Fast Population Coding

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CNS 2006

Edinburgh

Tennis

< 500ms to 1) infer ideal ball hit point 2) move there 3) decide where to return, 4) prepare return...

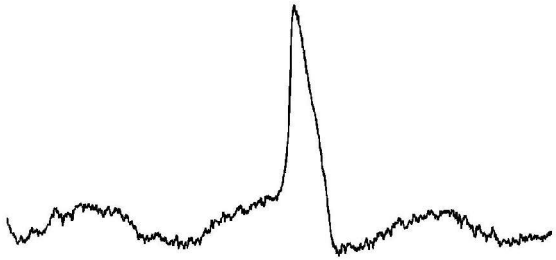
Trajectory knowledge

Fast stimuli $\Longrightarrow$ few spikes

Aim: return serve

1) Represent time-varying stimuli

2) Use spikes

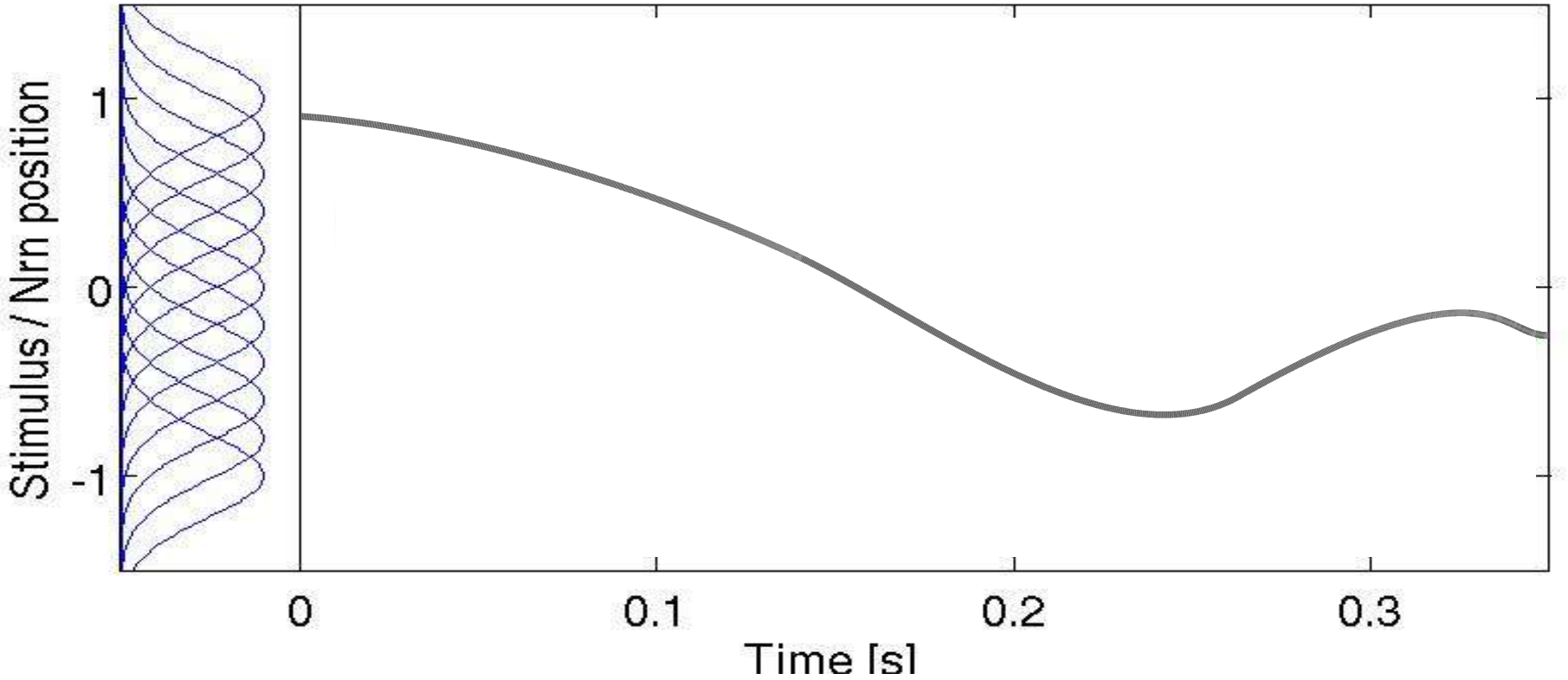


3) Computationally efficient representation

Overview

- Population codes
- Neural network
- Psychophysics

The problem



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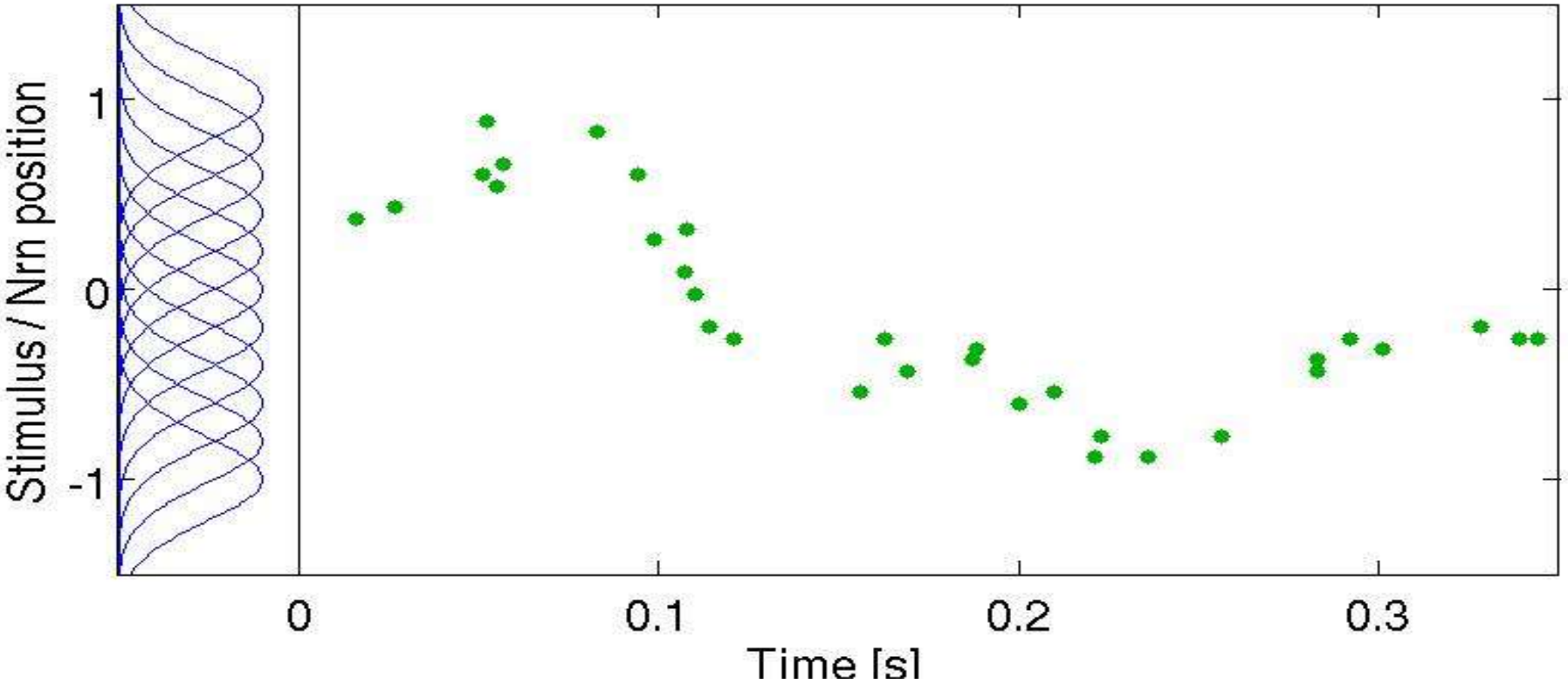

