

Computational Neuroscience Course

An Introduction to Computational Neuroscience

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University of Science and Technology of China

Sep | 2022

Course website

<https://github.com/Wenlab/Computation-Neuro-Course/tree/Fall2022>

The screenshot shows a dark-themed GitHub repository page for 'README.md'. The main content is a large heading 'Computational-Neuroscience-Course' followed by a descriptive paragraph about the course's purpose and structure. Below this, there are sections for 'When', 'Where', 'Teacher', and 'Teaching Fellow'. Further down are sections for 'Recommended Textbooks' and 'Course Performance Evaluation', each containing a bulleted list of items.

README.md

Computational-Neuroscience-Course

This repository serves as an ongoing effort to create a systems and computational neuroscience course. I hope to develop a two-semester course for USTC biophysics students. The first semester will cover some basic materials, and the second semester will introduce more advanced topics for undergraduate and graduate students.

When: Thursday 9:45 am - 11:20 am, Fall 2022

Where: 东区第二教学楼2208

Teacher: 温泉 qwen@ustc.edu.cn

Teaching Fellow: 李懿轩 hyperdunk2019@mail.ustc.edu.cn

Recommended Textbooks:

- Theoretical Neuroscience: Computational and Mathematical Modeling the Neural System
- Principles of Neural Design

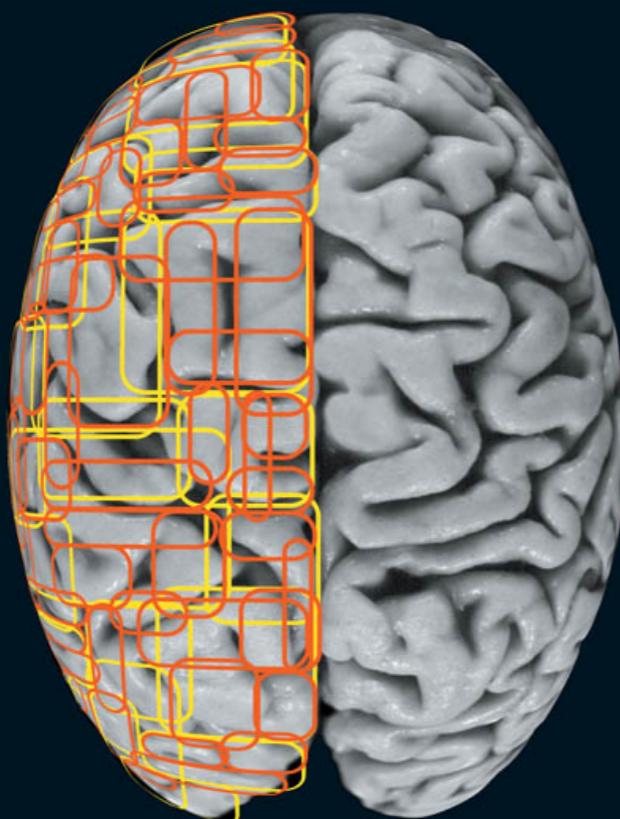
Course Performance Evaluation:

- Homework: 70%
- Final: 30%

Recommended textbooks

THEORETICAL NEUROSCIENCE

Computational and Mathematical
Modeling of Neural Systems



Peter Dayan and L. F. Abbott

How questions

Principles of
Neural Design



Peter Sterling and Simon Laughlin

Why questions

A brief pre-history

Theoretical Neurophysiology

1907 Lapique:
integrate-and-fire model

1952 Hodgkin-Huxley:
theory of action potential

1960's Rall:
cable theory of dendrites

1970's Wilson-Cowan:
firing-rate population models

1980's: Biophysics of neurons &
synapses, network dynamics

Psychology & Computer Science

1949 Hebb:
learning rules

1960's Rosenblatt, Minsky:
perceptrons

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1970's signal detection theory

1980's Hopfield:
associative memory model



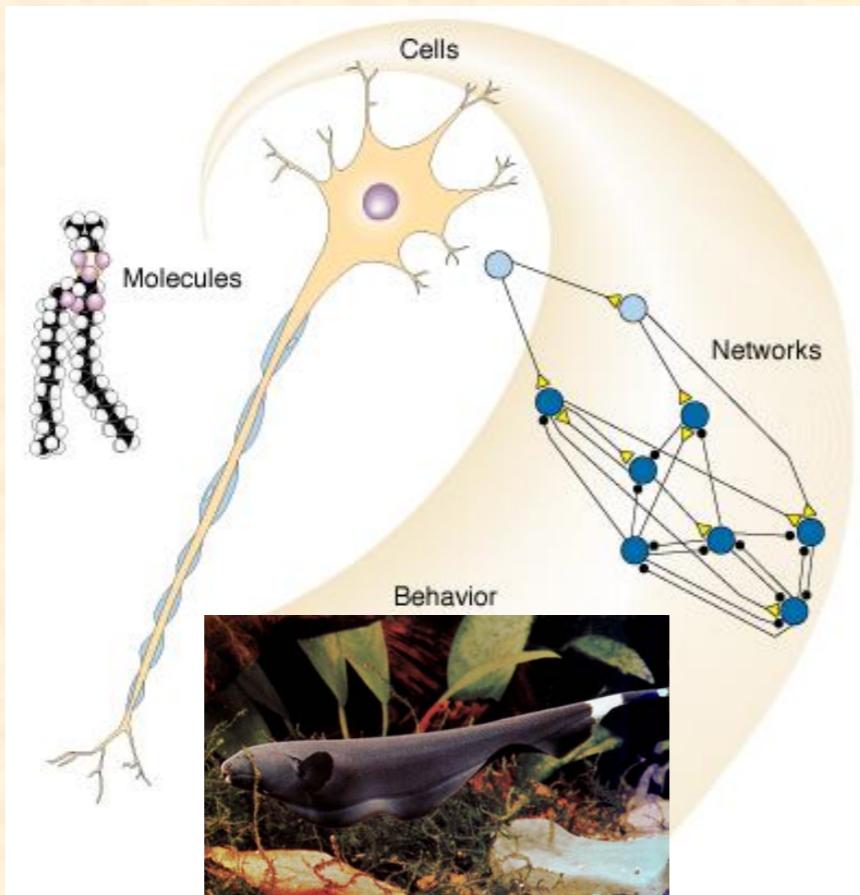
Sejnowski, Koch, Churchland, Computational neuroscience. *Science* 1988 241: 1299-1306
Methods in Computational Neuroscience Summer School, Marine Biological Laboratory

adapted from Xiaojing Wang's slide

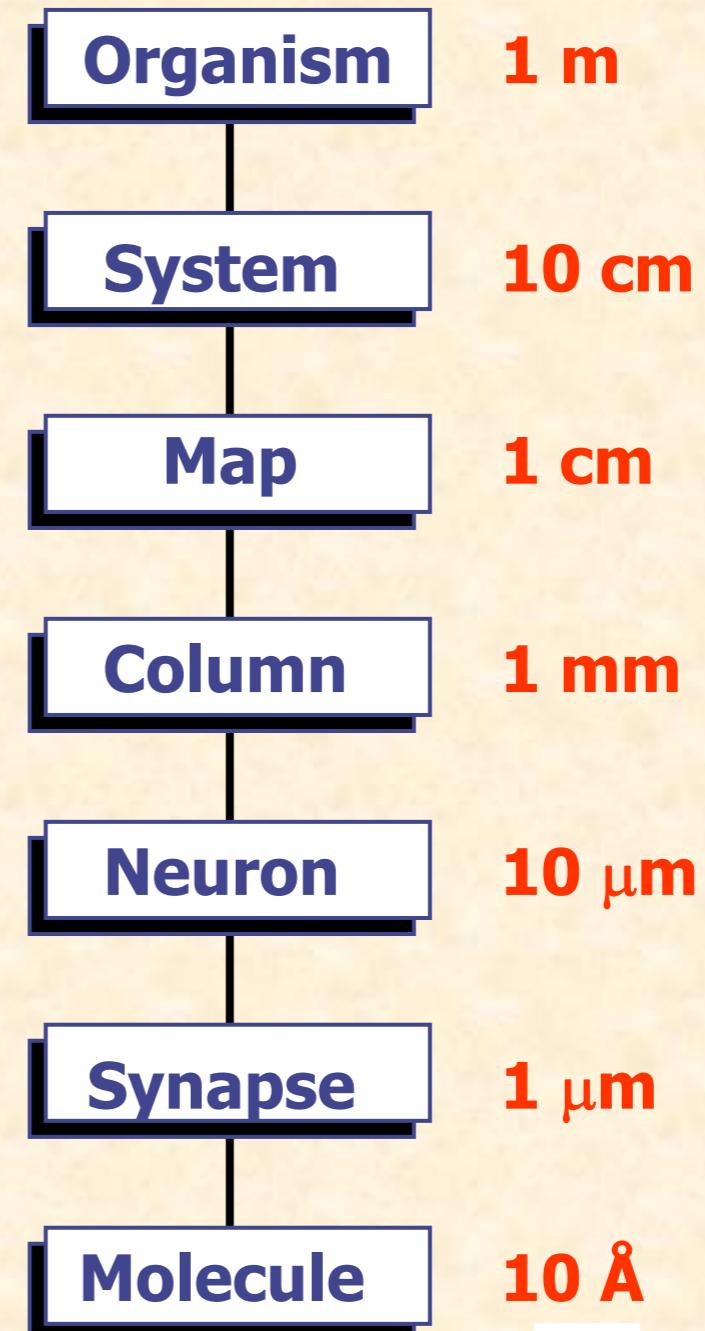
Principles of Neuroscience ?



Multiscale Organization of the Nervous System



Delcomyn 1998



“To pile speculation on speculation, I would say that the next stage could be hierarchy or specialization of function, or both.... with increasing complication at each stage, we go on up the hierarchy of sciences. We expect to encounter fascinating and, I believe, very fundamental questions at each stage in fitting together less complicated pieces into the more complicated system and understanding the basically new types of behavior which can result.”

P. W. Anderson, 1972
condensed matter physicist

More is different

Fitzgerald: The rich are **different** from us.

Hemingway: Yes, they have **more** money.

a conversation somewhere in Paris in 1920s



David Marr
1945-1980



Henry Markram
1962 -

VISION



David Marr

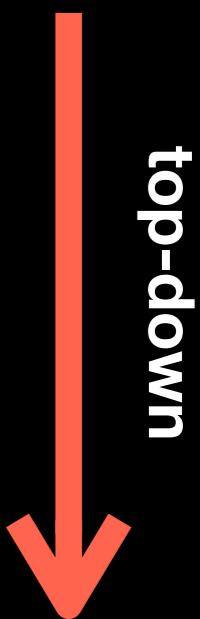
FOREWORD BY
Shimon Ullman
AFTERWORD BY
Tomaso Poggio

blue brain project



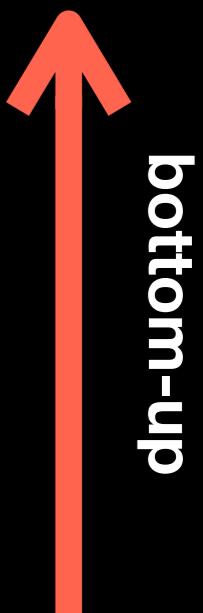
David Marr's three level theory

- **Computational level:** Identify the computational problem and task that the brain solves.
- **Algorithmic level:** Find the mathematical procedures that solve the problem.
- **Implementation level:** How the algorithms are realized by the nervous system.



Henry Markram's three level theory

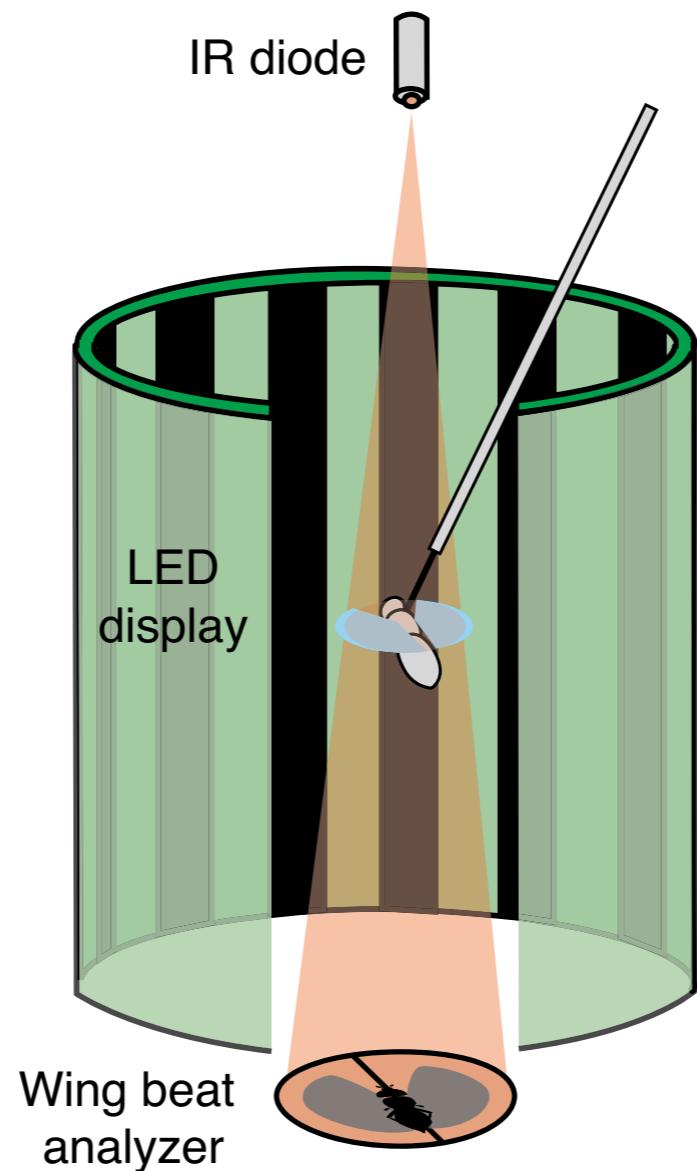
- **Systems level:** describe how population neural dynamics and behaviors emerge from ensembles of neurons.
- **Cellular level:** develop biophysically accurate models to describe input-output relationships of different cell types.
- **Structure level:** identify how neurons are statistically connected to each other in a circuit.



