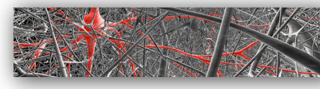
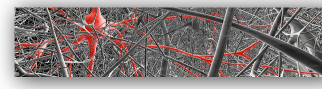


| | |
|---|---|
| August 4-5th, 2013<br>STSS Building Room 131A (Basement)<br>222 Pleasant St. | Introduction - Overview of Sensory-Motor Control<br>**Gunnar Blohm:** Queen's University, Kingston<br>**Kurt Thoroughman:** Washington Univ., St. Louis |
| August 6-7th, 2013<br>STSS Building Room 131A (Basement)<br>222 Pleasant St. | Lecture on Motor Control and Learning<br>**Reza Shadmehr:** Johns Hopkins, Baltimore<br>**Adrian Haith:** Johns Hopkins, Baltimore<br>**Alaa Ahmed:** University of Colorado, Boulder |
| August 8-9th, 2013<br>STSS Building Room 131A (Basement)<br>222 Pleasant St. | Sensory-motor processing<br>**Andrea Green:** University of Montréal, Montréal<br>**Paul Cisek:** University of Montréal, Montréal |
| August 11-12th, 2013<br>STSS Building Room 131A (Basement)<br>222 Pleasant St. | Prosthetics<br>**Jon Sensinger:** University of New Brunswick, New Brunswik<br>**Levi Hargrove:** Northwestern, Chicago |
| August 13-14th, 2013<br>STSS Building Room 131A (Basement)<br>222 Pleasant St. | The Bayesian Brain<br>**Paul Schrater:** University of Minnesota, Mineapolis<br>**Adam Johnson:** Bethel University, St Paul |
| August 15-16th, 2013<br>STSS Building Room 131A (Basement)<br>222 Pleasant St. | Computational Neuroimaging<br>**Thilo Womelsdorf:** York University, Toronto<br>**Matthijs van der Meer:** University of Waterloo, Waterloo |

| | | |
|---|---|---|
| Lecture | ~ 100 min. | • **Origins and Consequences** of Neuronal Synchronization |
| Lecture | ~ 50 min. | • **Measures** of Neuronal Synchronization and Brain Connectivity - An Introduction |
| Lecture | ~ 30 min. | • **Analysis** of Spiketrains, Spike-Field coherence and connectivity using the **FieldTrip** Open Source Toolbox |
| Hands-On | ~ 60-180 min. | • **Matlab** Analysis using Fieldtrip |

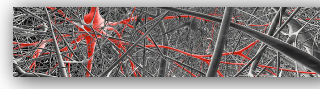


Three fundamental levels of analysis ***necessary*** to understand how the brain realizes a function such as flexible sensorimotor integr. (SMI)

*[D. Marr,1945-80]*

---

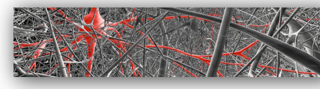
| | |
|---|---|
| 1. Computational Level - | ***Why*** does the brain care about a specific problem? |
| 2. Algorithmic Level - | ***What*** processes and neural code is used to solve it? |
| 3. Implementational Level - | ***How*** do Neurons and Networks realize the solution. |



Three fundamental levels of analysis ***necessary*** to understand how the brain realizes a function such as flexible sensorimotor integr. (SMI)

*[D. Marr,1945-80]*

| | | |
|---|---|---|
| 1. Computational Level - | ***Why*** does the brain care about a specific problem? | • SMI is key to **adjust *flexibly*** to changes in environment |
| 2. Algorithmic Level - | ***What*** processes and neural code is used to solve it? | • Networks of cells flexibly coordinate information. |
| 3. Implementational Level - | ***How*** do Neurons and Networks realize the solution. | • Here: How Cells and networks dynamically synchronize assemblies. |



| | | |
|---|---|---|
| Lecture | ~ 100 min. | • **Origins and Consequences** of Neuronal Synchronization |
| Lecture | ~ 50 min. | • **Measures** of Neuronal Synchronization and Brain Connectivity - An Introduction |
| Lecture | ~ 30 min. | • **Analysis** of Spiketrains, Spike-Field coherence and connectivity using the **FieldTrip** Open Source Toolbox |
| Hands-On | ~ 60-180 min. | • **Matlab** Analysis using Fieldtrip |

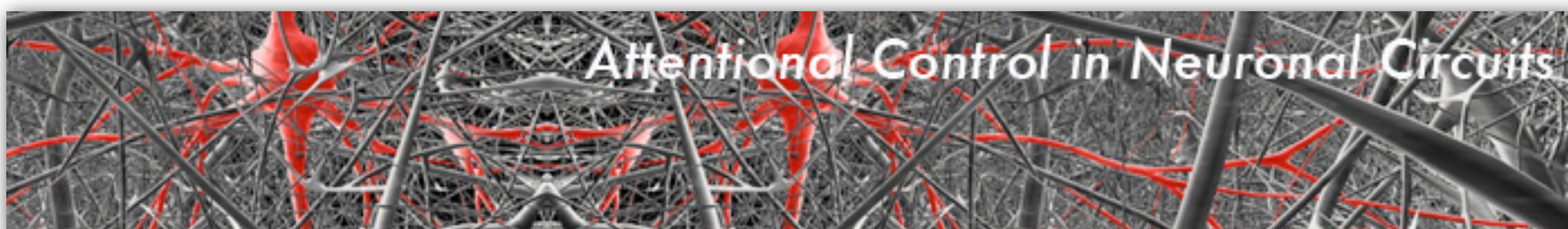
# Origins and Consequences of Precise Timing relations in Functional Networks: Cell and Circuit Levels

Thilo Womelsdorf

*Centre for Vision Research, York University, Toronto*

YORK U UNIVERSITÉ UNIVERSITY

attentionlab.ca



Prelude :

**Coding of Information** in Neuronal Networks is linked to **Spike Initiation Dynamics** of Single Cells and **Synchrony Transfer**.