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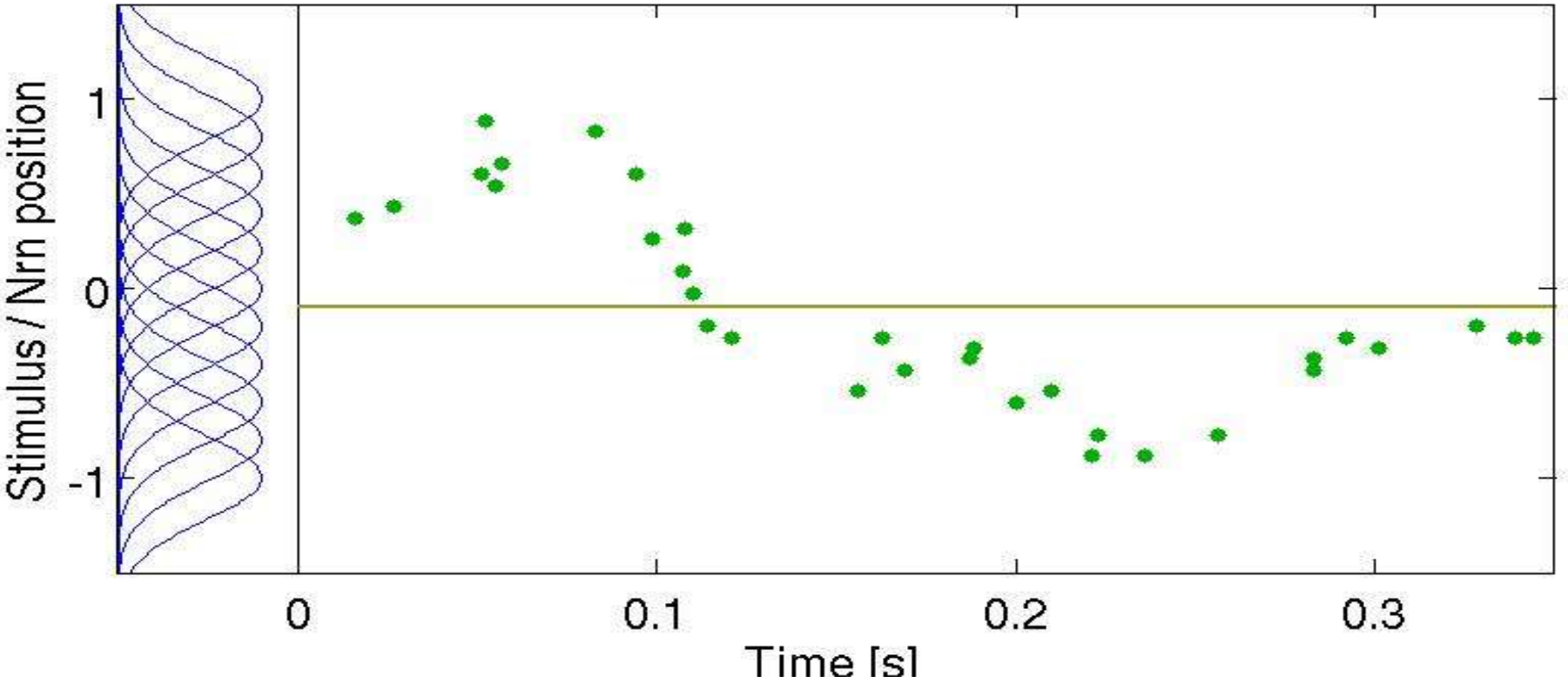

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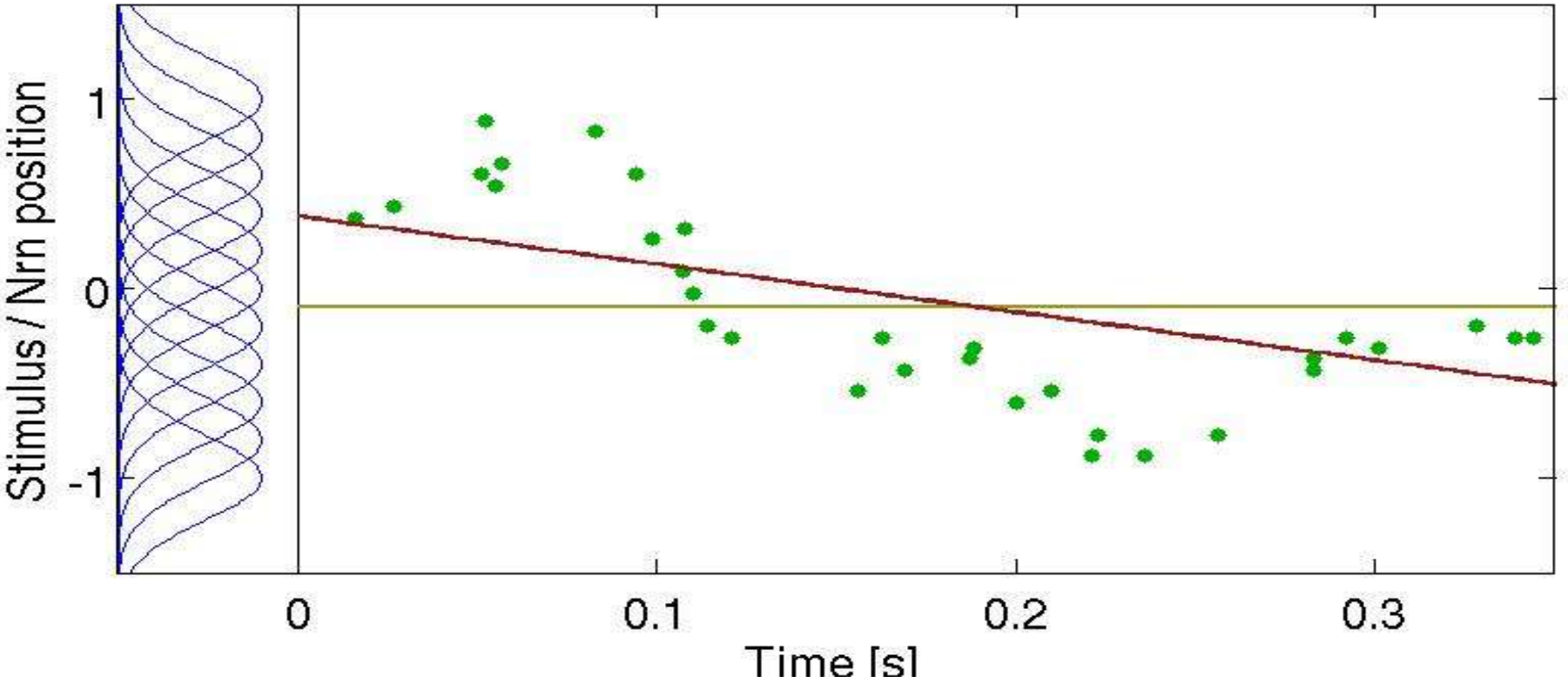

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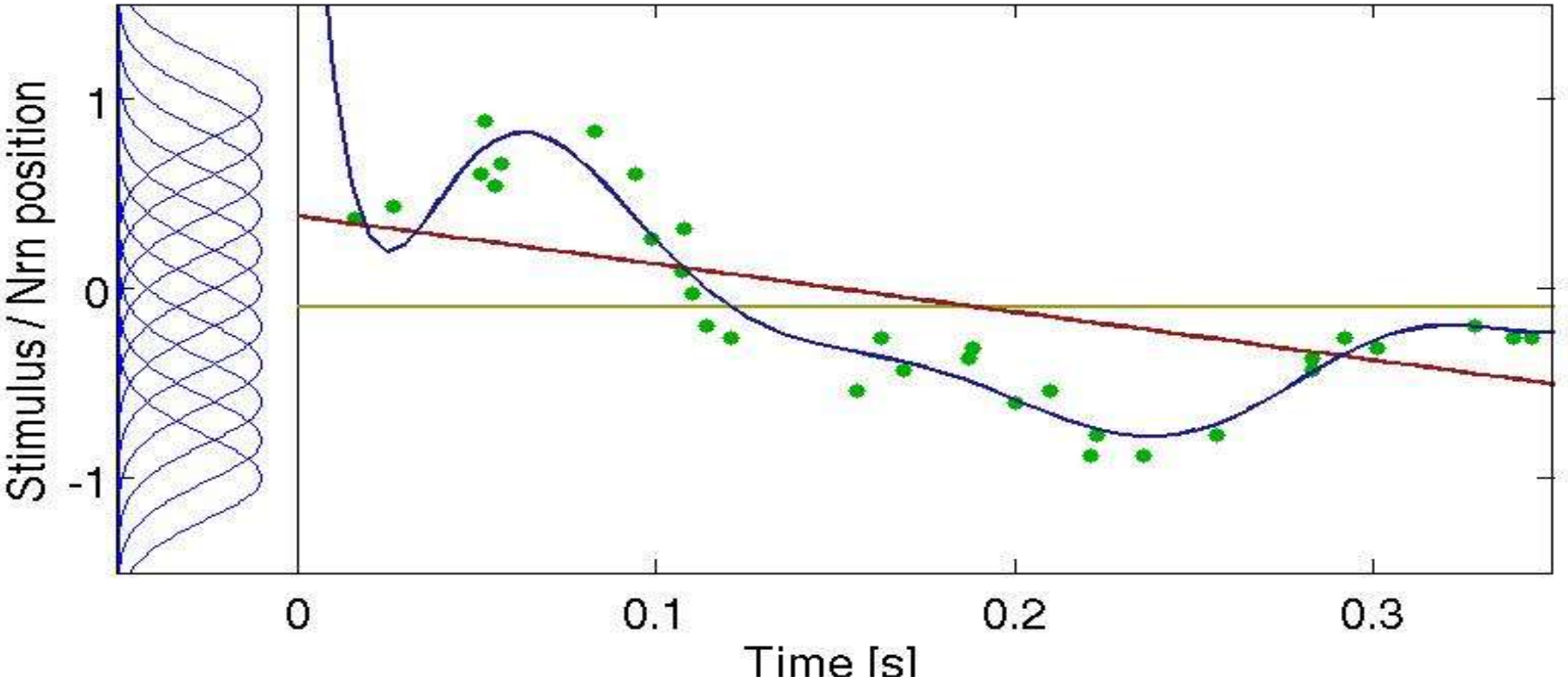

