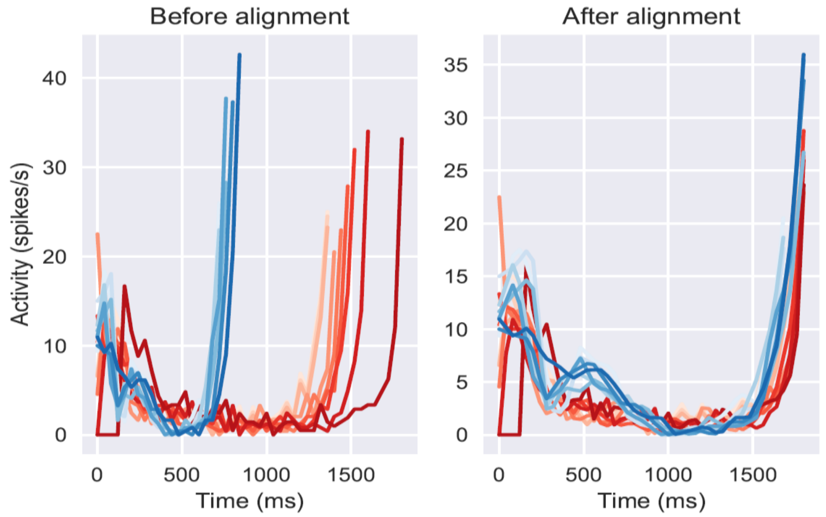
Lab meeting 11/28/17

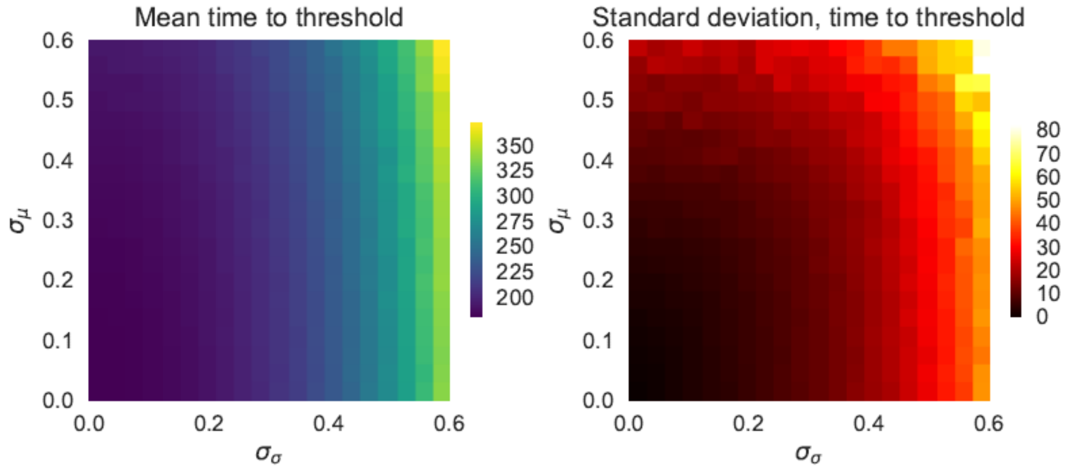
Nhat Minh Le

Overview

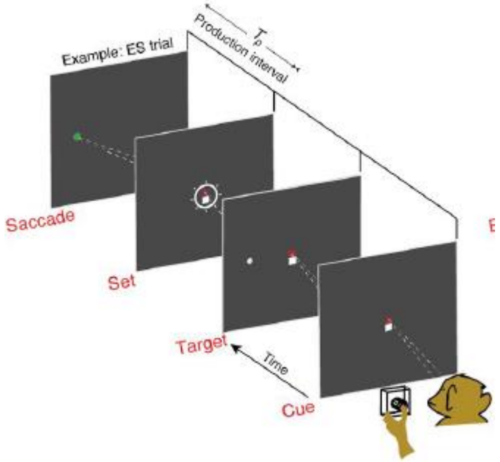
Part I: Techniques to quantify stretching of neural data



Part II: Noise in two-neuron model



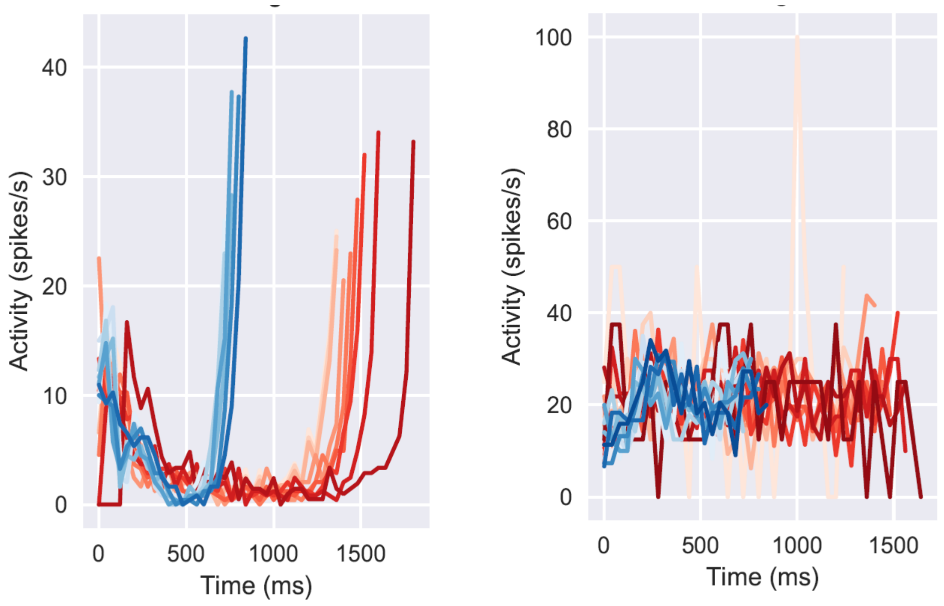
Part I: Stretching of neural data



Goal: given a PSTH of a neuron at different T_p's, can we quantify the degree of the neuron's temporal stretching?

Methods

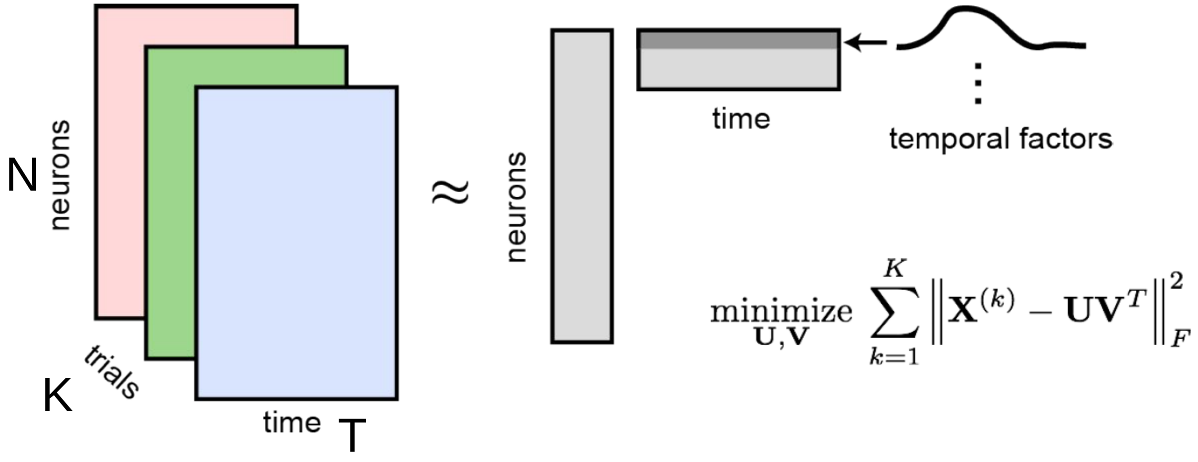
1. Time-warped PCA
2. Grid search of optimal stretch factor



