Neural Networks for Demixing

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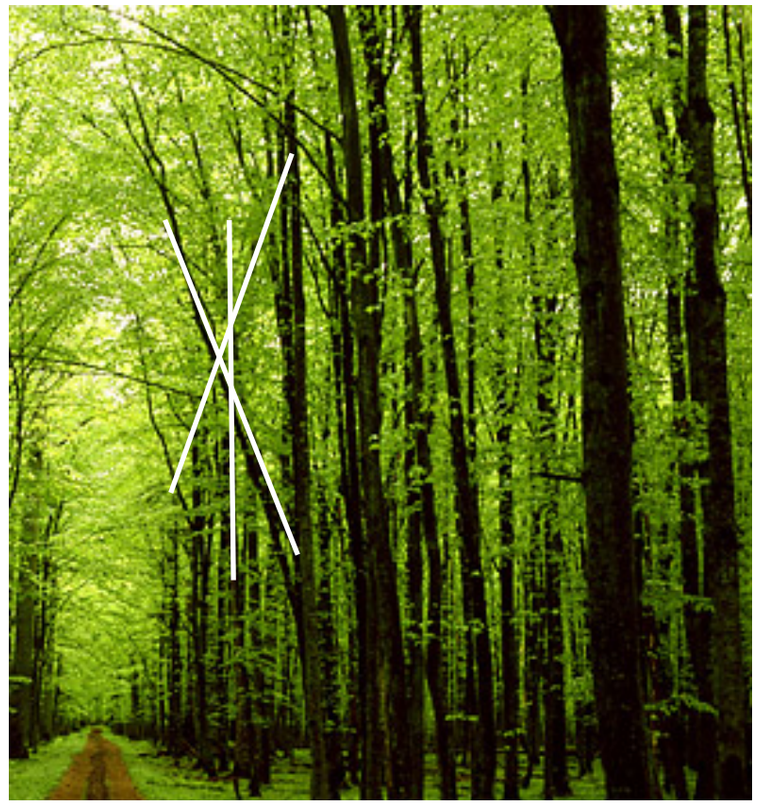
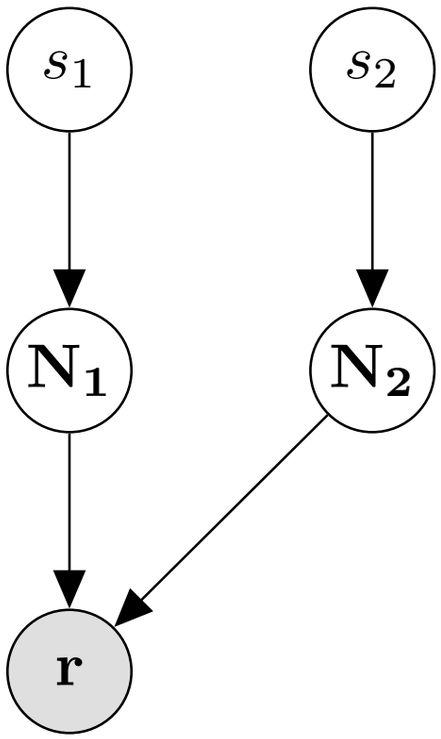
Demixing Odors/ Orientations

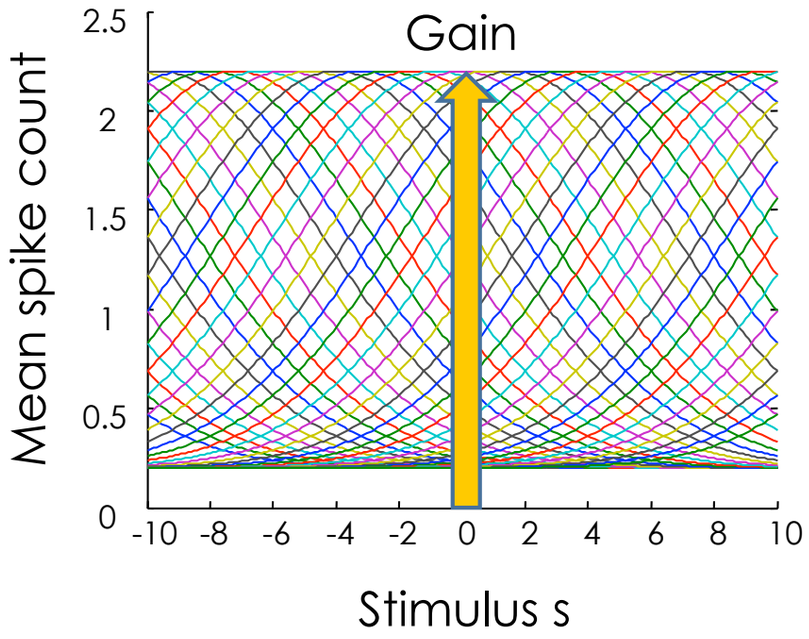
Lots of evidence for multiplexing neurons in the brain (cite evidence…)
Demixing is a very general problem for the brain