Cell PRESS

Neuron
Perspective
2013

# Impact of Neuronal Properties on Network Coding: Roles of Spike Initiation Dynamics and Robust Synchrony Transfer

Stéphanie Ratté,[1] Sungho Hong,[2] Erik De Schutter,[2] and Steven A. Prescott[1,*]
[1]Neurosciences and Mental Health, The Hospital for Sick Children and Department of Physiology, University of Toronto, Toronto, ON M5G 1X8, Canada
[2]Computational Neuroscience Unit, Okinawa Institute of Science and Technology, Okinawa 904-0495, Japan
*Correspondence: steve.prescott@sickkids.ca
http://dx.doi.org/10.1016/j.neuron.2013.05.030

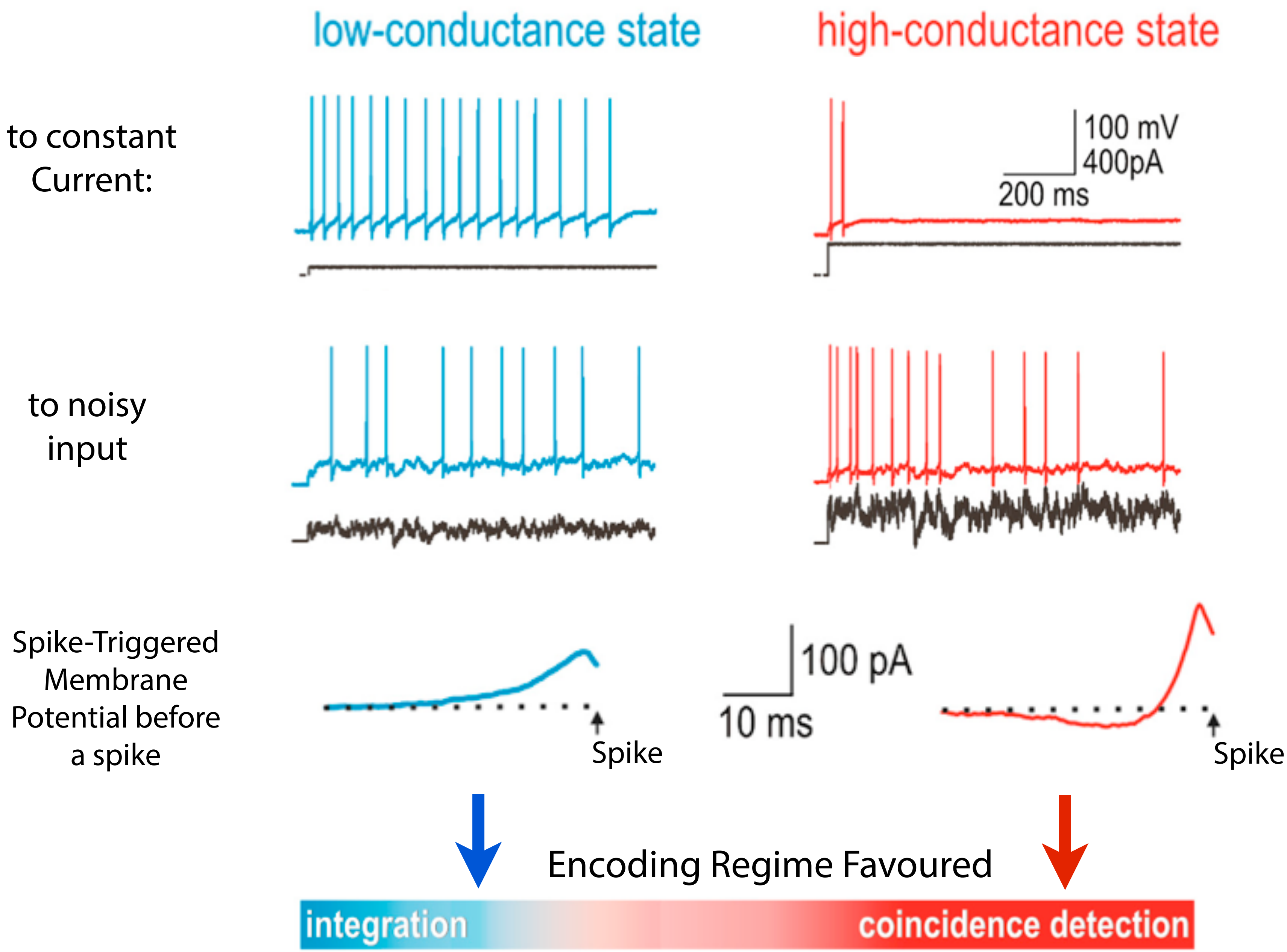
Neural networks are more than the sum of their parts, but the properties of those parts are nonetheless important. For instance, neuronal properties affect the degree to which neurons receiving common input will spike synchronously, and whether that synchrony will propagate through the network. Stimulus-evoked synchrony can help or hinder network coding depending on the type of code. In this Perspective, we describe how spike initiation dynamics influence neuronal input-output properties, how those properties affect synchronization, and how synchronization affects network coding. We propose that synchronous and asynchronous spiking can be used to multiplex temporal (synchrony) and rate coding and discuss how pyramidal neurons would be well suited for that task.