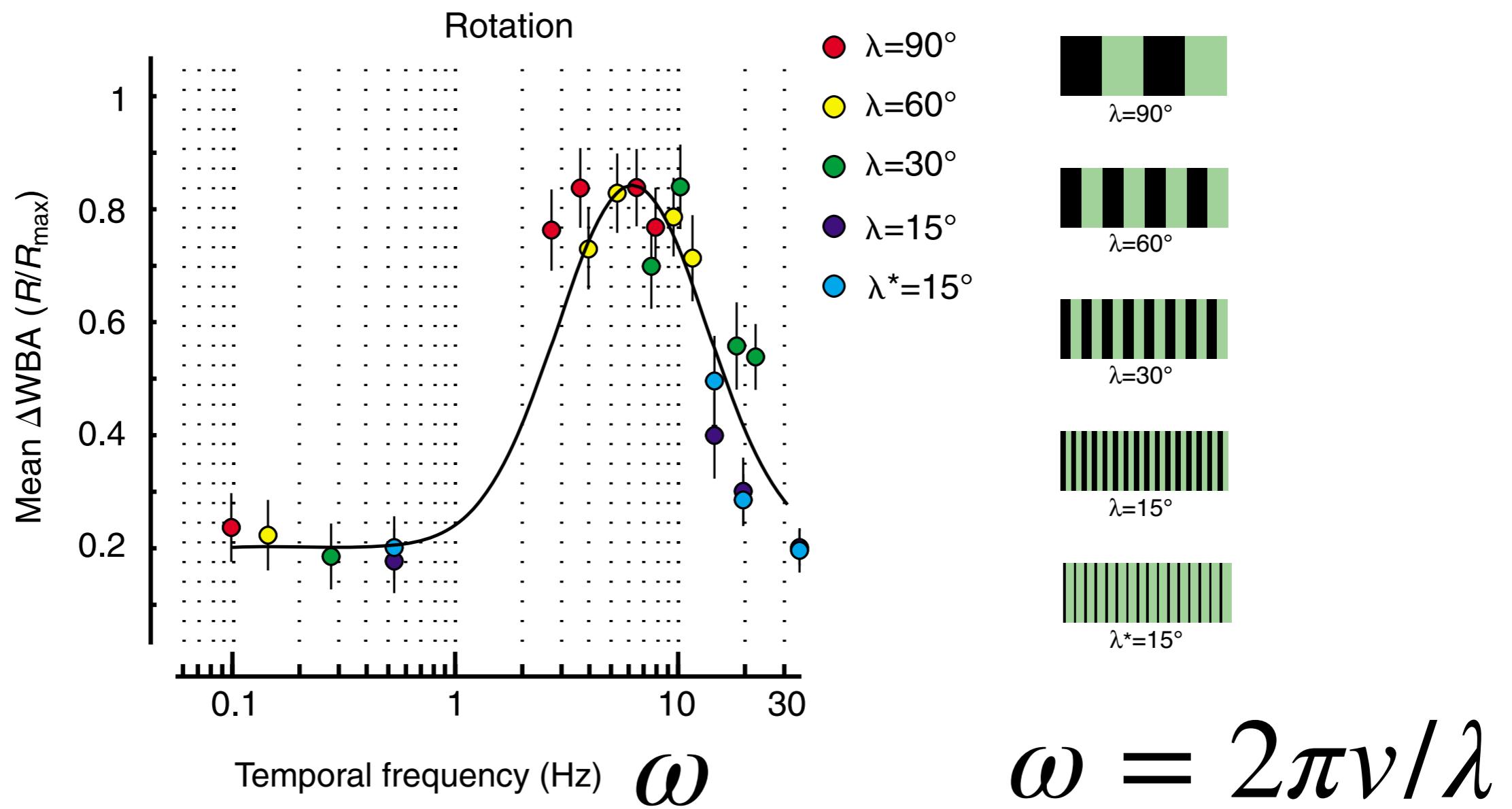
Motion detection, an example



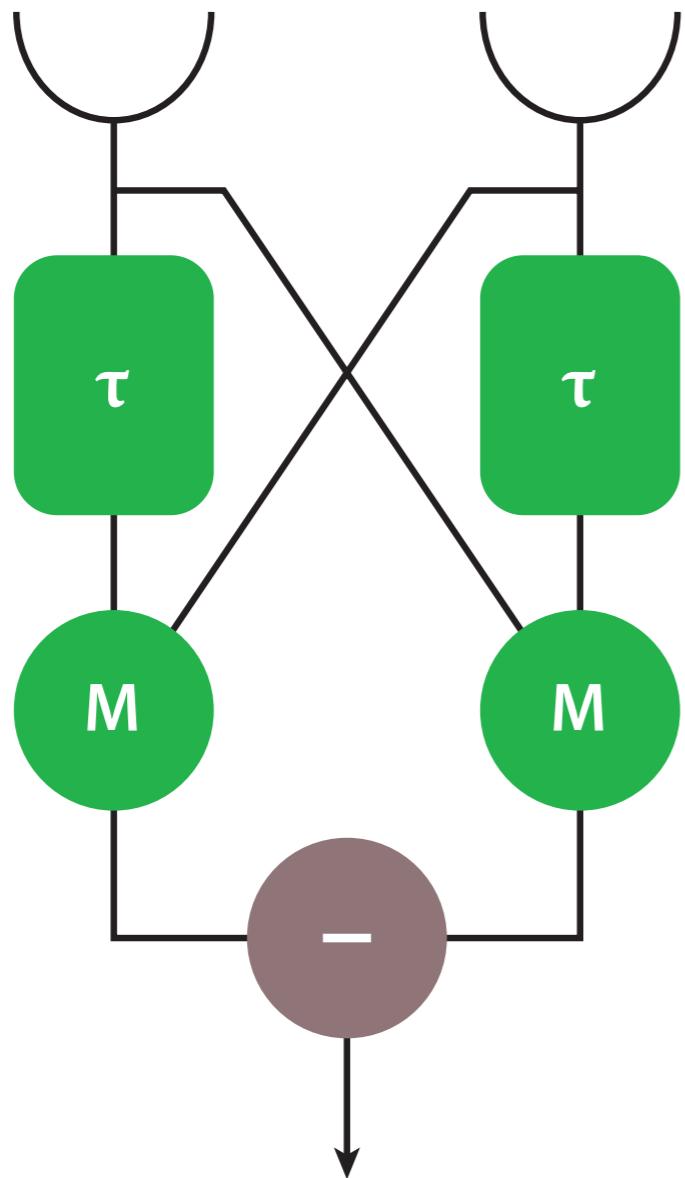
Optomotor response in fly



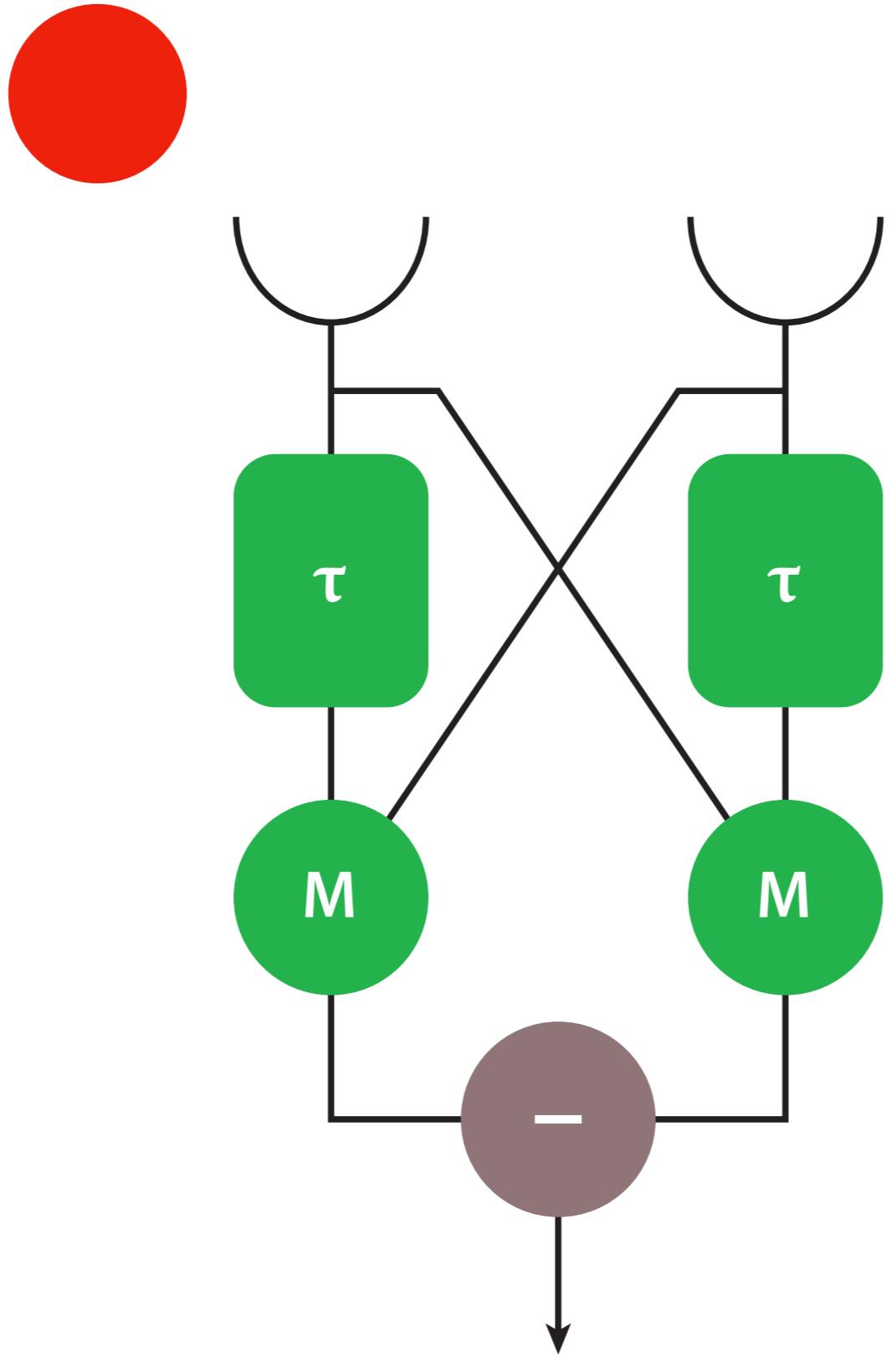
Optomotor response in fly

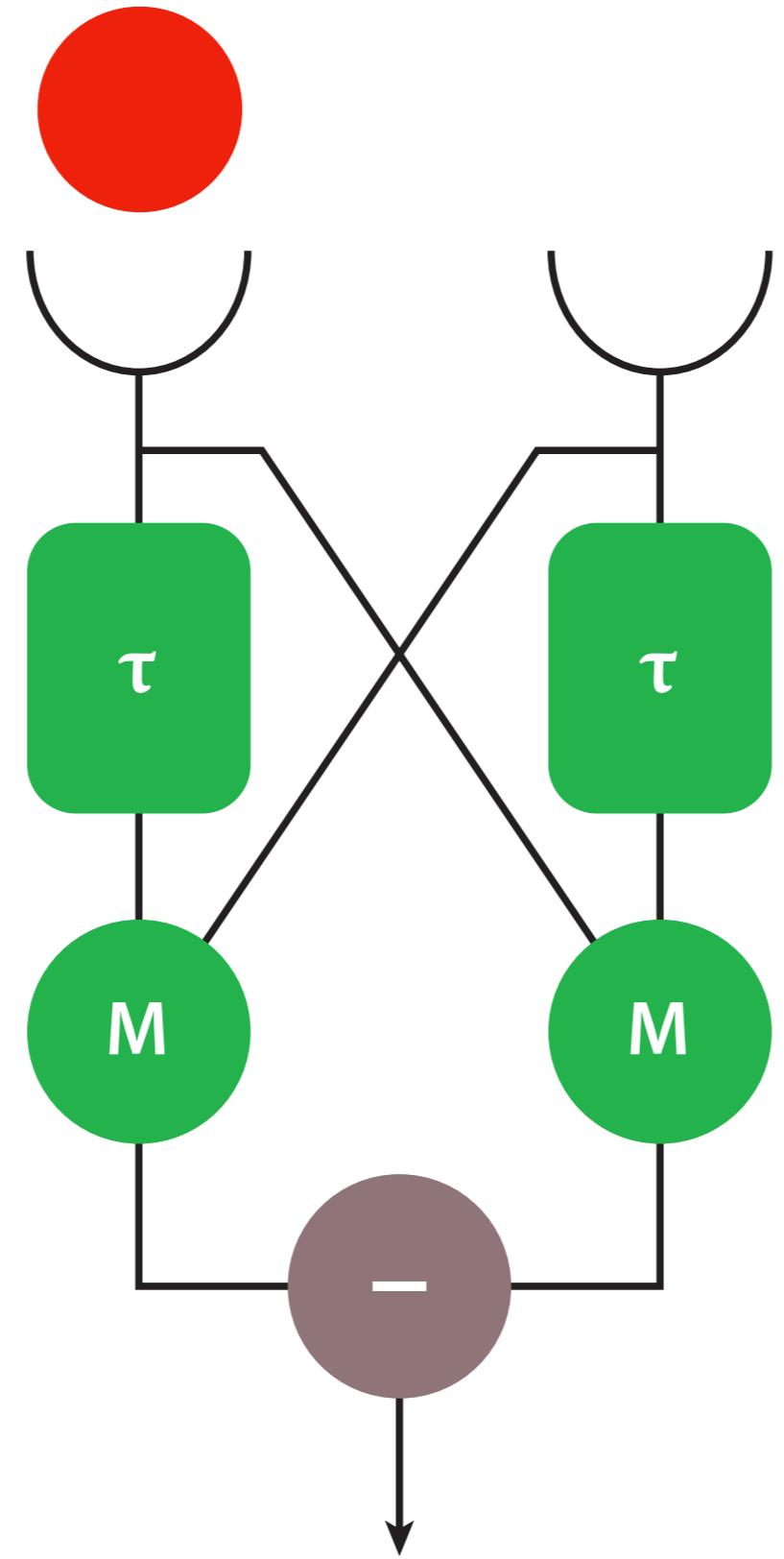


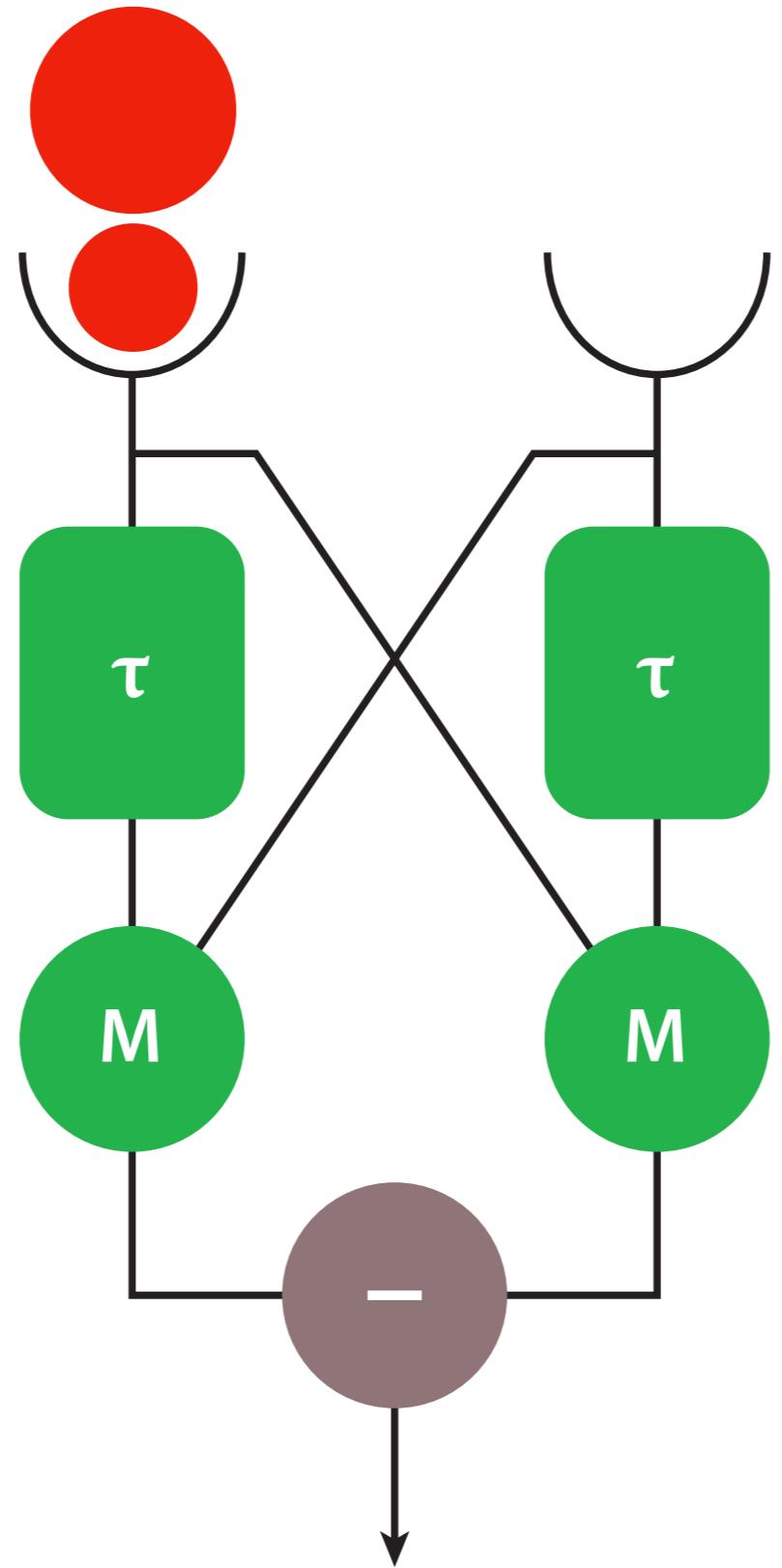
Hassenstein-Reichardt Detector Model

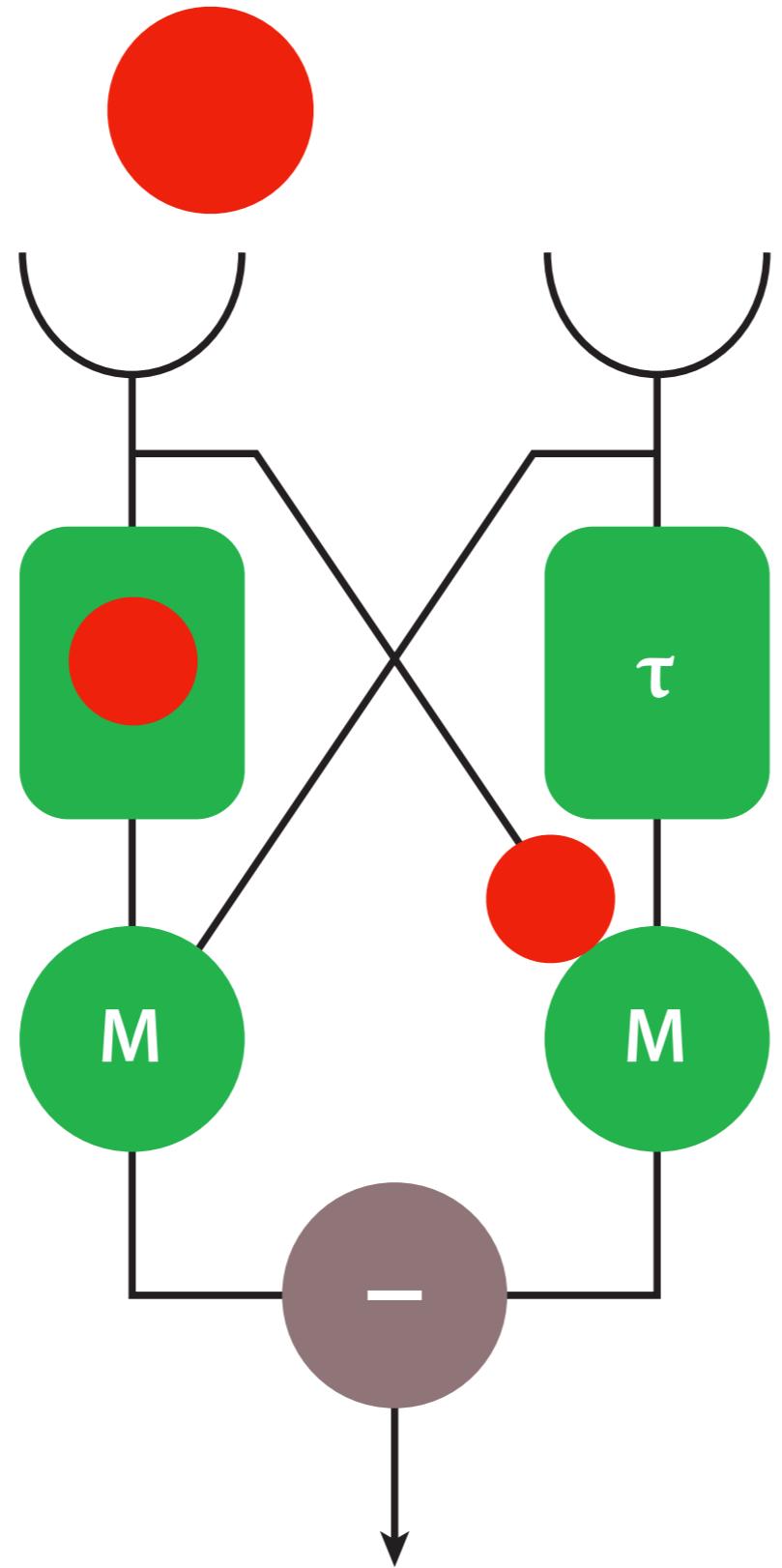


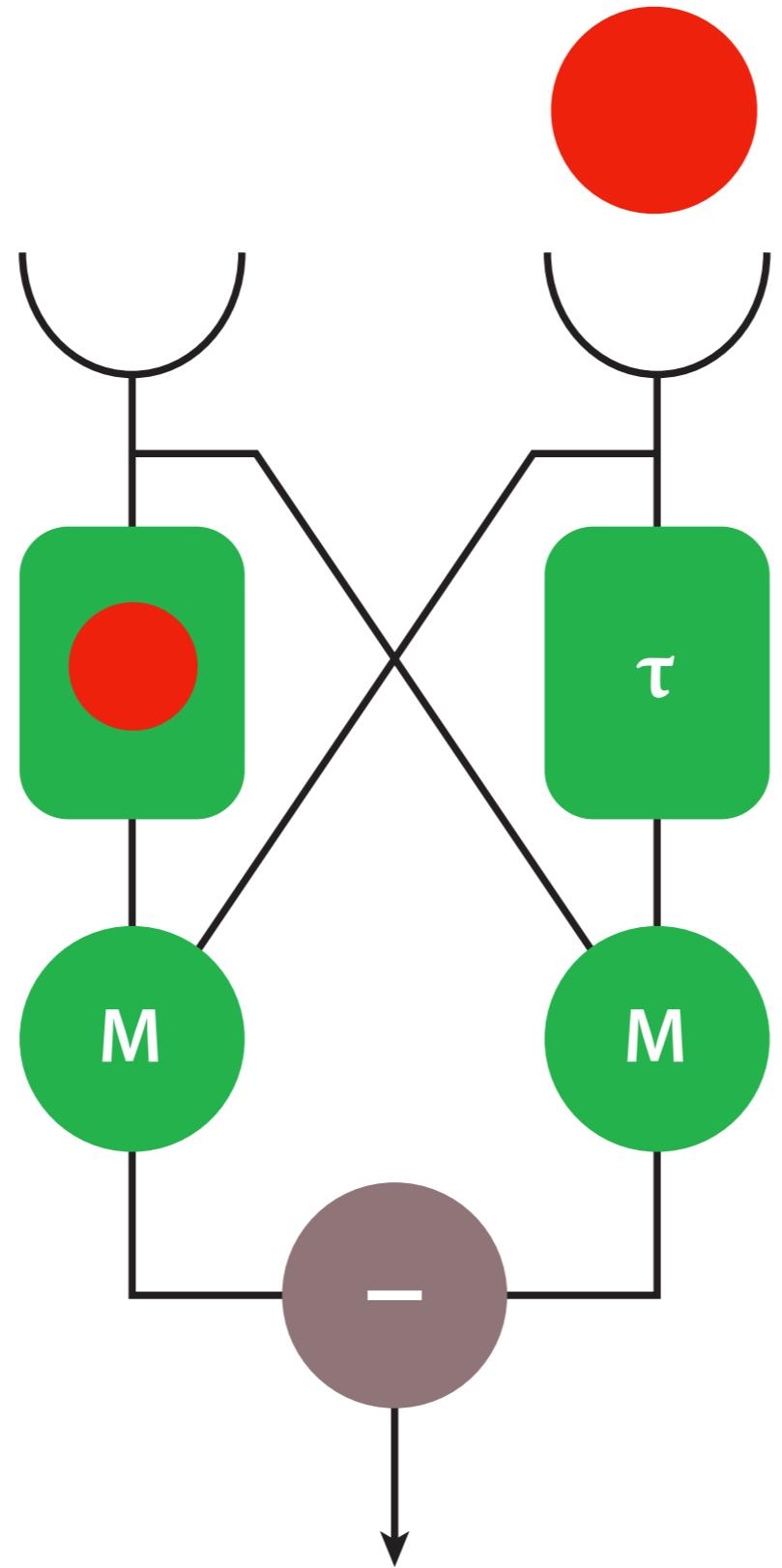
Werner Reichardt

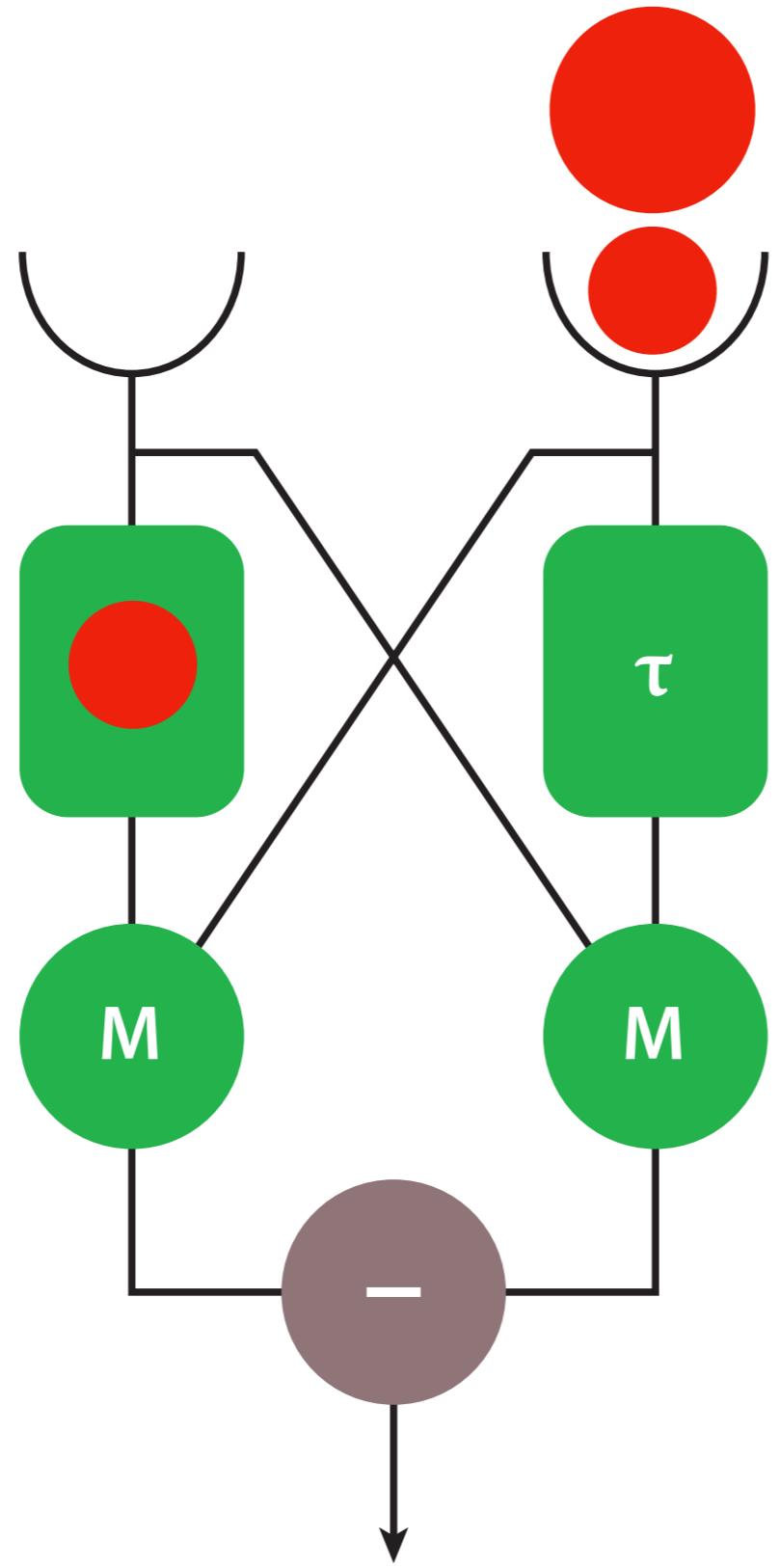


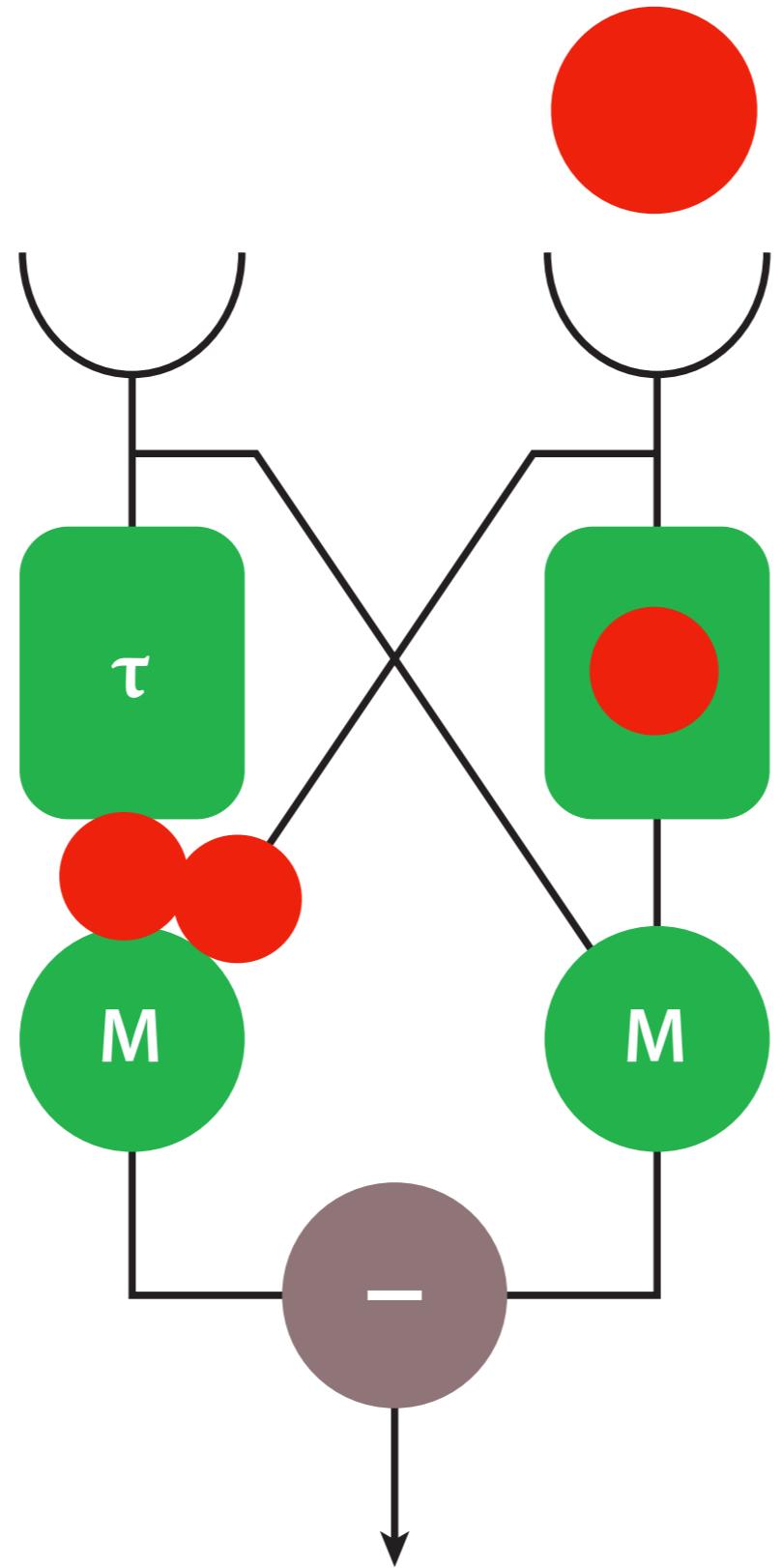


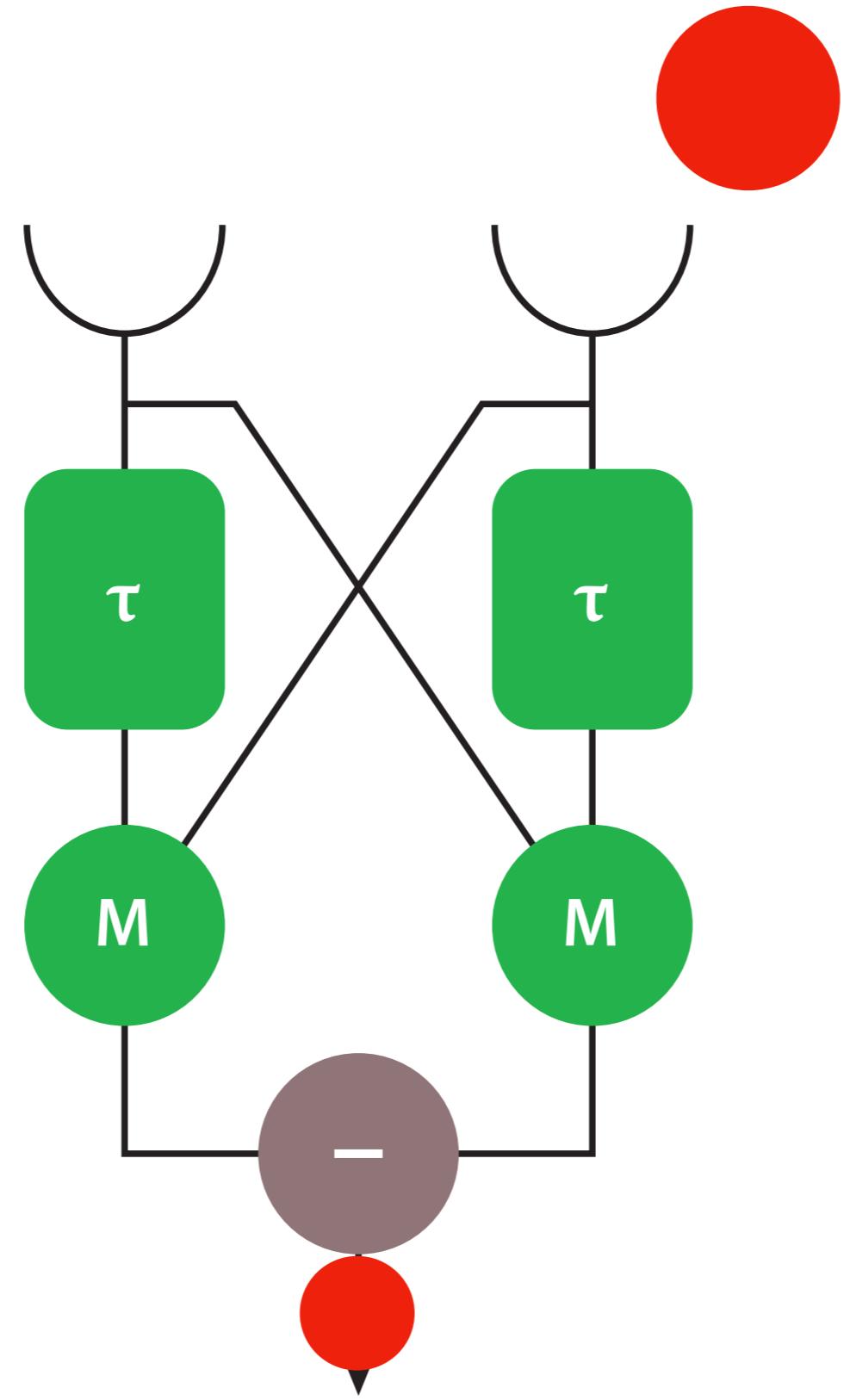




