Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions

Rencontres des Jeunes Physicien·ne·s 2021

Kevin Berlemont

Laboratoire de Physique de l'ENS
Center for Neural Science - NYU

PhD Advisor: Jean-Pierre Nadal (LPENS, CAMS - EHESS)
In Collaboration with: Jerôme Sackur (LSCP - EHESS) and Jean-Rémy Martin (CRCN - ULB)
Thanks to: Laurent Bonasse-Gahot (CAMS - EHESS)

Fellowship: CDSN Ecole Normale Supérieure Paris-Saclay

Introduction

Perceptual Decision-Making

- Visual Discrimination

Introduction

Perceptual Decision-Making

- Visual Discrimination
- Choice between categories

Introduction

Perceptual Decision-Making

- Visual Discrimination
- Choice between categories

Cat or Dog ?

Introduction

Perceptual Decision-Making

- Visual Discrimination
- Choice between categories
- Can be ambiguous

Cat or Dog ?

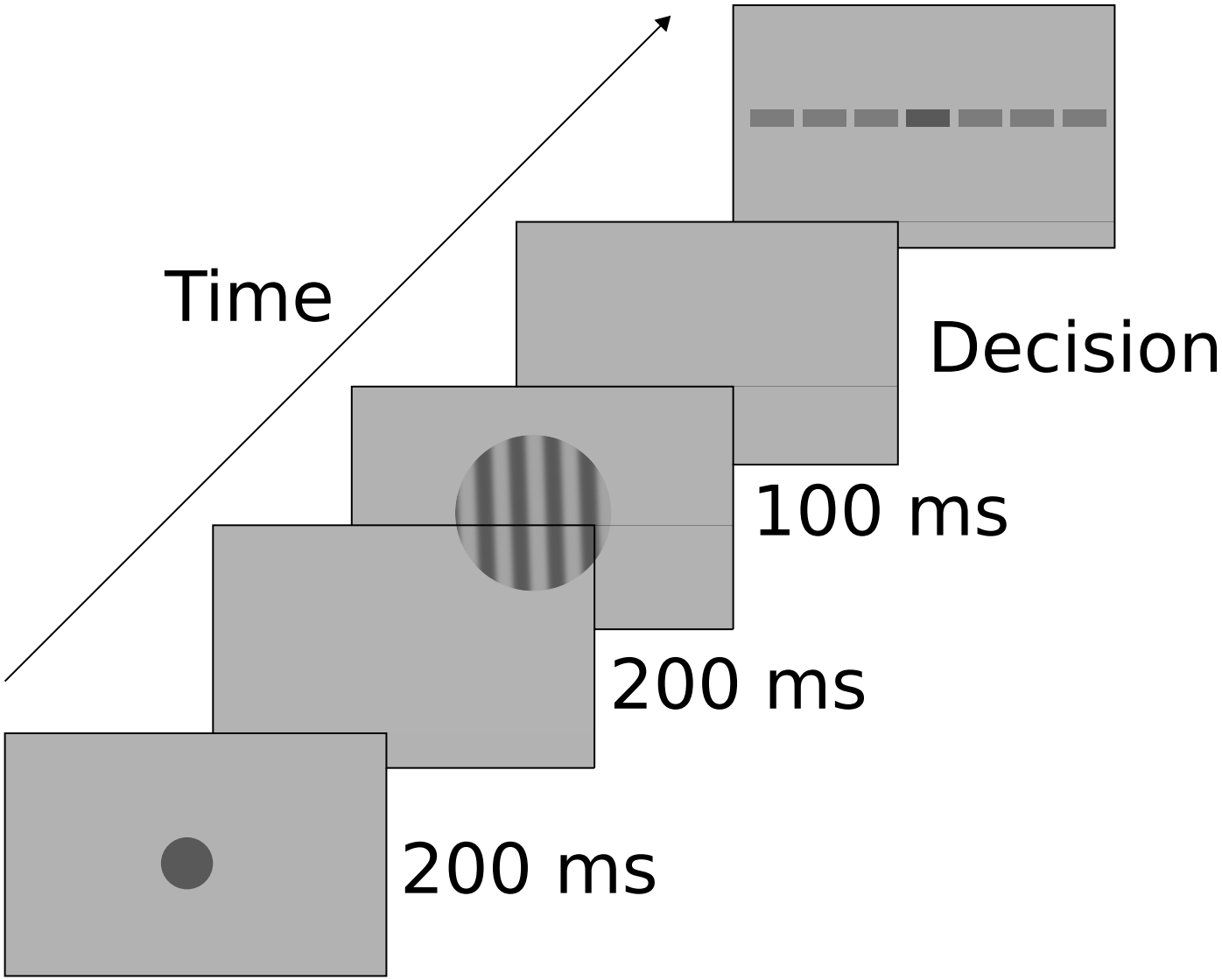
Introduction

Perceptual Decision-Making

- Visual Discrimination
- Choice between categories
- Can be ambiguous

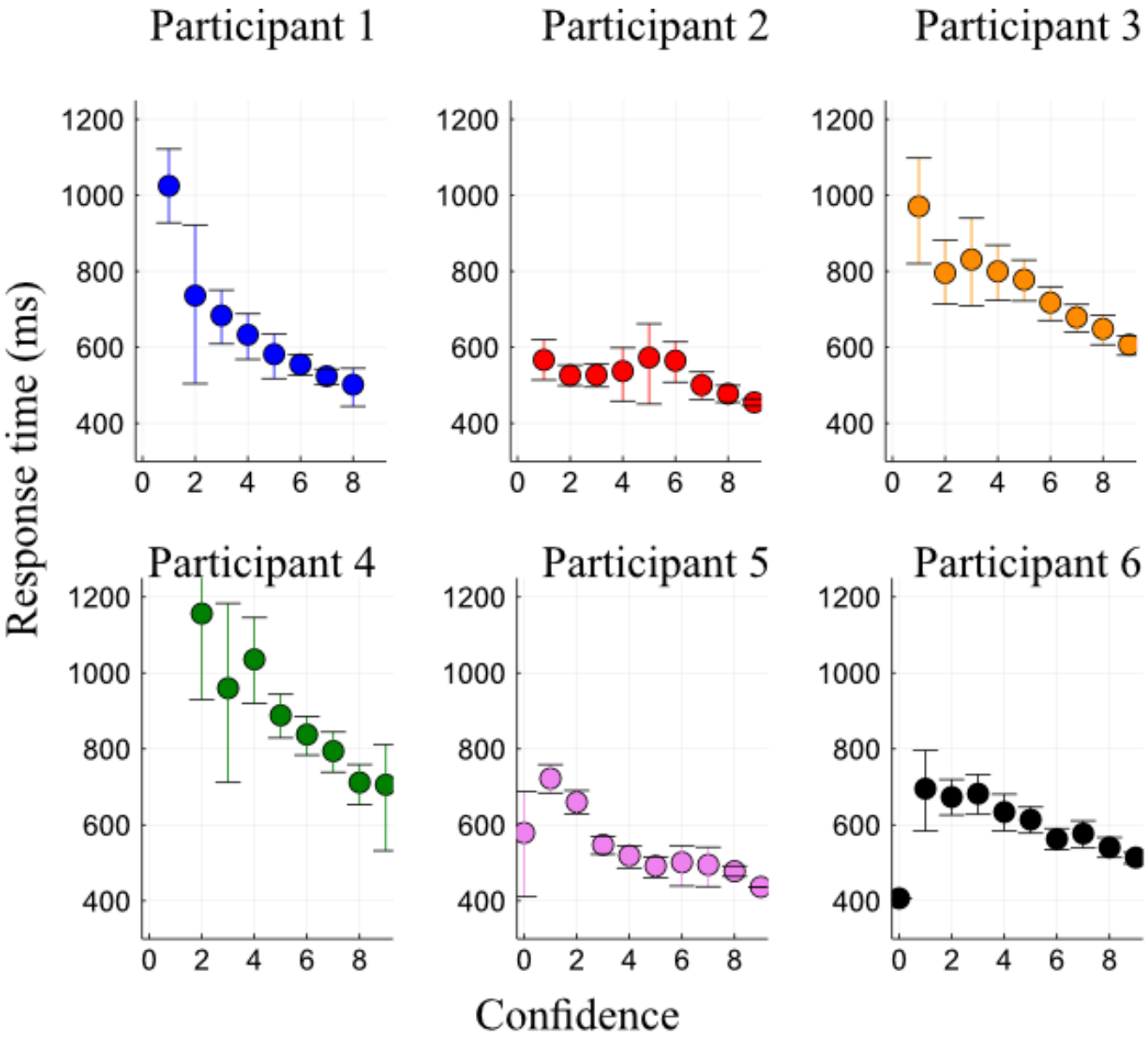
Cat or Dog ?

