Firing rates & spike time precision

The link to membrane characteristics

Bard Ermentrout

University of Pittsburgh

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Outline

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- With constant stimuli & noise, precision is low;
- Rapidly varying stimuli can be very precise
- Precision is tied to background level of excitation
- This can be related to the PRC by treating the neuron as a generalized oscillator

Neurons code via rate & timing

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- Rate seems to matter at high spike rates
- Timing may be more important at low rates

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  - de Ruyter *et al* work on fly lobular plate
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- *In vitro* Mainen & Sejnowski show cortical neurons respond reliably to fast stimuli

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- **Strategy:** Use dynamics of action potential initiation to study the role of frequency on spike timing

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  - All or none action potentials
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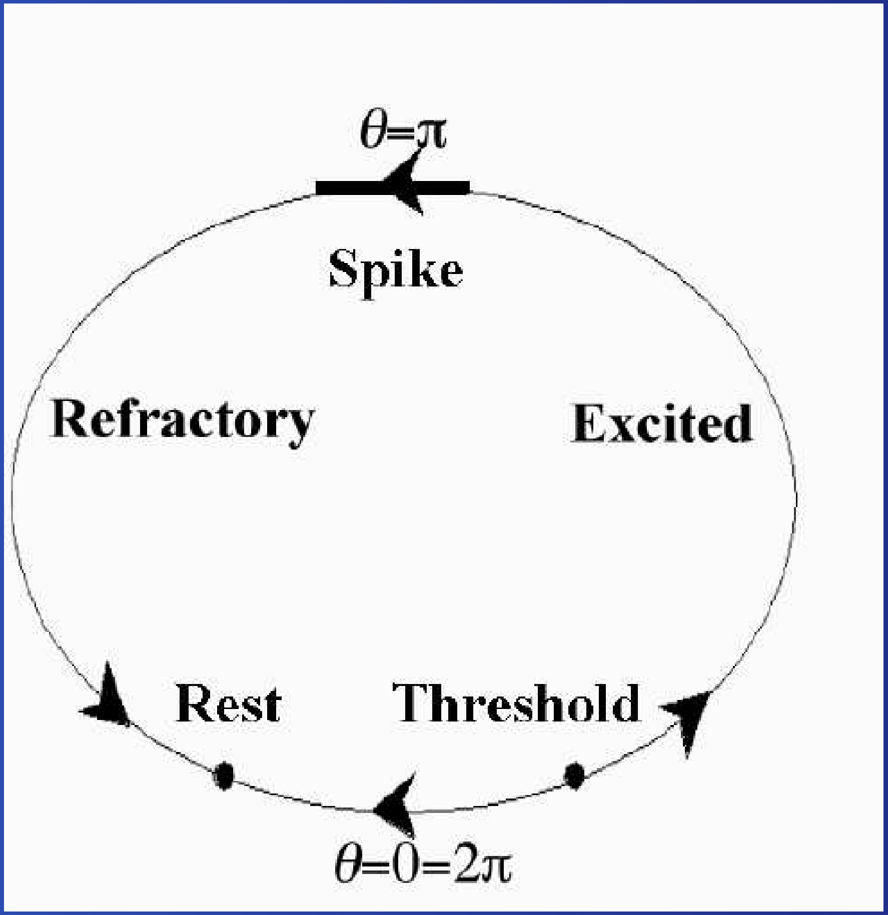
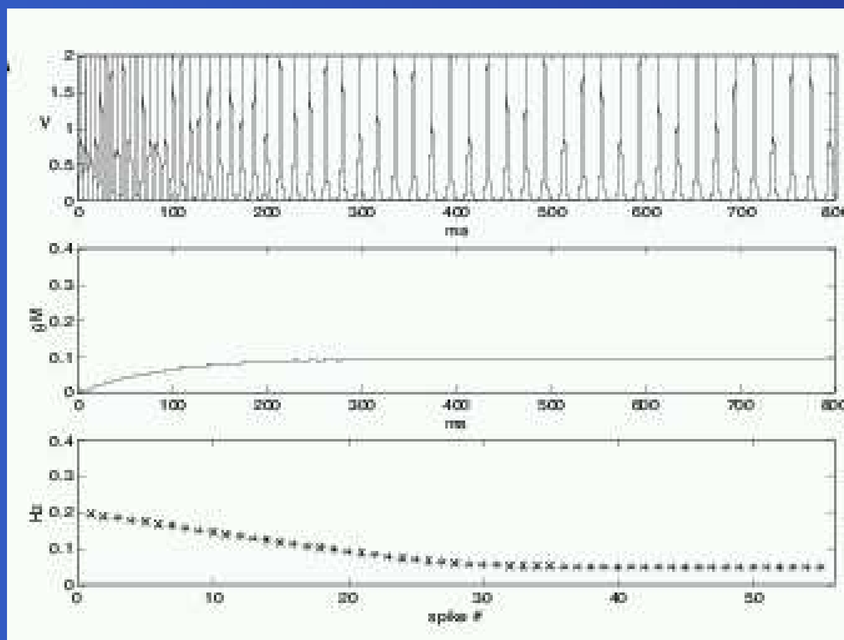
- Ermentrout *et al* extended to include SFA:

