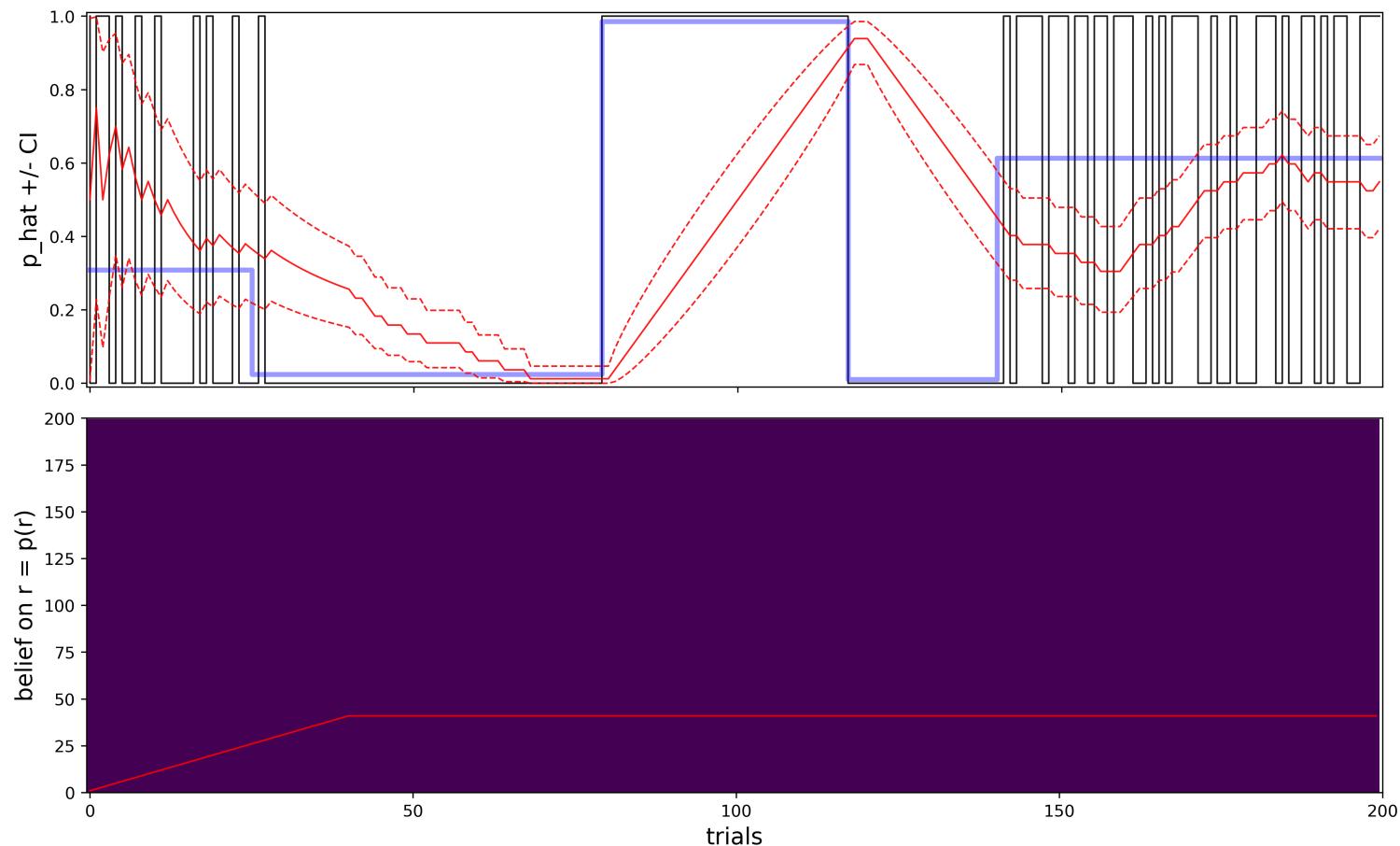
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Results using the BCP - Fixed window