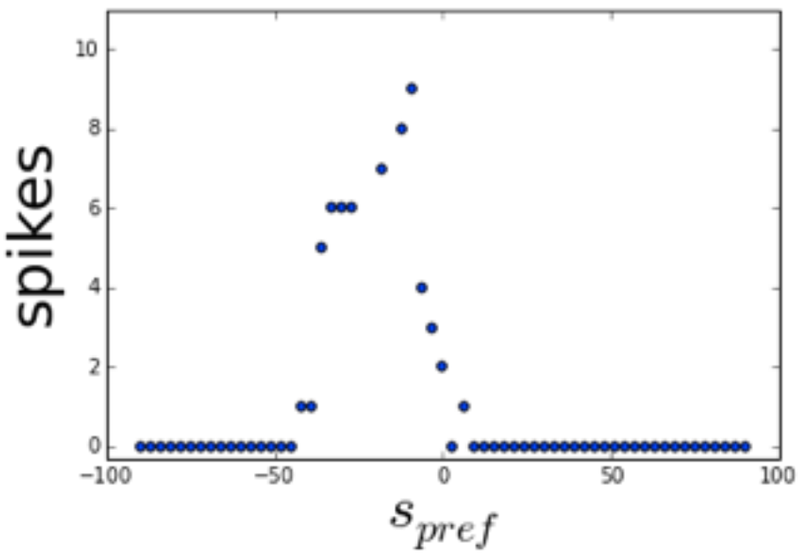


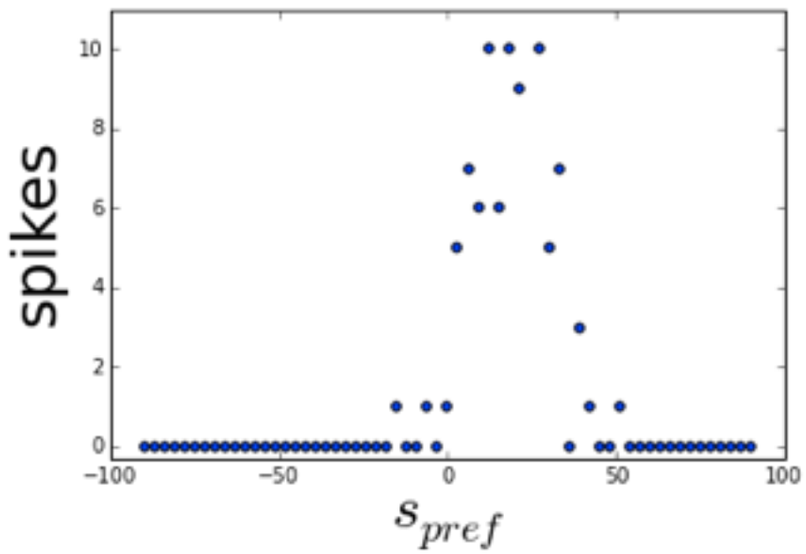
Strawberries Cake Coffee

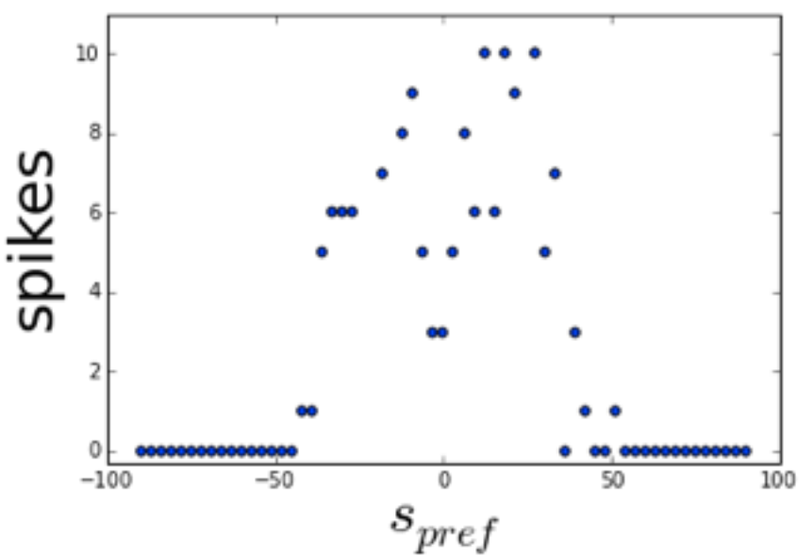
0 20 -20


s_1
s_2
$\mathbf{N_1}$
$\mathbf{N_2}$
$\mathbf{r}$

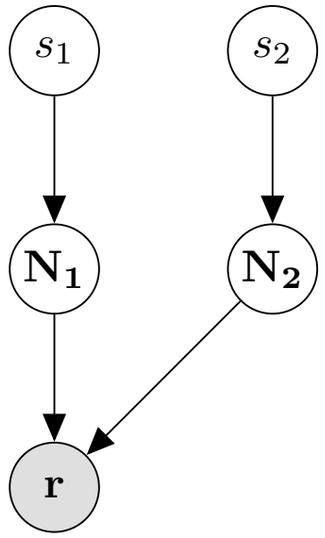

Gain
Mean spike count
2.5
2
1.5
1
0.5
0
-10 -8 -6 -4 -2 0 2 4 6 8 10
Stimulus s