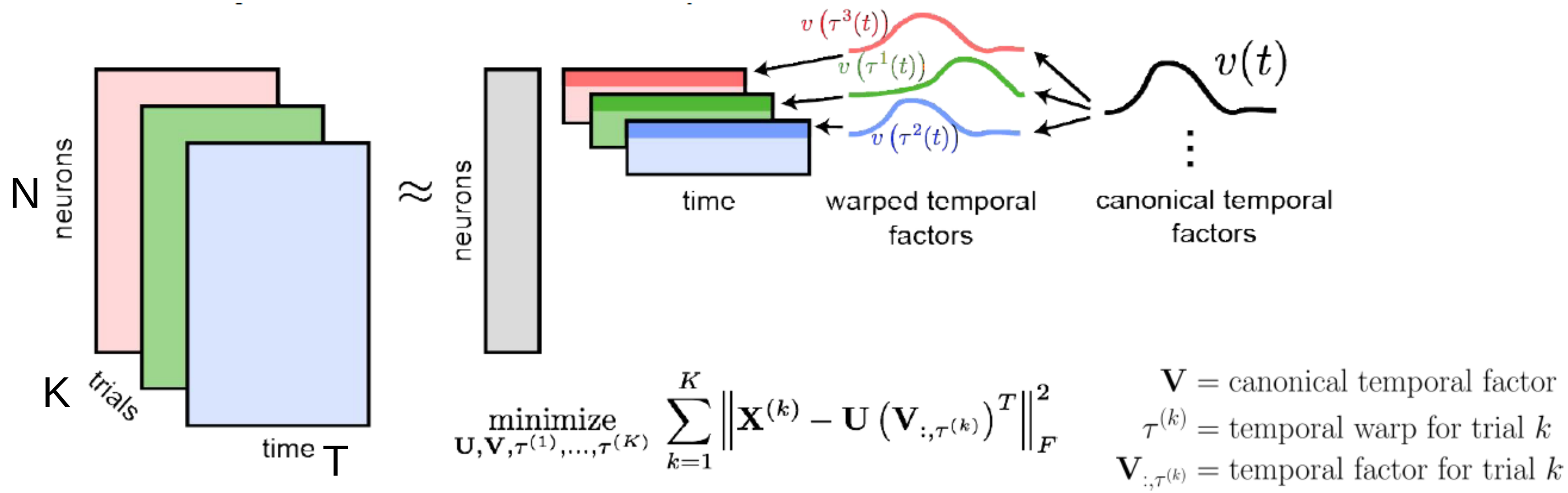
Examples of raw data from two neurons

Time-warped PCA

PCA



tw-PCA

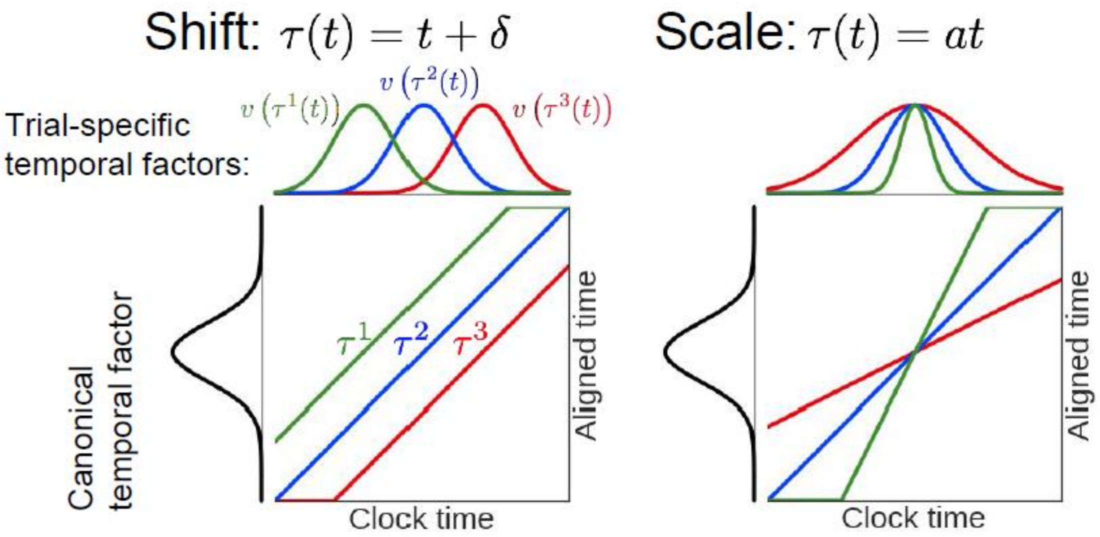


Poole et al. Time-warped PCA: simultaneous alignment and dimensionality reduction of neural data

Warp functions are parametric

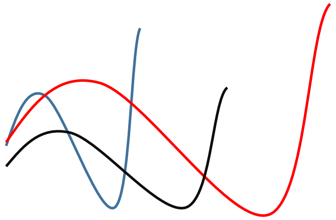
tw-PCA returns the optimal parameters (*a* or *δ*) that result in the ‘best’ alignment.

Since the problem is non-convex, a good initial guess is important to avoid local minima

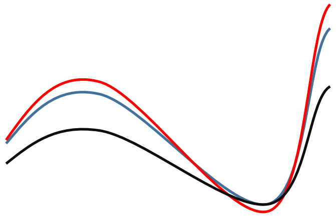


Poole et al. Time-warped PCA: simultaneous alignment and dimensionality reduction of neural data