$$I(t) = I_0(t) - g_m z \quad \frac{dz}{dt} = f(\theta)(1 - z) - z/\gamma$$

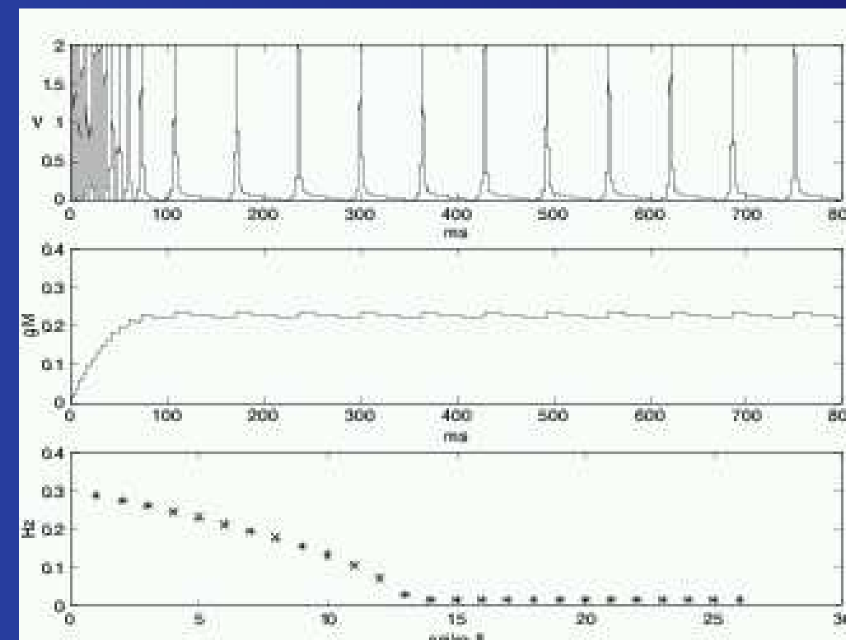
Intuitive picture



With adaptation



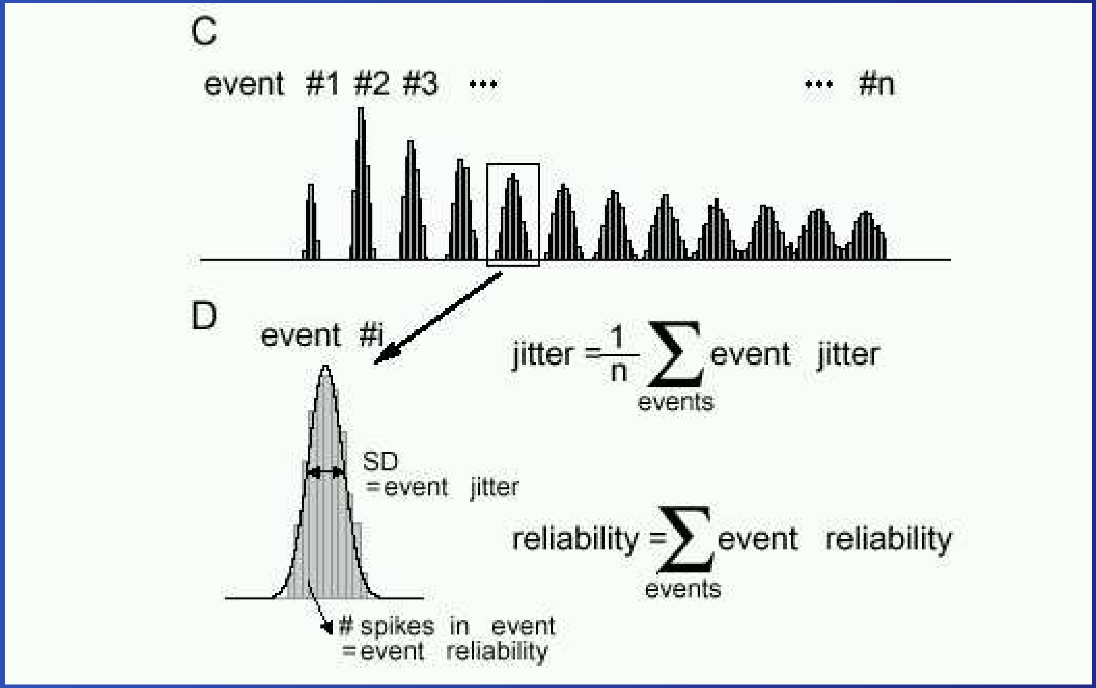