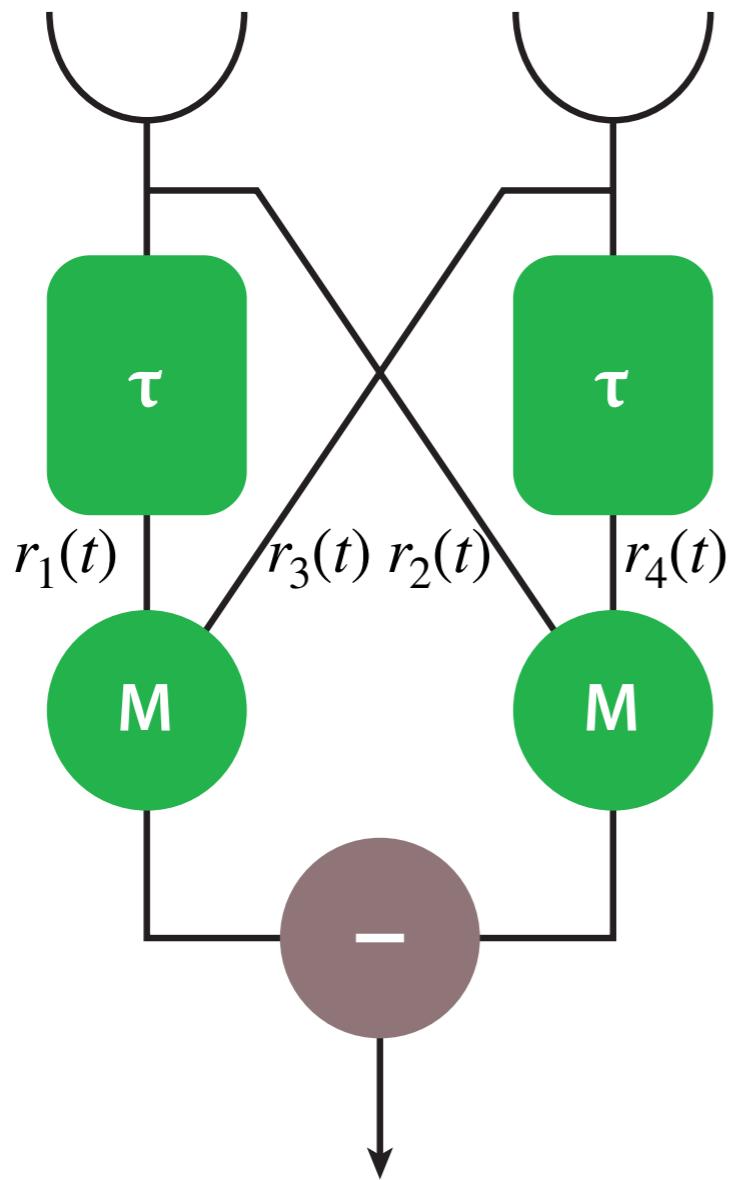








Hassenstein-Reichardt Detector Model

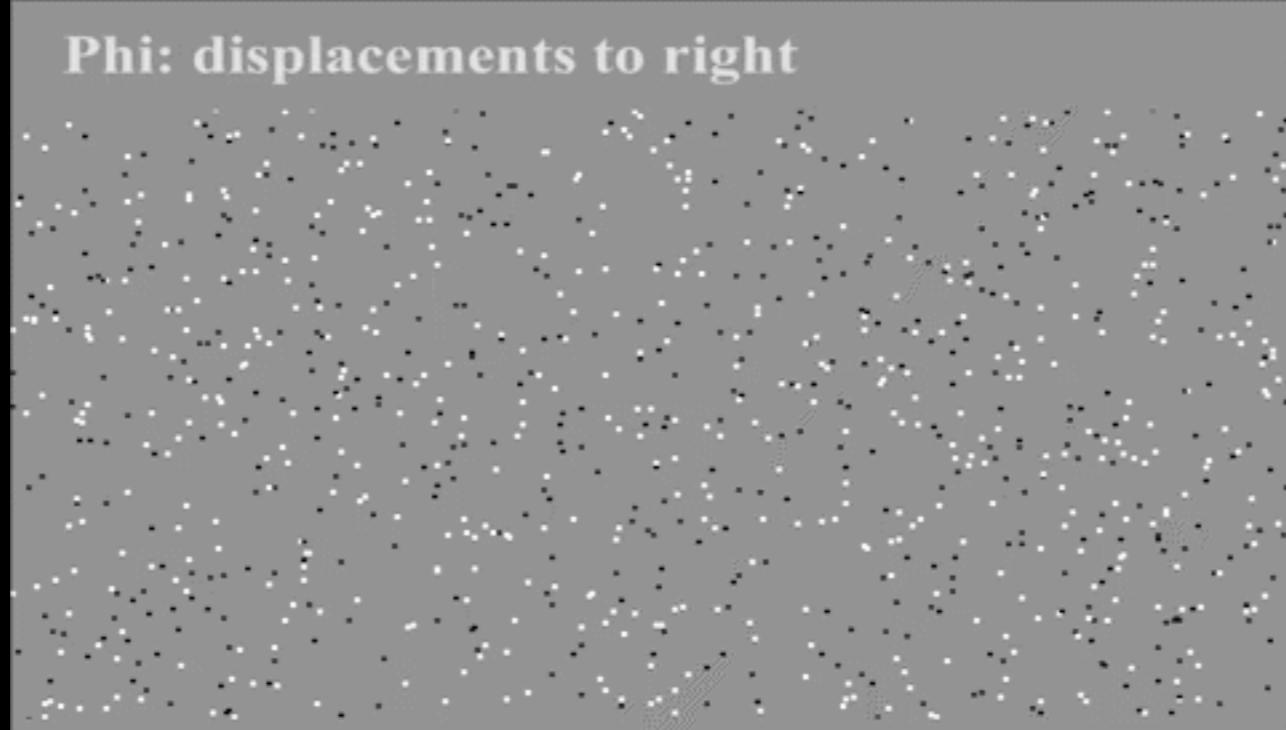


$$r_1(t) = \int_0^{\infty} s_1(t - \tau) D(\tau) d\tau; \quad r_2(t) = \int_0^{\infty} s_1(t - \tau) \delta(\tau) d\tau$$
$$r_3(t) = \int_0^{\infty} s_2(t - \tau) \delta(\tau) d\tau; \quad r_4(t) = \int_0^{\infty} s_2(t - \tau) D(\tau) d\tau;$$
$$R(t) = r_1(t)r_3(t) - r_2(t)r_4(t)$$

$$D(\tau) = \frac{1}{\tau_0} \exp(-\tau/\tau_0)$$

$$\langle R \rangle = \frac{\omega \tau_0}{\omega^2 \tau_0^2 + 1}$$