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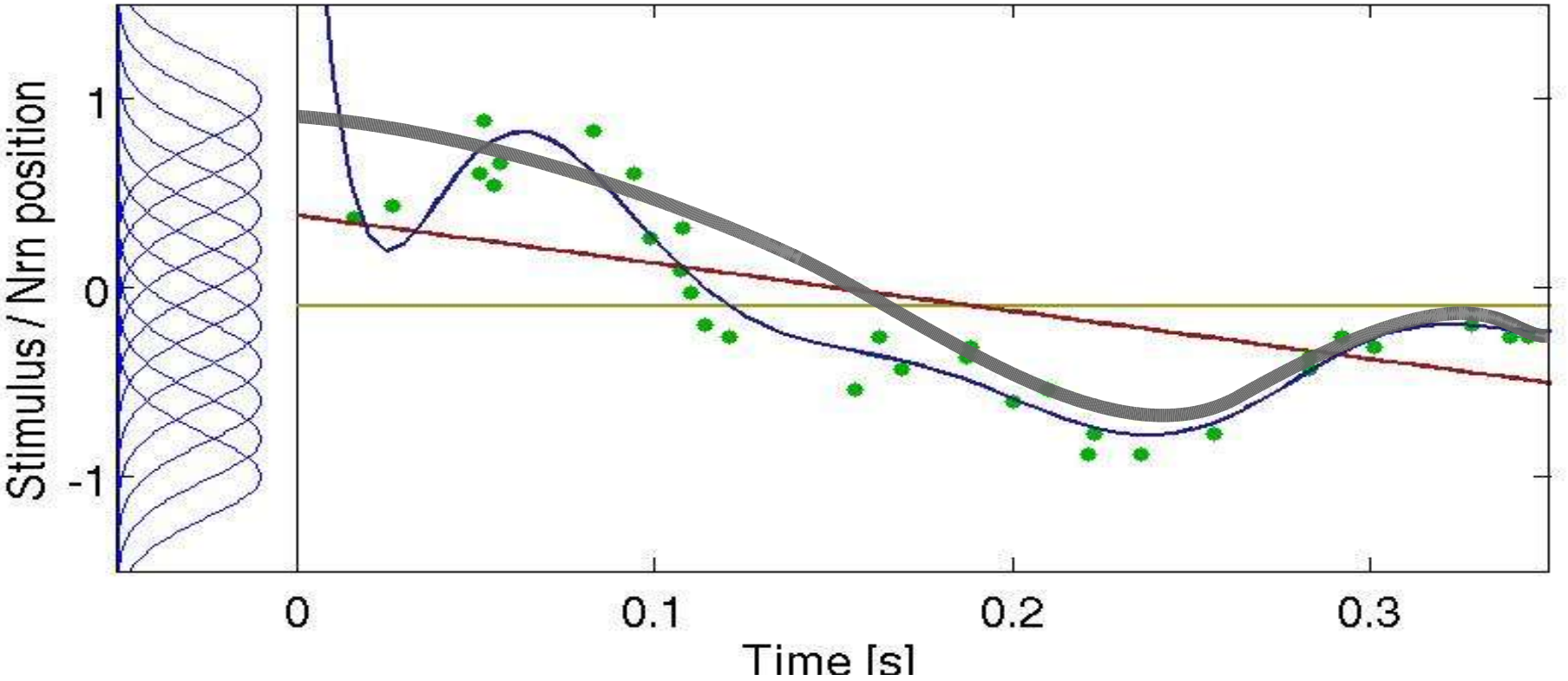
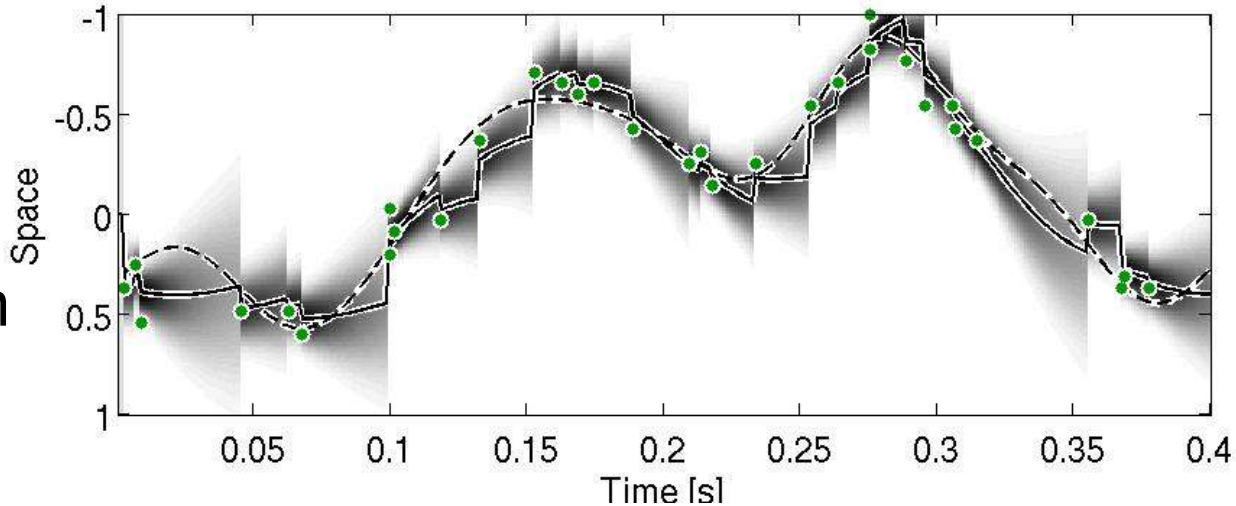
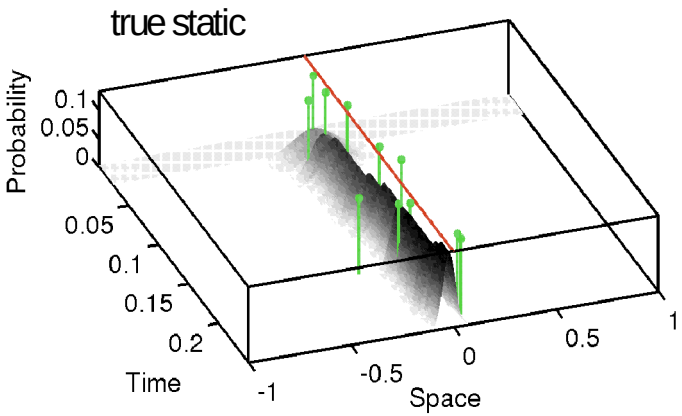