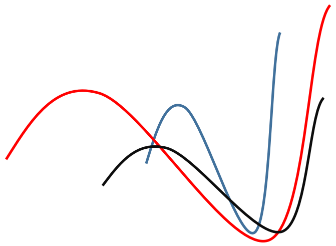
Time-warped PCA: initialization modes



‘Identity’ mode



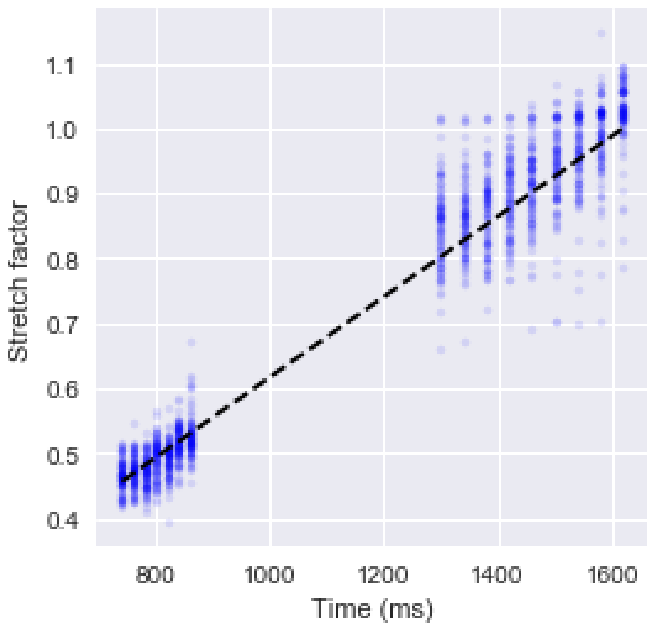
‘Scale’ mode



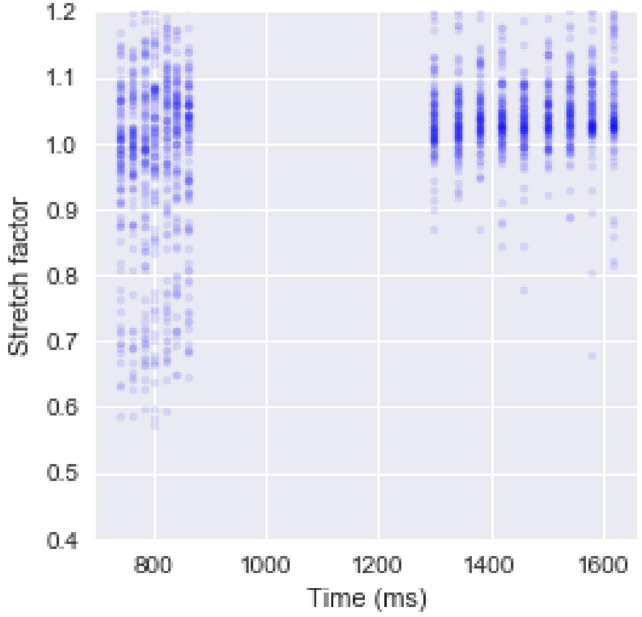
‘Shift’ mode

time

Problem is *non-convex*
Different initialization modes can lead to different results



‘Scale’ mode



‘Shift’ mode

Time-warped PCA

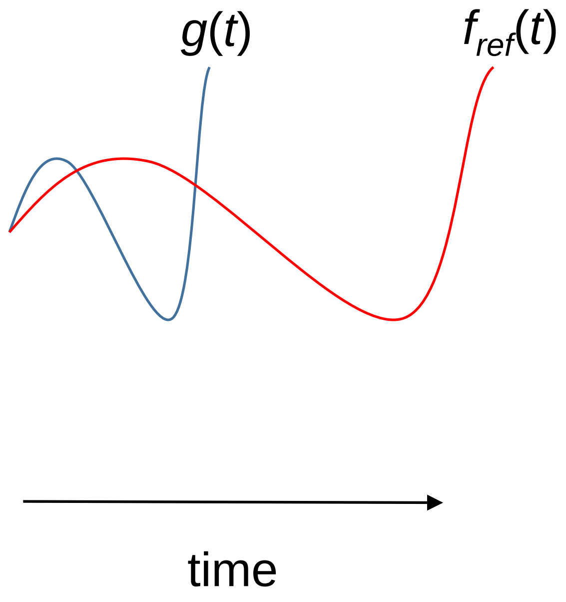
- Strengths:
  - Can align data that involve simultaneous recordings
  - If the initial guess is good, fast convergence

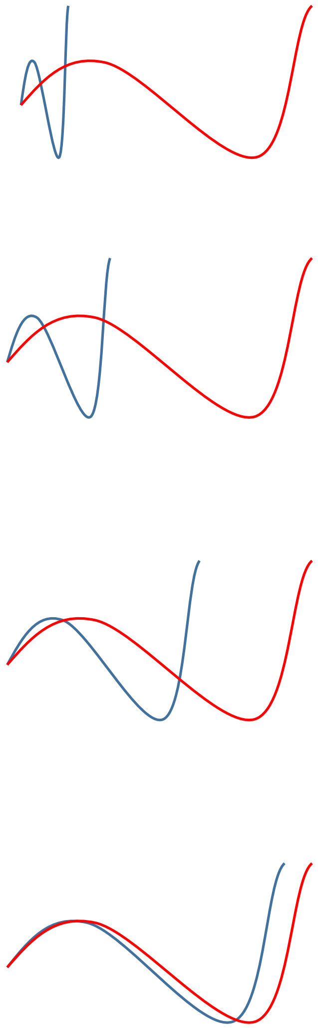
- Weaknesses:
  - Performance and results strongly depends on initialization
  - Currently only supports linear warp types
  - More computationally intensive

Grid search of stretch factor

Model: $t' = at$

Original signal





$g(1.2t)$

$g(t)$

$g(0.8t)$

$g(0.6t)$

Objective

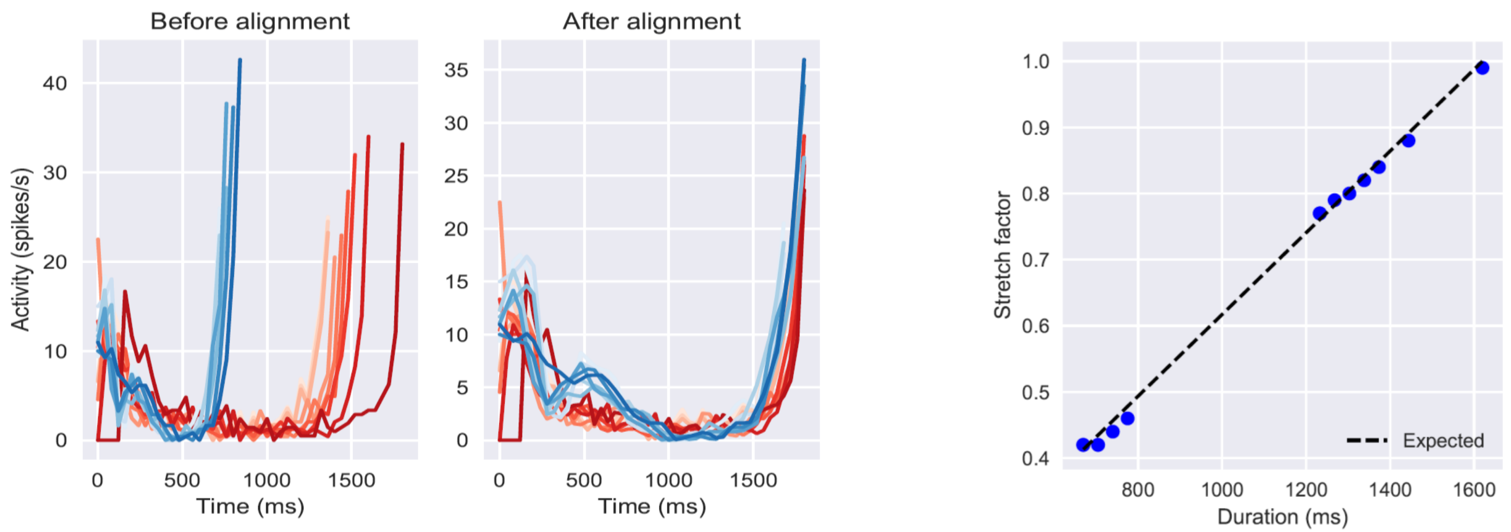
$$\min_a \frac{1}{N} \sum_{t=1}^{N} (f(t) - g(at))^2$$