spikes
10
8
6
4
2
0
−100 −50 0 50 100
s_{pref}


spikes
10
8
6
4
2
0
−100 −50 0 50 100
s_{pref}


spikes
10
8
6
4
2
0
−100 −50 0 50 100
s_{pref}

Given r, what are s_1 and s_2?

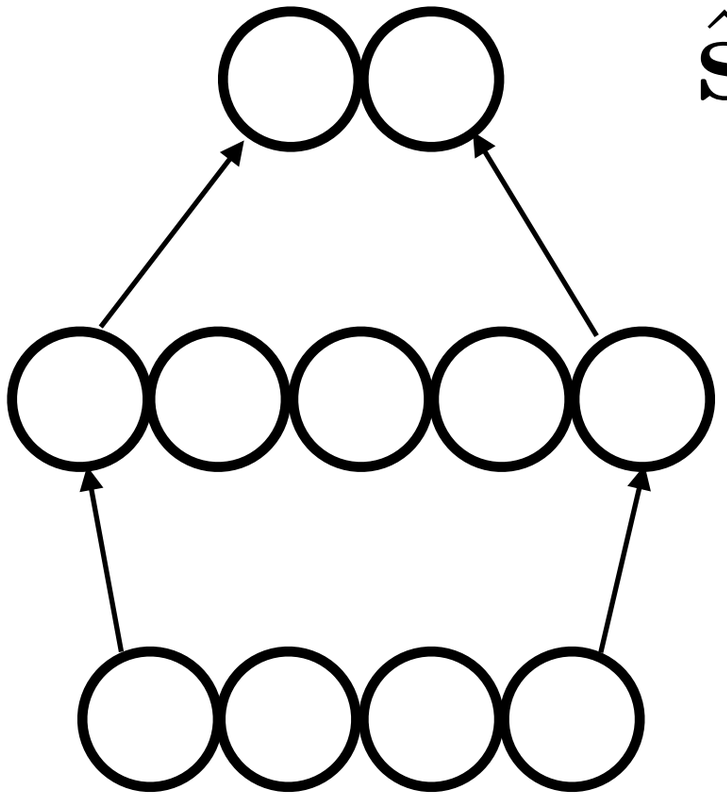


Maximum Likelihood Estimation: $\hat{s} = \arg\max_s p(r|s)$

Can a generic neural network accomplish ML demixing?