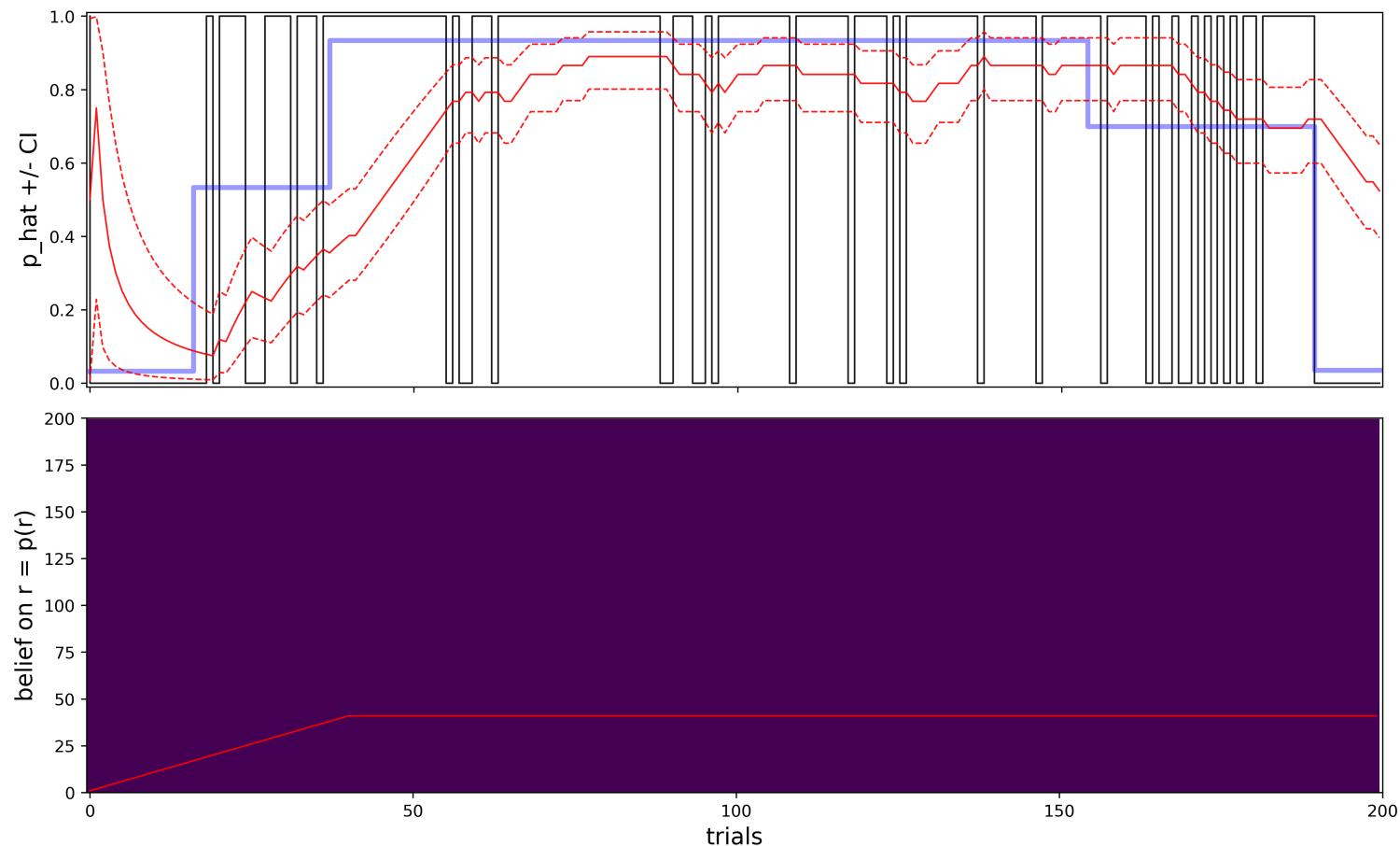
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Results using the BCP - Fixed window