---

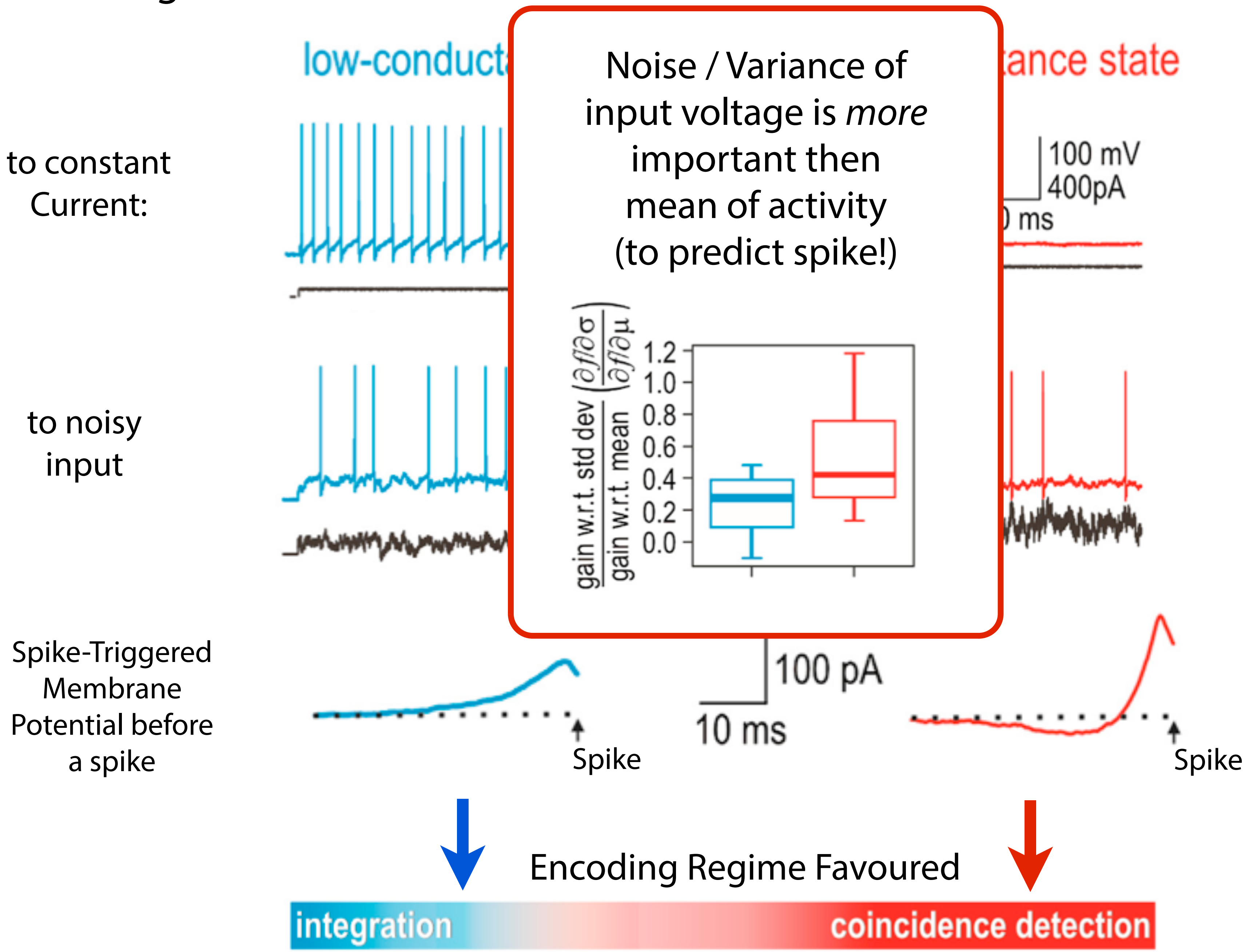
- Quote: "**Spike initiation dynamics** regulate **synchrony transfer properties**, and synchrony transfer properties regulate **network coding strategies**;

  ... therefore, spike initiation dynamics regulate network coding strategies."

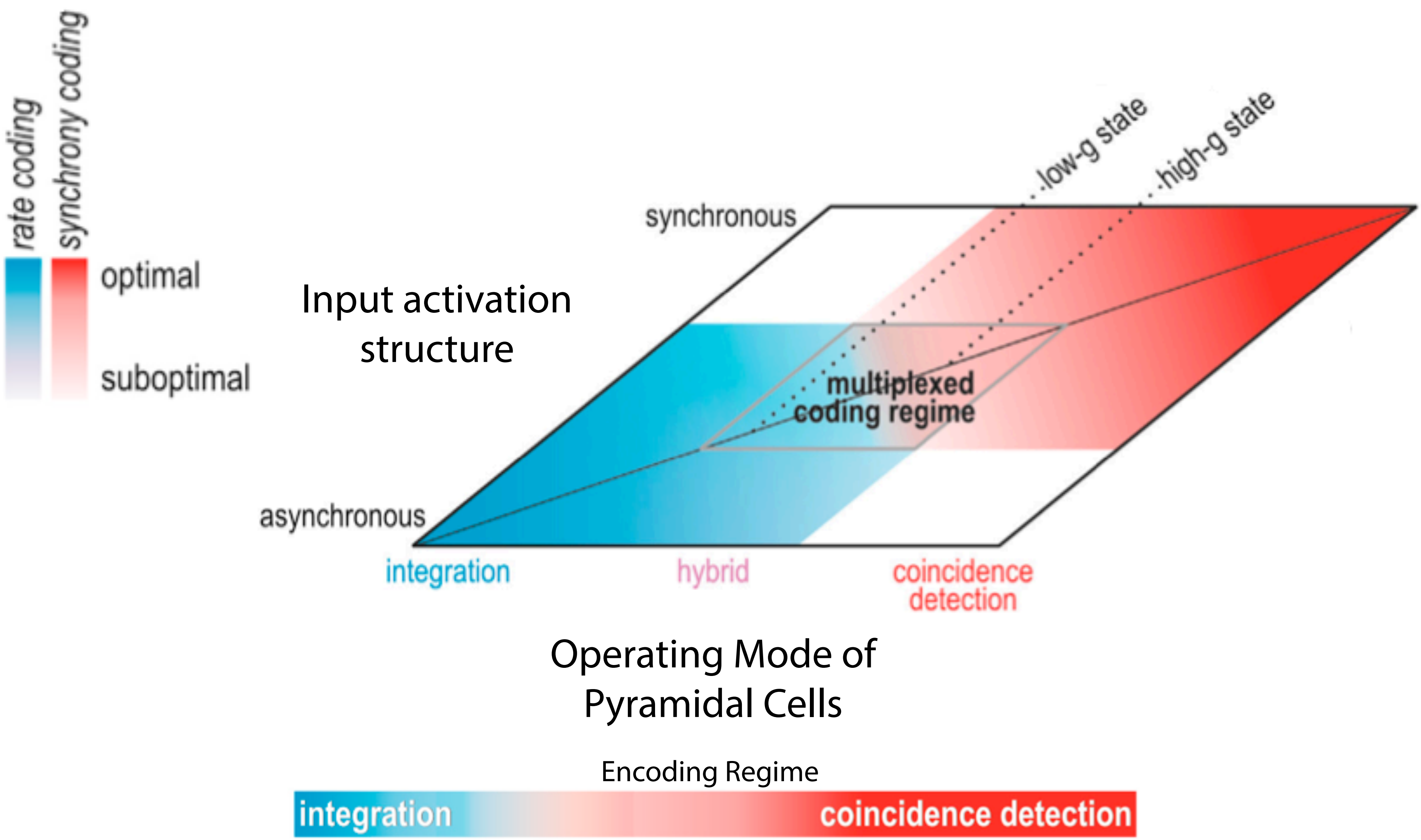
• Pyramidal Cells are in different operating modes during low and high conductance states.