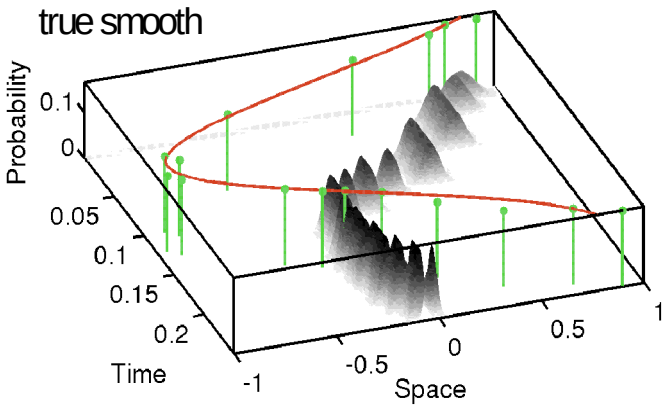
Informative priors

- Informative prior allows accurate representation with sparse spikes



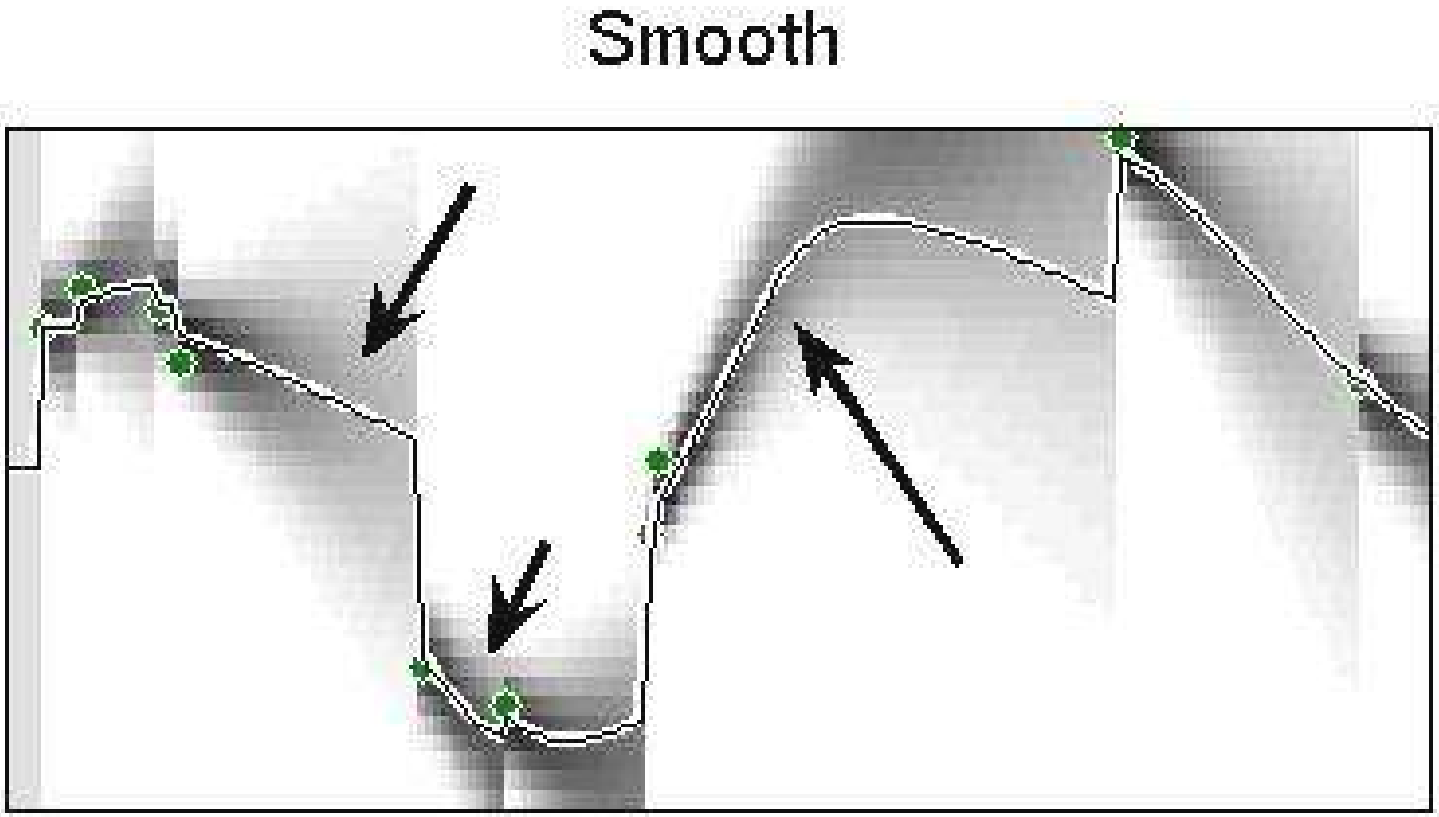
- Need to use right prior: arbitrarily large losses for wrong prior





Prior determines code structure

- Smooth prior allows **no** recursive information access



- Cannot interpret spikes independently

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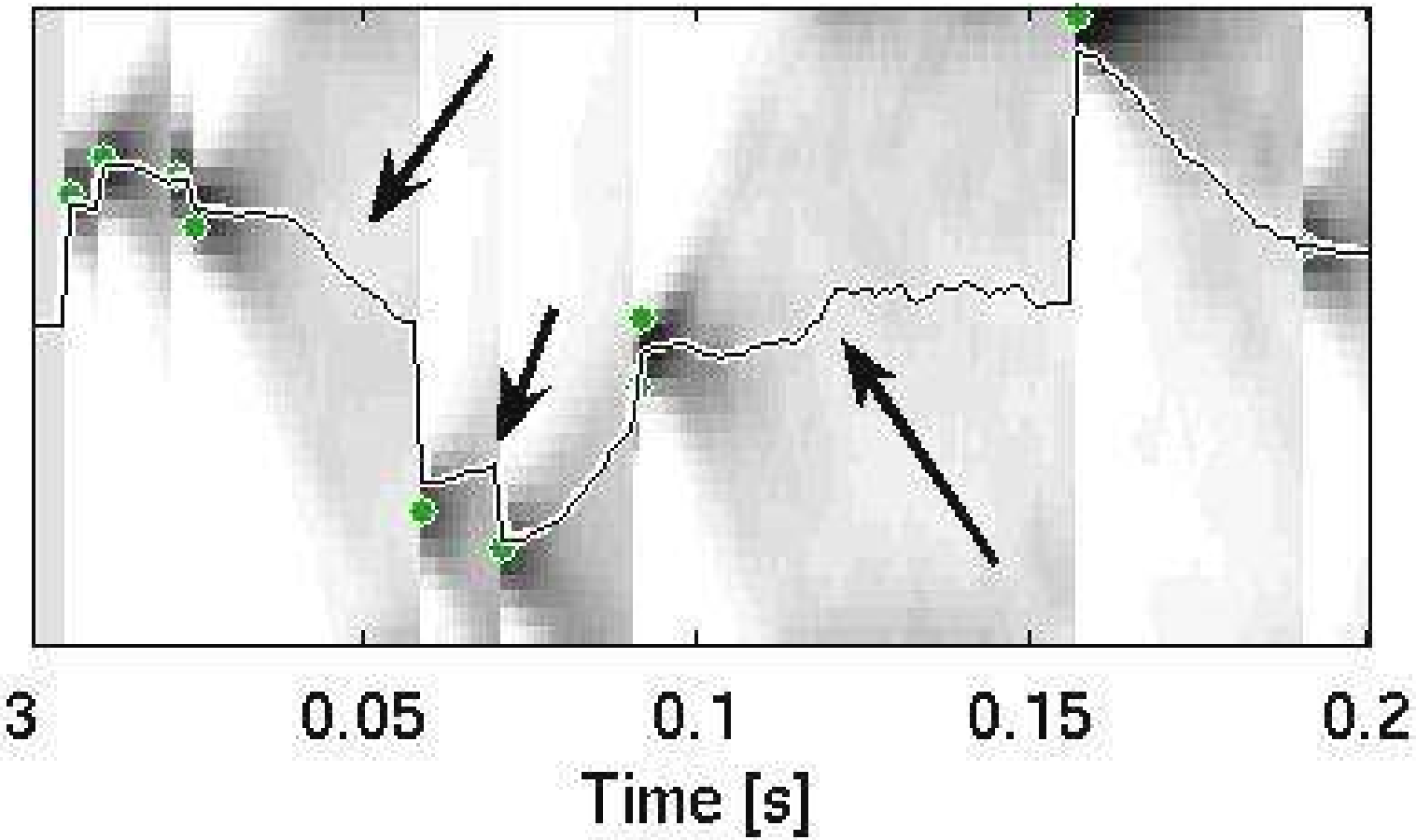

- Cannot interpret spikes independently -> Recode

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  - Prior enables use of spikes to represent trajectories
  - But :: natural priors -> complex code
- Recurrent neural network
- Psychophysics