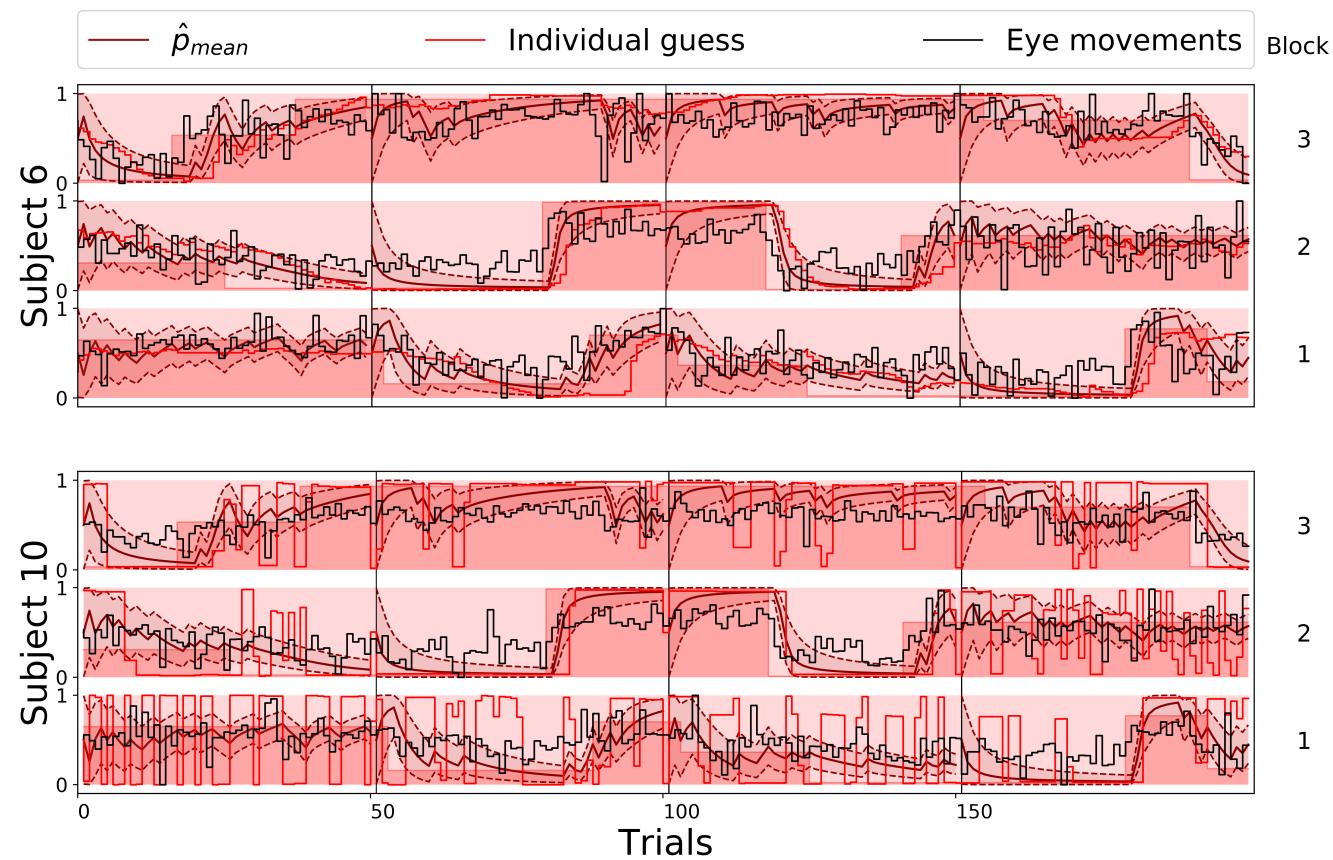
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Results using the BCP - Fixed window