Experimental setup

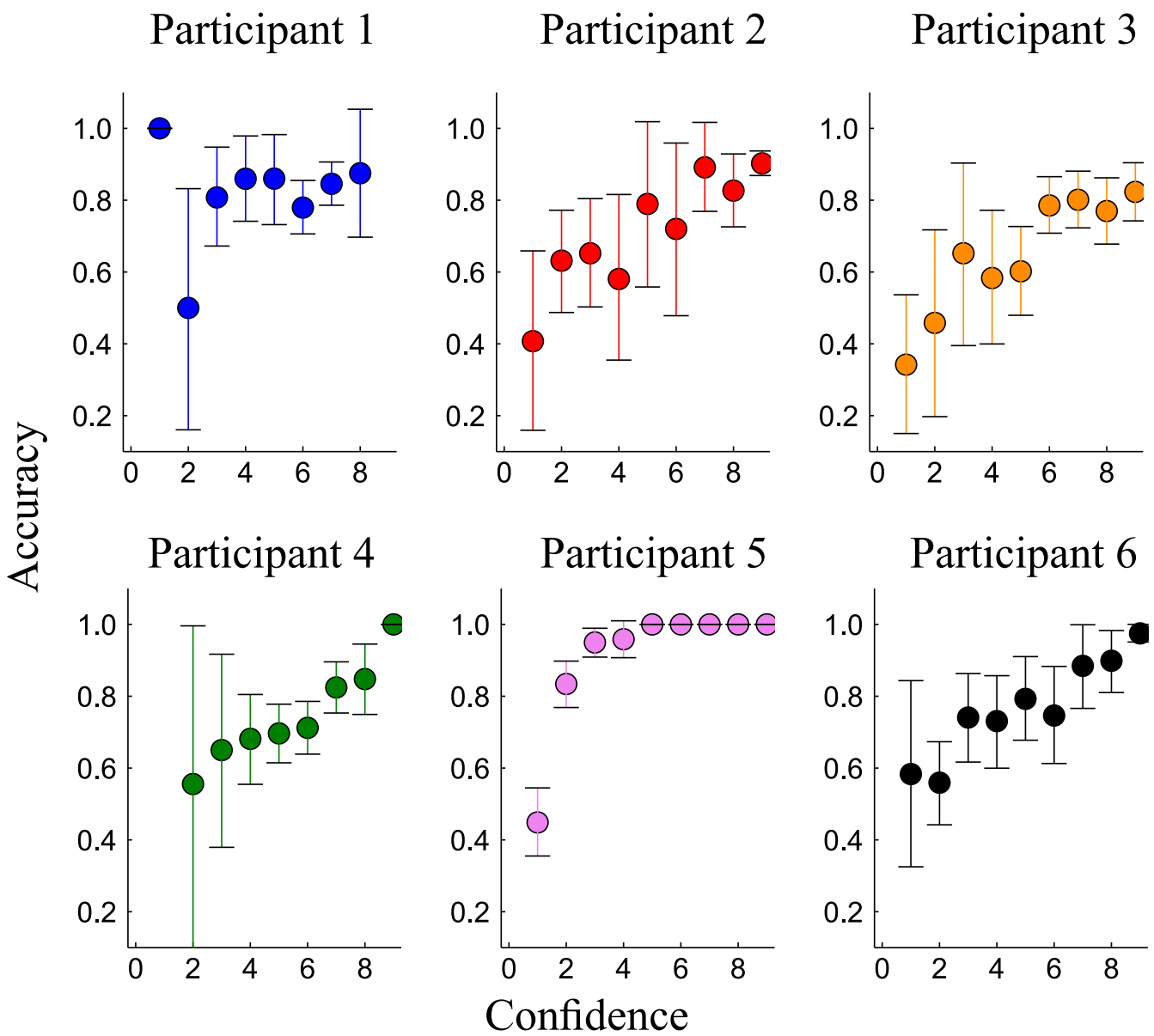


K. Berlemont et al. (2020). "Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions". *Scientific reports* 10.1, pp. 1–16.

Confidence and behavior



Confidence and behavior



Attractor Model

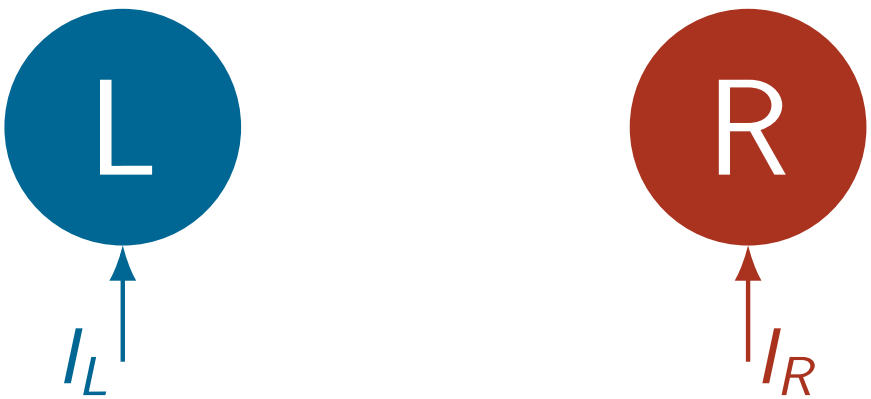
$$\frac{\mathrm{d}S_i}{\mathrm{d}t} = -\frac{S_i}{\tau_s} + (1 - S_i)\,\gamma f(I_{i,tot})$$

$$f(I_{i,tot}) = \frac{af(I_{i,tot}) - b}{1 - \exp\left[-d\left(af(I_{i,tot}) - b\right)\right]}$$

K.-F. Wong and X.-J. Wang (2006). "A Recurrent Network Mechanism of Time Integration in Perceptual Decisions". *Journal of Neuroscience* 26.4, pp. 1314–1328.