Low SFA



High SFA

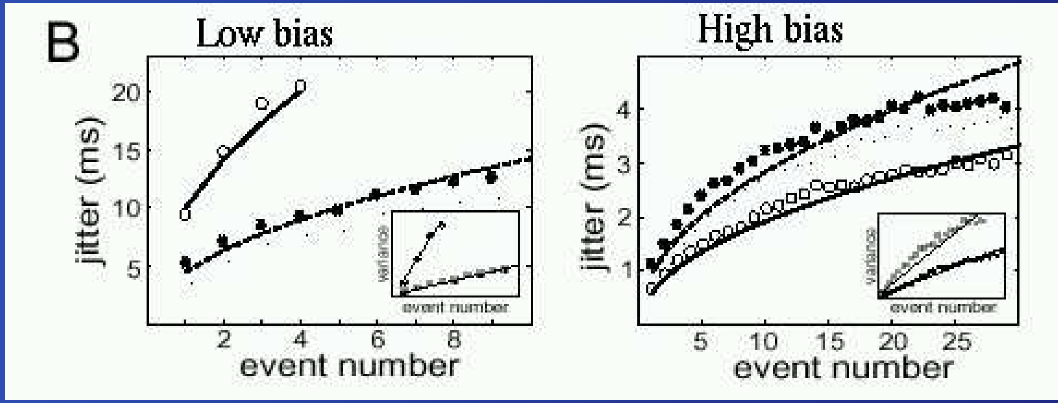
Precision

- Background noise plus baseline deploarization plus stimulus.
- Measure spike time histogram over many repeated trials

