Shunting Inhibition and Synchrony

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Introduction

1. Effect of variation of the number of synaptic connections on synchrony
2. Effect of variation of inter-neuron synaptic strength on synchrony
3. Effect of variation of inter-neuron synaptic delay on synchrony
4. Effect of linearization of the network on synchrony

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Variation of number of synaptic connections

Hypotheses

Hypothesis 1

Increase in connectivity leads to increased inter-neuron inhibition and increased coherence.

Hypothesis 2

Increase in inter-neuron inhibition leads to reduction in mean firing rate and reduction in the number of active neurons.

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Mean Firing Rate

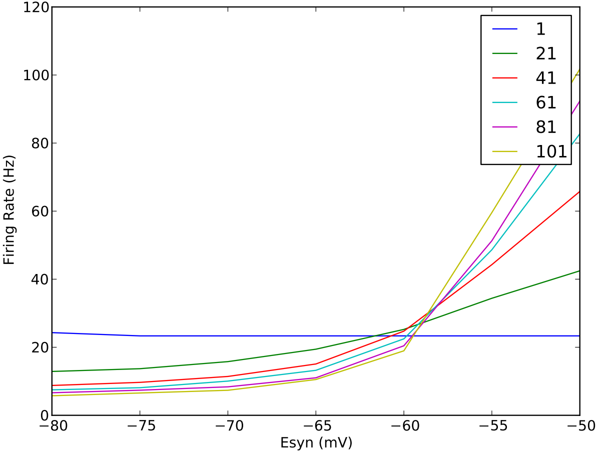

Figure: This figure shows the effect of increasing number of inter-neuron synaptic connections on mean firing rate. Mean firing rate increases with the increase in synaptic connectivity in the depolarized state, but reduces with increase in synaptic connectivity in the hyperpolarized state.

Coherence

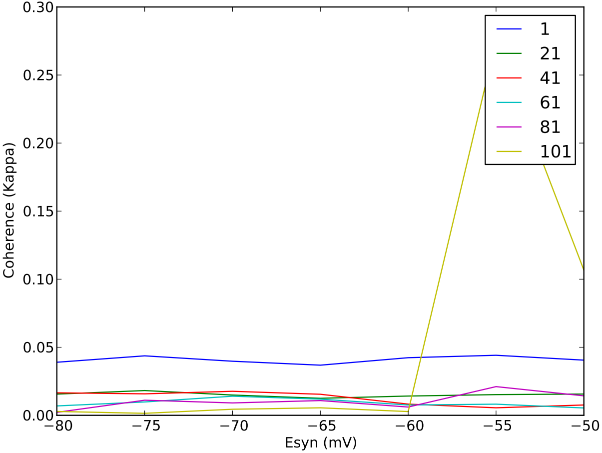

Figure: This figure shows the effect of an increase in synaptic connectivity on coherence. While the E_{syn} value for peak coherence is unchanged, coherence values are high when there are either very few, or very many connections.

Active Neurons

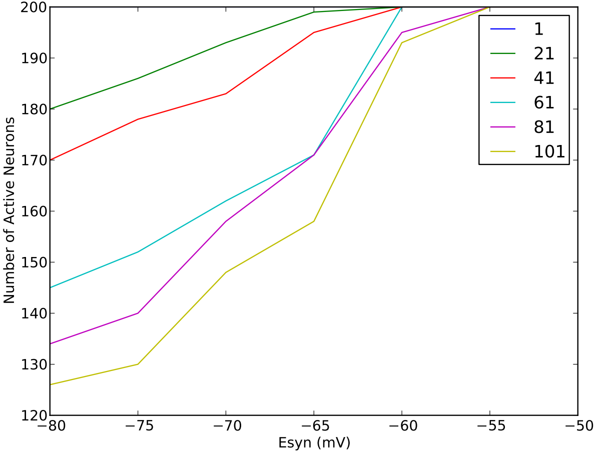

Figure: This figure shows the negative effect of increasing synaptic connections on the number of active neurons. As the number of connections increases, the inter-neuron inhibition grows, reducing the number of active neurons.

Variation of inter-neuron synaptic weight

Hypotheses

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Increase in synaptic weight leads to increased inter-neuron inhibition and increased coherence.