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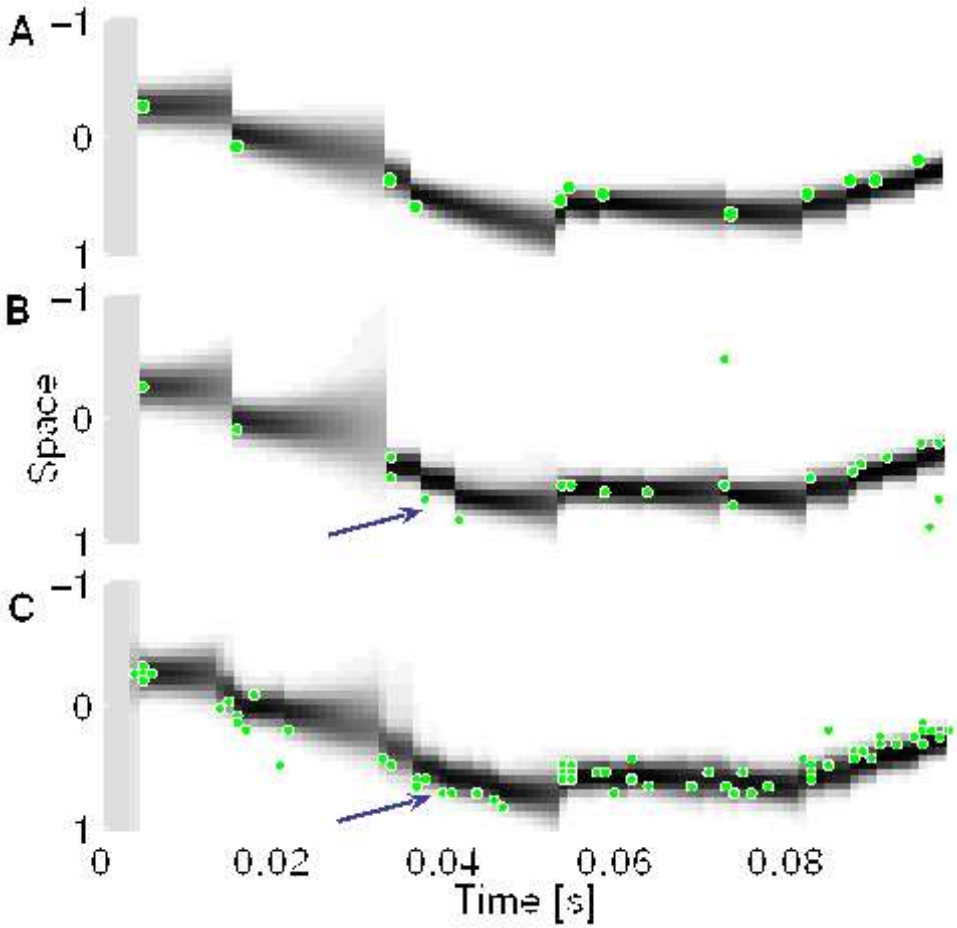
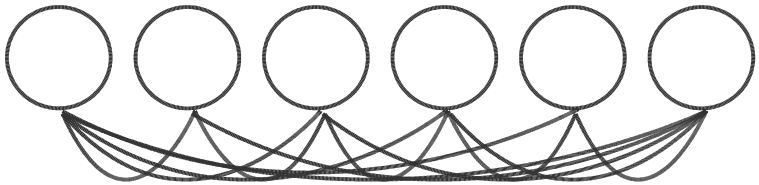
Network task: Recoding

Give network input spikes and true posterior. Objective: find simply decodeable spikes that represent the true posterior well.

Add in spikes that represent the prior.



Nonlinear recurrent neural network



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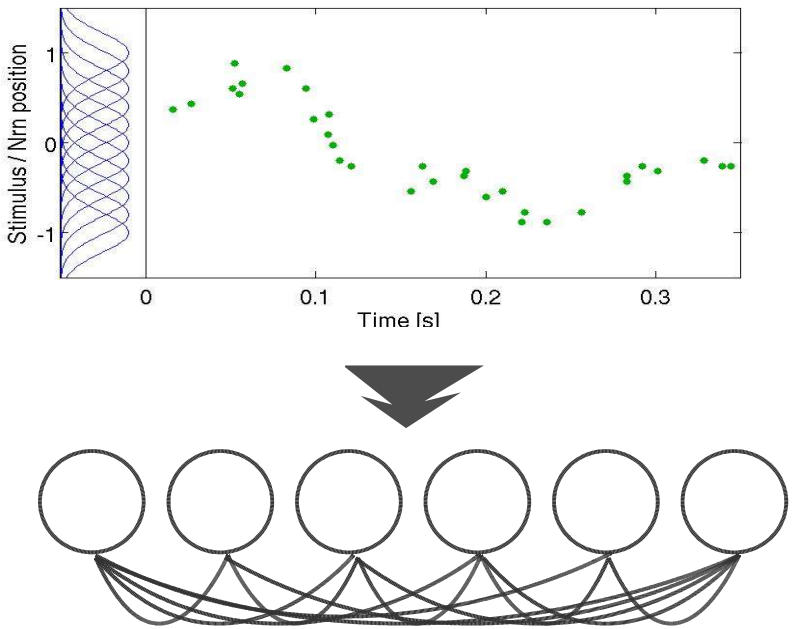

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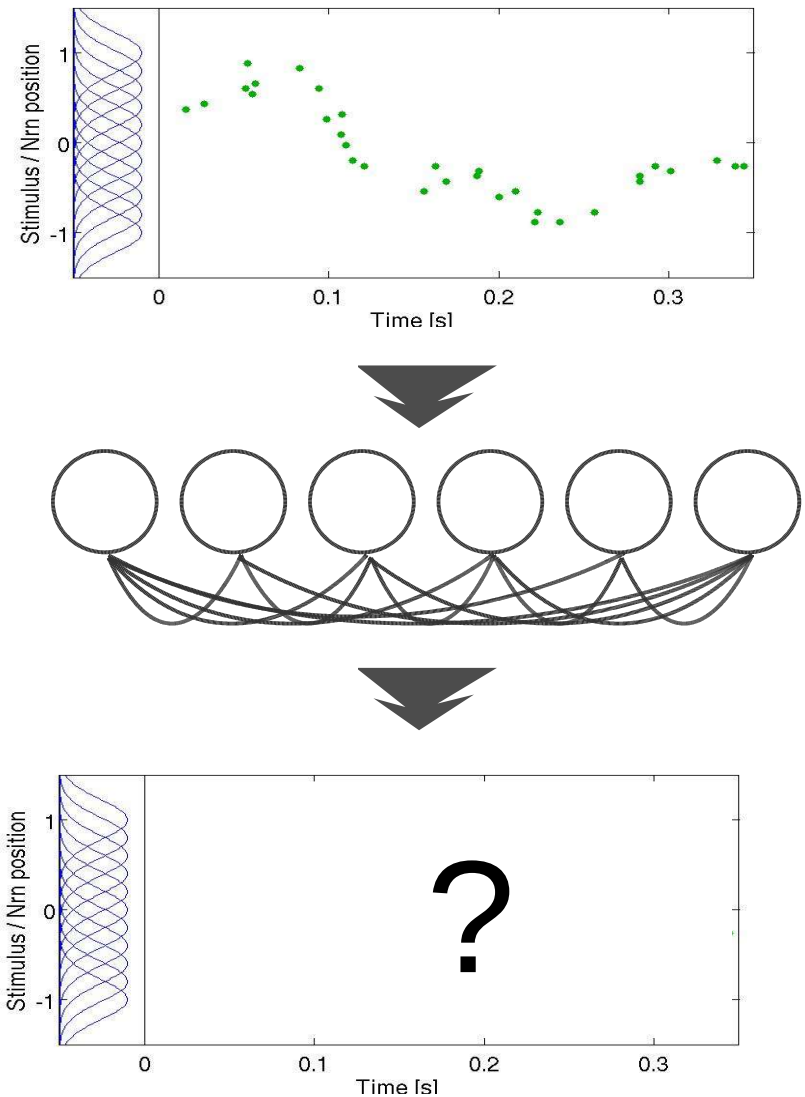