Attractor Model

$$I_{L,tot} = I_0 + I_L + I_{noise,L}$$



K.-F. Wong and X.-J. Wang (2006). "A Recurrent Network Mechanism of Time Integration in Perceptual Decisions". *Journal of Neuroscience* 26.4, pp. 1314–1328.

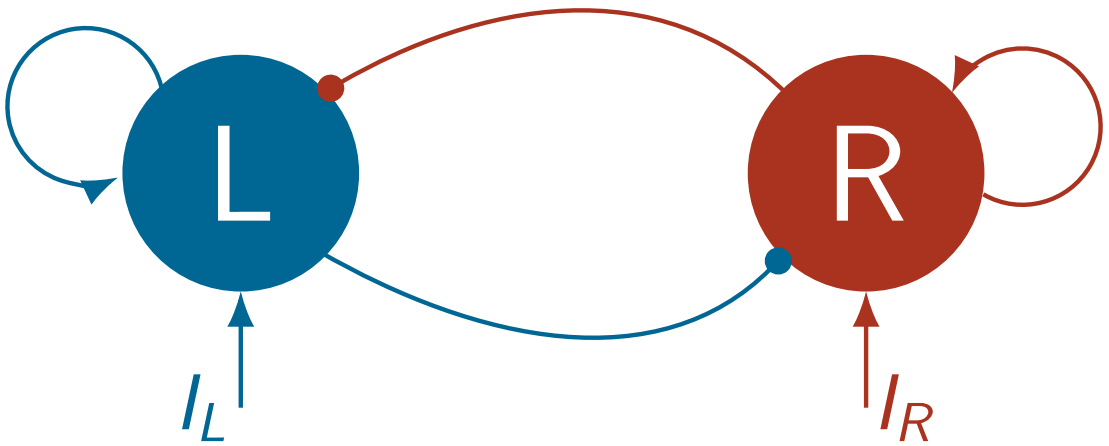
Attractor Model

$$I_{L,tot} = I_0 + I_L + I_{noise,L} + J_{LL} S_L$$

K.-F. Wong and X.-J. Wang (2006). "A Recurrent Network Mechanism of Time Integration in Perceptual Decisions". *Journal of Neuroscience* 26.4, pp. 1314–1328.

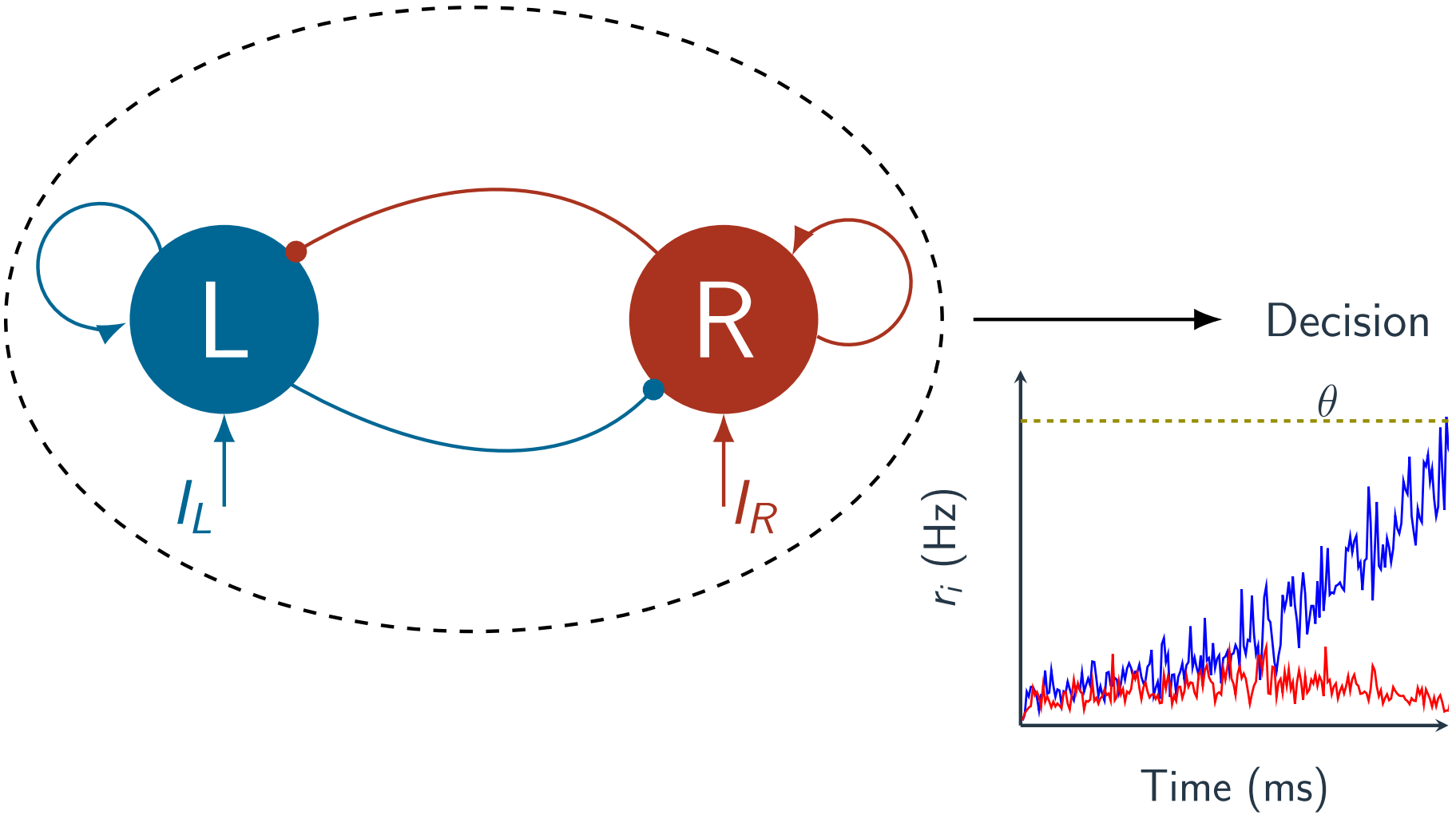
Attractor Model

$$I_{L,tot} = I_0 + I_L + I_{noise,L} + J_{LL}S_L - J_{LR}S_R$$



K.-F. Wong and X.-J. Wang (2006). "A Recurrent Network Mechanism of Time Integration in Perceptual Decisions". *Journal of Neuroscience* 26.4, pp. 1314–1328.