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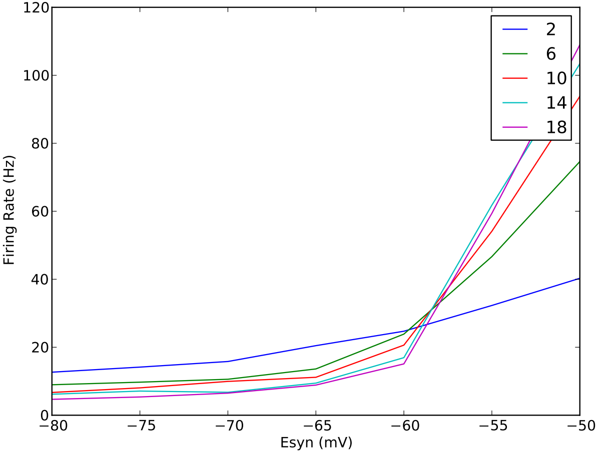

Figure: At hyperpolarized states, increase in synaptic weight reduces firing rate. At depolarized sates, increase in synaptic weight increases firing rate.

Coherence

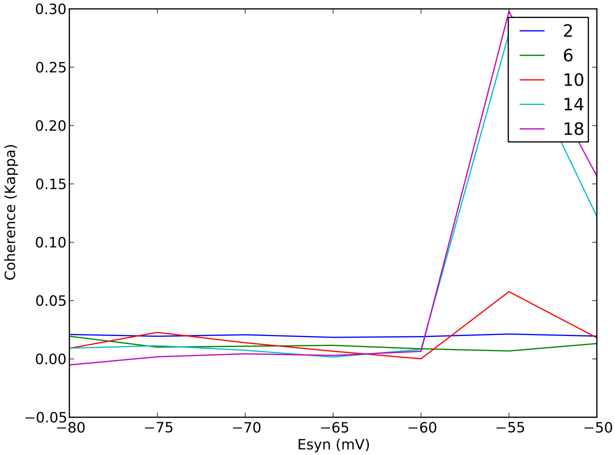

Figure: Increase in synaptic weight does not affect location of peak coherence, but increases its value.

Active Neurons

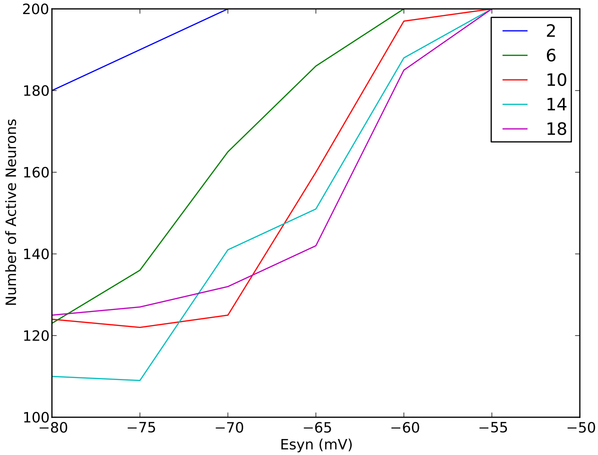

Figure: Increase in synaptic weight increases inhibition, reducing the number of active neurons.

Effect of variation of inter-neuron synaptic delay on synchrony

Hypotheses

Hypothesis 1

Changing synaptic delay affects the network's ability to synchronize, thereby affecting coherence.

Hypothesis 2

Changing synaptic delay does not affect a neuron's excitation or inhibition. Therefore, no significant effects are expected on mean firing rate and number of active neurons.

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Low Synaptic Delay (0.1 ms)

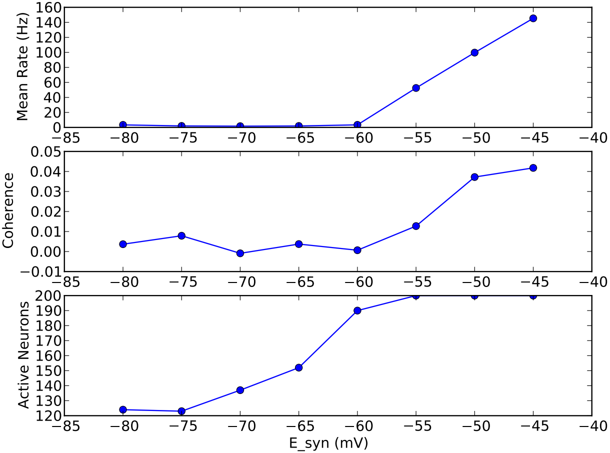

Figure: Low values of synaptic delay produce extremely low coherence, but do not affect mean firing rate or the number of active neurons.