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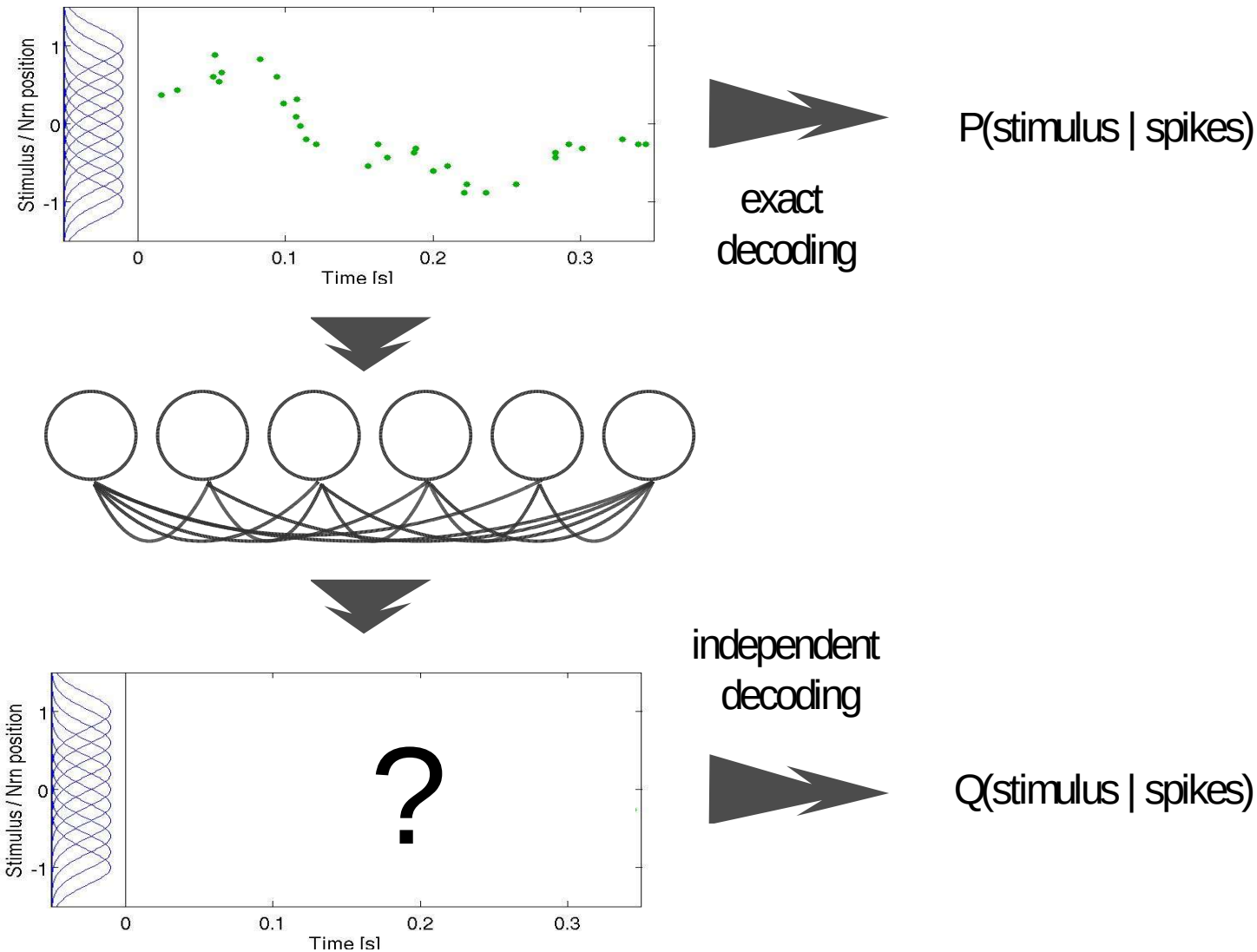

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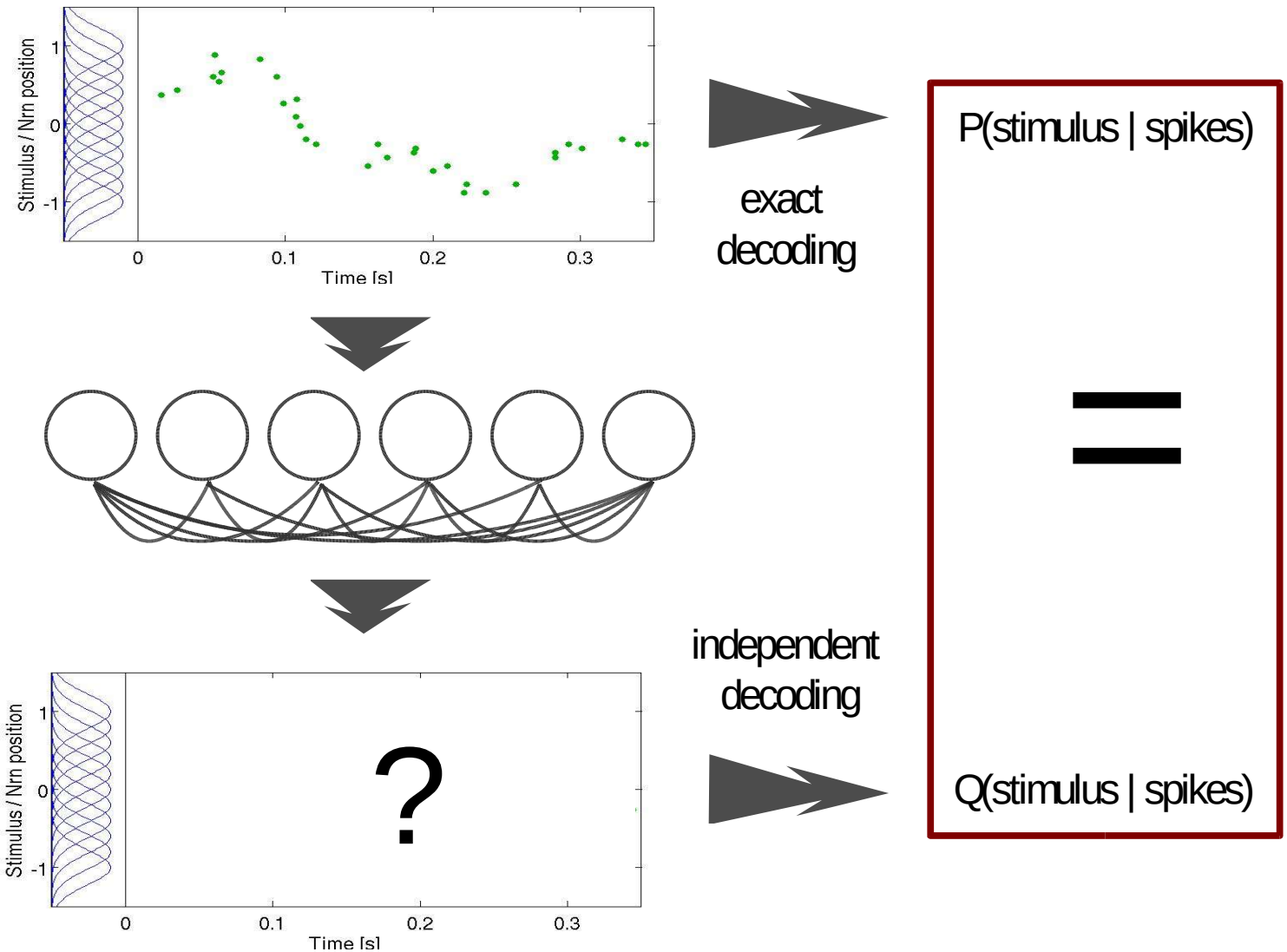
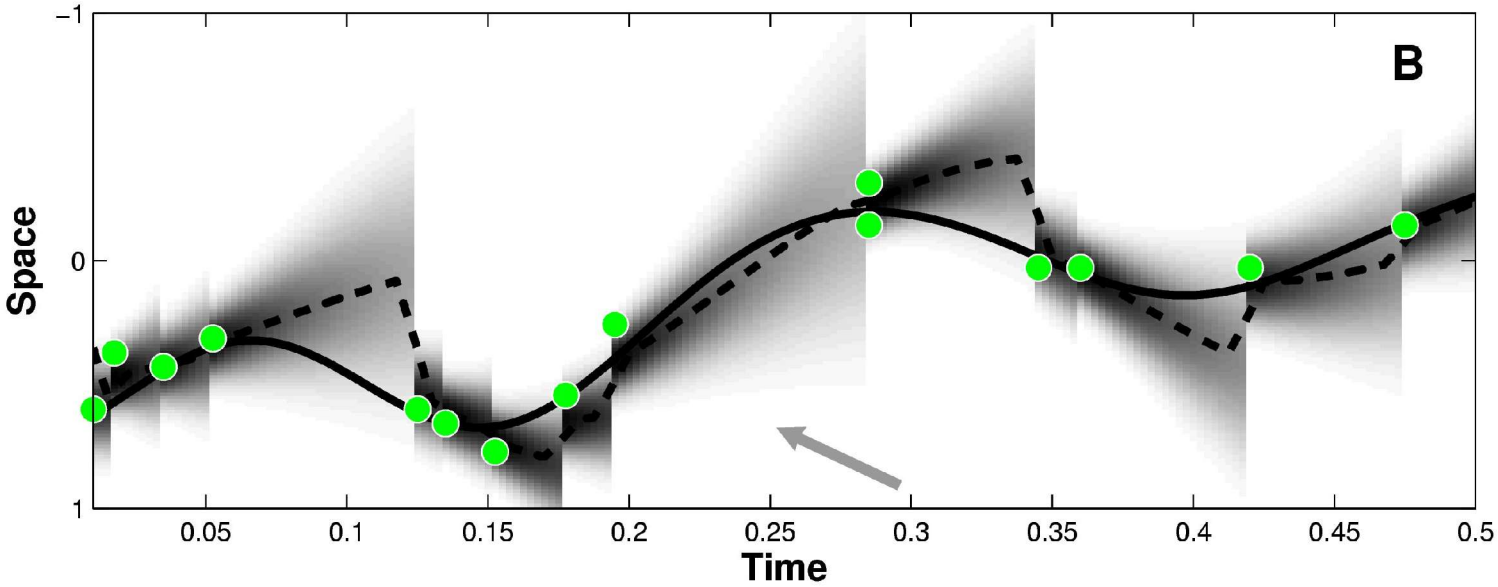