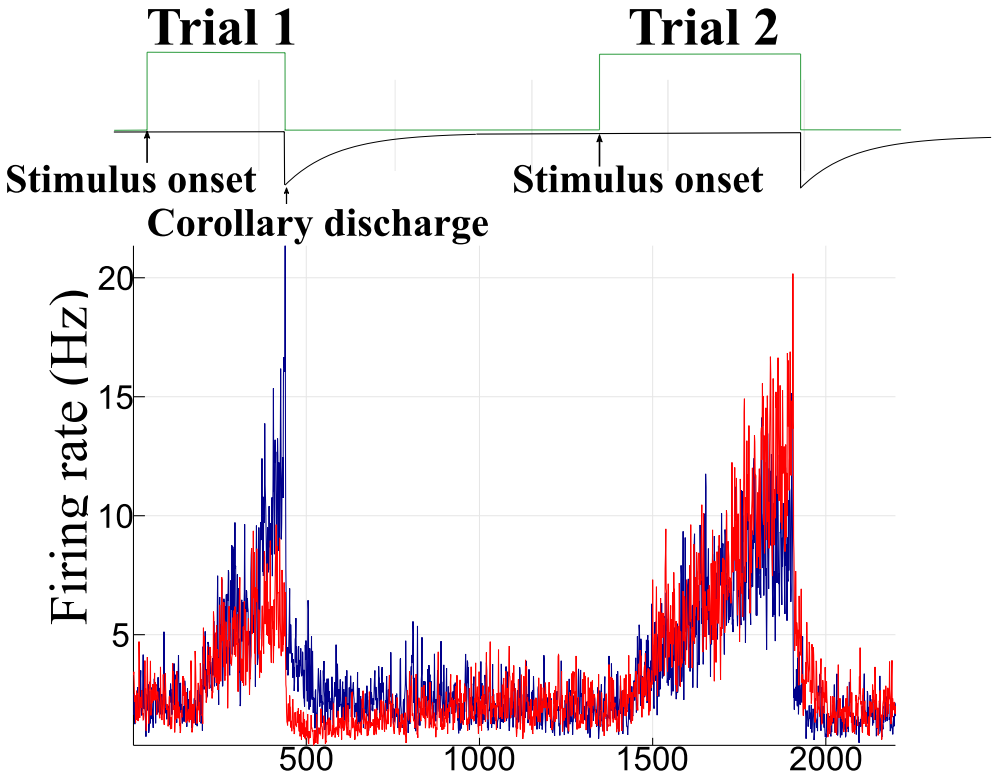
Attractor Model



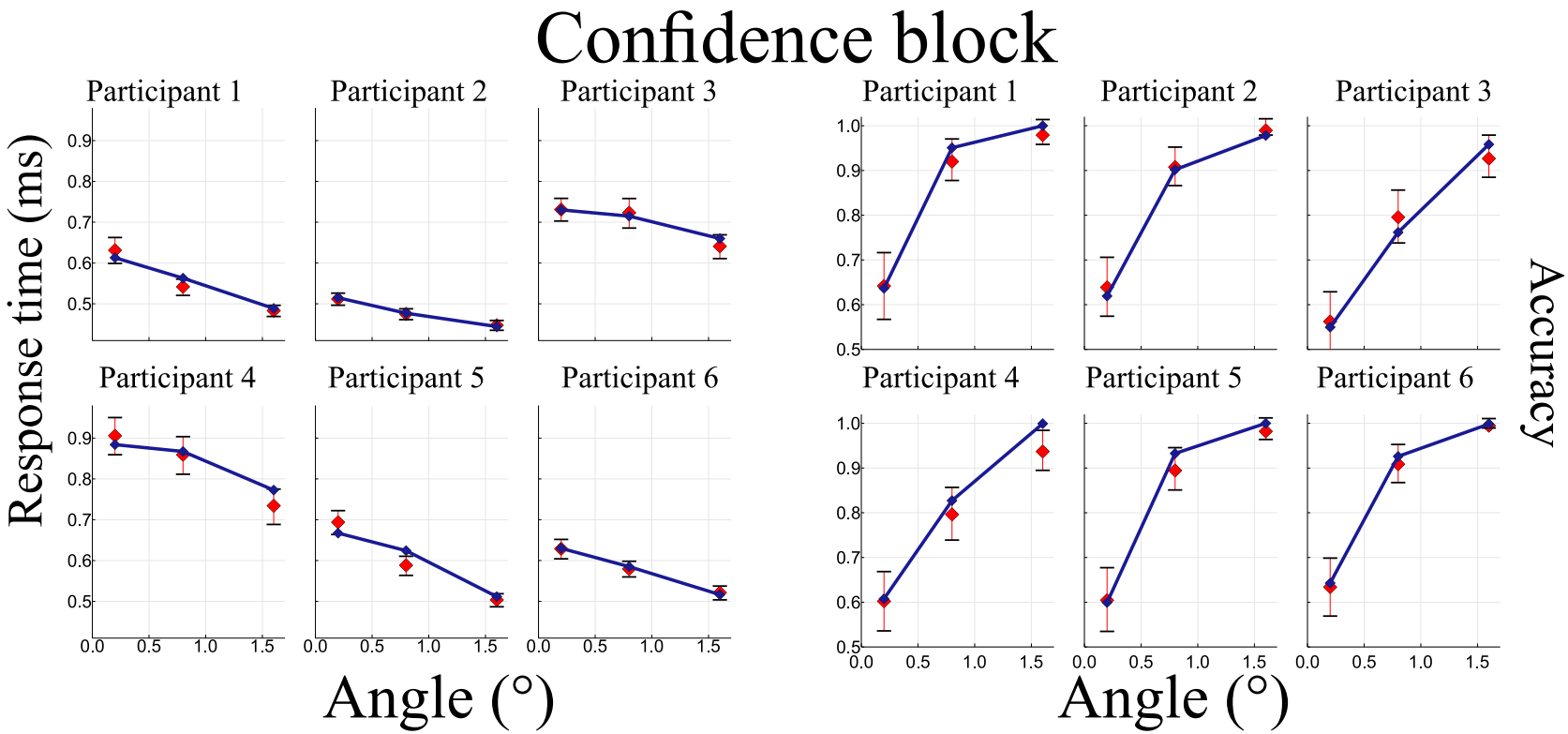
K.-F. Wong and X.-J. Wang (2006). "A Recurrent Network Mechanism of Time Integration in Perceptual Decisions". *Journal of Neuroscience* 26.4, pp. 1314–1328.