Phi: displacements to right

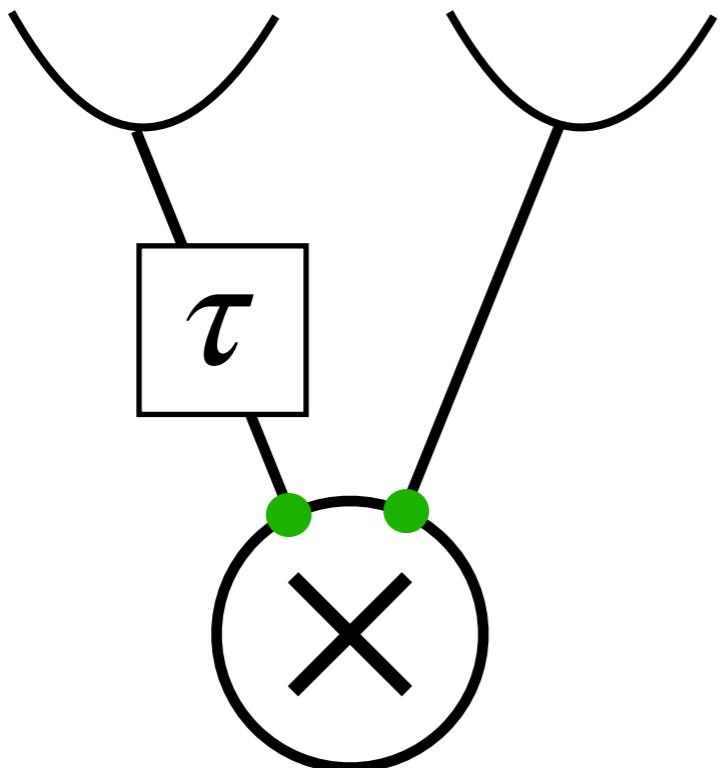


adapted from Damon Clark's slide

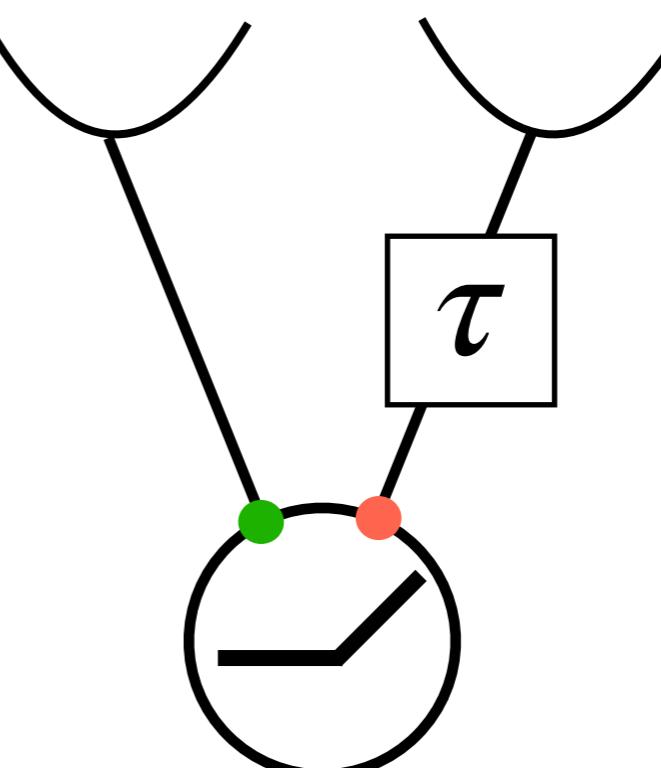
preferred
direction



null
direction

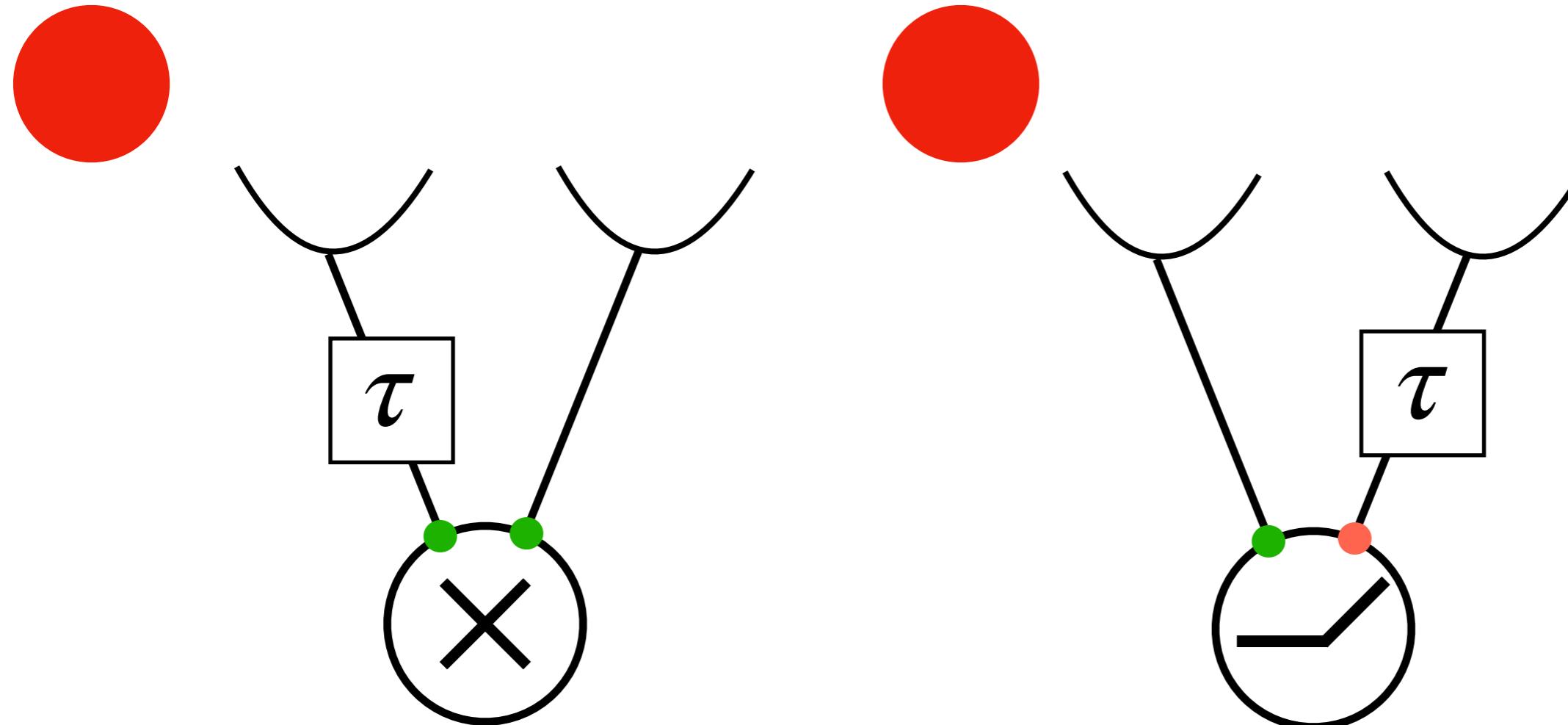


Reichardt model



barlow-levick model

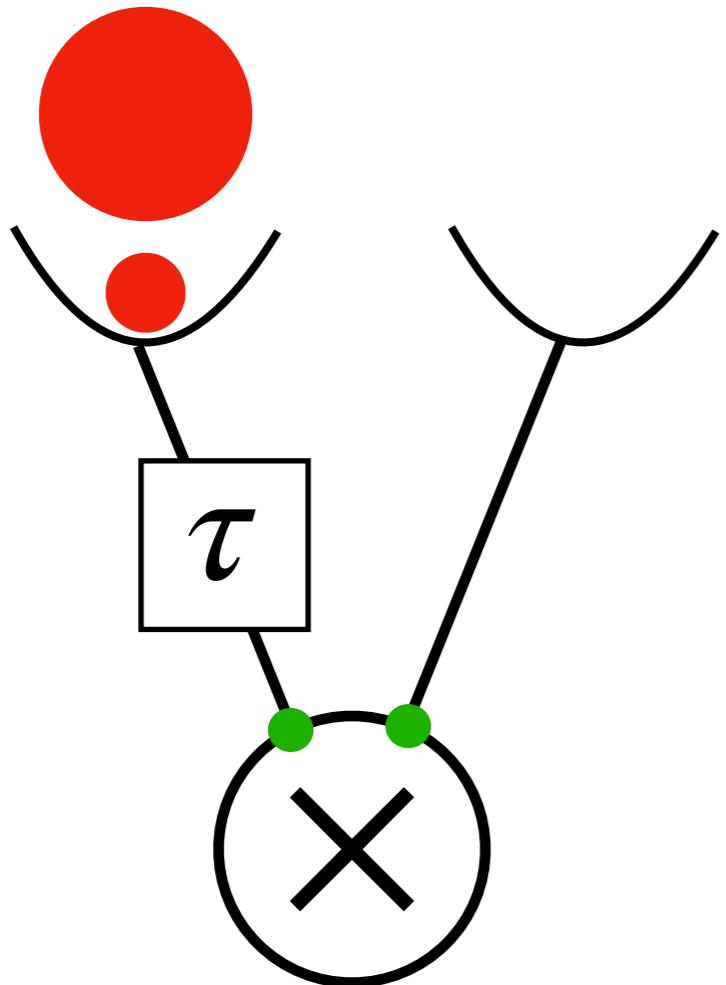
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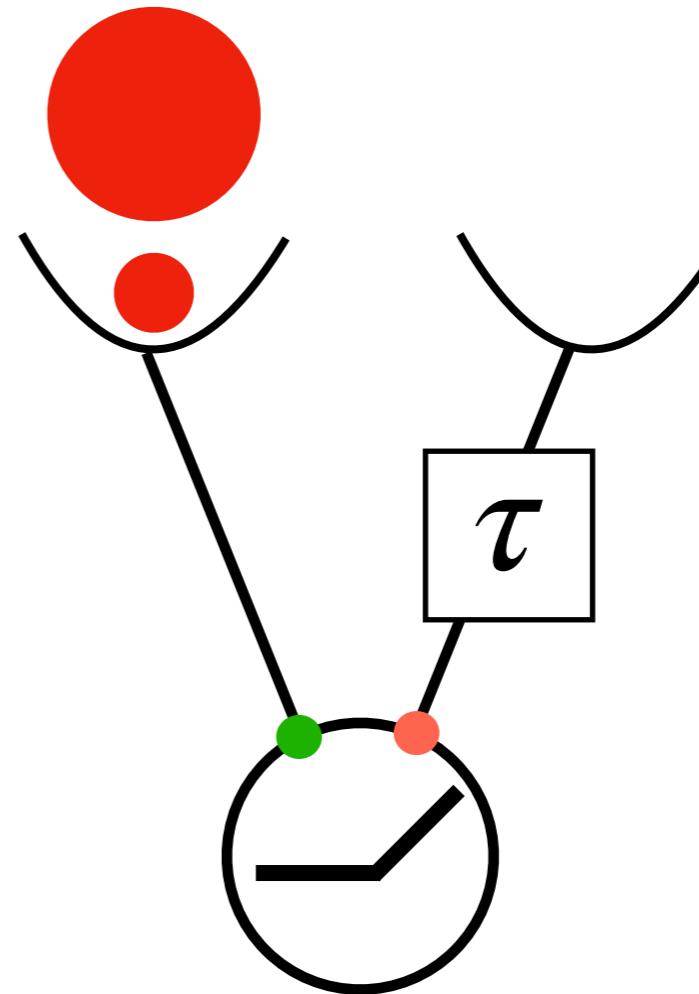
Reichardt model

barlow-levick model

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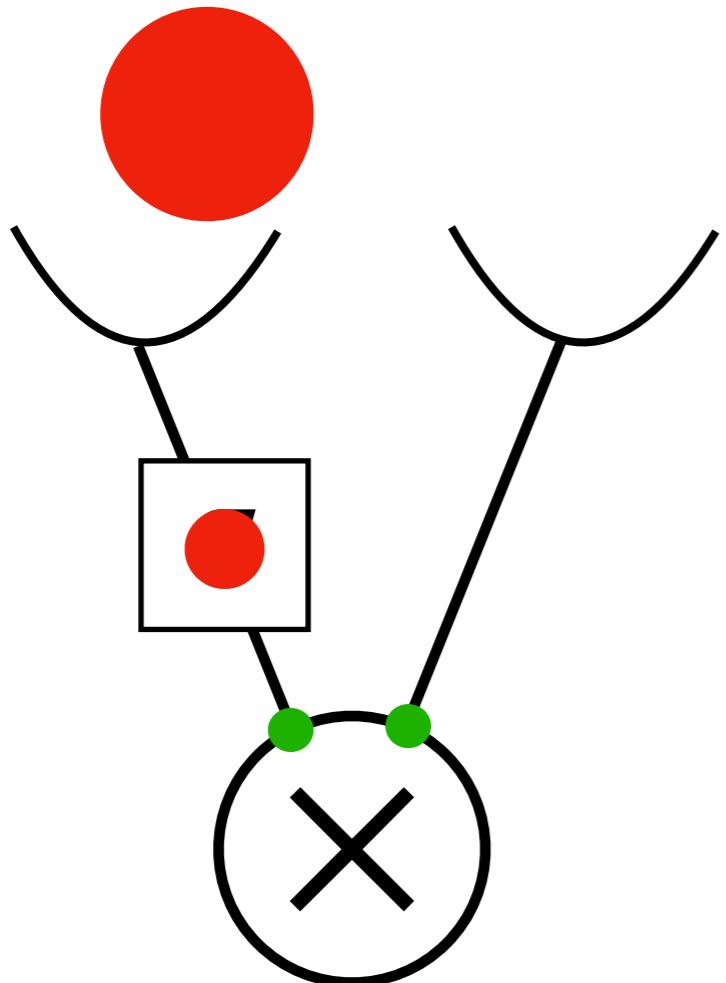