• Pyramidal Cells are in different operating modes during low and high conductance states.

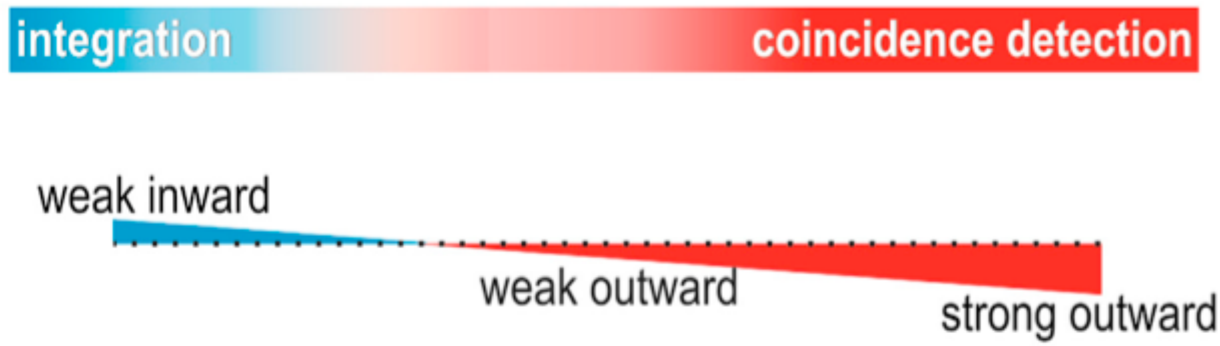


• Neuronal Coding depends jointly on the Operating Mode of Pyramidal Cells and the Input Properties



• Neuronal Coding depends jointly on the Operating Mode of Pyramidal Cells and the Input Properties

• The Operating Mode is set by the *Net-Slow Current at Peri-Threshold (V)*. Slow current compete with fast currents during high conductance states