↓

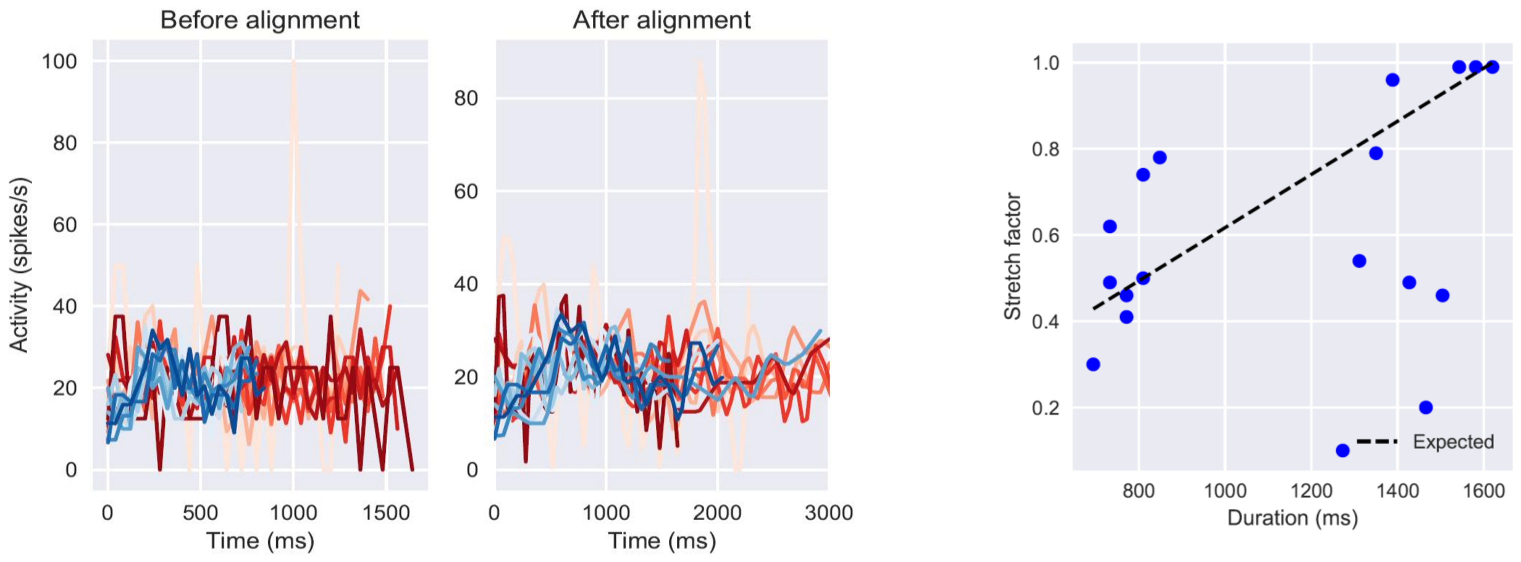
Stretch factor

Hypothesis: stretch factor = Tp / Tp_{ref}

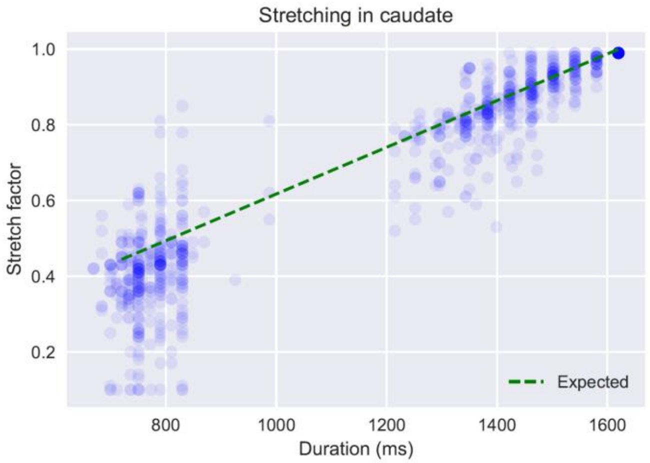
Example neuron for which hypothesis holds

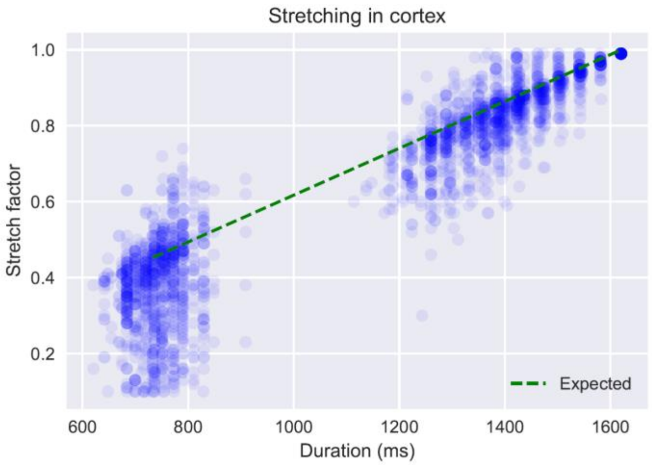


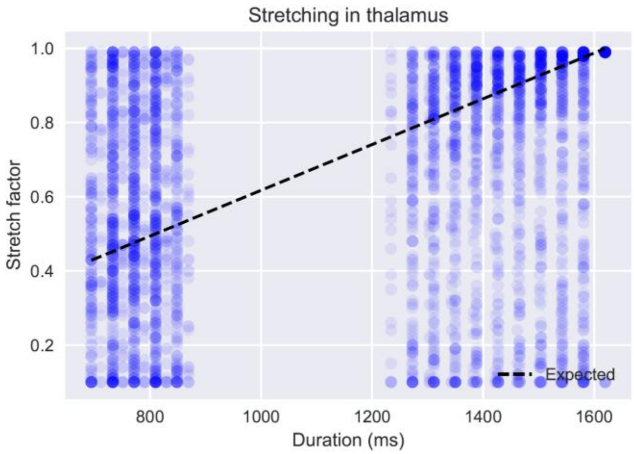
Example neuron for which hypothesis does not hold



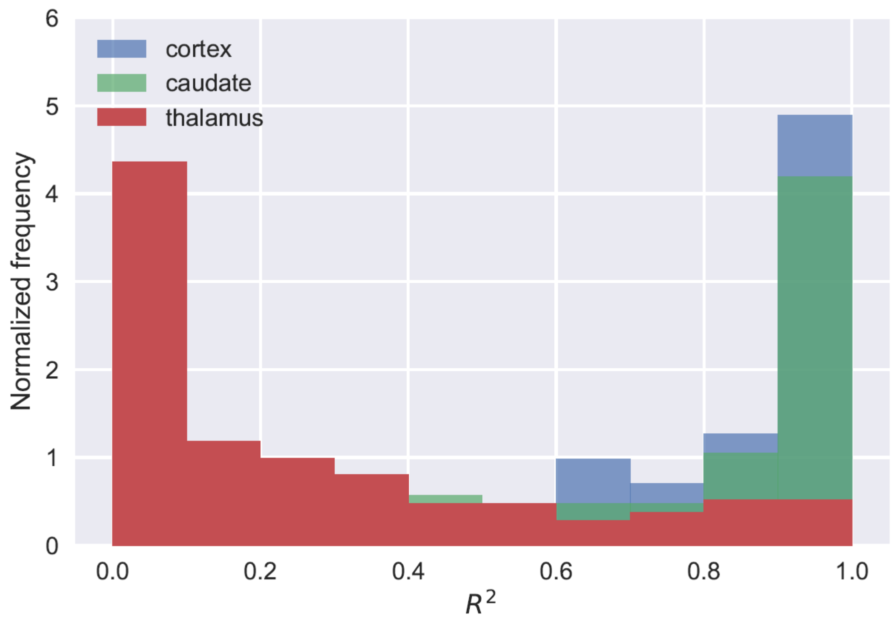
Stretching in thalamus, caudate and cortex