Medium Synaptic Delay (0.5 ms)

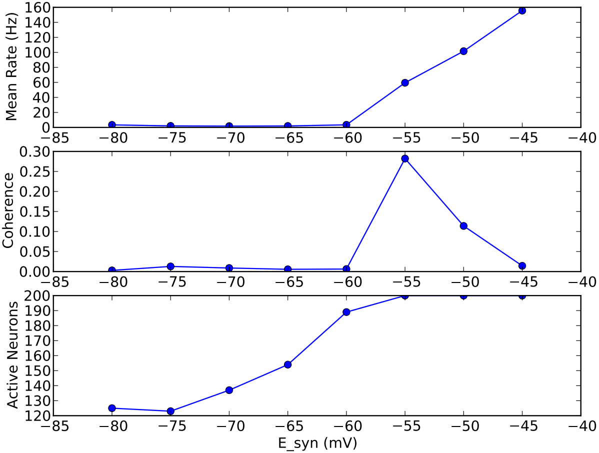

Figure: Medium values of synaptic delay produce higher values of coherence, but do not affect mean firing rate or the number of active neurons.

High Synaptic Delay (1 ms)

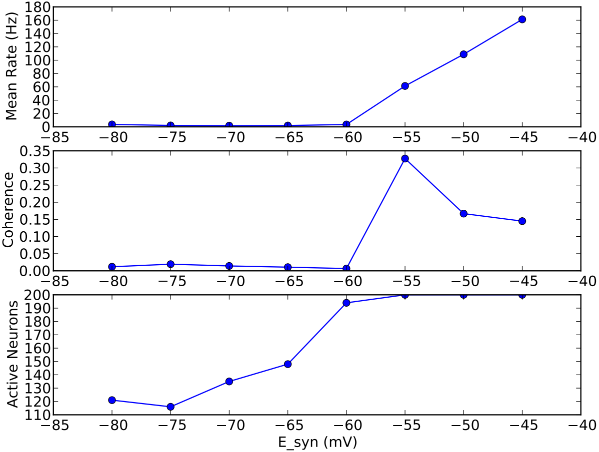

Figure: High values of synaptic delay produce higher coherence, but do not affect mean firing rate or the number of active neurons.

Effect of Linearization of the Network

Hypotheses

Hypothesis 1

Conversion of the network from ring to linear should affect the ability of the network to synchronize.

Linear Network

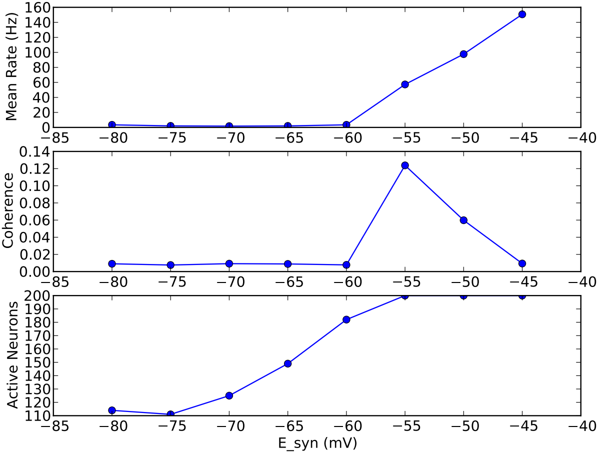

Figure: A linear network exhibits no shift in the location of peak coherence, but shows a lower peak.

Ring Network

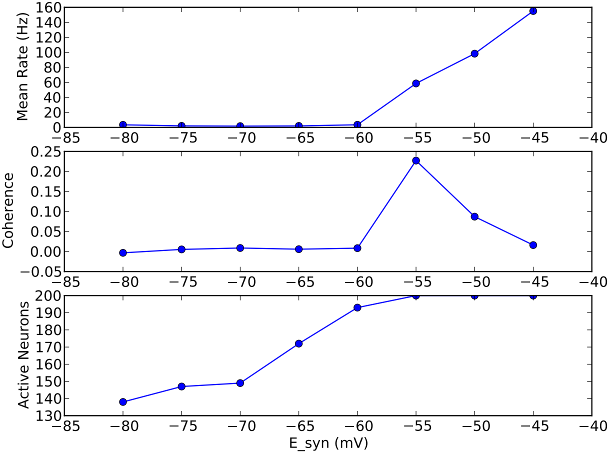

Figure: A ring network exhibits no shift in the location of peak coherence, but shows a higher peak.

Conclusions

Shunting inhibition allows for the generation of robust models of neuronal synchrony, which allows

1. *in vivo*, the generation of γ-rhythms
2. *in silico*, allows the investigation of variation in a number of different synaptic parameters.

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Questions?