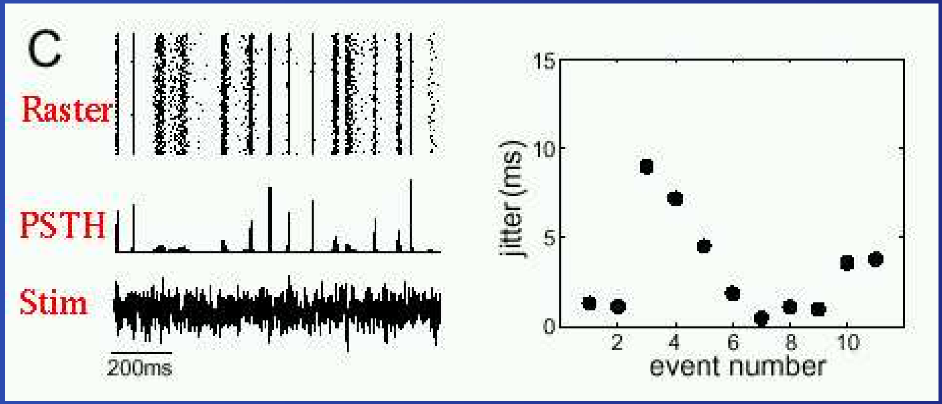


Jitter

- ... is a diffusion process when the cell is oscillating



- ... but not when bias is low



Generic behavior

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- Use the theta model with adaptation – all class I models are equivalent.

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- Easily computed for models and for experiments