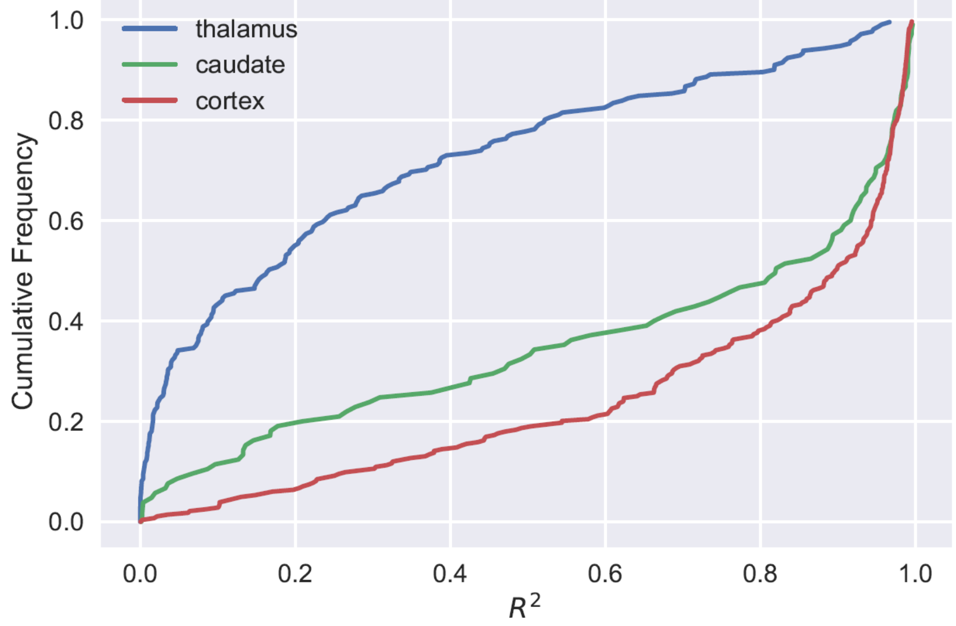






Stretching in thalamus, caudate and cortex

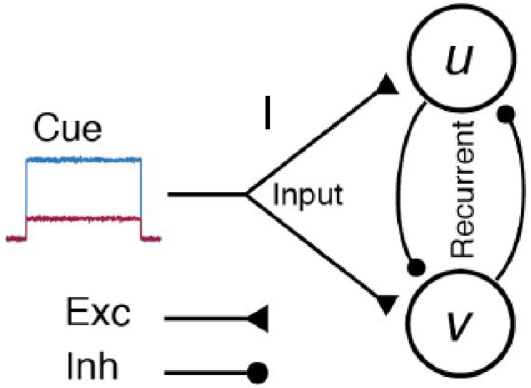




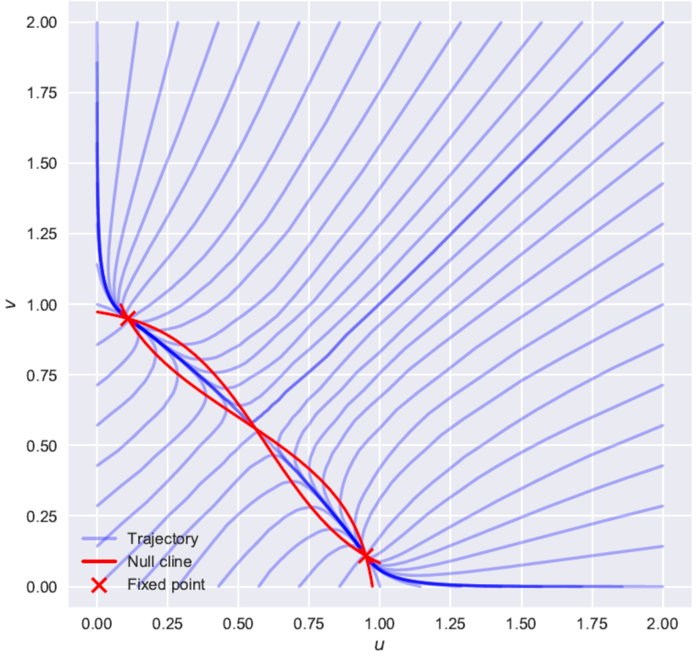
Grid search of stretch factor

- Strengths:
  - Finds global optimum
  - Fast
  - Can handle arbitrary warp functions
- Weakness:
  - Does not handle population data
  - Imprecise, due to inefficient search of factor space
- **Future direction**: start from a coarse grid search and use gradient descent to reach the minimum point

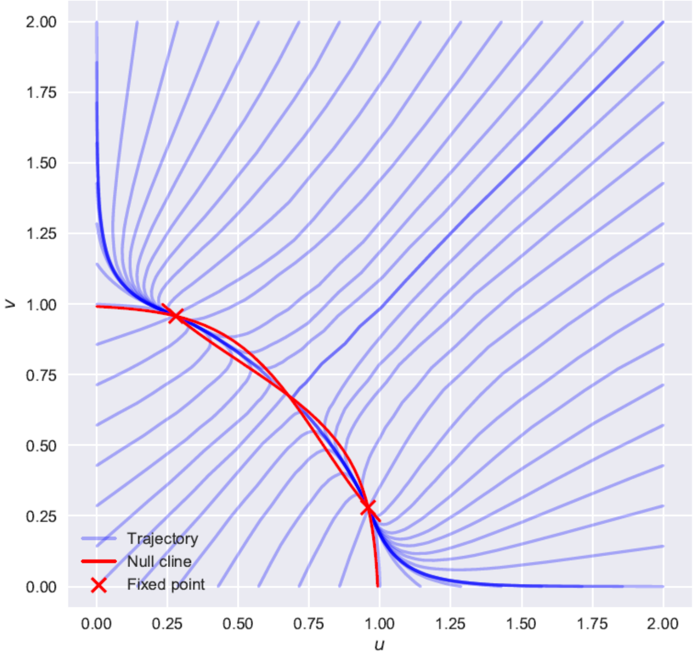
Part II: Noise in two-neuron model



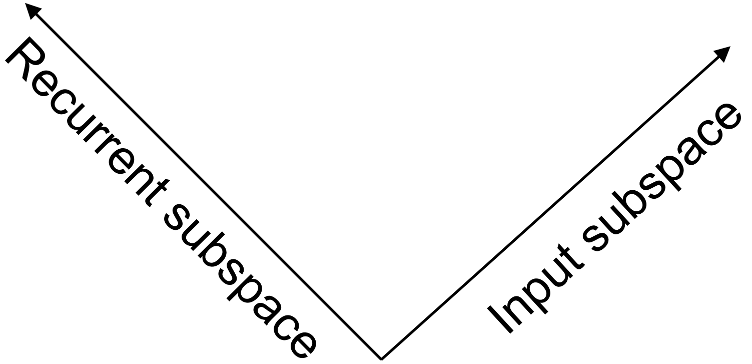
I = 0.6



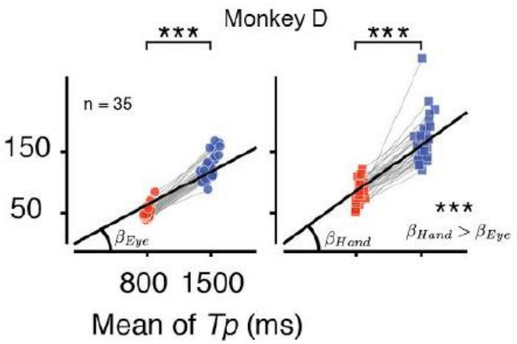
I = 0.8



$$\begin{cases} \tau \dot{u} = -u + f(\mathbf{W}_{u\theta}\theta - \mathbf{W}_{uv}v) \\ \tau \dot{v} = -v + g(\mathbf{W}_{v\theta}\theta - \mathbf{W}_{vu}u) \end{cases} \quad \cdots (\star)$$