Typical timecourse

Typical timecourse

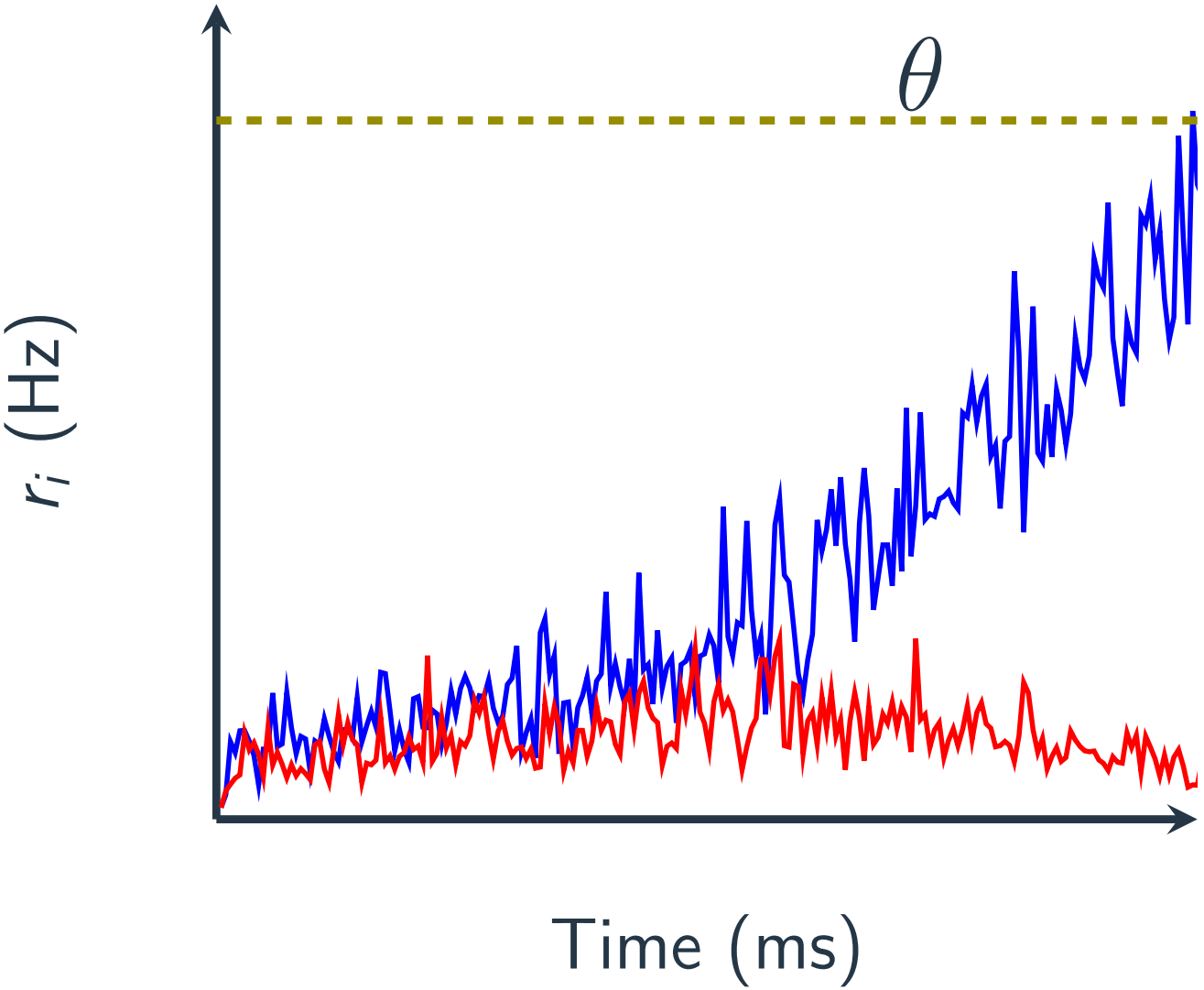


Behavioral results

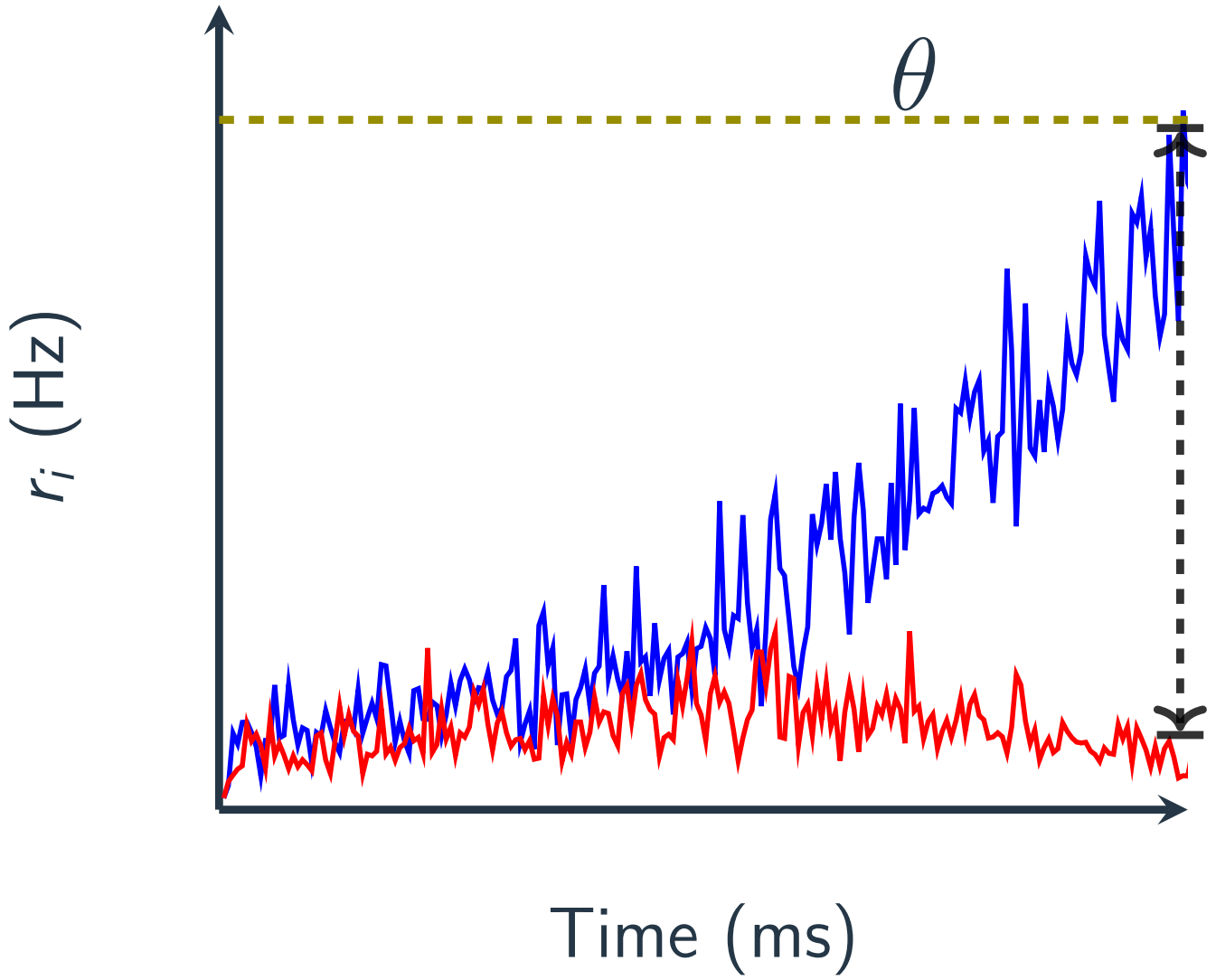


K. Berlemont et al. (2020). "Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions". *Scientific reports* 10.1, pp. 1–16.

