Now You See Me, *Now You Don't!*
Attentional Modulation in a L2/3 V1 Pyramidal Neuron Model

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IMBB-FORTH

1. Introduction


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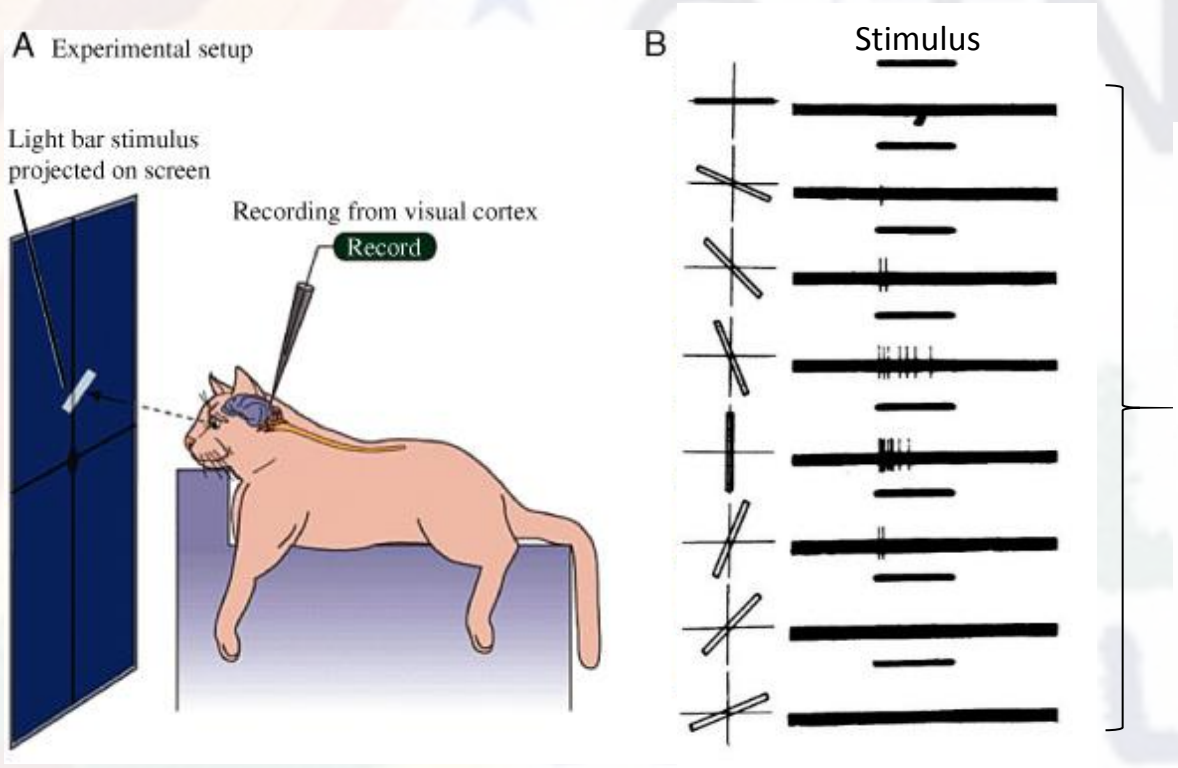
…but more on that later.