(Eventually, we would like to have:

- Unknown and variable numbers of stimuli
- Unknown and variable contrasts/gains)



$$\hat{\mathbf{s}} = \mathbf{W}\mathbf{r}_{\text{hid}}$$

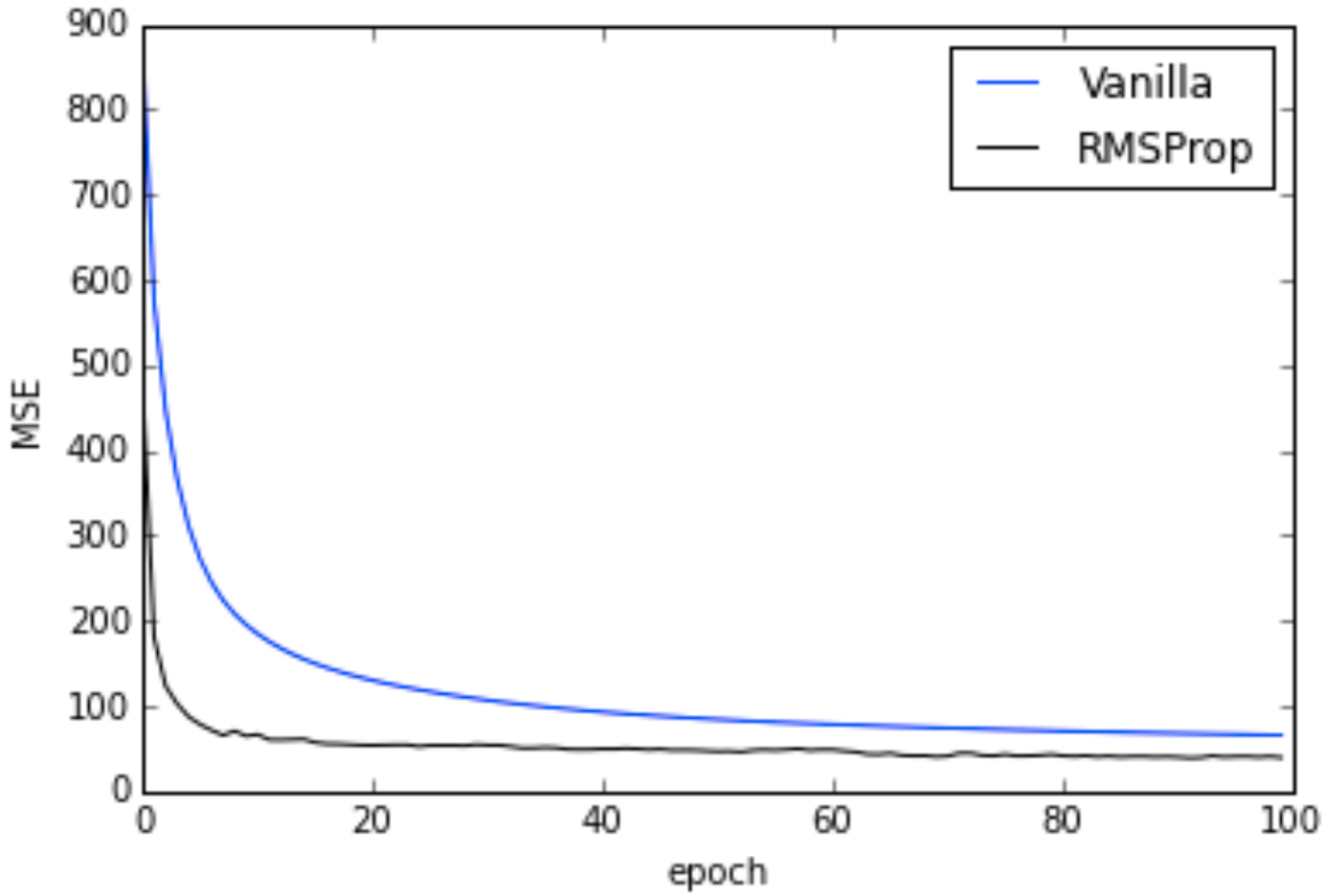
$$\mathbf{r}_{\text{hid}} = \phi(\mathbf{W}\mathbf{r}_{\text{hid}} + \mathbf{b})$$