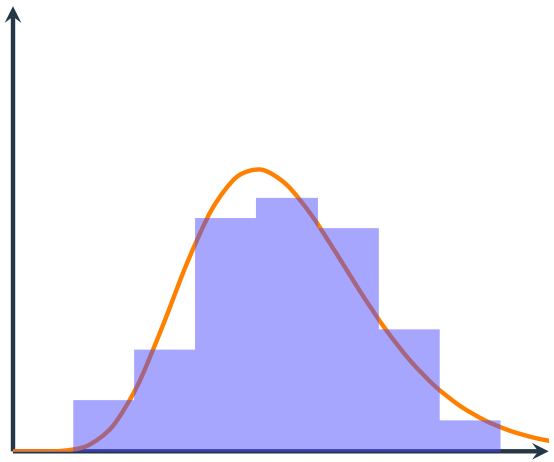
Confidence modelisation



Confidence modelisation

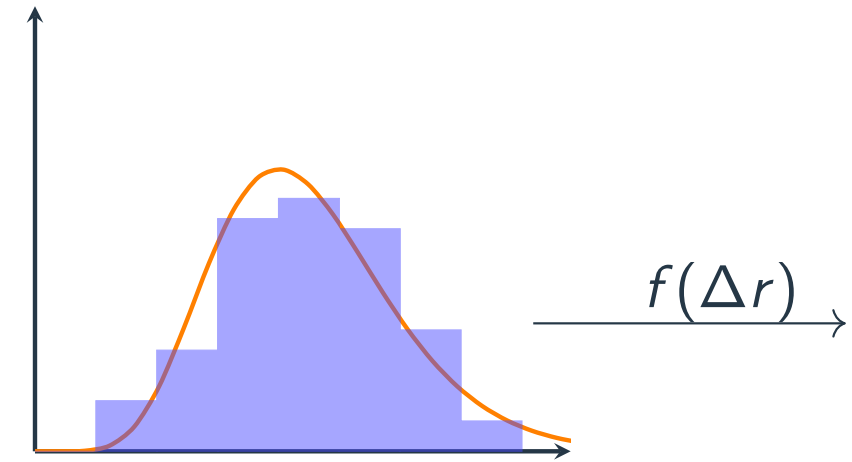


Confidence modelisation

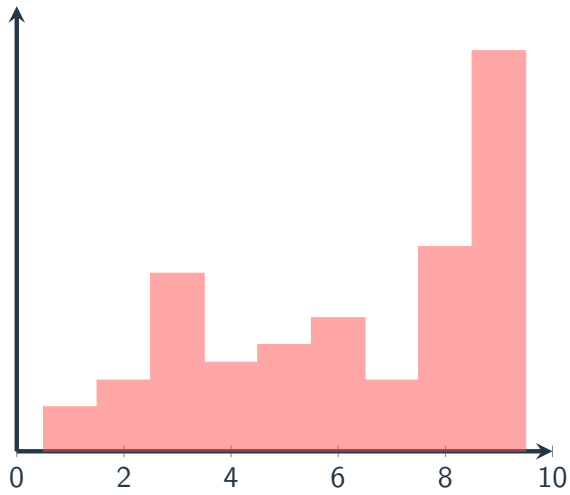