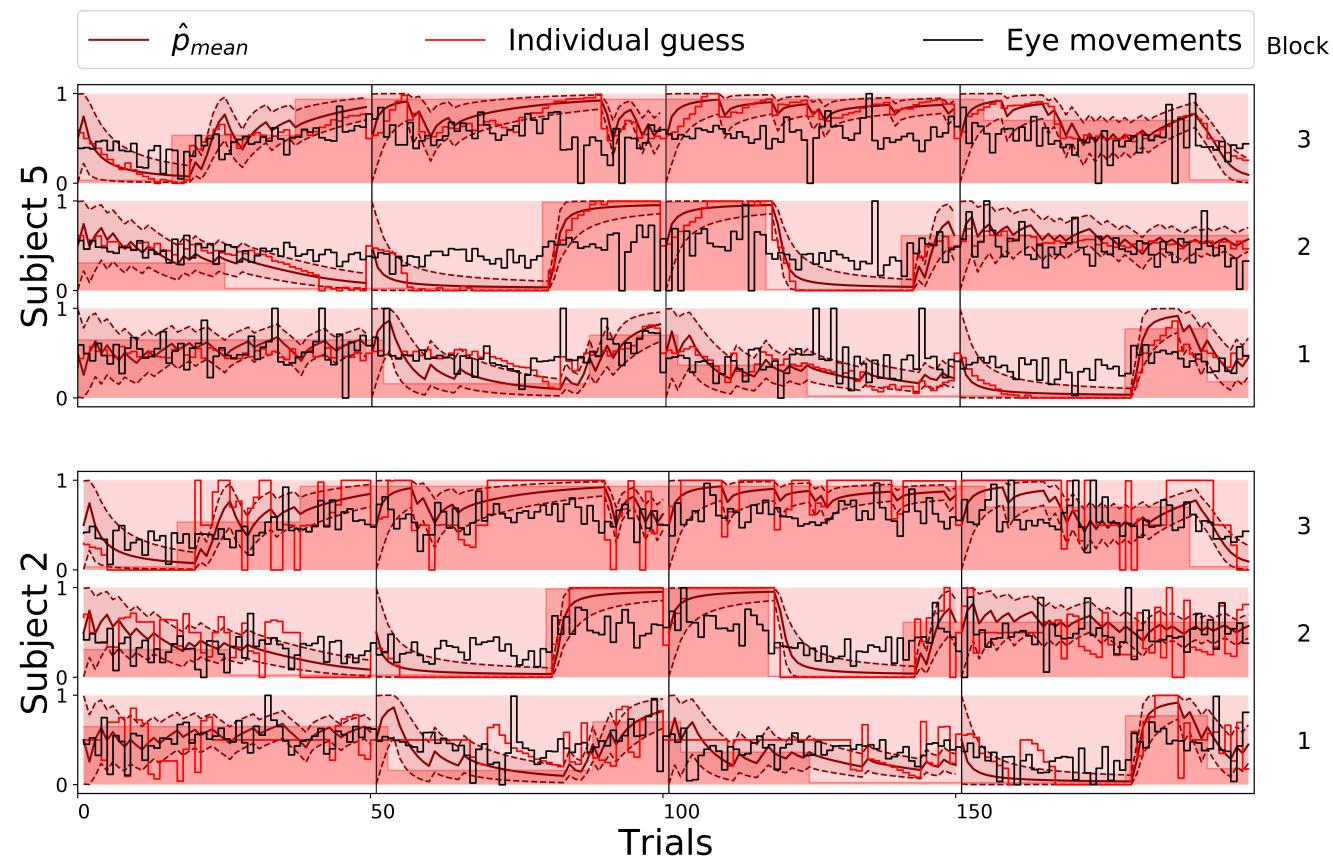


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Results using the BCP - fit with BCP