$$\phi(h) = \max(0, h)$$

20 hidden units

$$\mathbf{r}_{\text{in}} \sim \text{Poisson}(\mathbf{f}(c_1 s_1 + c_2 s_2))$$

61 input units

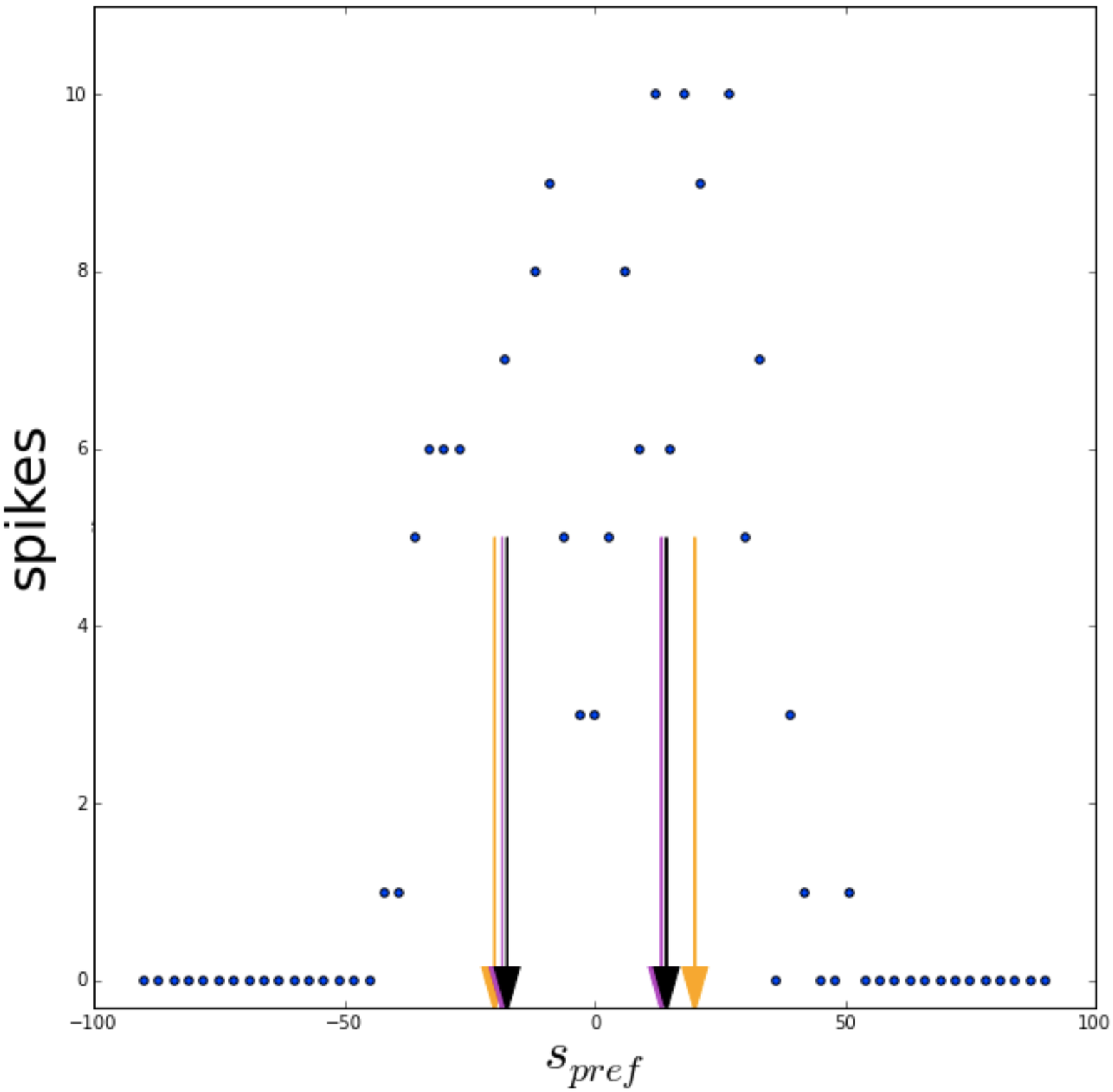


MSE loss function (enforced $s_1 < s_2$)