**Net-Inward Current is depolarizing** (and helps sustaining the depolarization caused by external inputs)

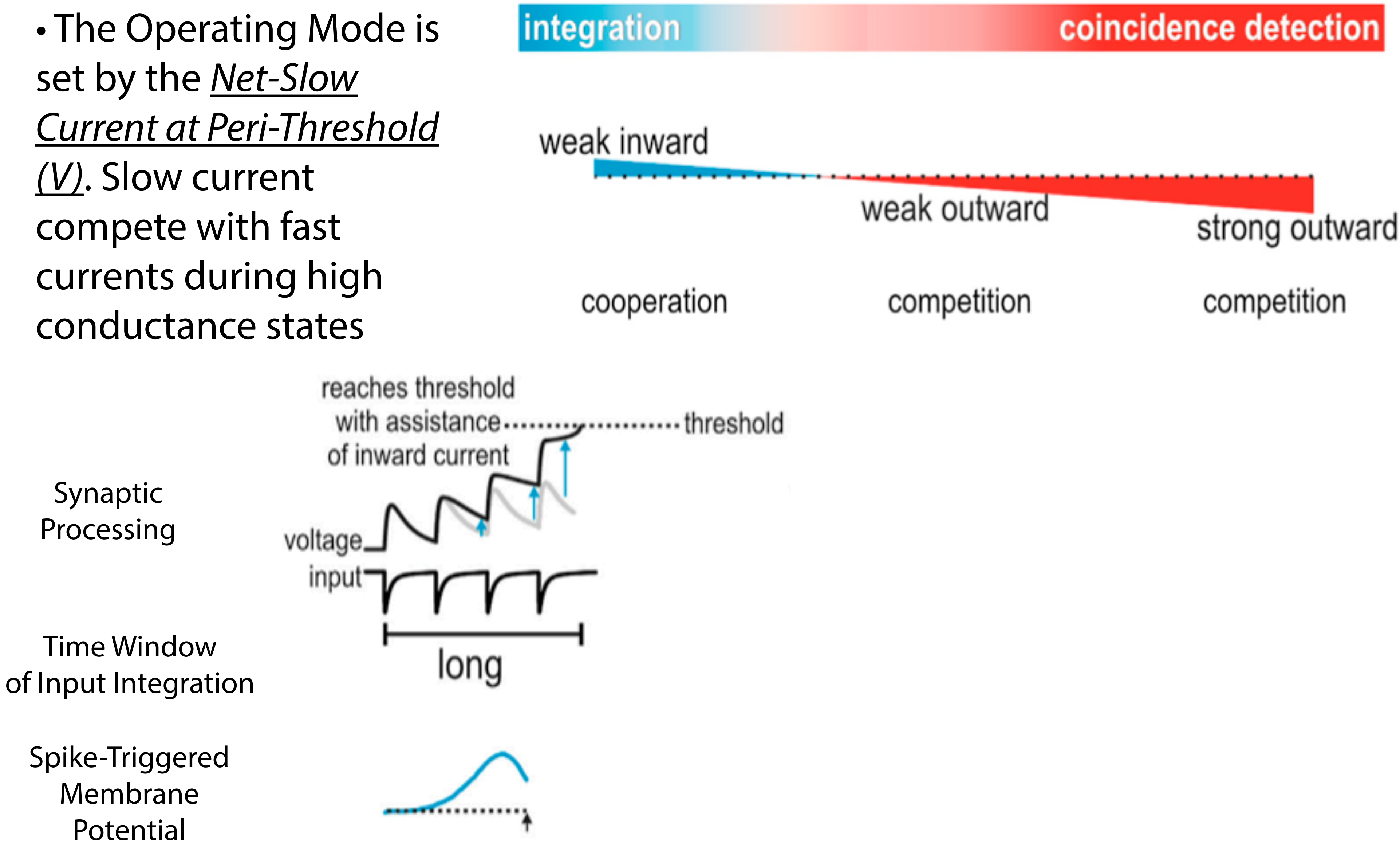
... this encourages temporal summation

**Net-Outward Current is hyperpolarizing** (and competes with fast, depolarizing inward current)

... this discourages summation

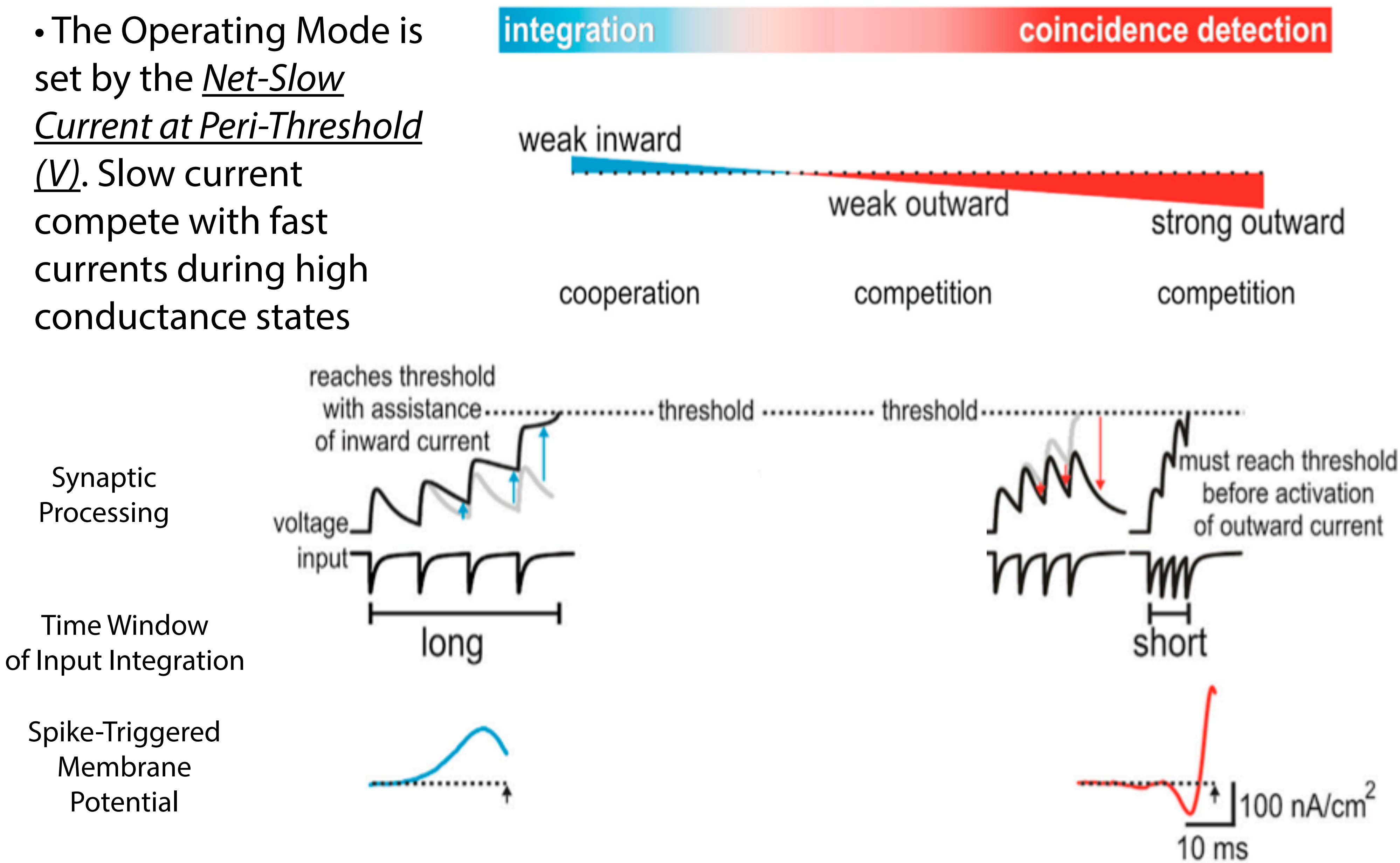
• Pyramidal Cells are in different operating modes during low and high conductance states.

• The Operating Mode is set by the *Net-Slow Current at Peri-Threshold (V)*. Slow current compete with fast currents during high conductance states



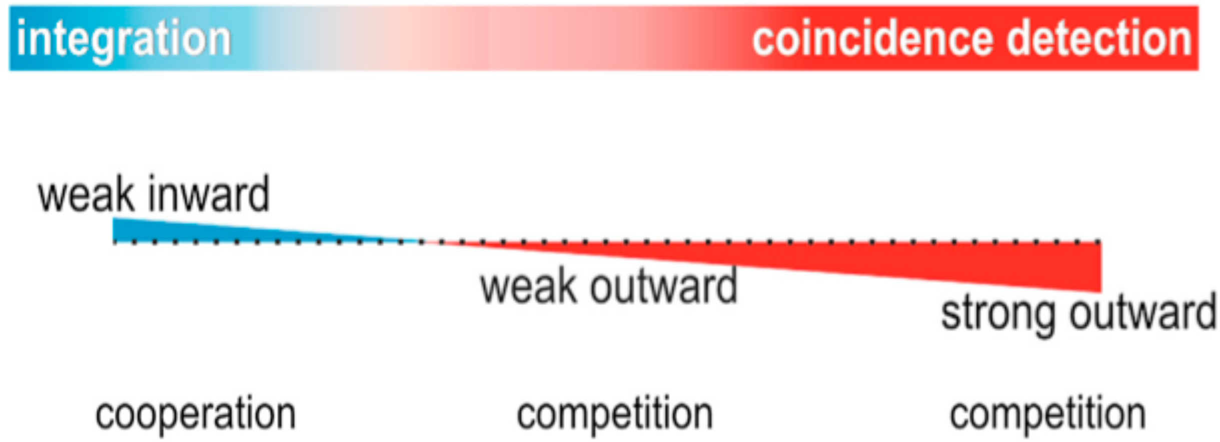
• Pyramidal Cells are in different operating modes during low and high conductance states.