Δr (Hz) - Simulations

Confidence modelisation

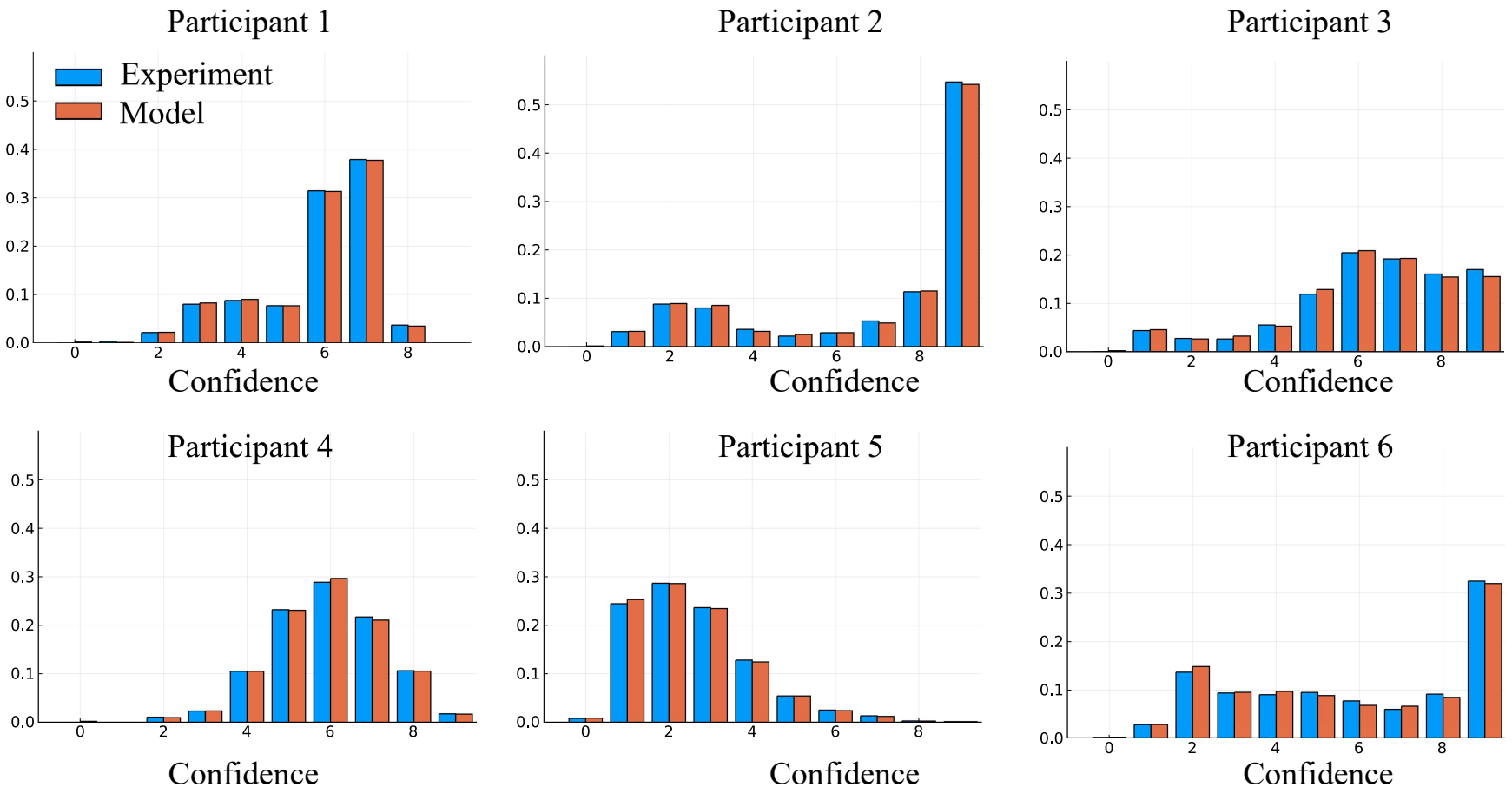


Δr (Hz) - Simulations



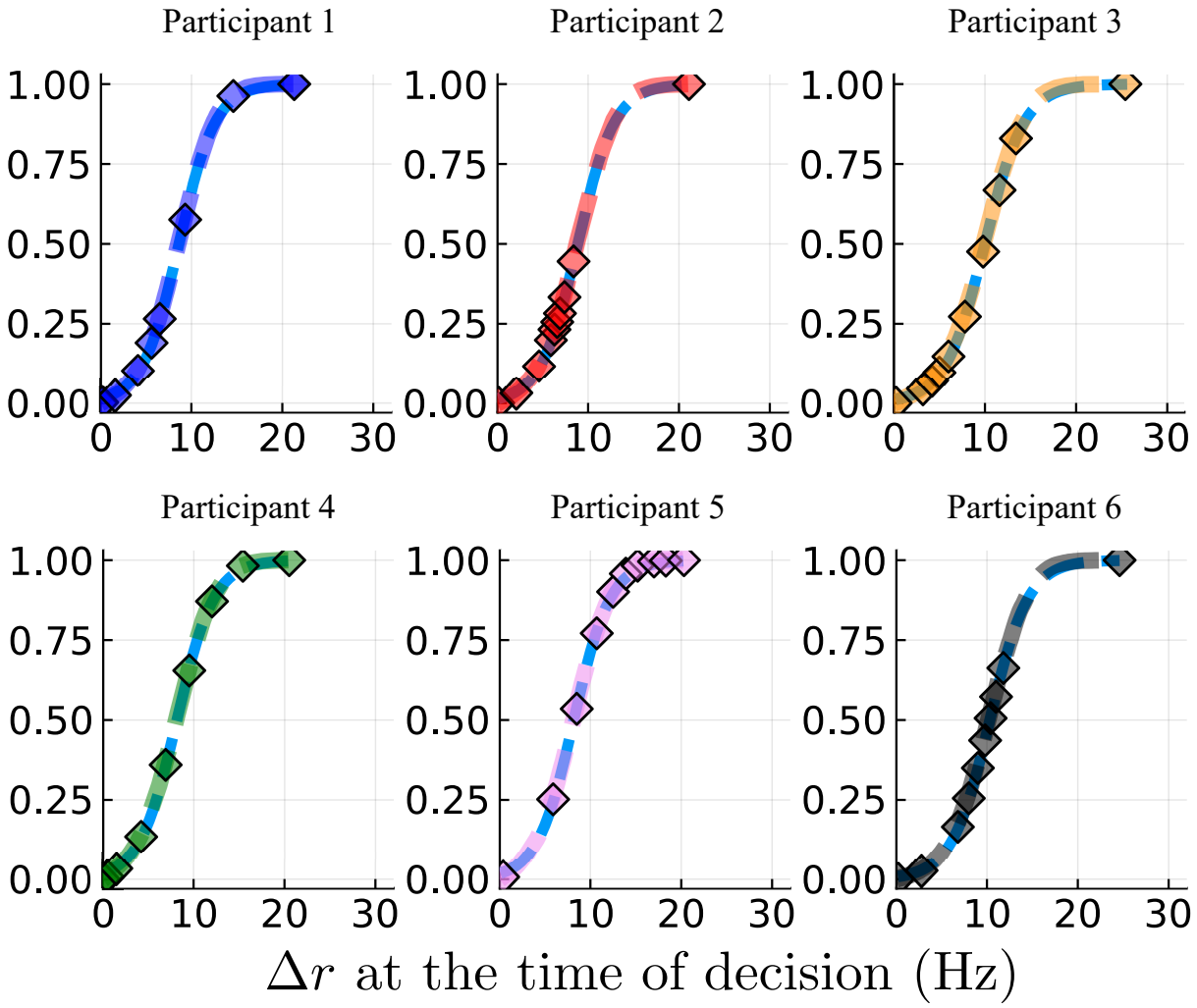
Confidence (Data)