Introduction

Orientation Selectivity

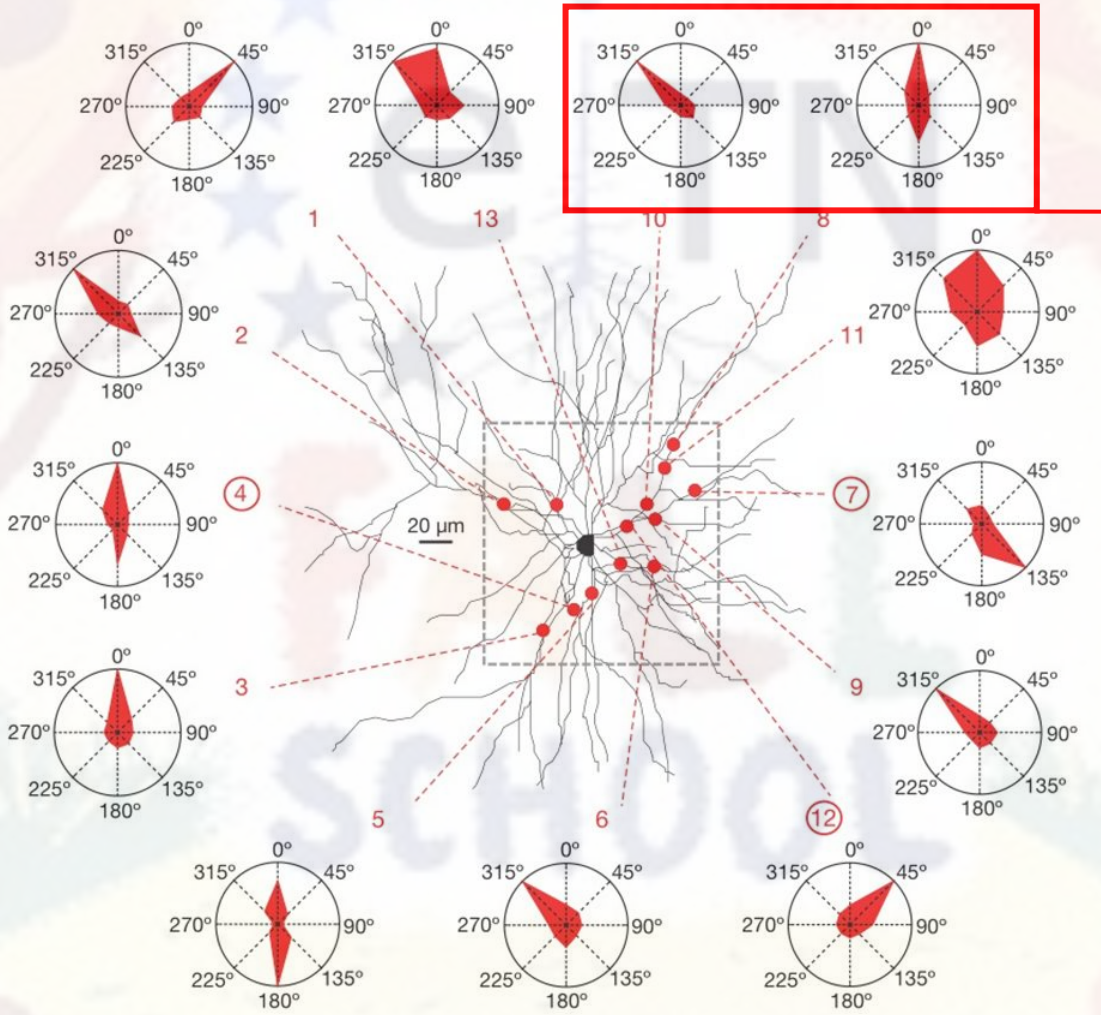
$$OSI = \frac{Rp - Ro}{Rp + Ro}$$



Hubel and Wiesel, 1962

Introduction

Synaptic Orientation Preference

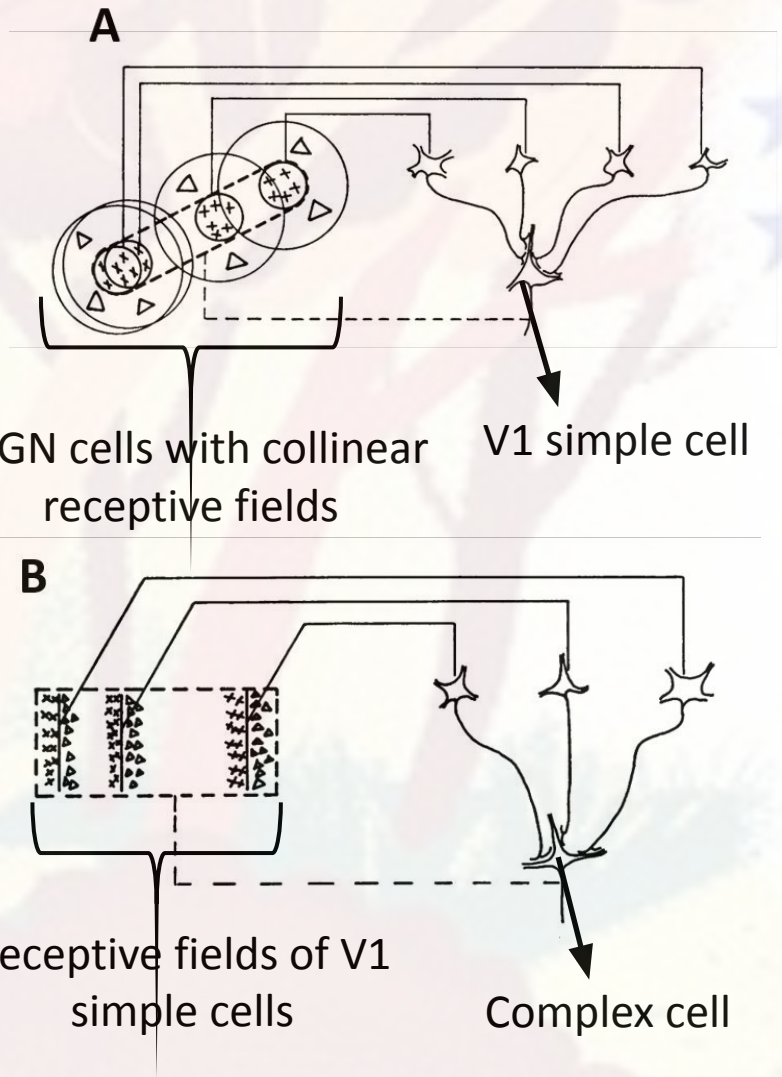


Same dendrite, <u>different synaptic orientation preference</u>