Application to coding

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- Stimulus consists of a slow DC bias
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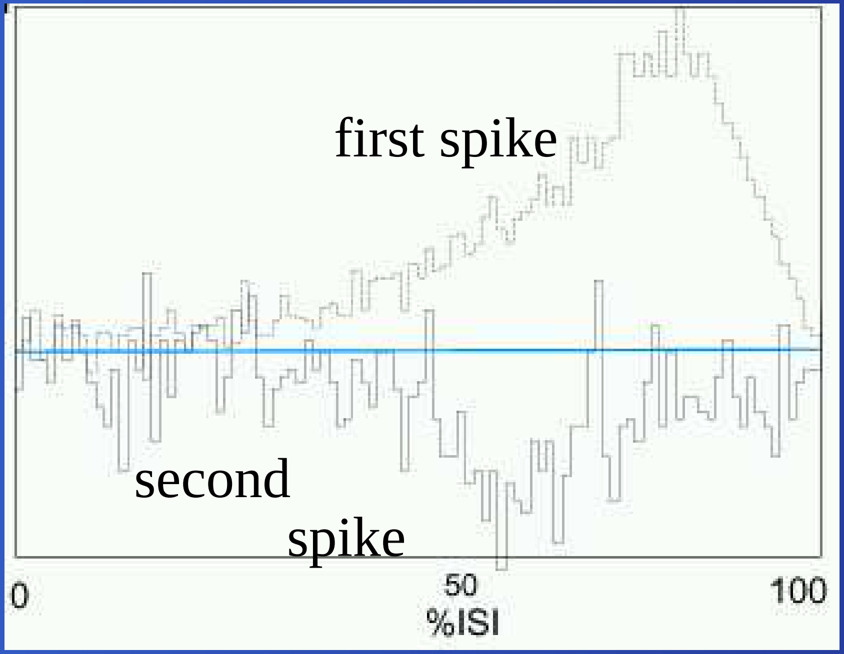
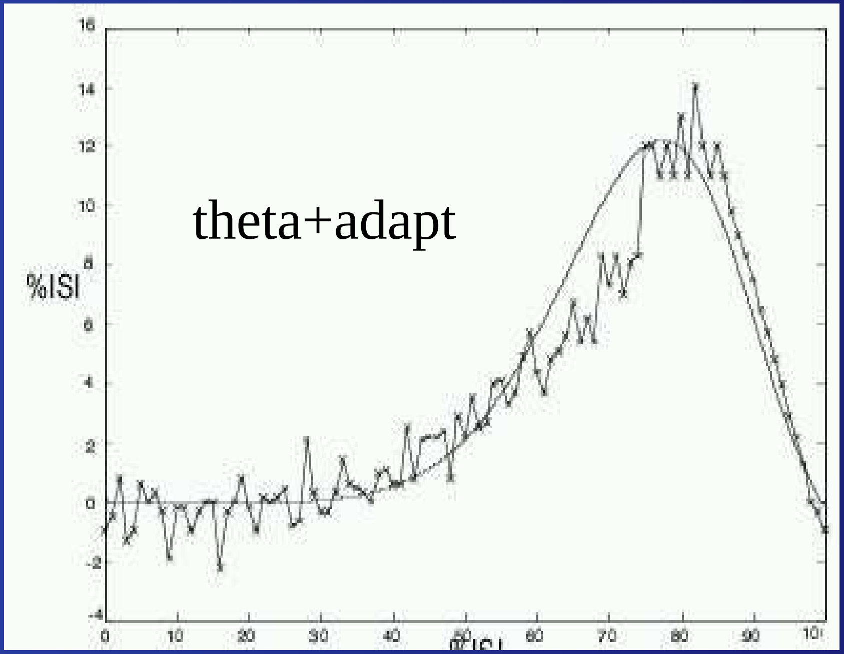
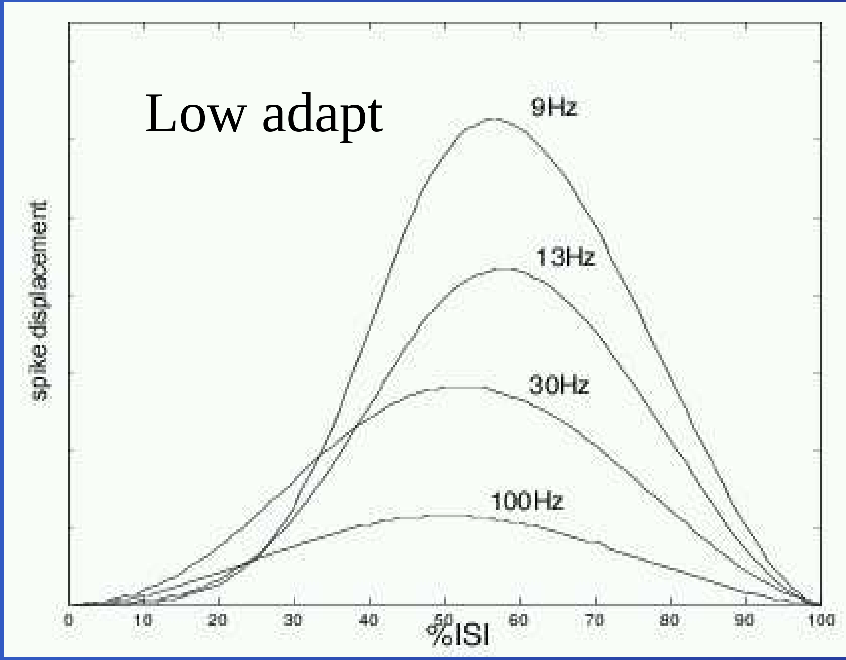
- Thus PRC informs us **when** the neuron will fire