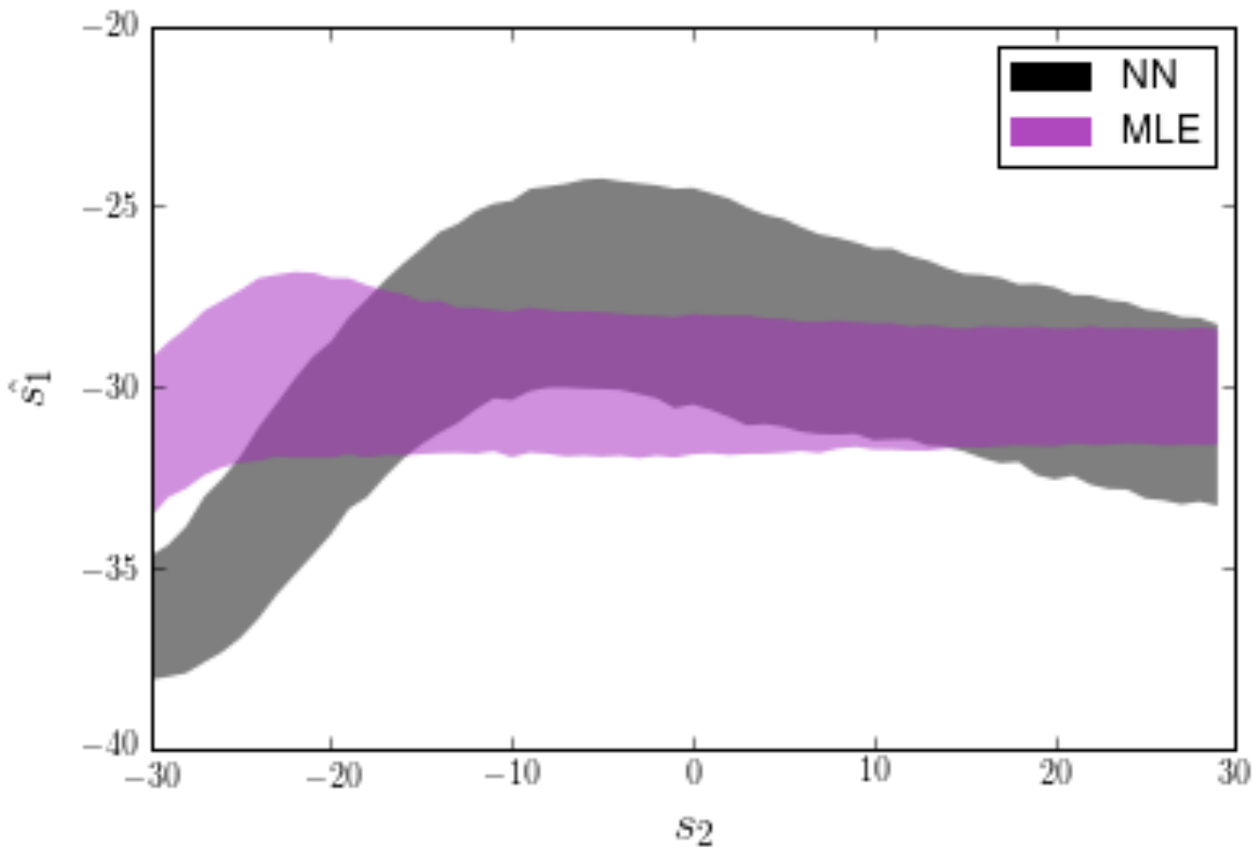
Used backpropagation with SGD (with RMSProp) for training