Histogram matching



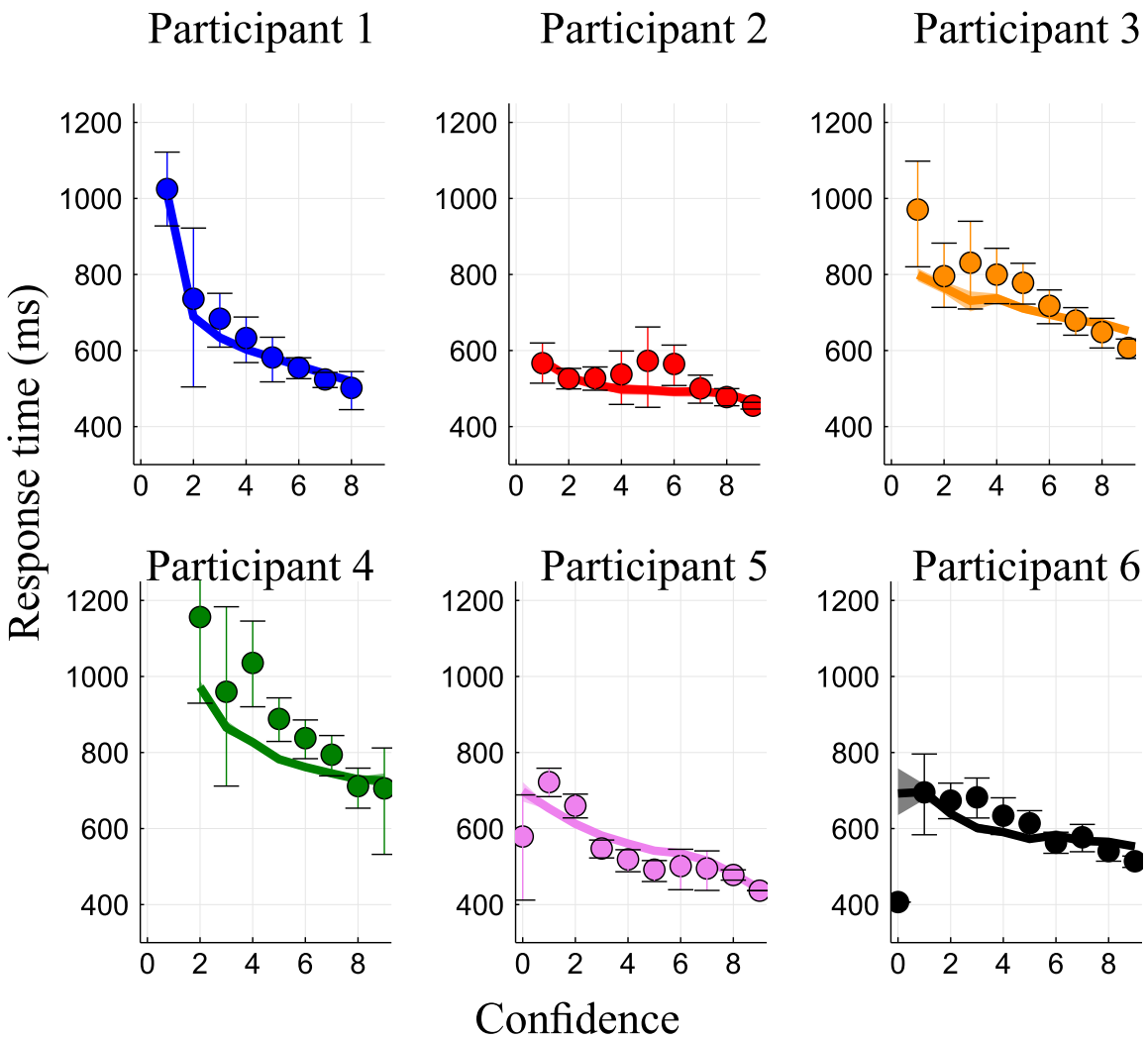
K. Berlemont et al. (2020). "Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions". *Scientific reports* 10.1, pp. 1–16.

Histogram matching



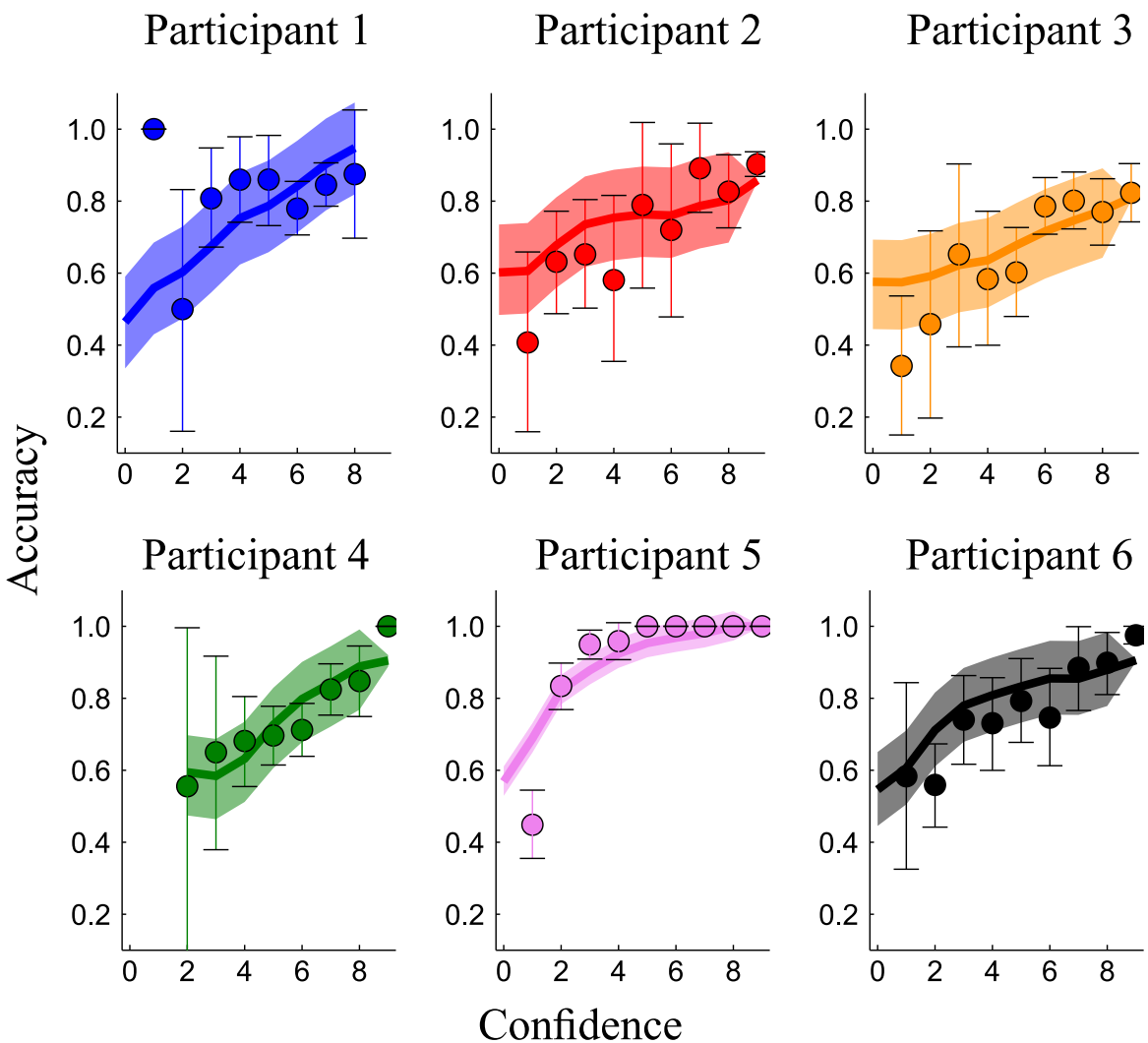
K. Berlemont et al. (2020). "Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions". *Scientific reports* 10.1, pp. 1–16.

Matching with data



K. Berlemont et al. (2020). "Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions". *Scientific reports* 10.1, pp. 1–16.

Matching with data



K. Berlemont et al. (2020). "Nonlinear neural network dynamics accounts for human confidence in a sequence of perceptual decisions". *Scientific reports* 10.1, pp. 1–16.

Conclusion

- Attractor neural networks can be fitted to individual participants.

Conclusion

- Attractor neural networks can be fitted to individual participants.
- It relates accurately confidence, response times and accuracy.

Conclusion

- Attractor neural networks can be fitted to individual participants.
- It relates accurately confidence, response times and accuracy.
- Non-linearity explains various effects observed in decision-making experiments.