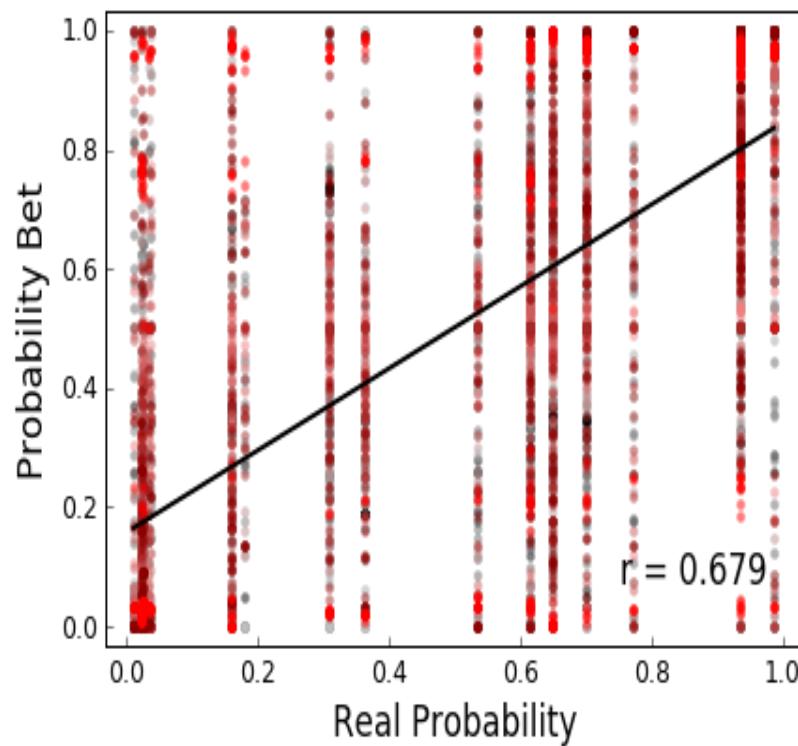


Results using the BCP - fit with BCP

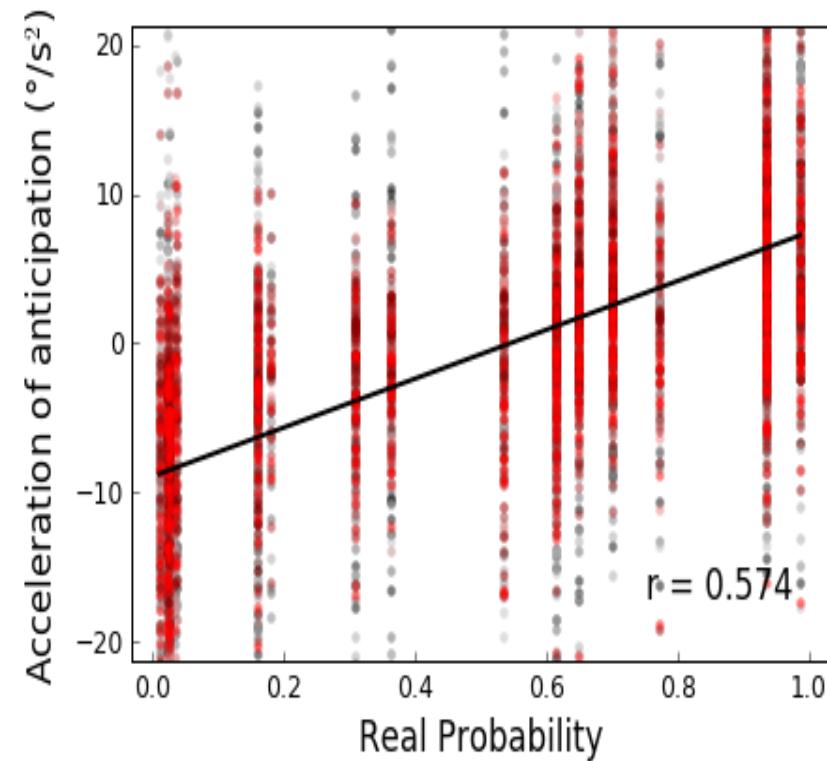


Results using the BCP

Probability Bet