• The Operating Mode is set by the *Net-Slow Current at Peri-Threshold (V)*. Slow current compete with fast currents during high conductance states



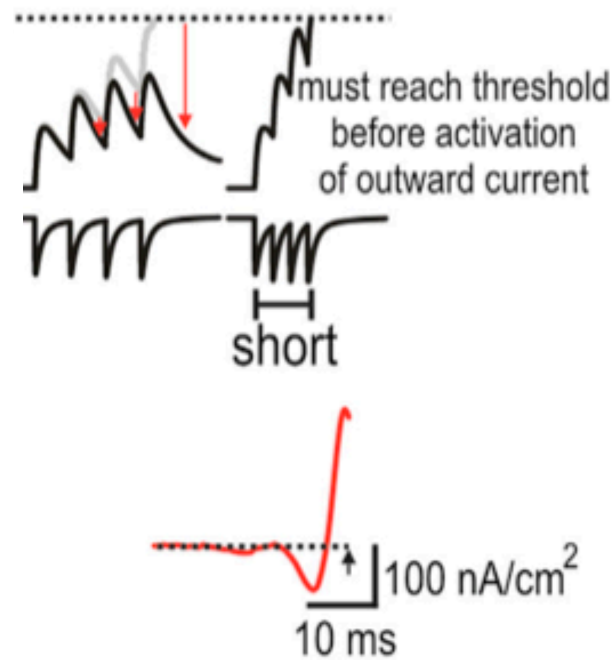
• Pyramidal Cells are in different operating modes during low and high conductance states.

• The Operating Mode is set by the *Net-Slow Current at Peri-Threshold (V)*. Slow current compete with fast currents during high conductance states



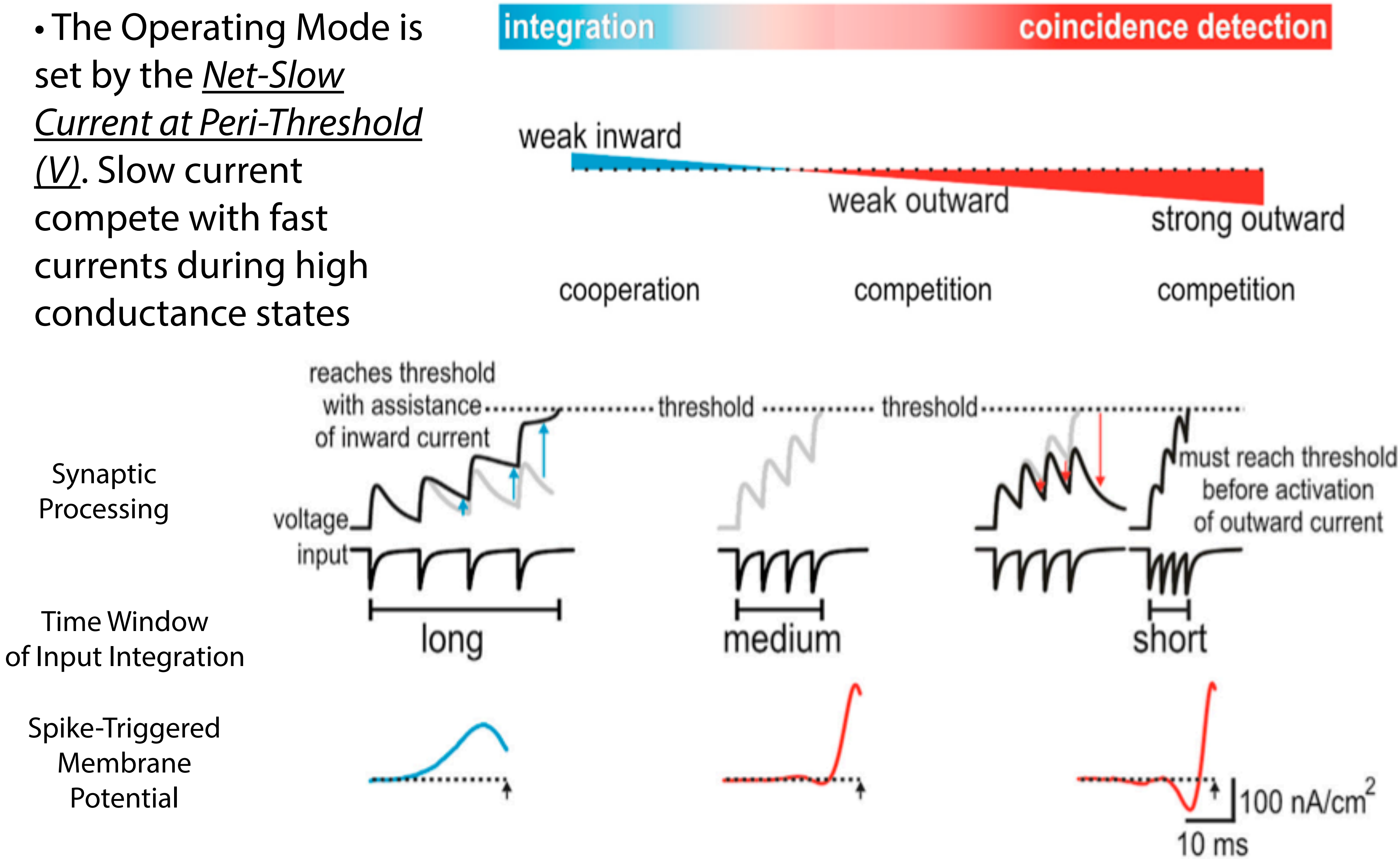

***The outward current acts as an active (voltage gated) negative feedback***

The net outward current (voltage-dependent) has an effect very *similar to that mediated by feedforward synaptic inhibition* in E-I circuits, which is well recognized as a mechanism that limits the integration time window.