Smooth recoding



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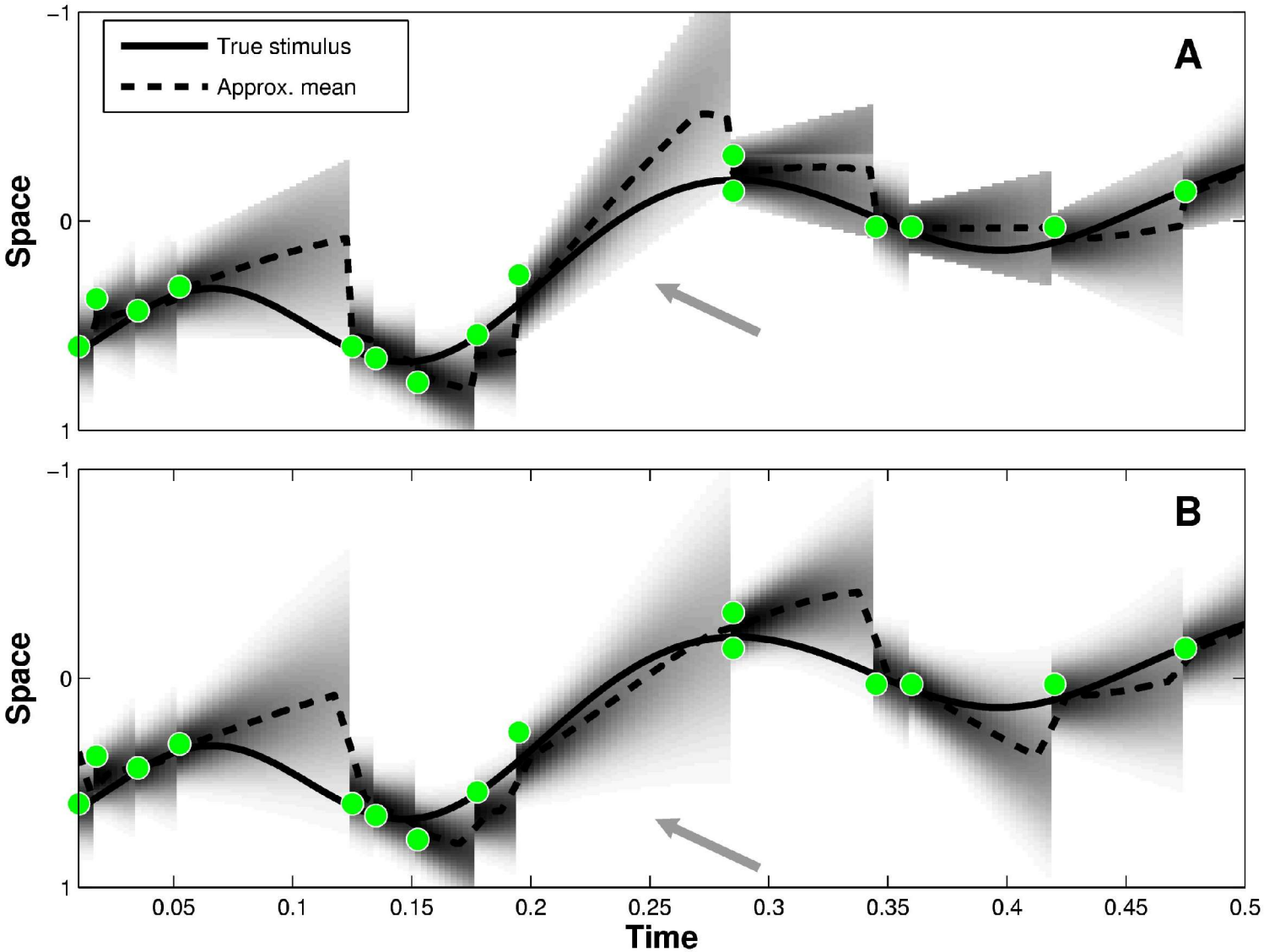
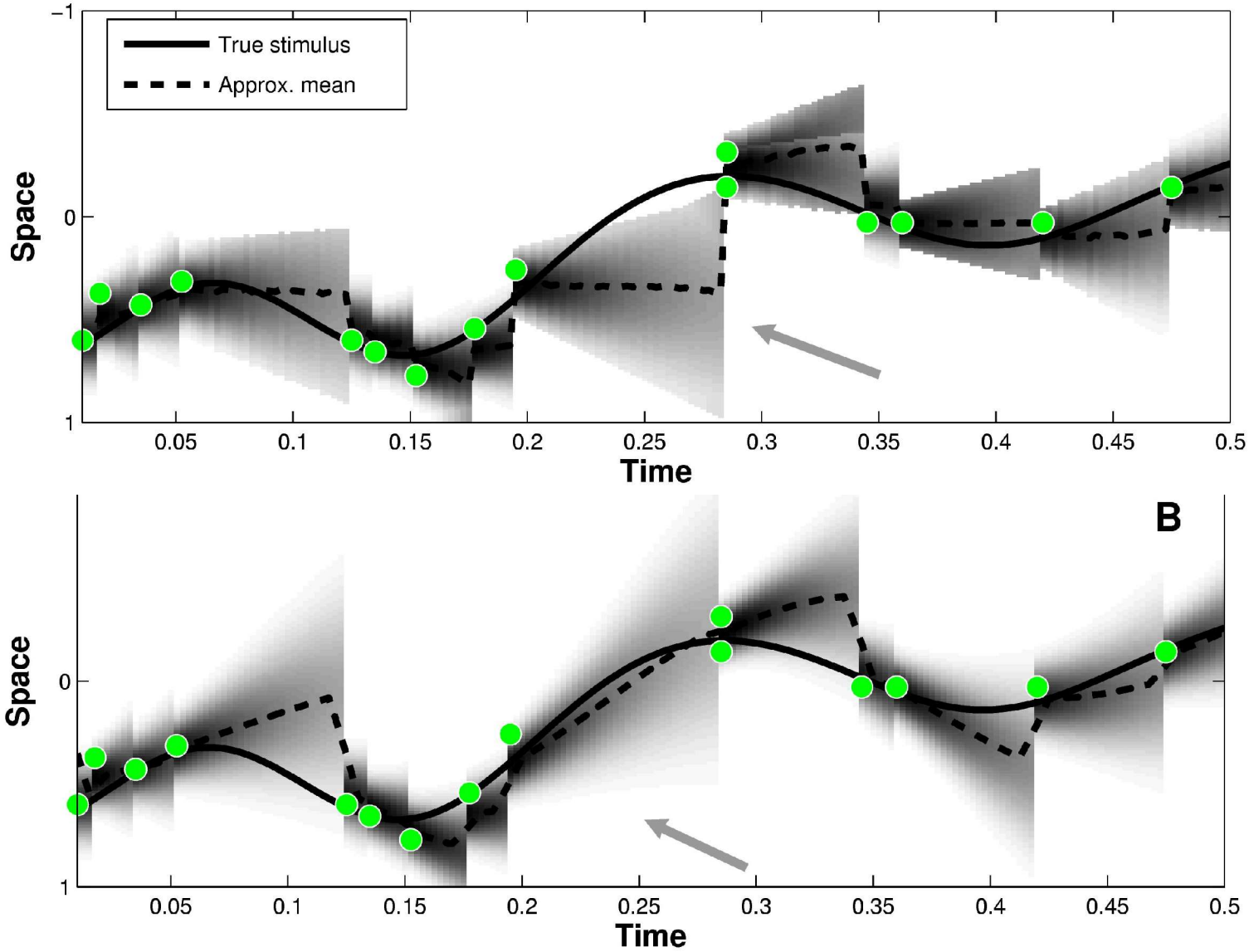
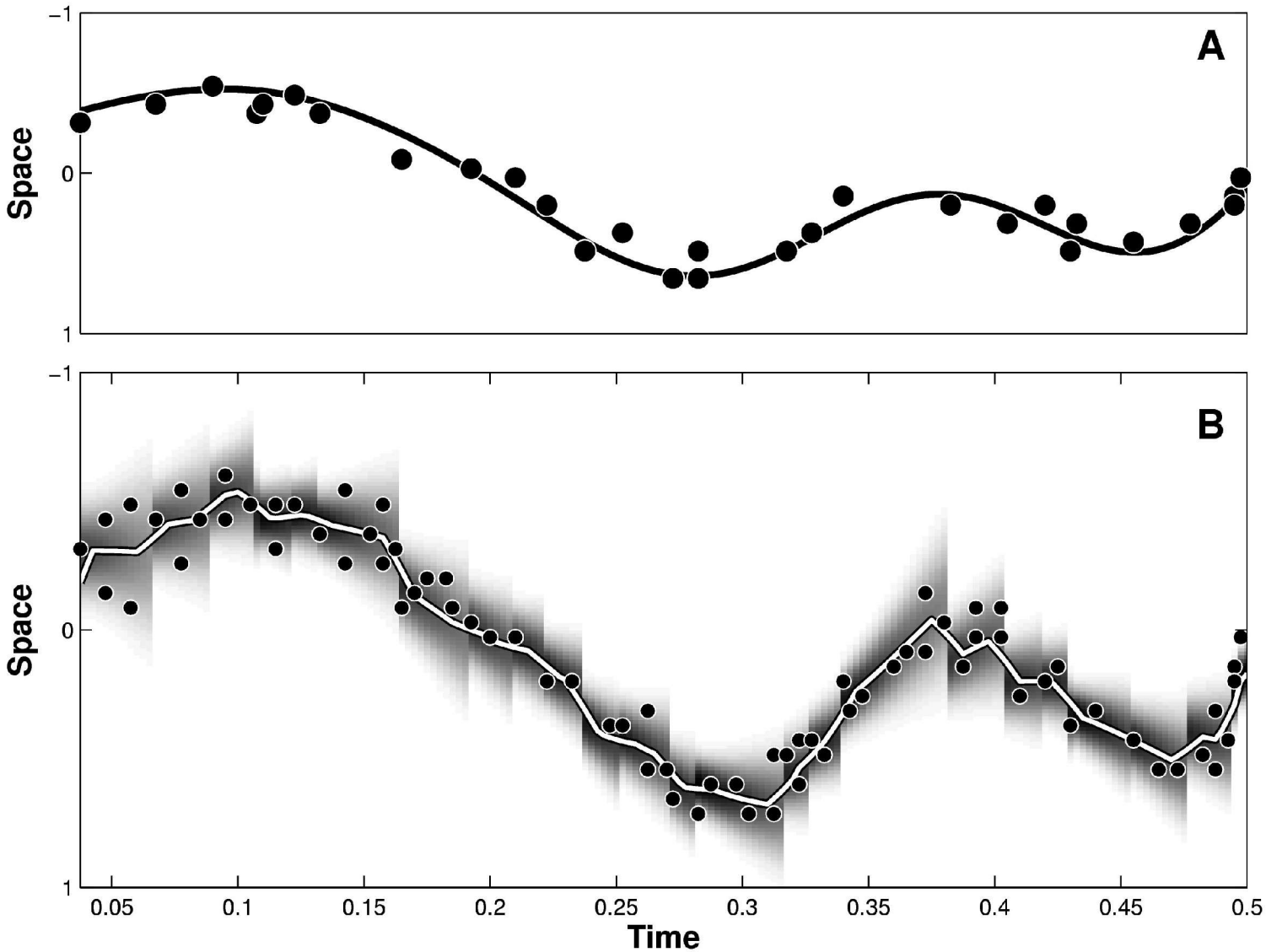