Reichardt model

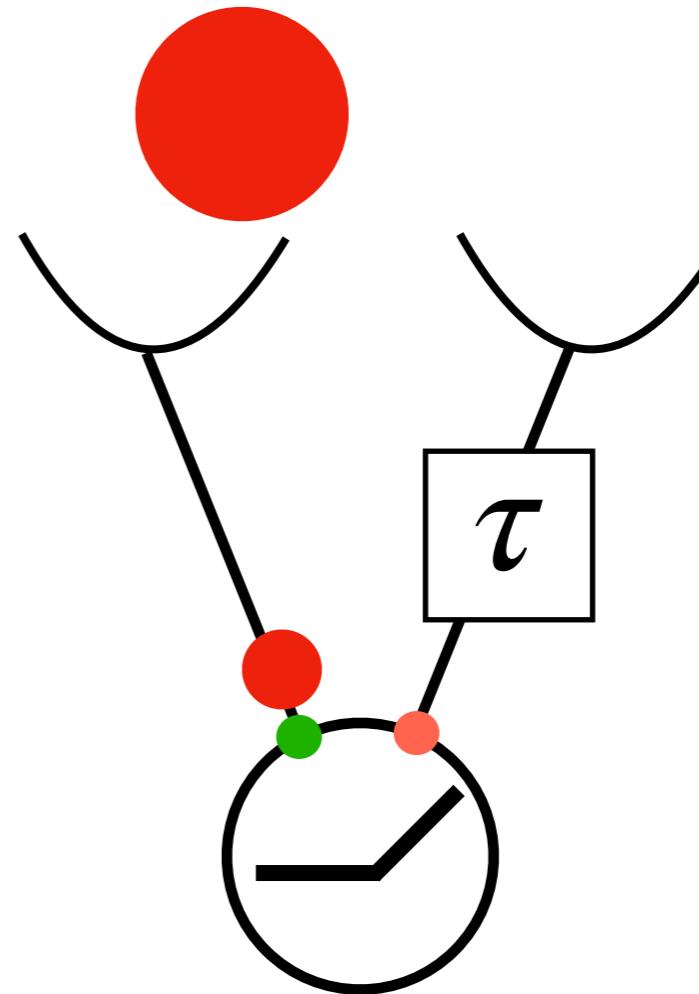


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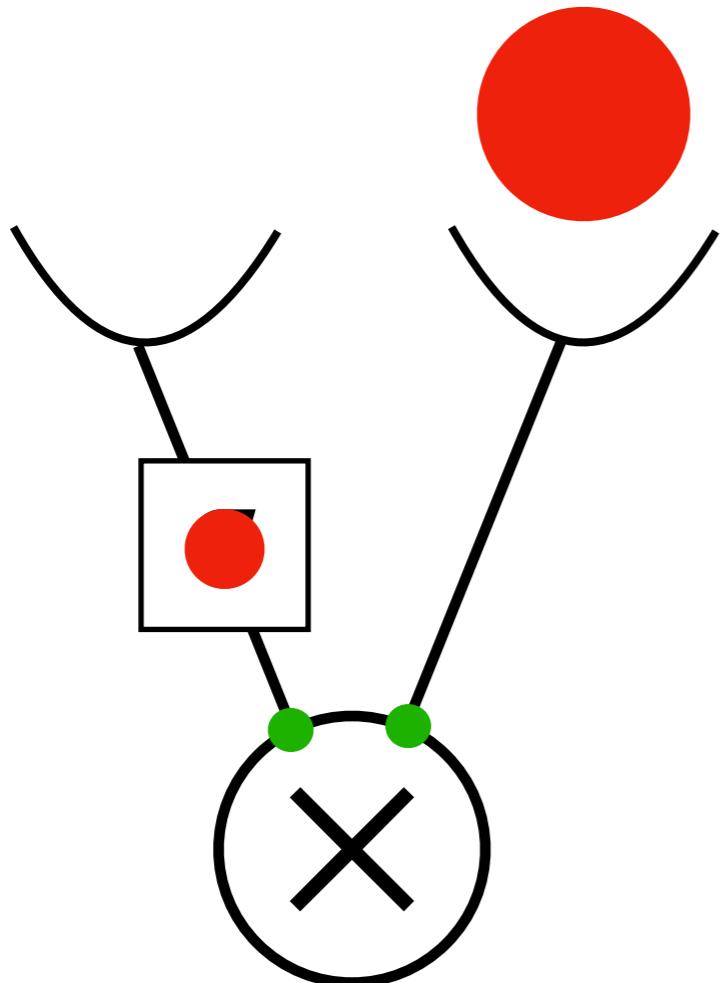


Reichardt model

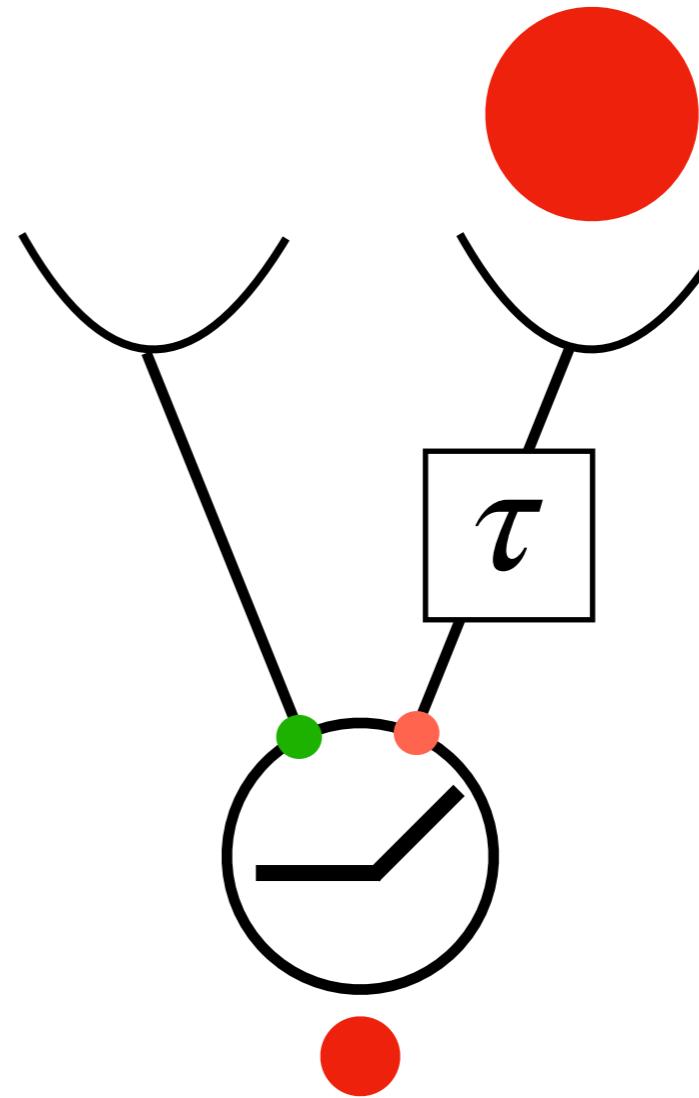


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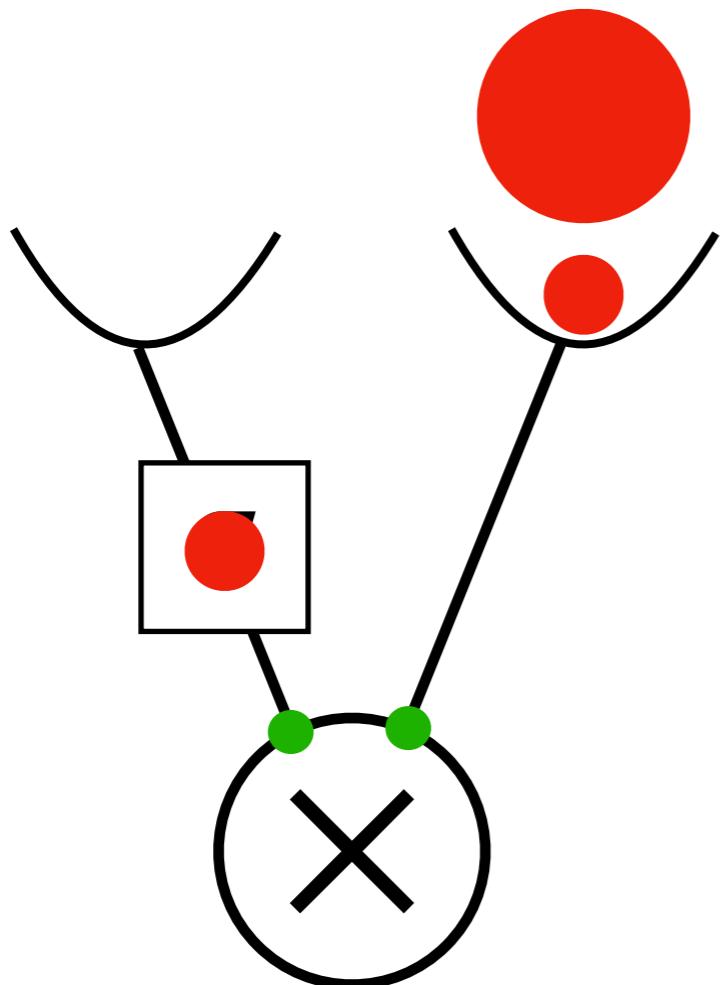


Reichardt model

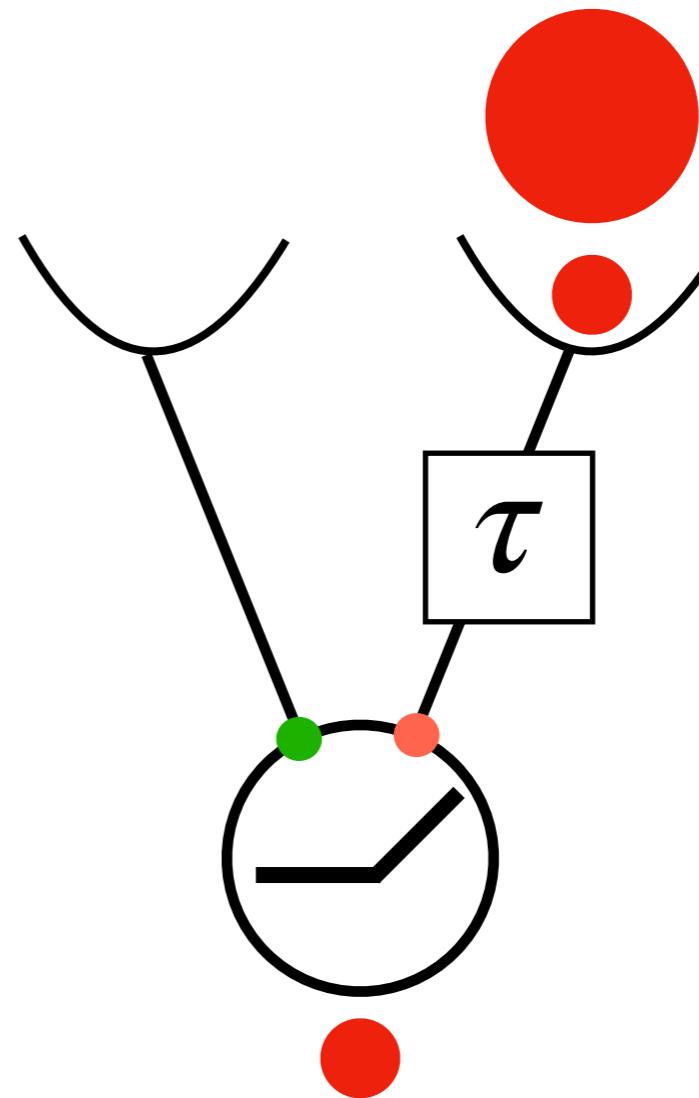


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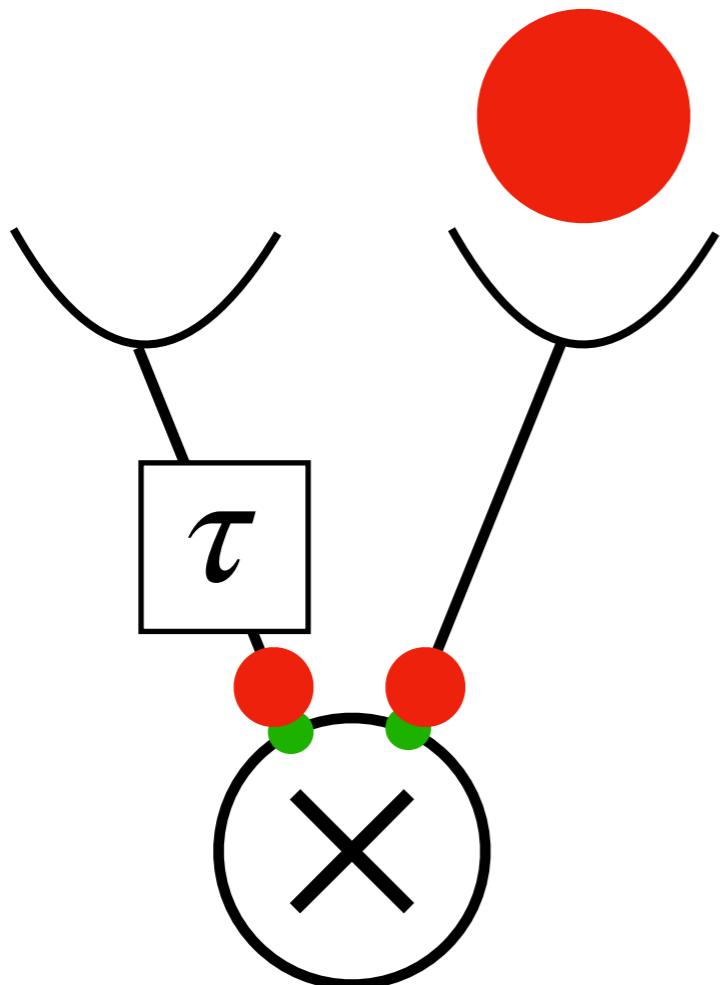


Reichardt model

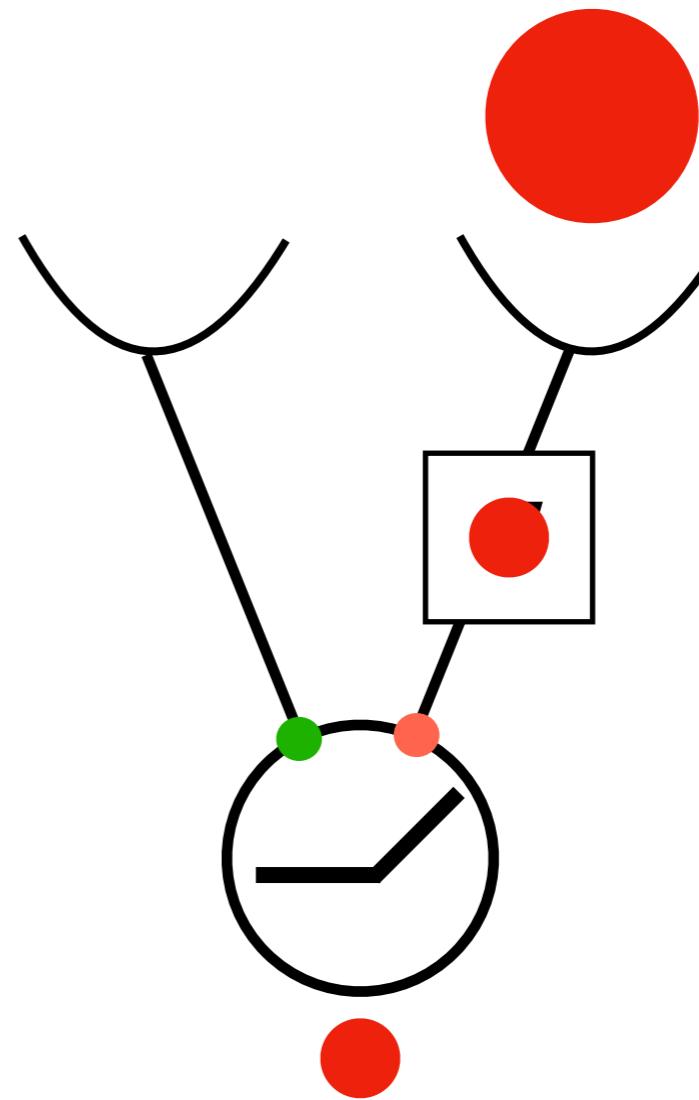


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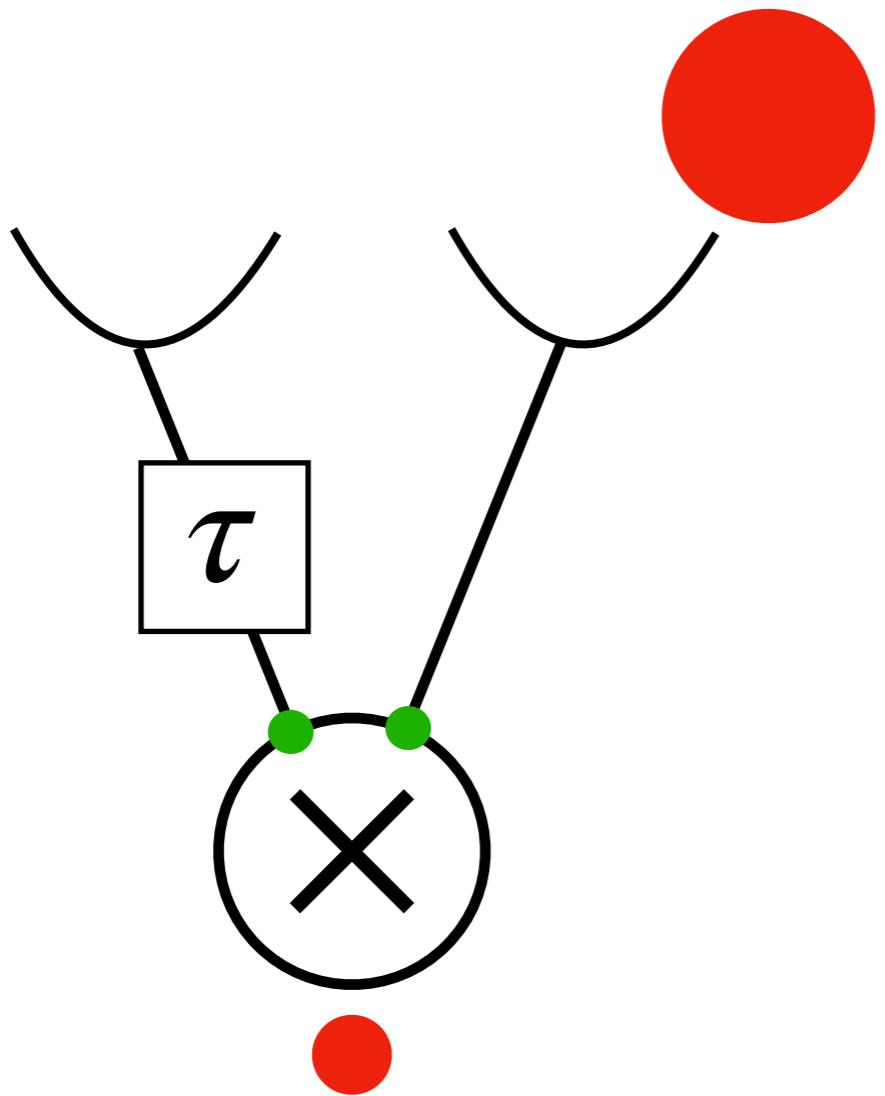