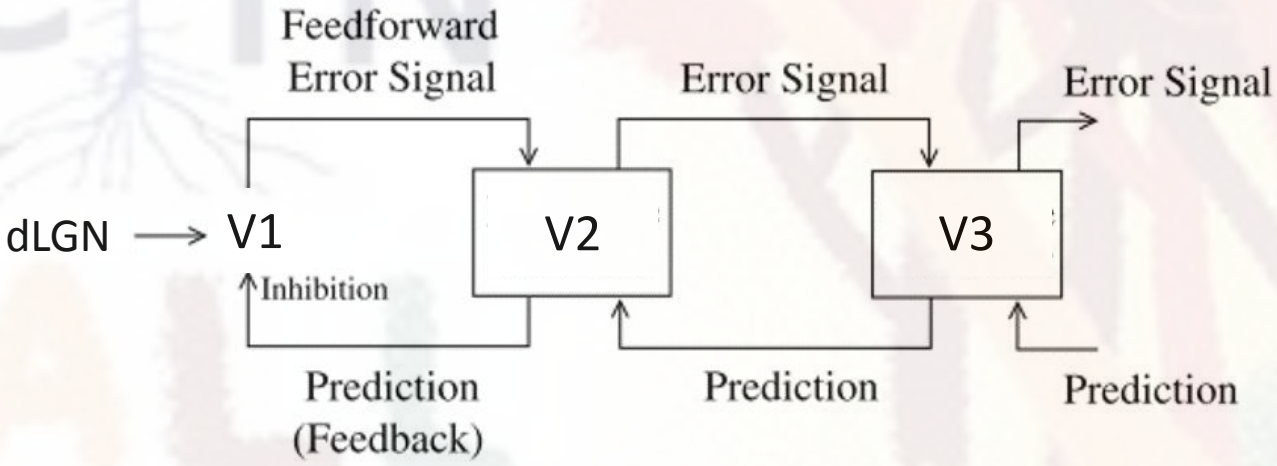
Jia, Rochefort and Chen, 2010

Introduction

Hubel & Wiesel model / Predictive Coding model



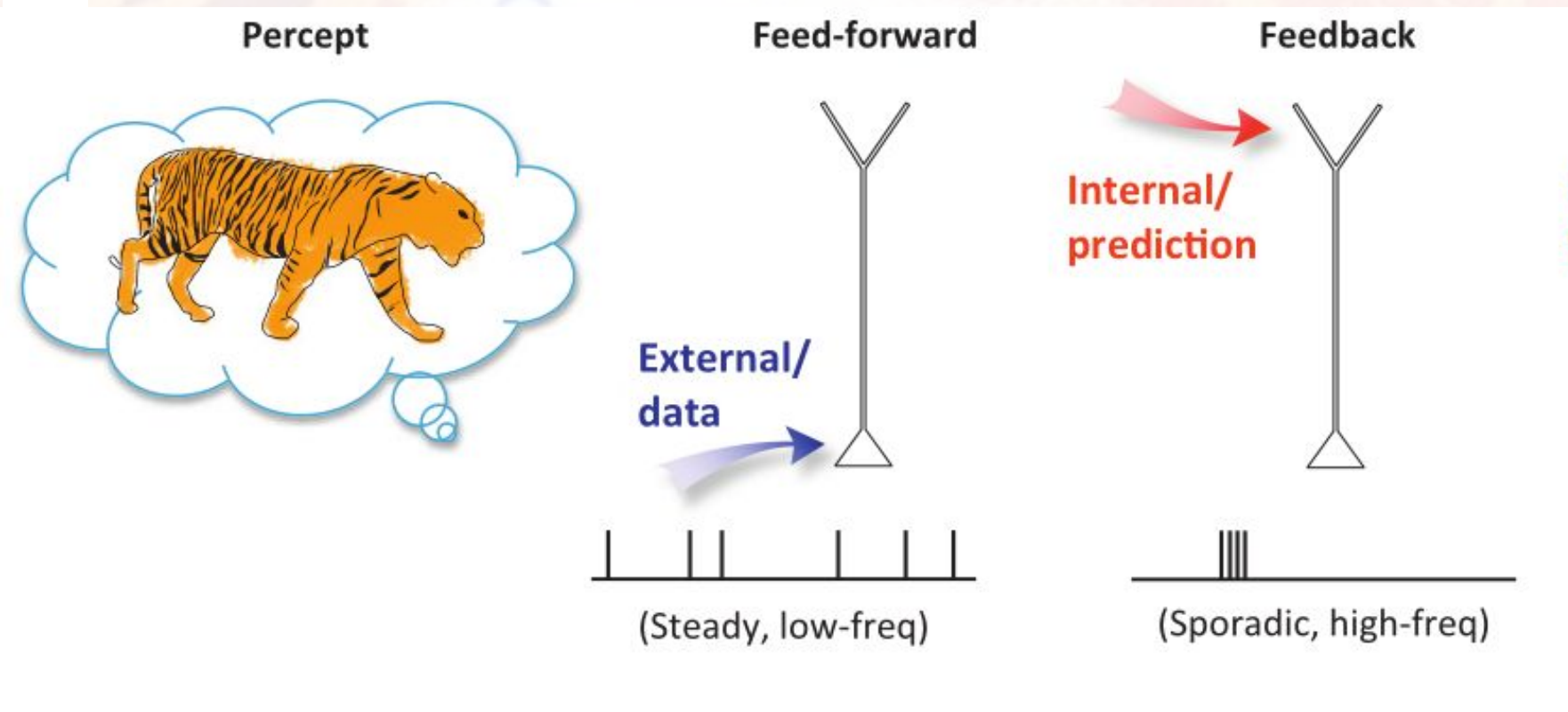
Hubel and Wiesel, 1962



Rao and Ballard, 1999

Introduction

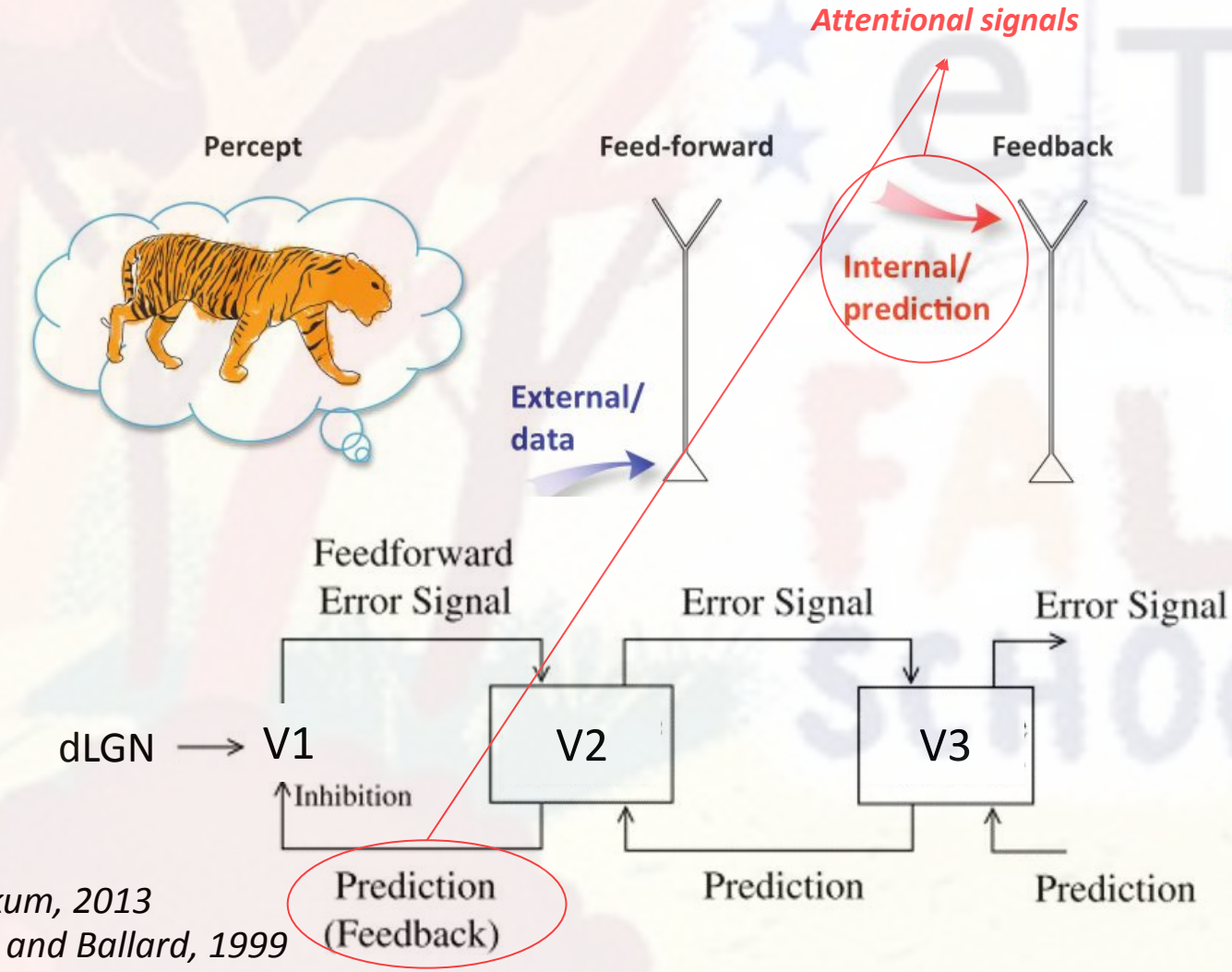
Feedforward vs Feedback inputs