Priors are learned



Inserted spikes



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- Population codes
  - Prior enables use of spikes to represent trajectories
  - But :: natural priors -> complex code
- Recurrent neural network
  - Smooth priors + simple code
  - Nonlinear, recursive approximation
  - Temporal prior encoded in recurrent weight of RNN
- Psychophysics

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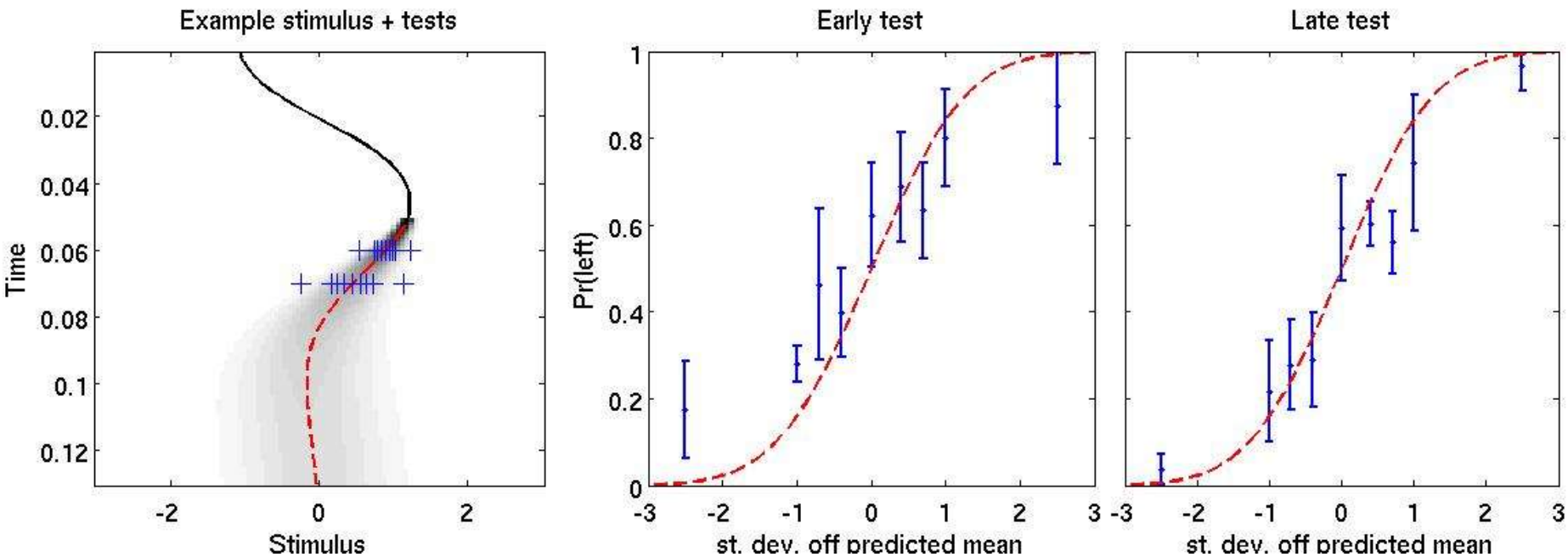
  - is this relevant?

Preliminary psychophysics

Human observers can correctly extrapolate smooth motion



Overview

- Population codes
  - Prior enables use of spikes to represent trajectories
  - But :: natural, smooth priors engender complex code
- Recurrent neural network
  - we can have our cake and eat it: smooth priors + simple code
  - Nonlinear, recursive approximation
  - Trajectory prior encoded in recurrent weight of RNN
- Psychophysics
  - preliminary results

Joint work with

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Peggy Series

Discussion

- Need for more data
  - Psychophysics, neurones, stimulus statistics
  - Re-analysis of decoding datasets, eg hippocampus
- Supervised / Unsupervised learning
- Other sources of uncertainty
  - Computational uncertainty (aperture problem)
  - (Doubly) distributional population codes