Scaling invariance - observation

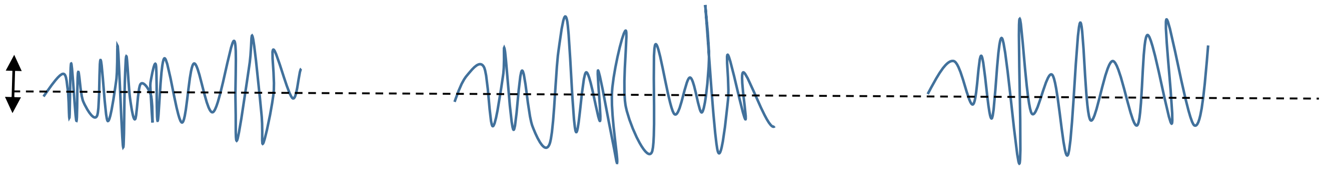


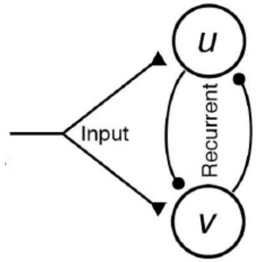
In interval production task, standard deviation scales linearly with mean

Noise in production times can be caused by:

a. Fluctuations in the input during a trial

σ_σ





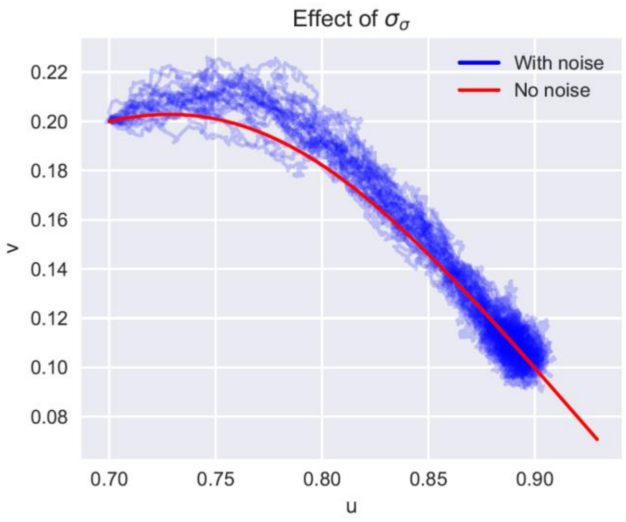
b. Fluctuations in the mean of the input across trials

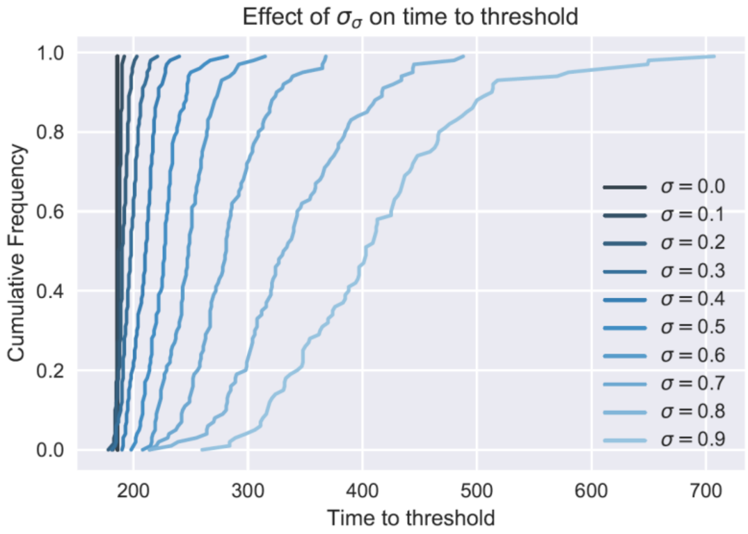
σ_μ

Which factor(s) can account for the observed scale invariance?

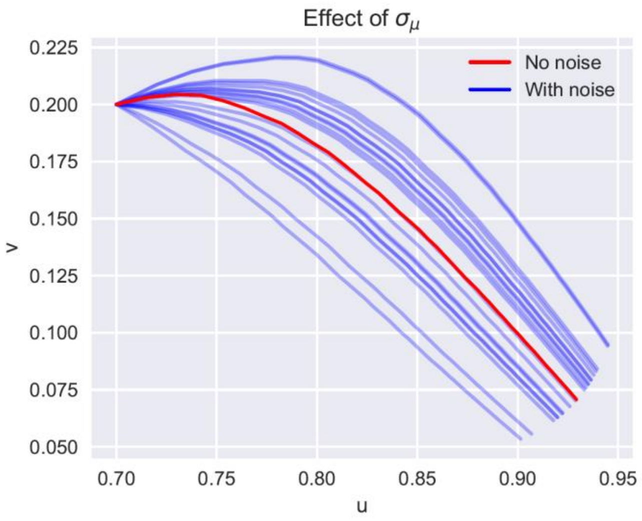
Trajectory | **Distribution of time to threshold**