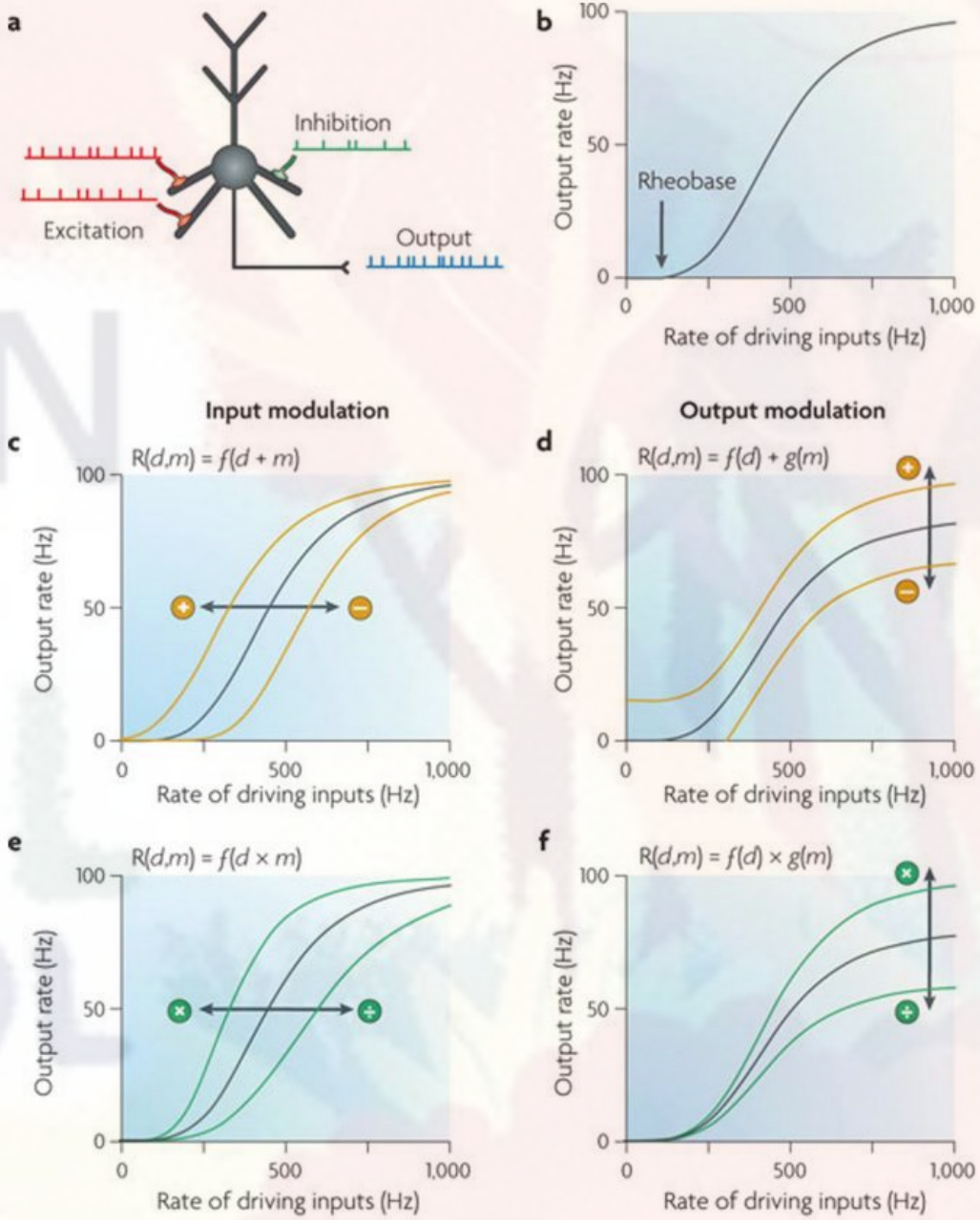
Larkum, 2013

Introduction

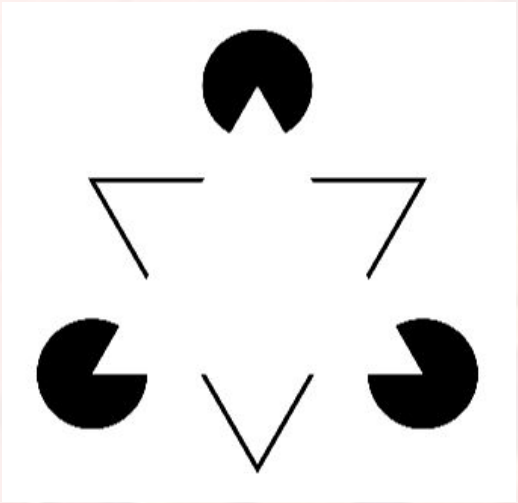
Attentional Signals and Modulation



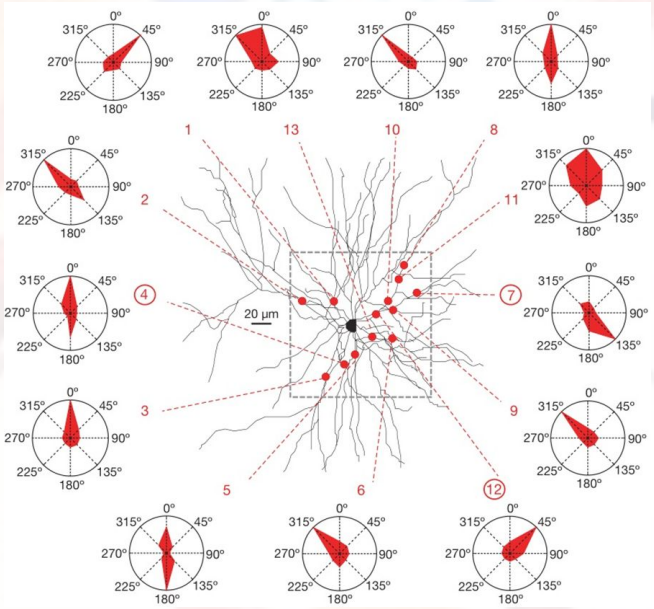
Larkum, 2013
Rao and Ballard, 1999



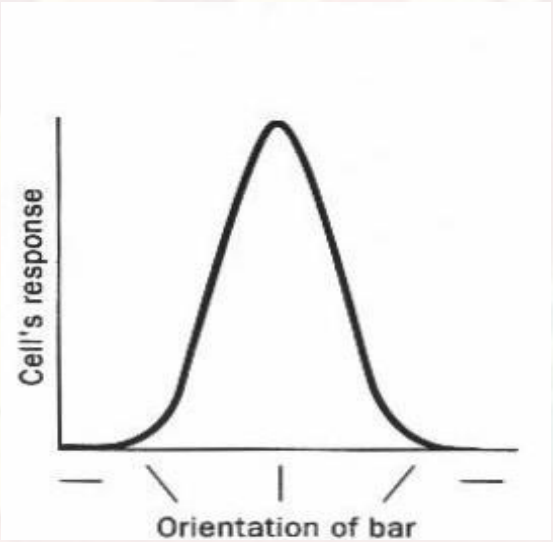
Silver, 2010

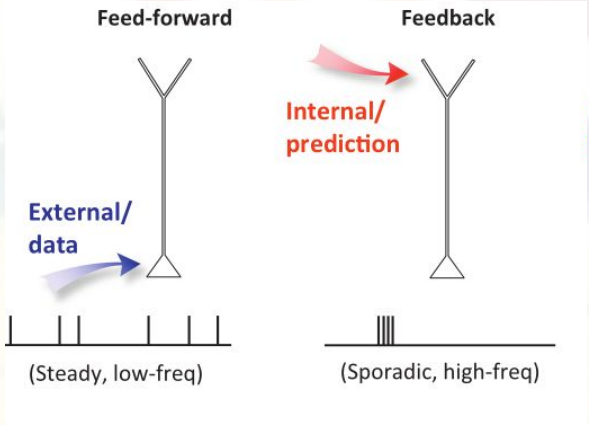