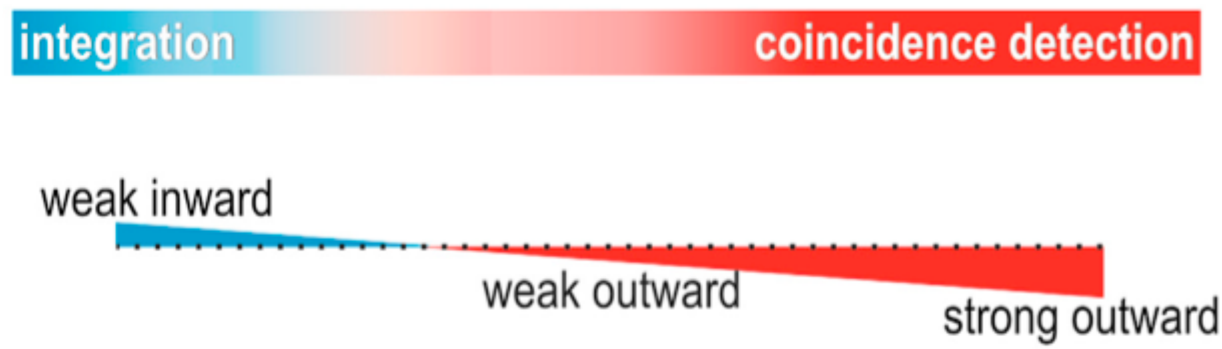
• Pyramidal Cells are in different operating modes during low and high conductance states.

• The Operating Mode is set by the *__Net-Slow Current at Peri-Threshold (V)__*. Slow current compete with fast currents during high conductance states



• Pyramidal Cells are in different operating modes during low and high conductance states.

• The Operating Mode is set by the *<u>Net-Slow Current at Peri-Threshold (V)</u>*. Slow current compete with fast currents during high conductance states