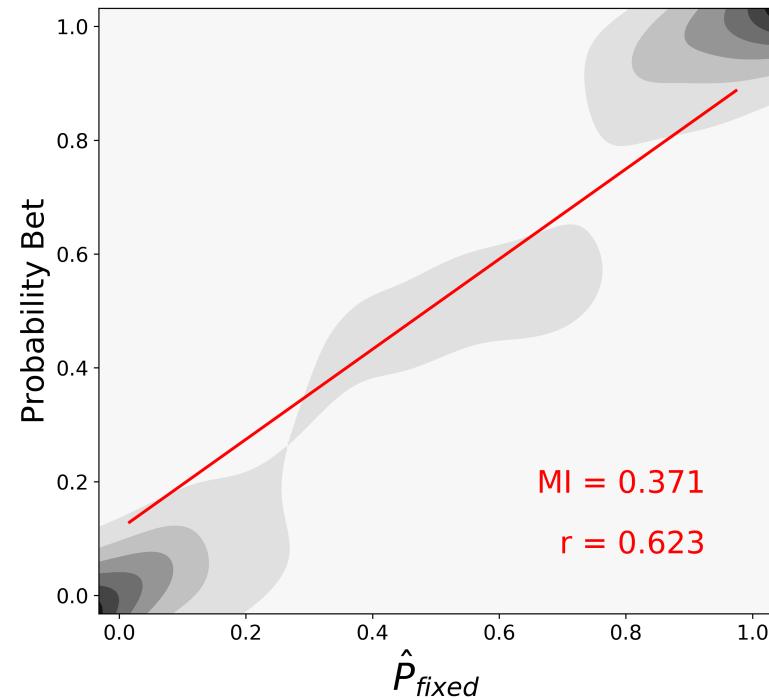
Acceleration



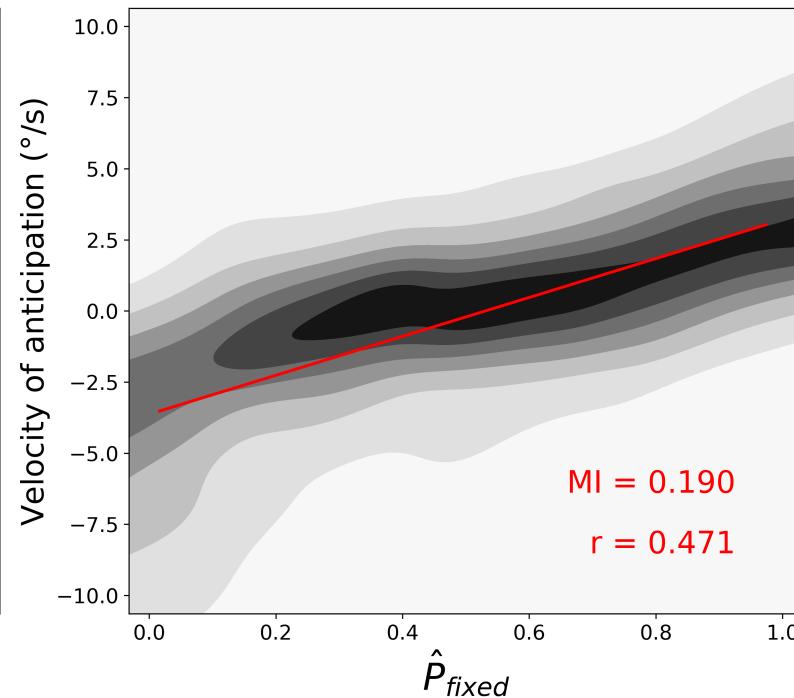
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Results using the BCP - Fixed window