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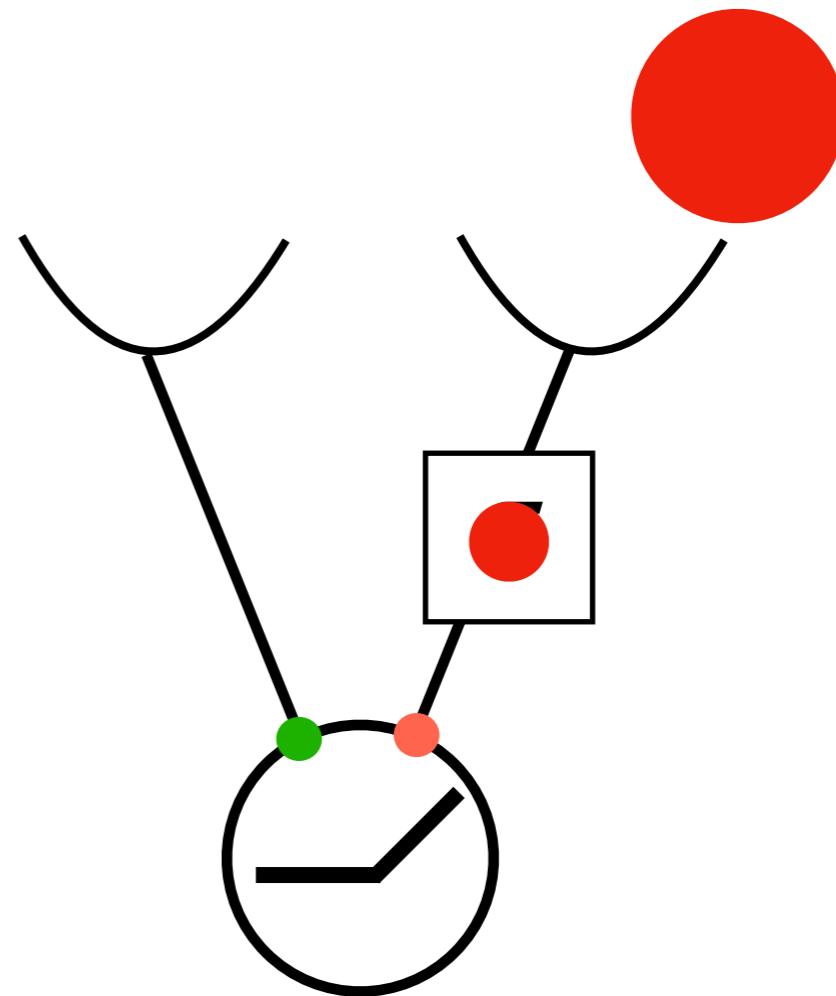


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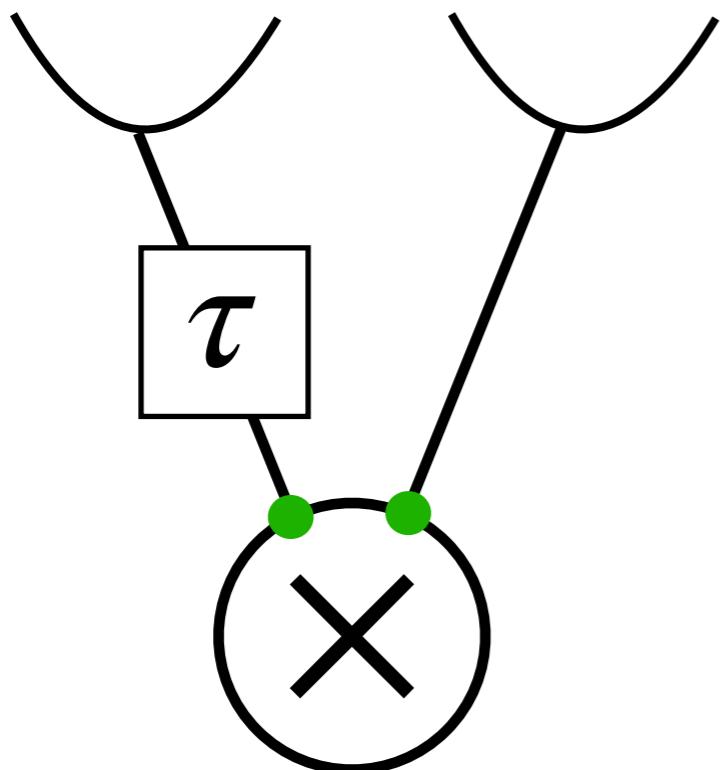


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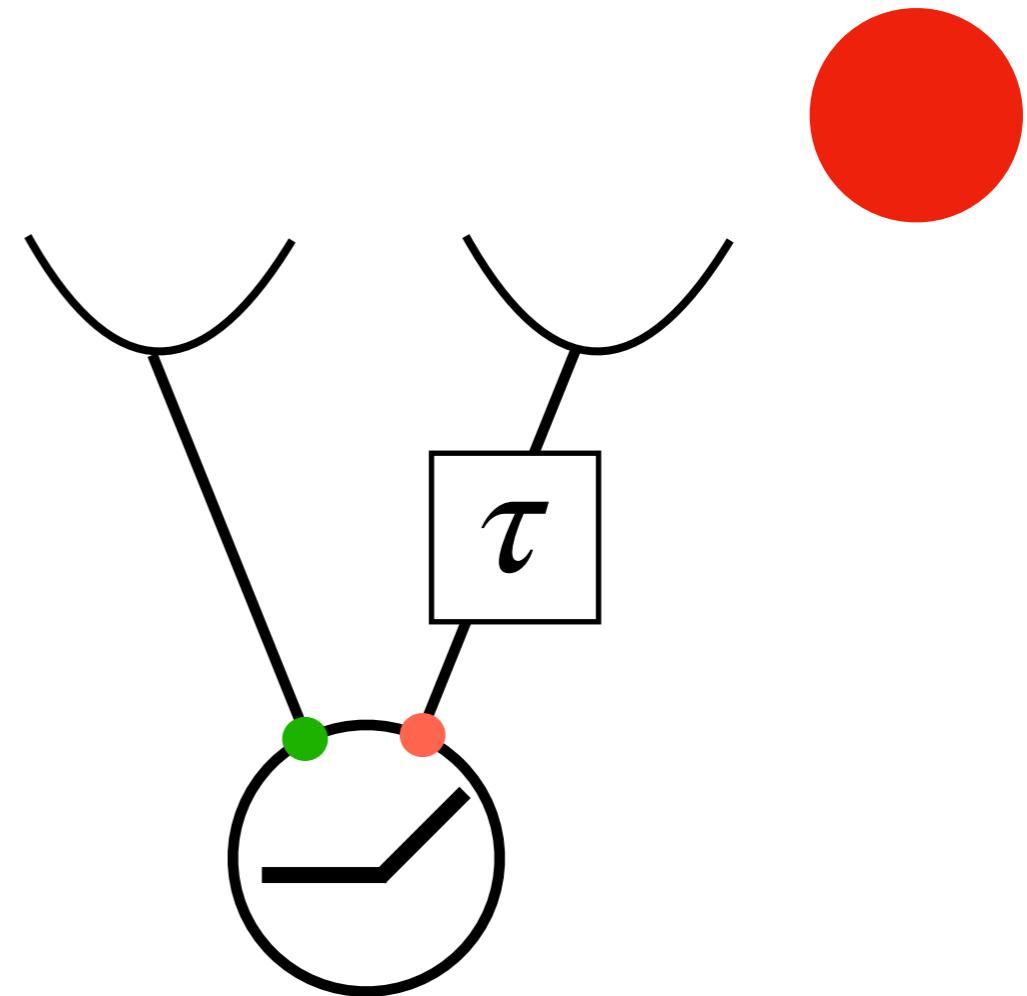


barlow-levick model

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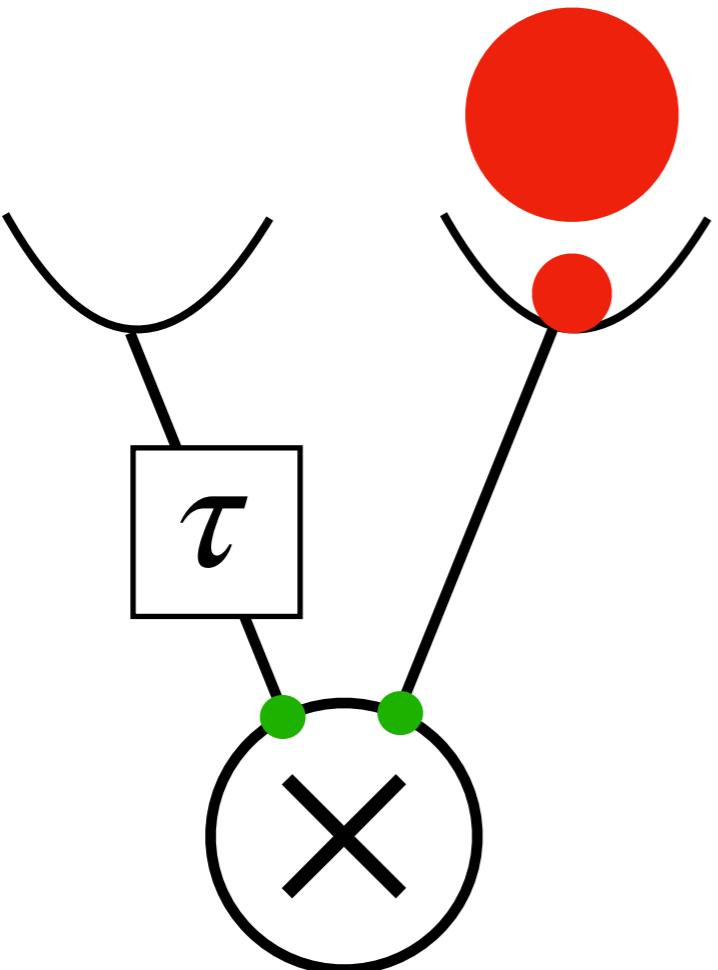


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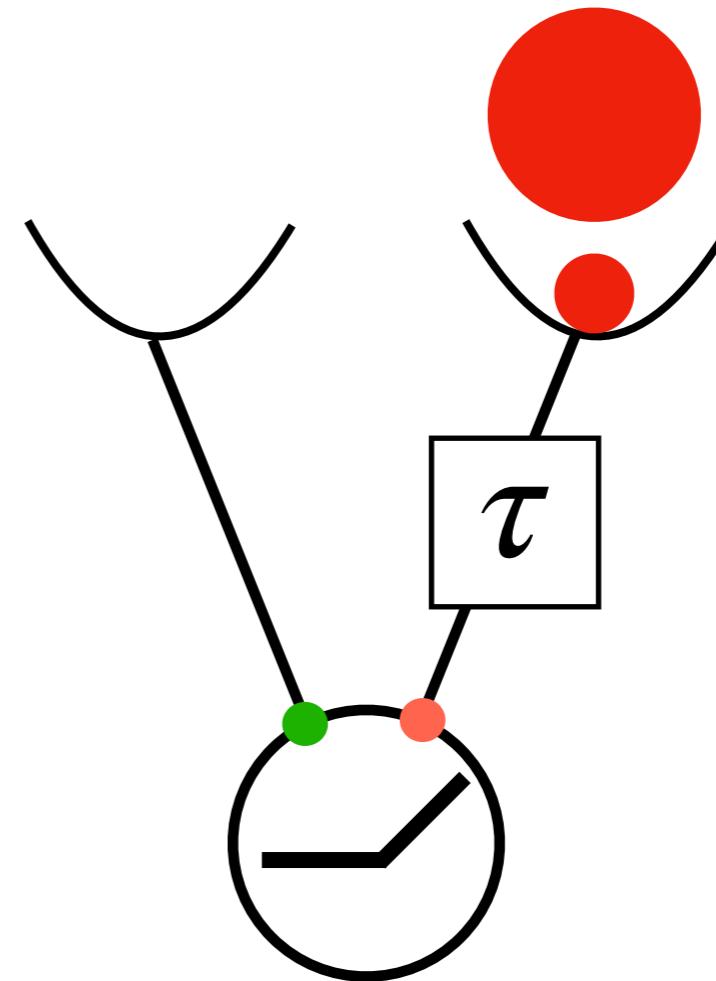


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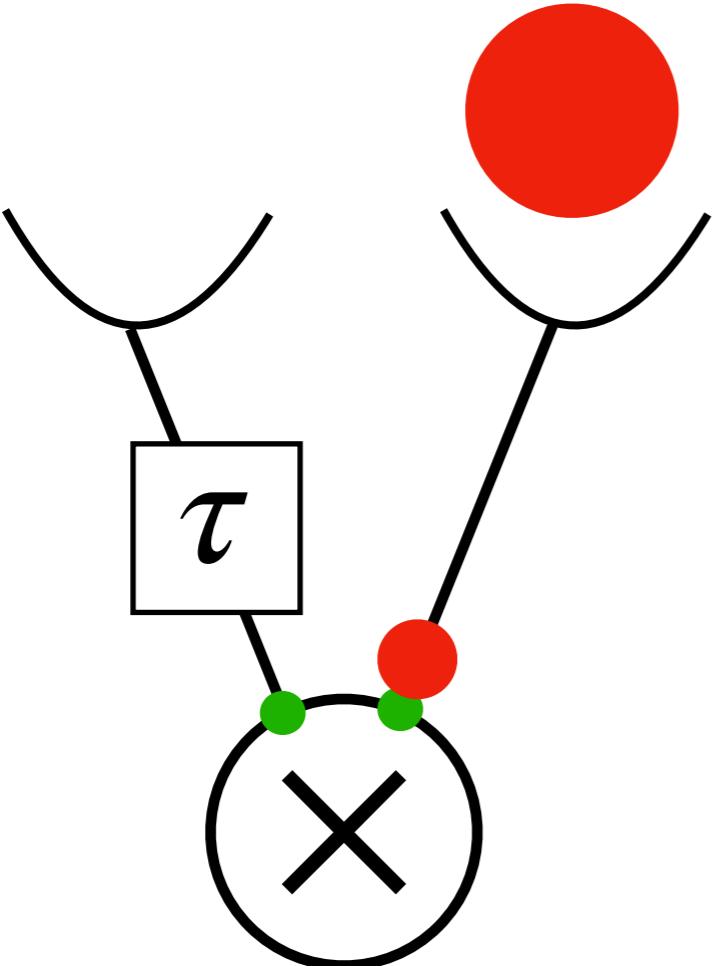


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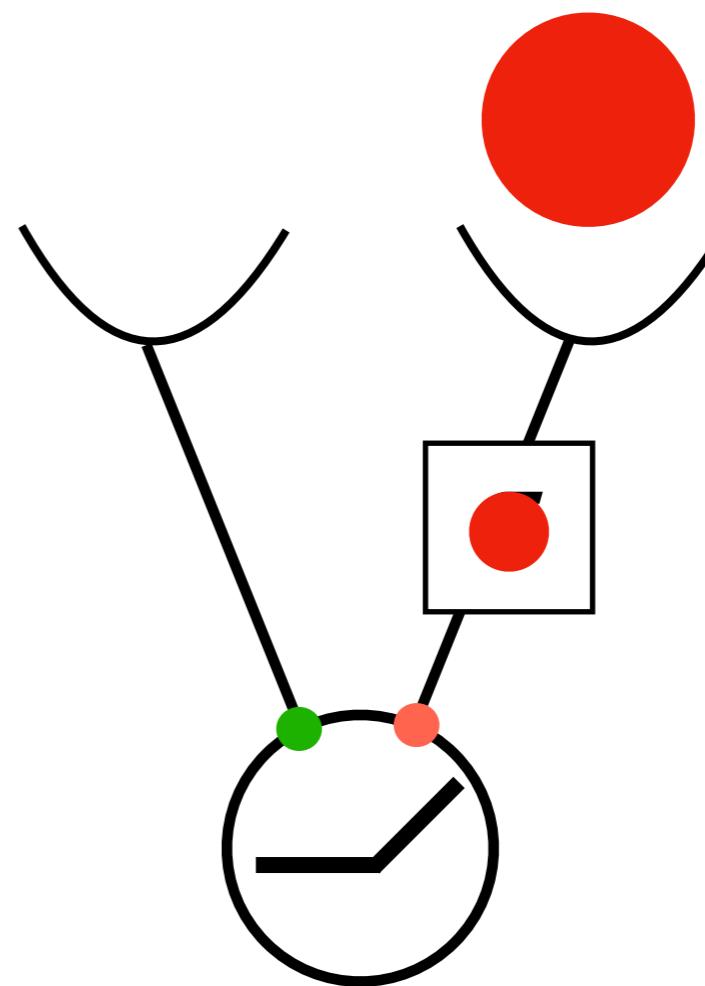