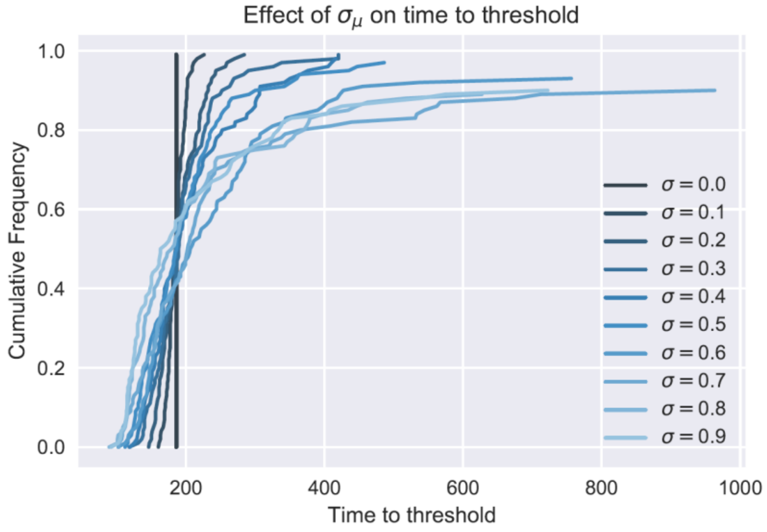
Effect of σ_σ



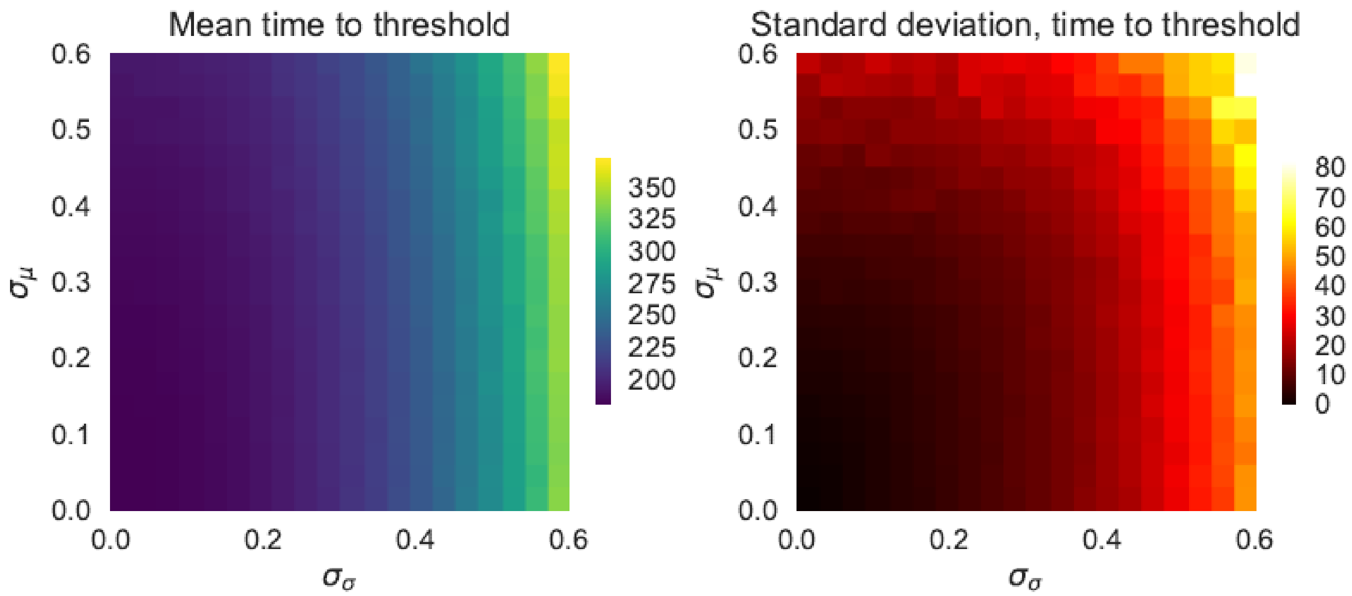


Effect of σ_μ



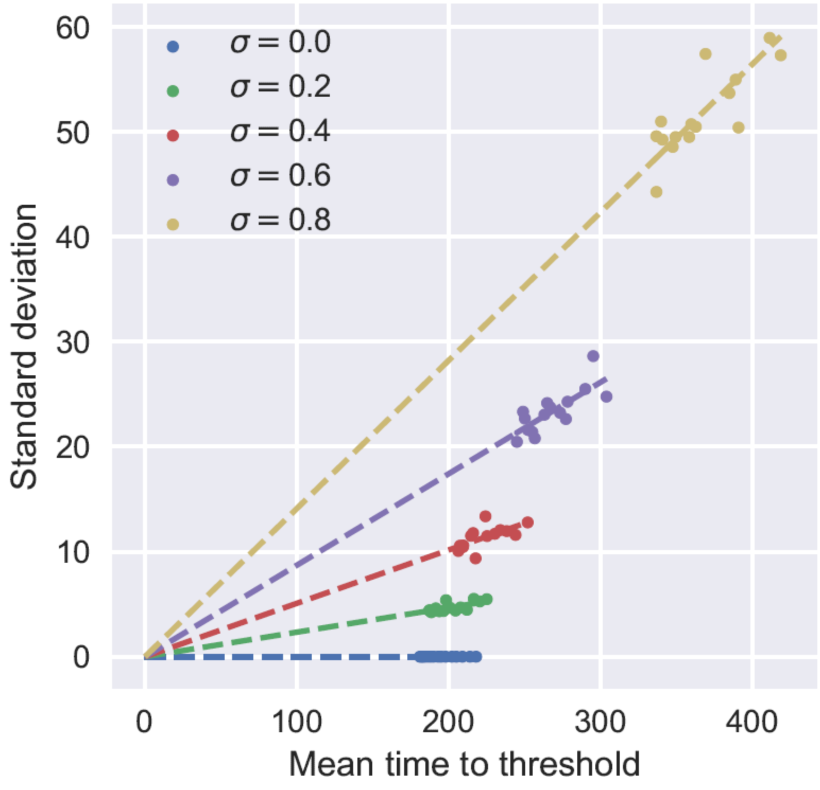


Combined effect of σ_σ and σ_μ

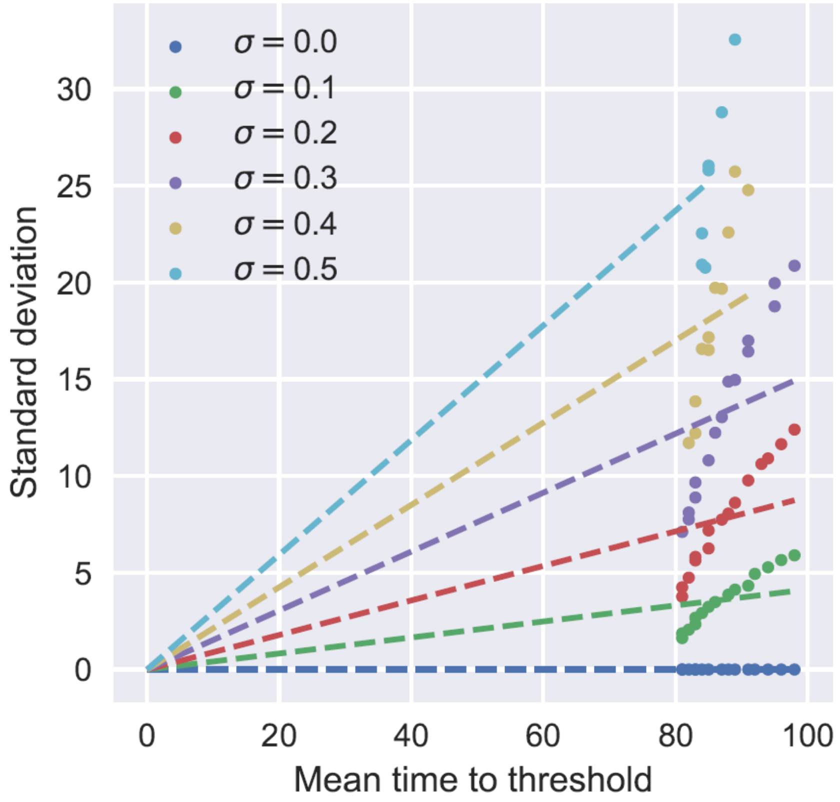


Scaling invariance

Effect of σ_σ

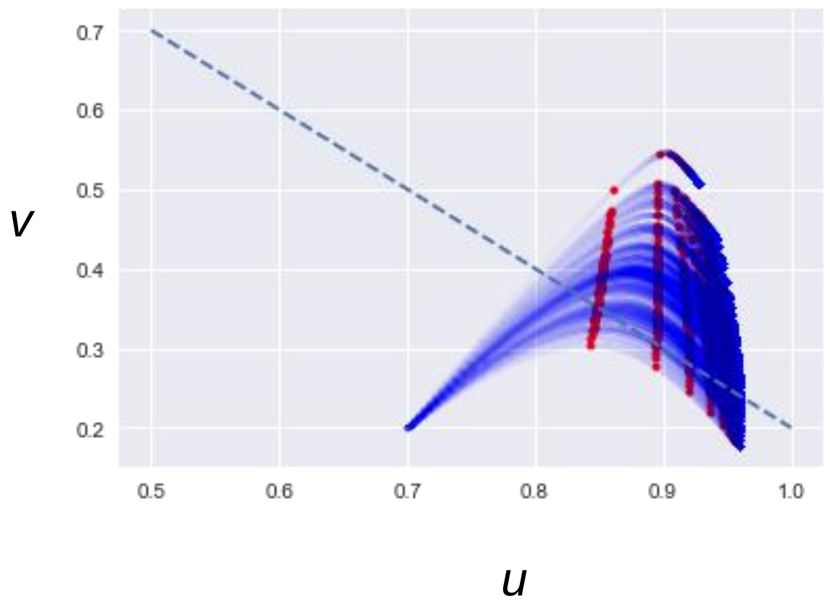


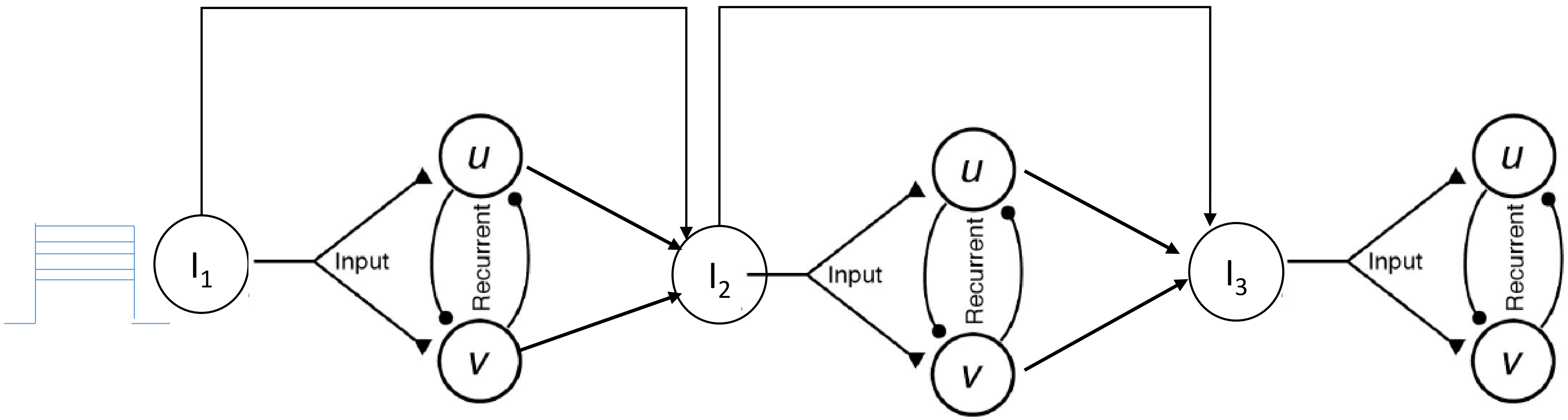
Effect of σ_μ



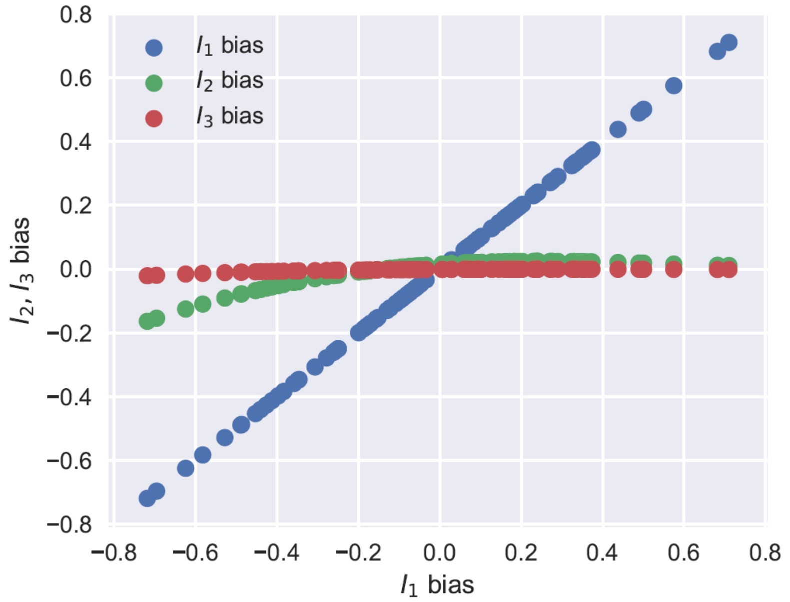
Future work