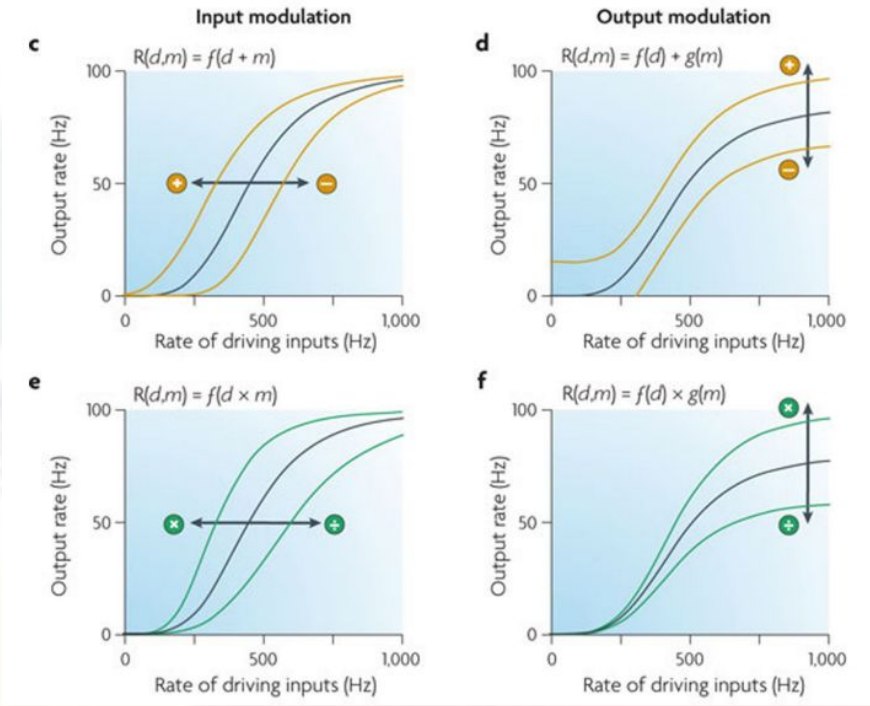
Feedback - Attentional/Predictive Input



Feedforward - Visual Input



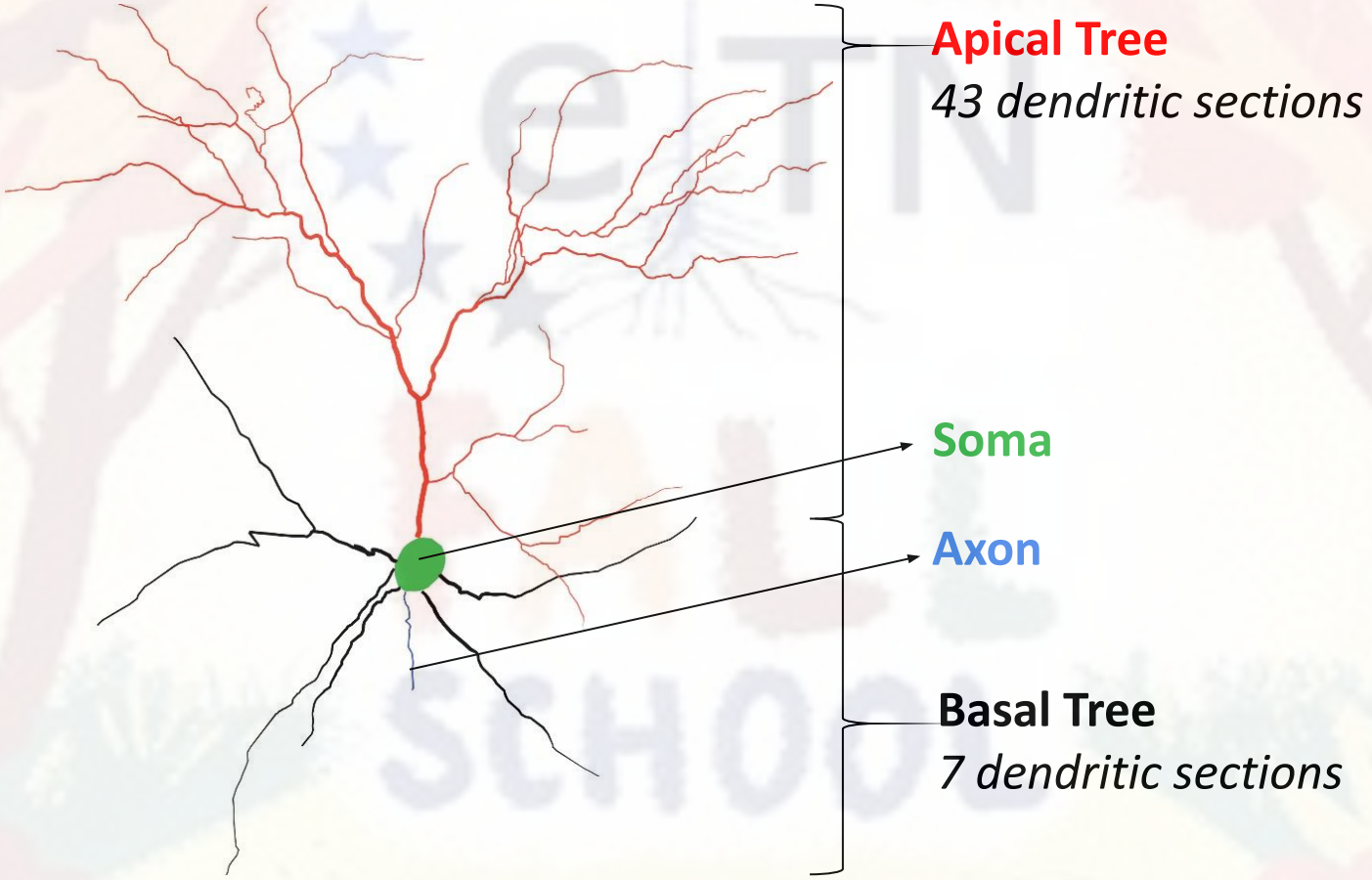




2. Project Formulation

Setup

Model morphology



Setup

Model biophysics

Apical Tree
43 dendritic sections

Soma

Axon

Basal Tree