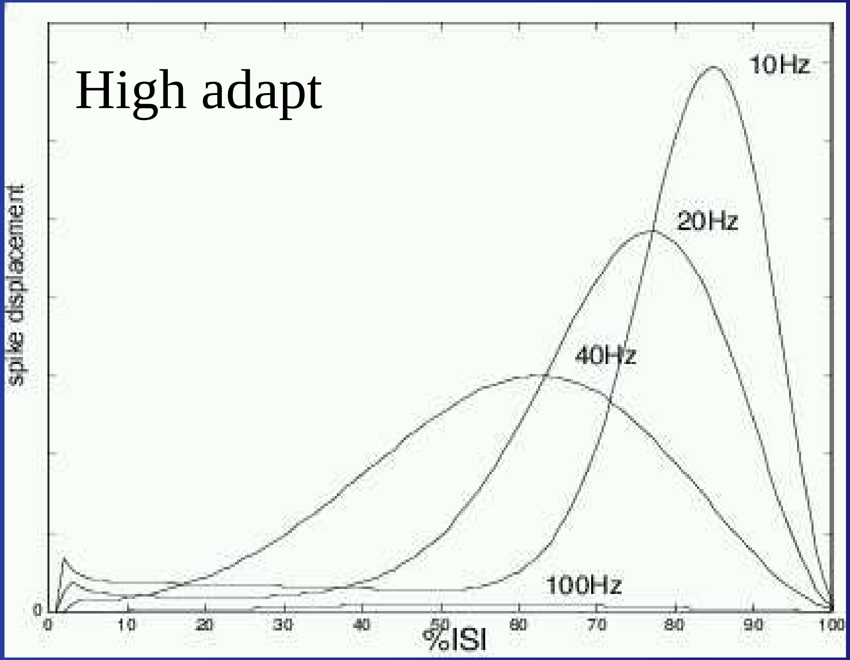
Experiment & theory





Firing rate & sensitivity





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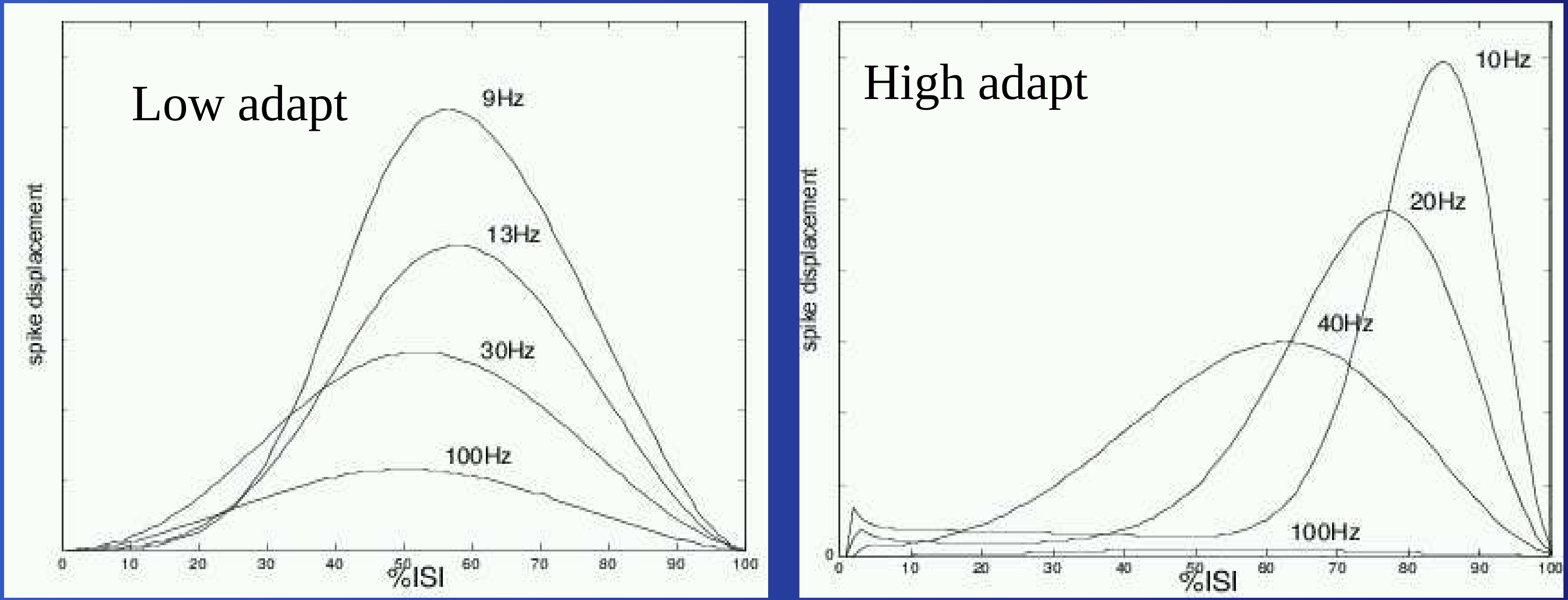

- At low frequencies - very sensitive
- With mauch adaptation, a coincidence detector
- At high frequencies - low sensitivity; “integrator”

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- The effect of SFA on the PRC can enhance the ability of coupled cells to synchronize
- Many neuromodulators affect SFA
  - Dopamine & ACh decrease K_m
  - Should decrease synchrony at lower frequencies by decreasing skew of PRC

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