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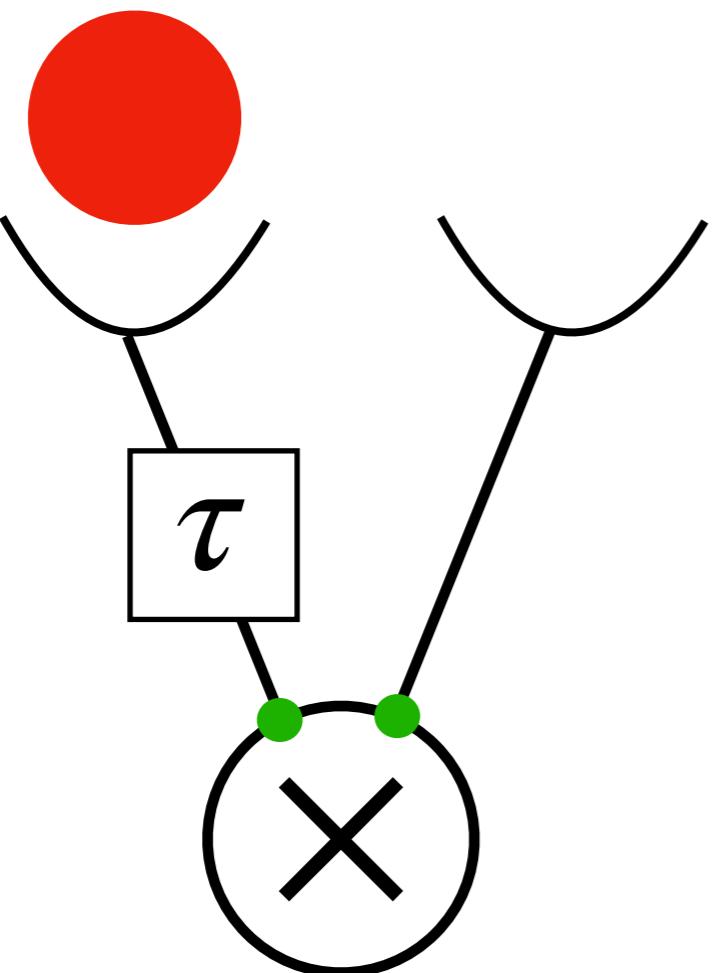


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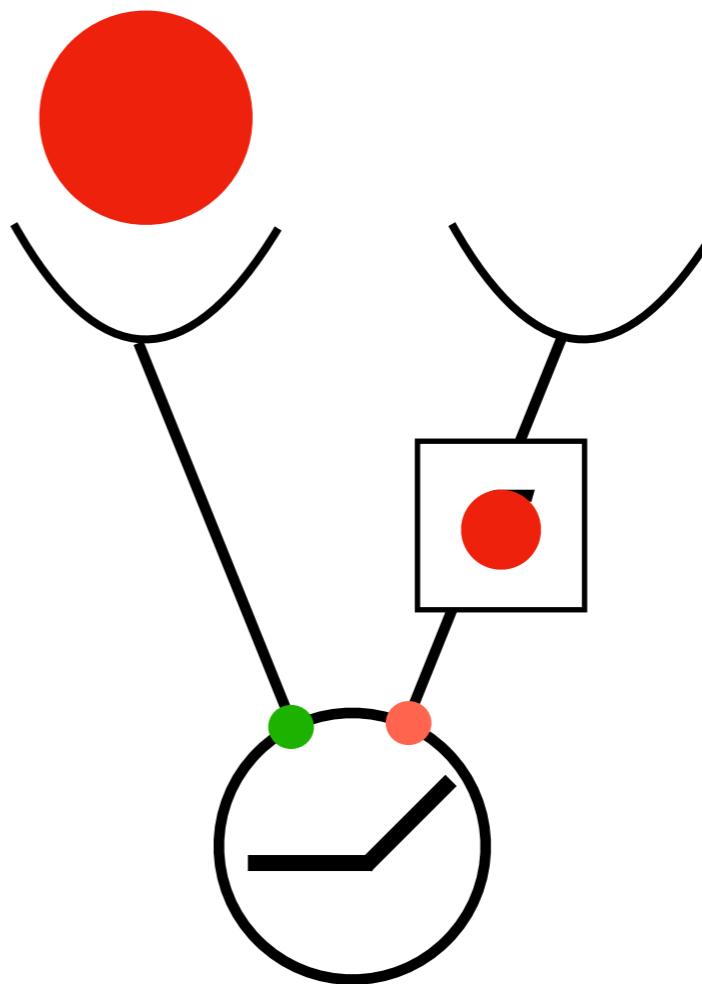


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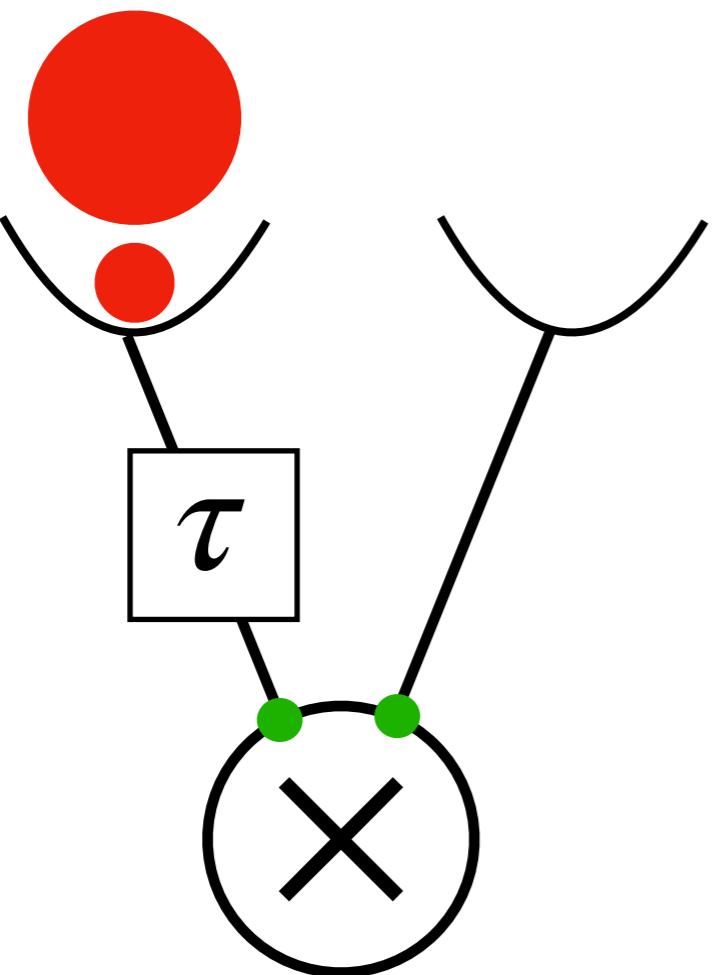


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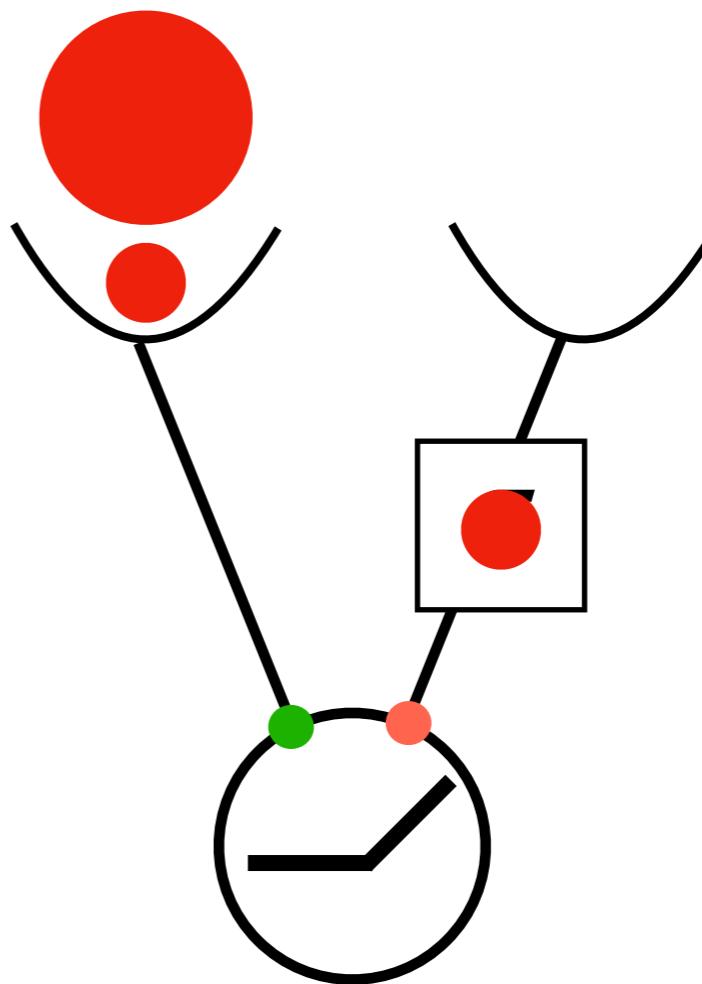


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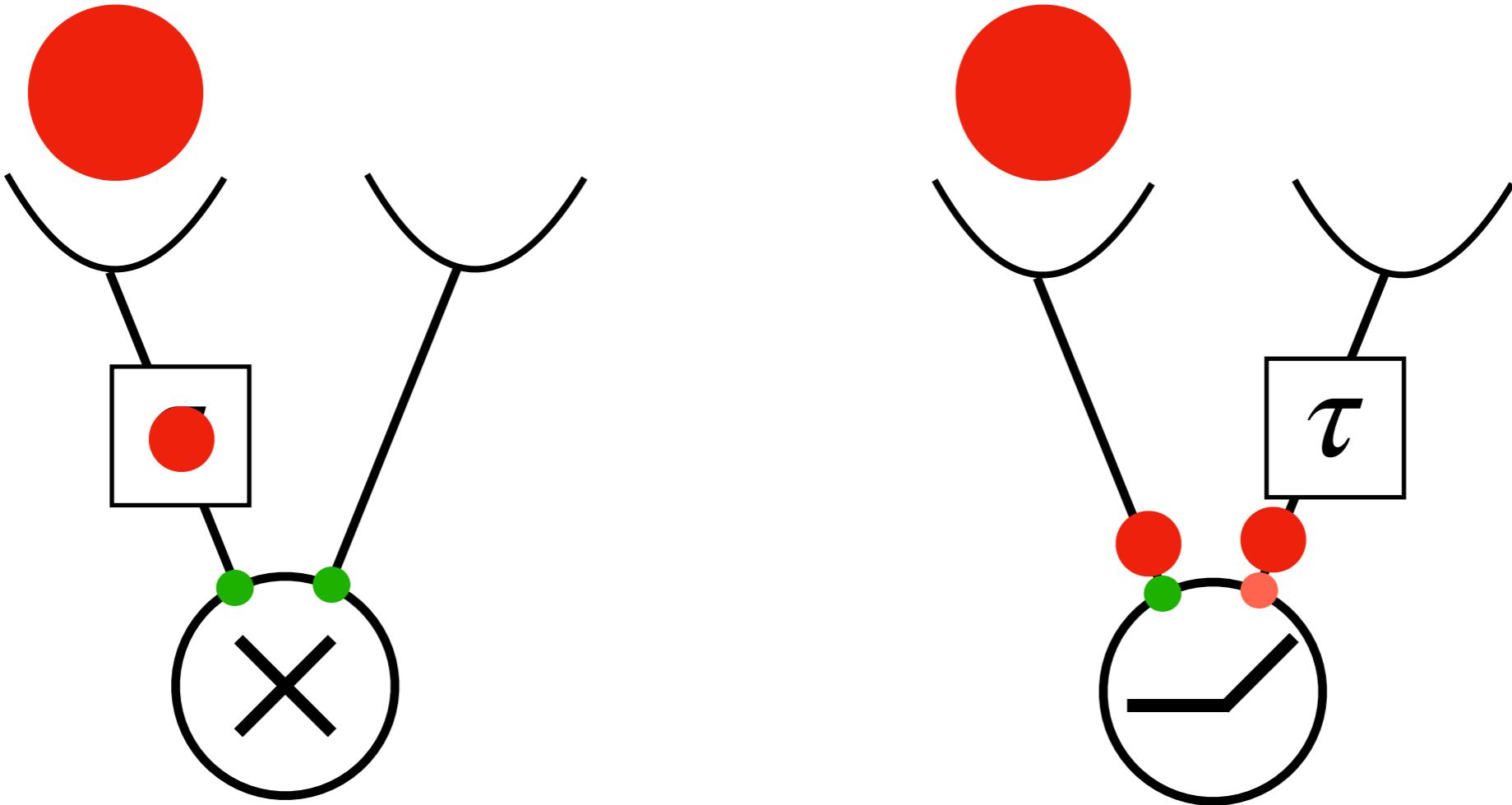
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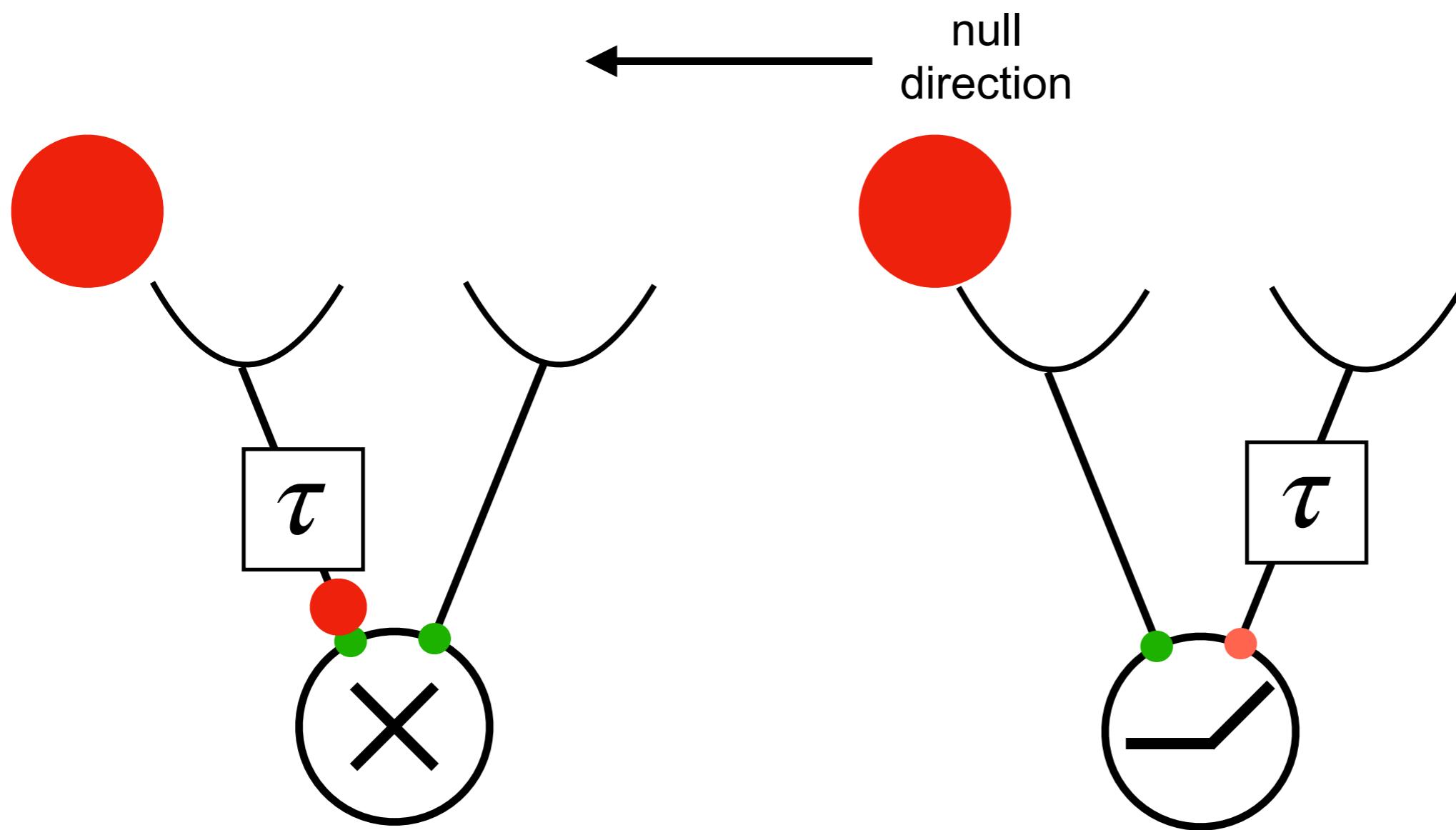