7 dendritic sections

- Hodgkin/Huxley voltage-gated Na^{+} channels
- Hodgkin/Huxley voltage-gated K^{+} channels
- Muscarinic voltage-gated K^{+} channels
- A-Type voltage-gated K^{+} channels
- T-Type Ca^{++} channels
- High voltage activated (HVA) Ca^{++} channels
- Calcium-dependent K^{+} channels
- Active ATP Ca^{++} pumps

…all configured properly!

Goal

Synaptic Allocation

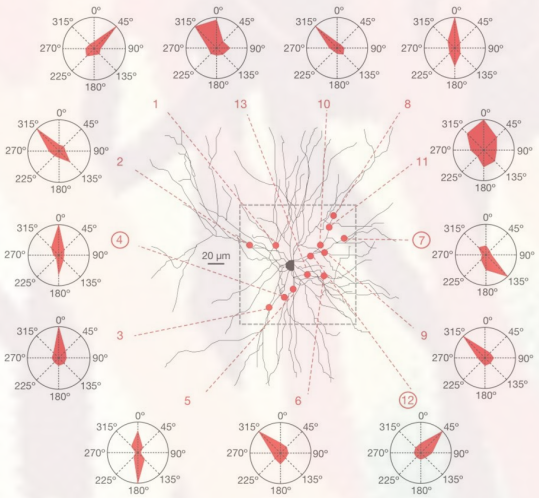
???????

Stimulus-Driven

Excitatory Synapses

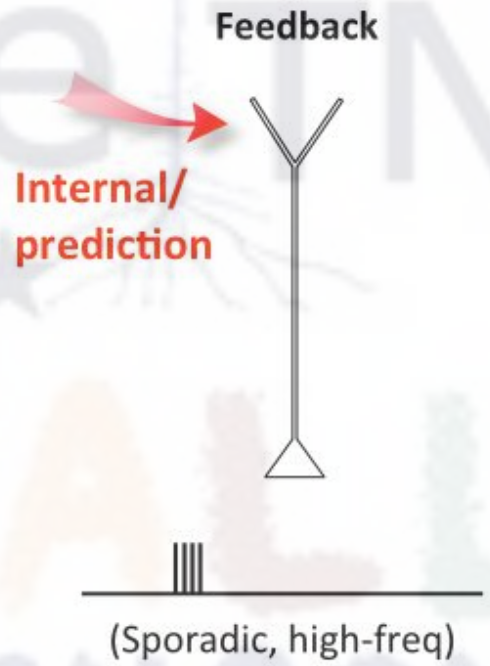
Inhibitory Synapses

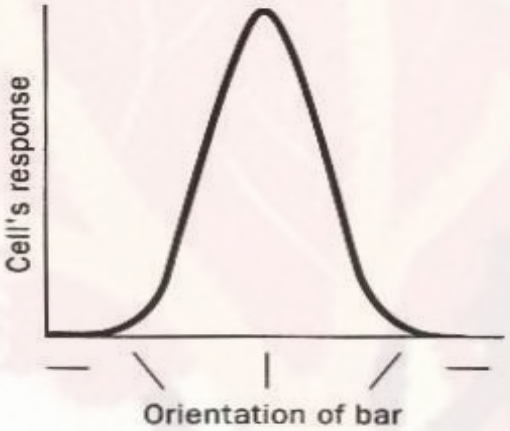
Background-Driven
("noise")