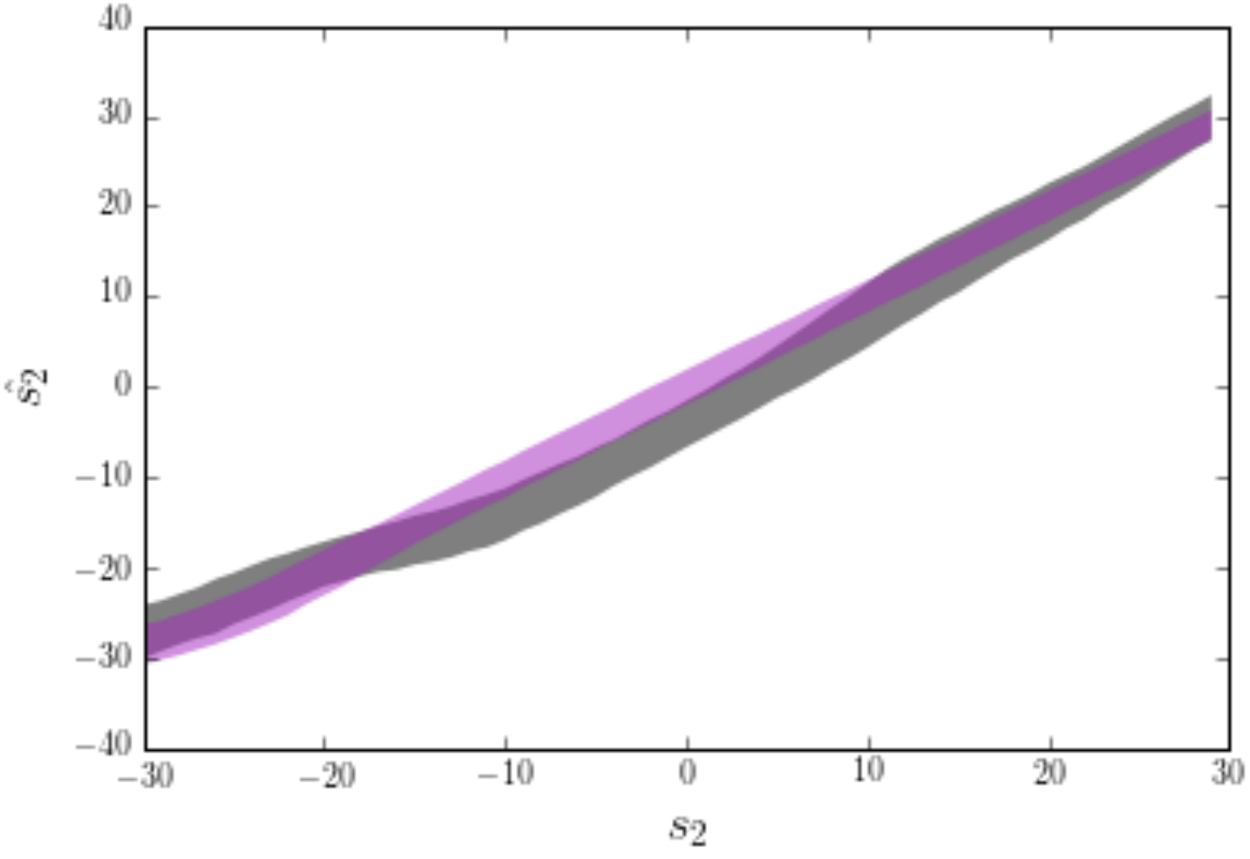
20,000 training trials

100 epochs



MLE Ground Truth Neural Network


NN
MLE
$\hat{s}_1$
s_2
−20
−25
−30
−35
−40
−30
−20
−10
0
10
20
30


$\hat{s}_2$
s_2
40
30
20
10
0
−10
−20
−30
−40
−30
−20
−10
0
10
20
30

-40, 40, square

Conclusions

- So far we have only been able to train the neural networks to be slightly biased estimators

- Future directions
  - Variable gains
  - Multiple stimuli
  - Unknown number of stimuli
  - Network properties