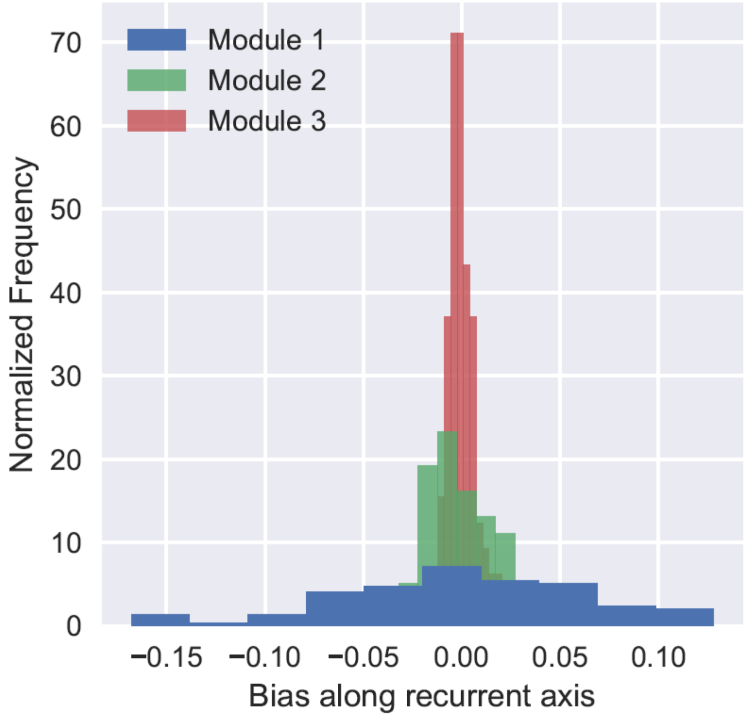
Cascade model to correct bias in input, given sensory feedback





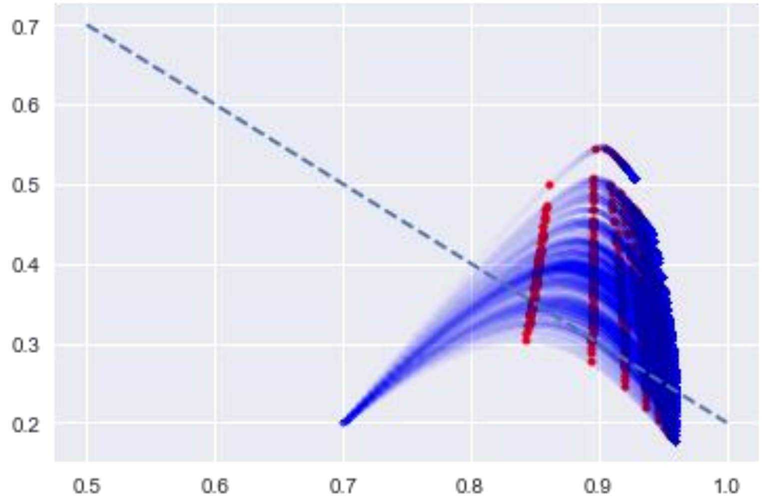
Cascade corrects bias in individual inputs





Question: how does the network learn the correct threshold to correct itself?

What I'm working on



v

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Question: how does the network learn the correct threshold to correct itself?