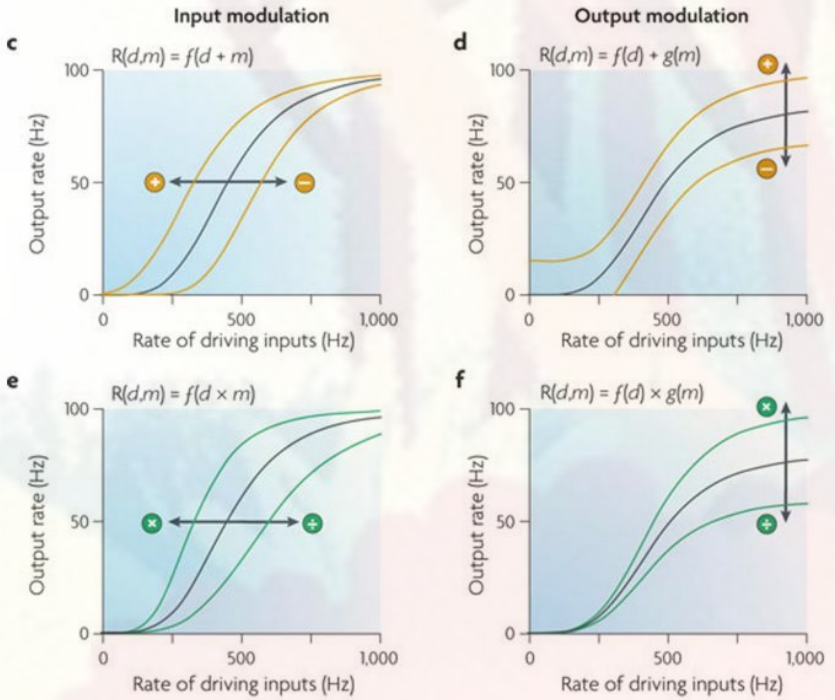
Goal

Attentional Modulation



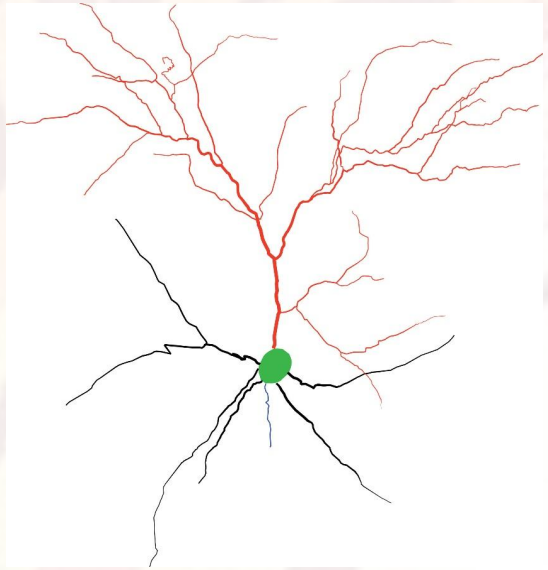


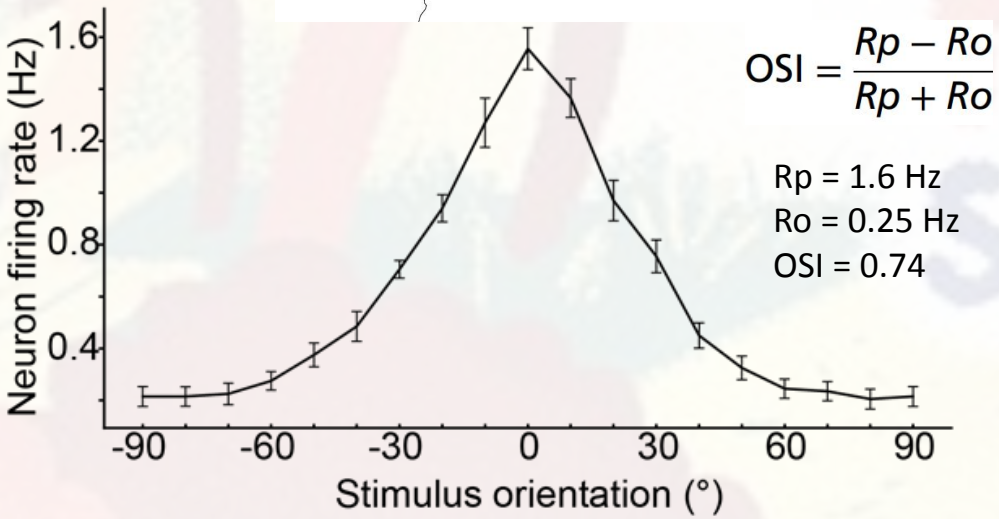
$$OSI = \frac{Rp - Ro}{Rp + Ro}$$



Goals

Overview





$$OSI = \frac{Rp - Ro}{Rp + Ro}$$

Rp = 1.6 Hz
Ro = 0.25 Hz
OSI = 0.74

Project Milestones:

- Allocate a single synapse and ensure correct function
- Allocate multiple synapses according to a set plan
- Ensure that stimulus-driven synapses feature orientation selectivity
- Implement a subset of synapses as attentional (feedback) inputs
- Allocate all synapses (feedforward & feedback)
- Show that the neuron exhibits orientation tuning (tuning curve/OSI)
- Investigate the effect of attention on neuronal output
- Demonstrate the effect (or lack thereof) of attention
- ???
- Present your results!

Materials

Useful Papers and Other Resources

Useful Papers:

- Silver, R. A. (2010). Neuronal arithmetic. *Nature Reviews Neuroscience*, *11*(7), 474-489.
- Goetz, L., Roth, A., & Häusser, M. (2021). Active dendrites enable strong but sparse inputs to determine orientation selectivity. *Proceedings of the National Academy of Sciences*, *118*(30), e2017339118.
- Park, J., Papoutsi, A., Ash, R. T., Marin, M. A., Poirazi, P., & Smirnakis, S. M. (2019). Contribution of apical and basal dendrites to orientation encoding in mouse V1 L2/3 pyramidal neurons. *Nature Communications*, *10*(1), 1-11.

Other Resources:

- The NEURON tutorials by András Ecker (tomorrow!)
- https://neuron.yale.edu/neuron/static/py_doc/index.html [NEURON/Python documentation]
- https://docs.python.org/3/reference/ [Python documentation]

Good Luck!
*Don't forget to have **fun**!**

**Doing science and learning. All other kinds of fun subject to personal and institutional discretion. Contact your supervisor or other parental figure for more information. This is not legal advice.*
;-)