**Net-Inward Current is depolarizing** (and helps sustaining the depolarization caused by external inputs)

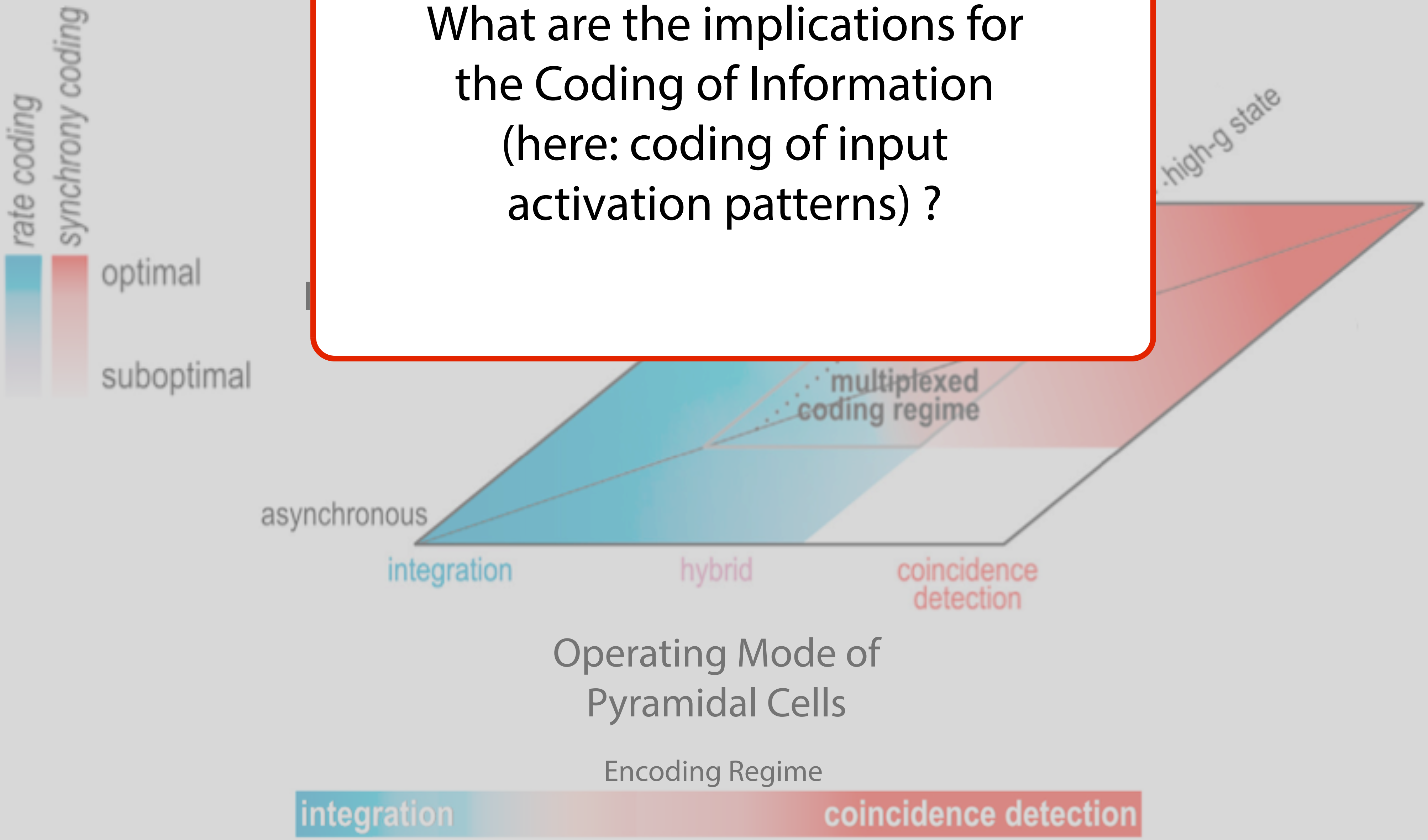
... this encourages temporal summation

**Net-Outward Current is hyperpolarizing** (and competes with fast, depolarizing inward current)

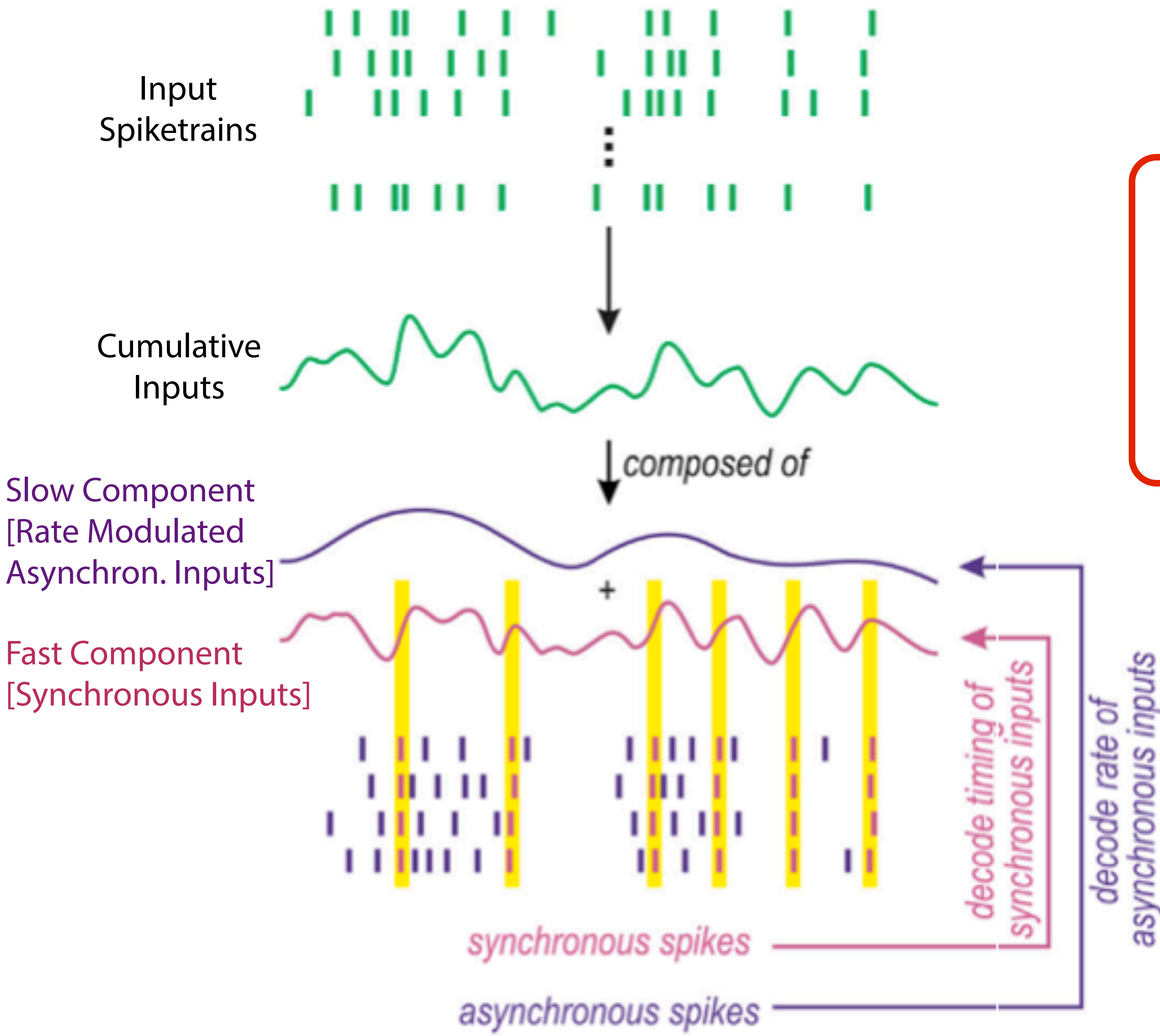
... this discourages summation

• Neuronal Coding depends jointly on the Operating Mode of Cells and Input Properties

What are the implications for the Coding of Information (here: coding of input activation patterns) ?



• Neurons in 'Hybrid Mode' can be sensitive to synchronous and asynchronous input - at the same time - They effectively "multiplex".




In 'Hybrid Mode' Pyramidal Cells Decode Synchronous And Asynchronous input.

Neuron
Perspective

# Impact of Neuronal Properties on Network Coding: Roles of Spike Initiation Dynamics and Robust Synchrony Transfer

Stéphanie Ratté,[1] Sungho Hong,[2] Erik De Schutter,[2] and Steven A. Prescott[1,*]
[1]Neurosciences and Mental Health, The Hospital for Sick Children and Department of Physiology, University of Toronto, Toronto, ON M5G 1X8, Canada
[2]Computational Neuroscience Unit, Okinawa Institute of Science and Technology, Okinawa 904-0495, Japan
*Correspondence: steve.prescott@sickkids.ca
http://dx.doi.org/10.1016/j.neuron.2013.05.030

Neural networks are more than the sum of their parts, but the properties of those parts are nonetheless important. For instance, neuronal properties affect the degree to which neurons receiving common input will spike synchronously, and whether that synchrony will propagate through the network. Stimulus-evoked synchrony can help or hinder network coding depending on the type of code. In this Perspective, we describe how spike initiation dynamics influence neuronal input-output properties, how those properties affect synchronization, and how synchronization affects network coding. We propose that synchronous and asynchronous spiking can be used to multiplex temporal (synchrony) and rate coding and discuss how pyramidal neurons would be well suited for that task.

---

- Quote: “**Spike initiation dynamics** regulate **synchrony transfer properties**, and synchrony transfer properties regulate **network coding strategies**;

  ... therefore, spike initiation dynamics regulate network coding strategies.”