Probability Bet

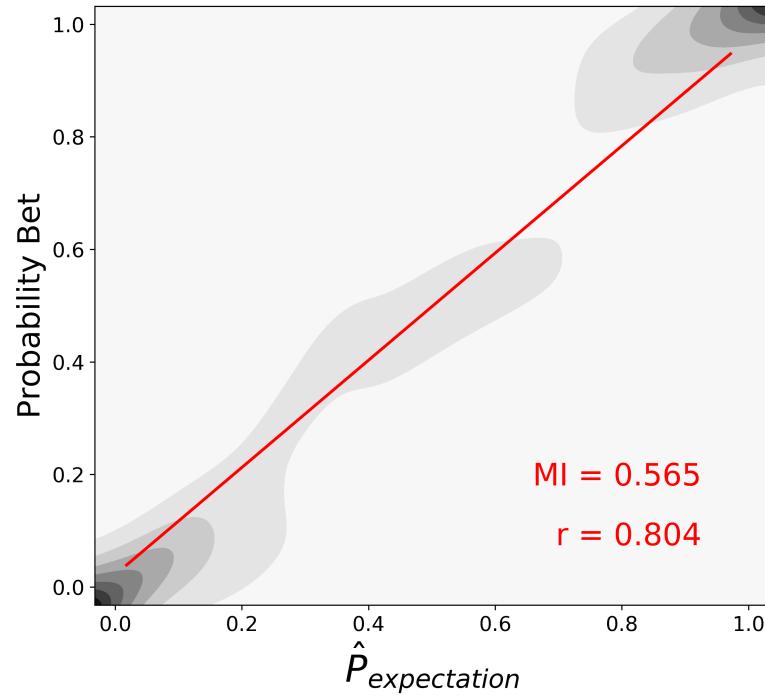


Velocity

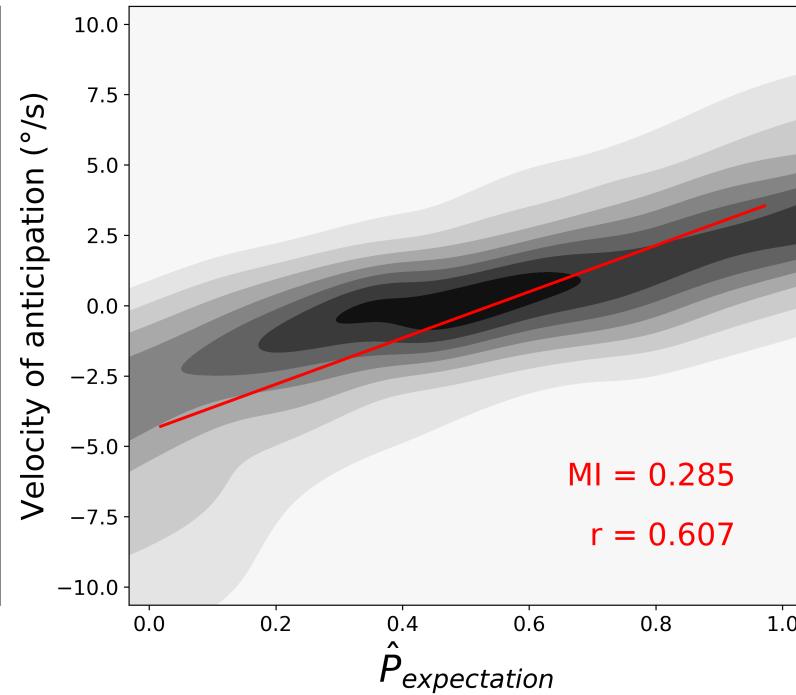


Results using the BCP - Full model

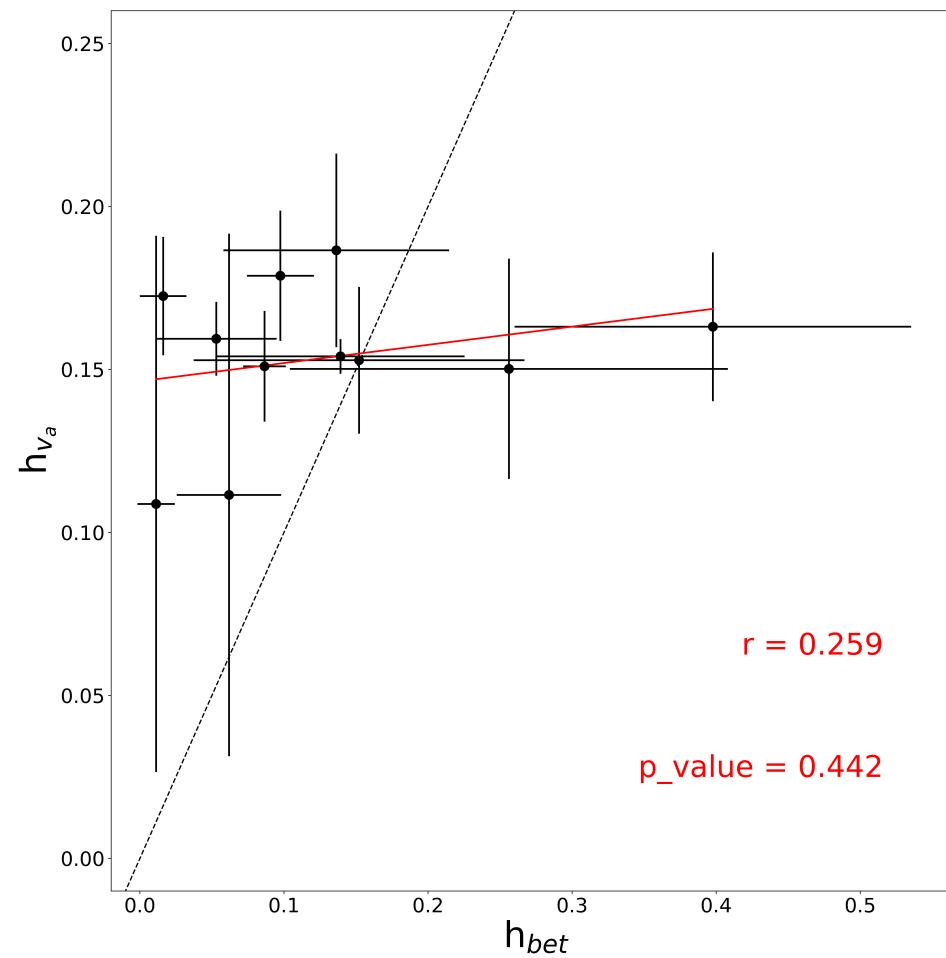
Probability Bet



Velocity



Results using the BCPinterindividual differences



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