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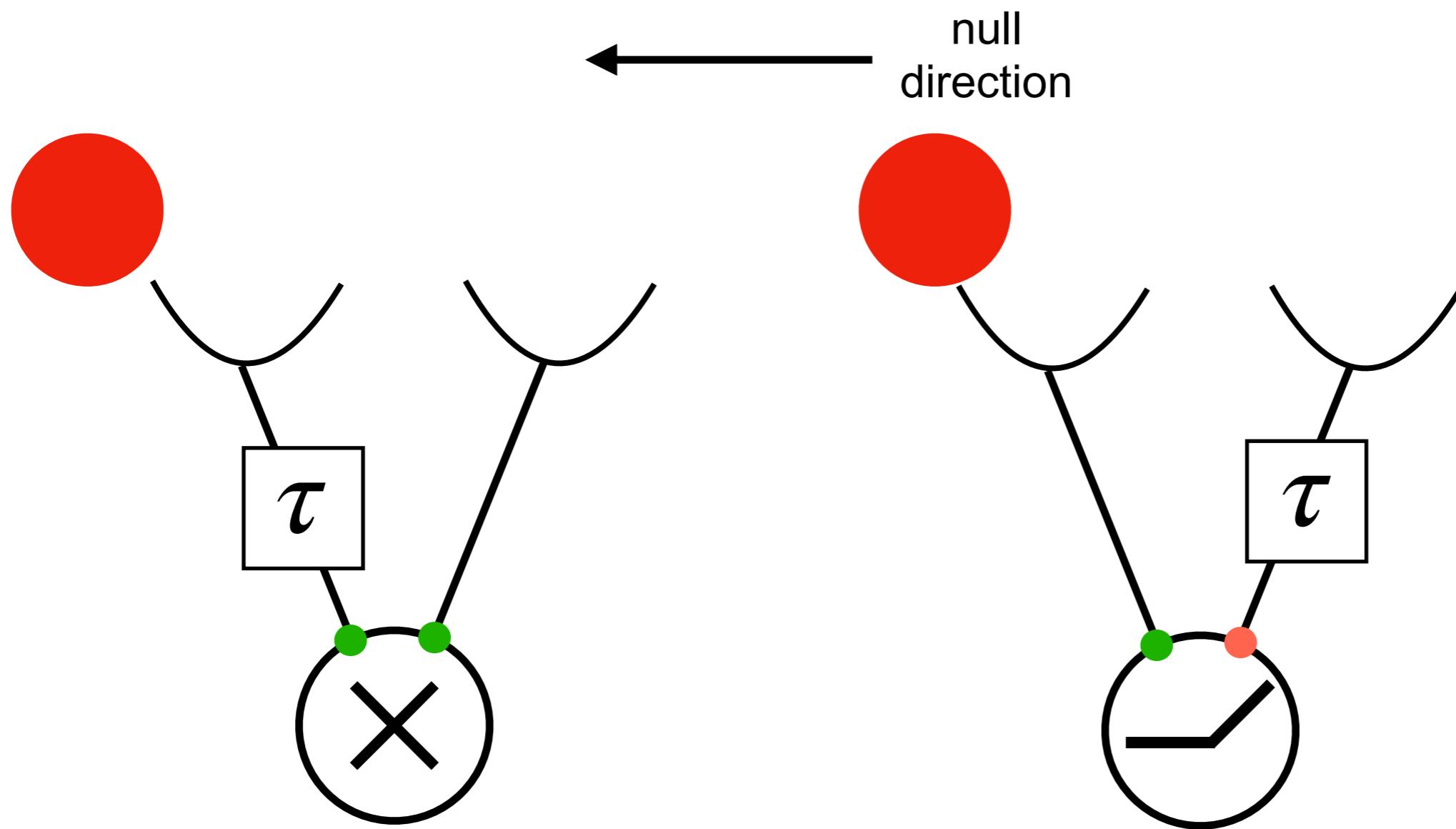
Reichardt model

barlow-levick model



Reichardt model

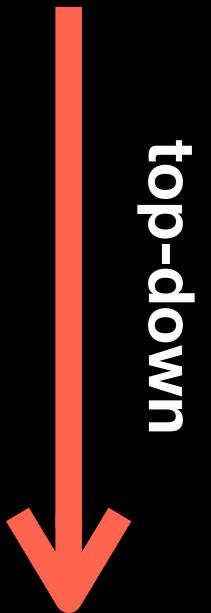
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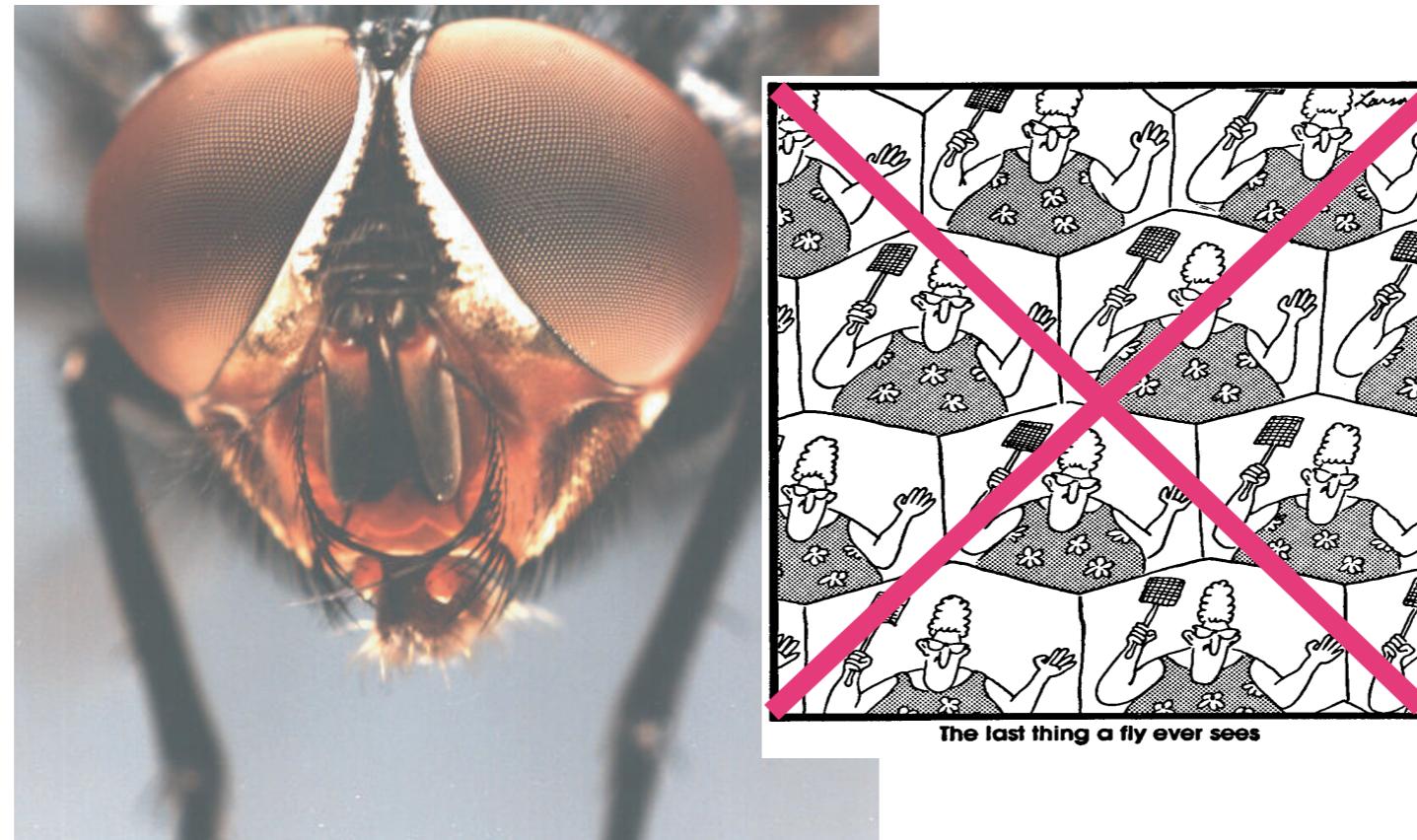
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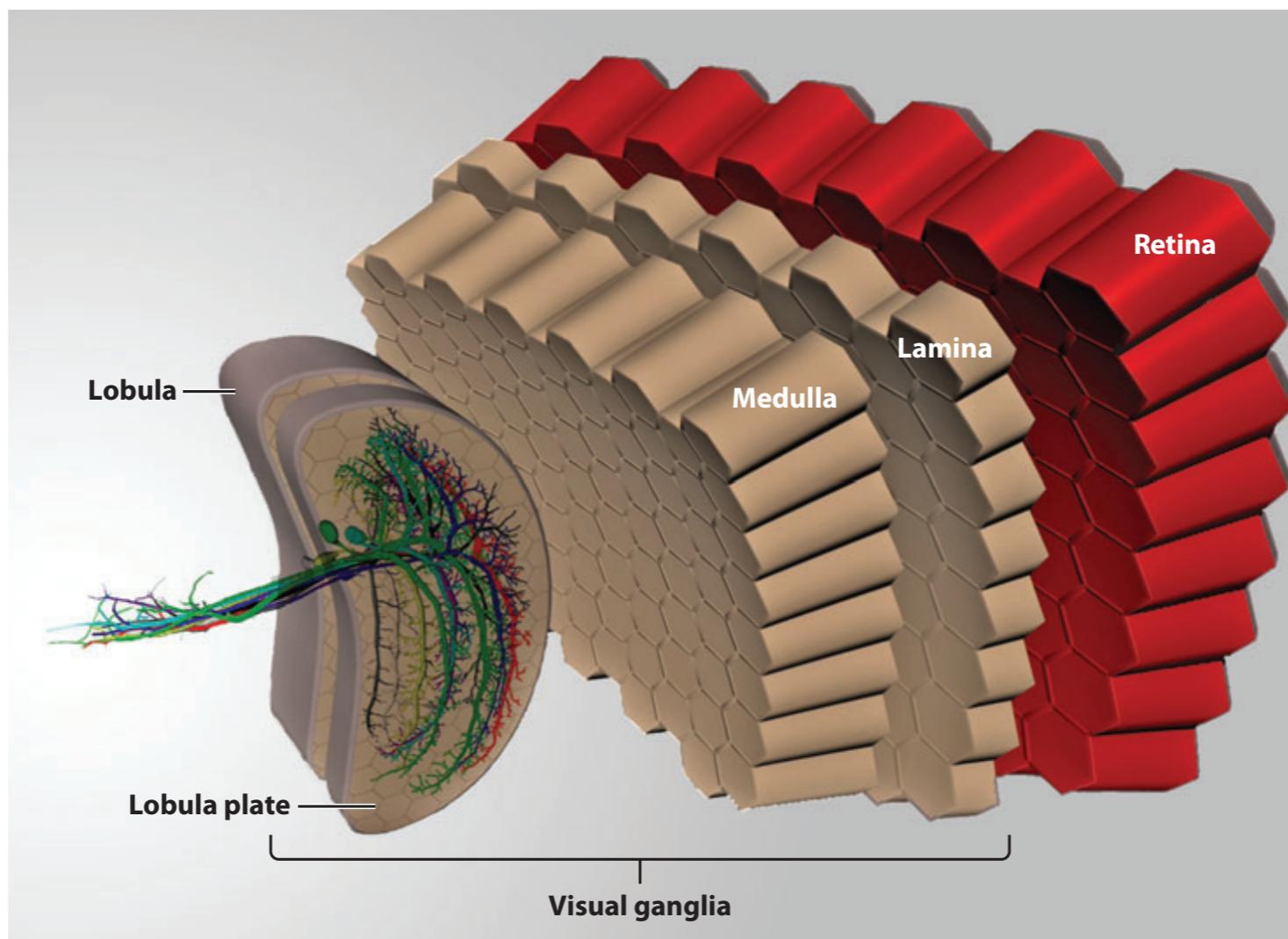
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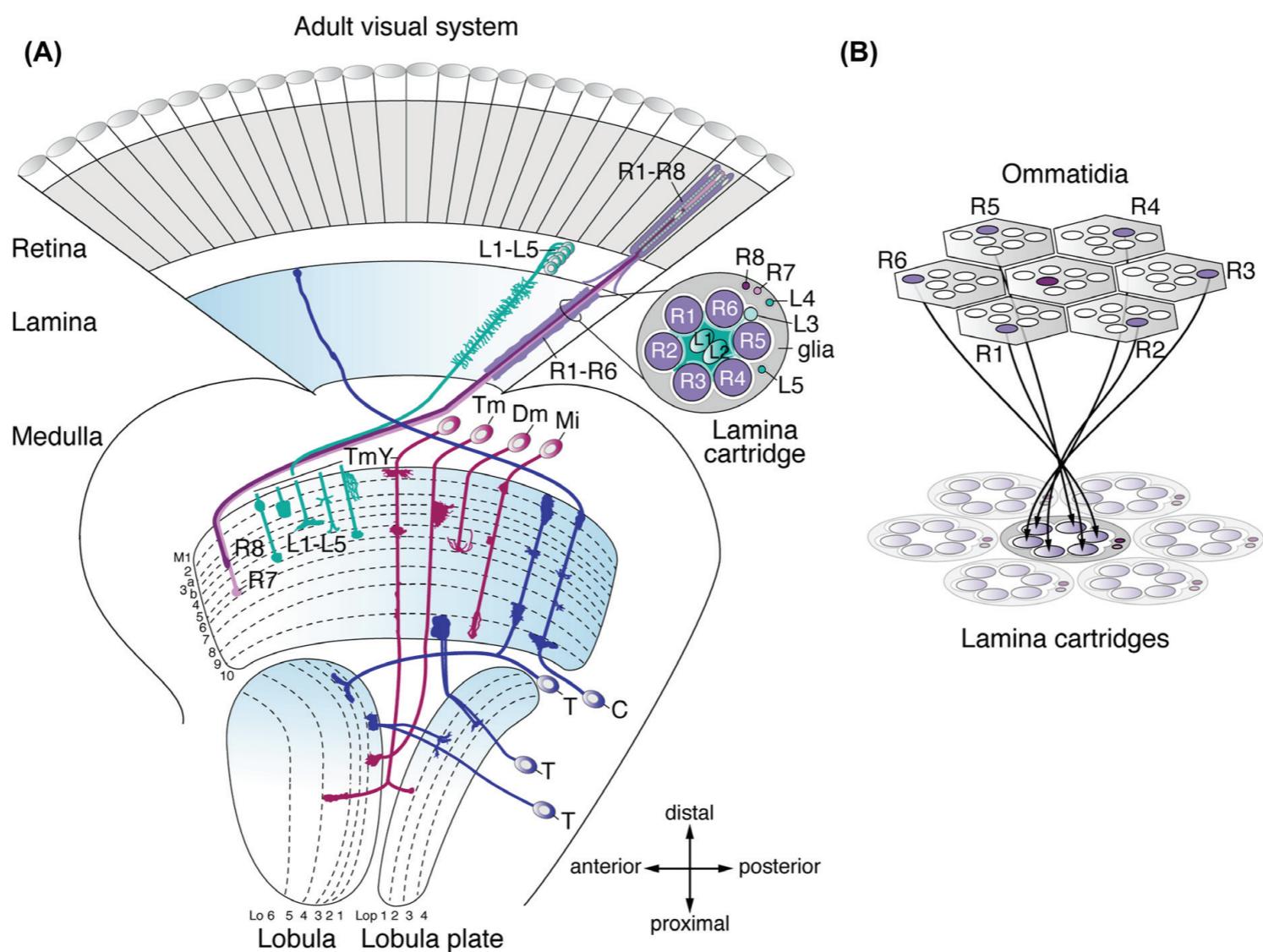
The Fly Visual System

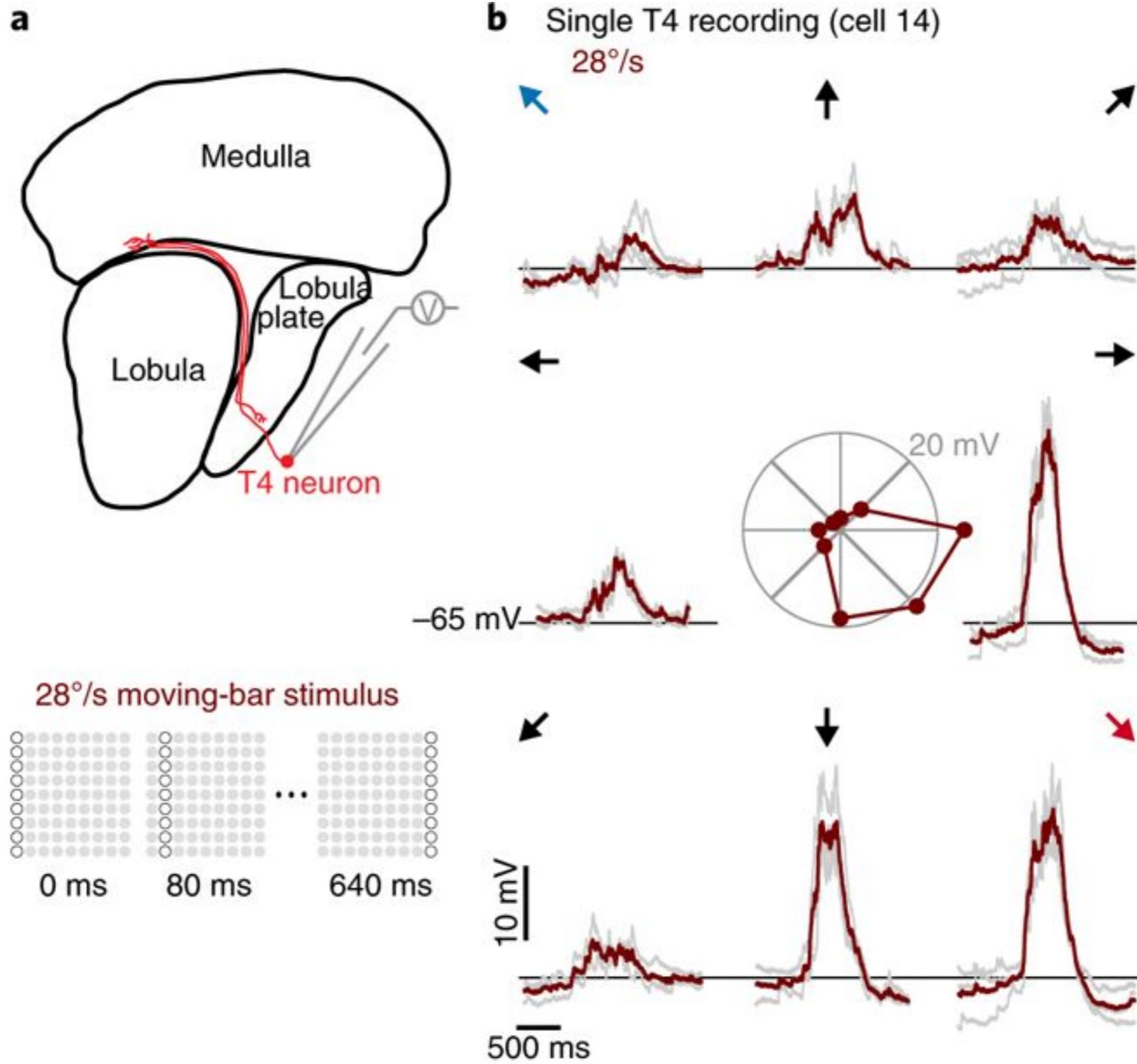


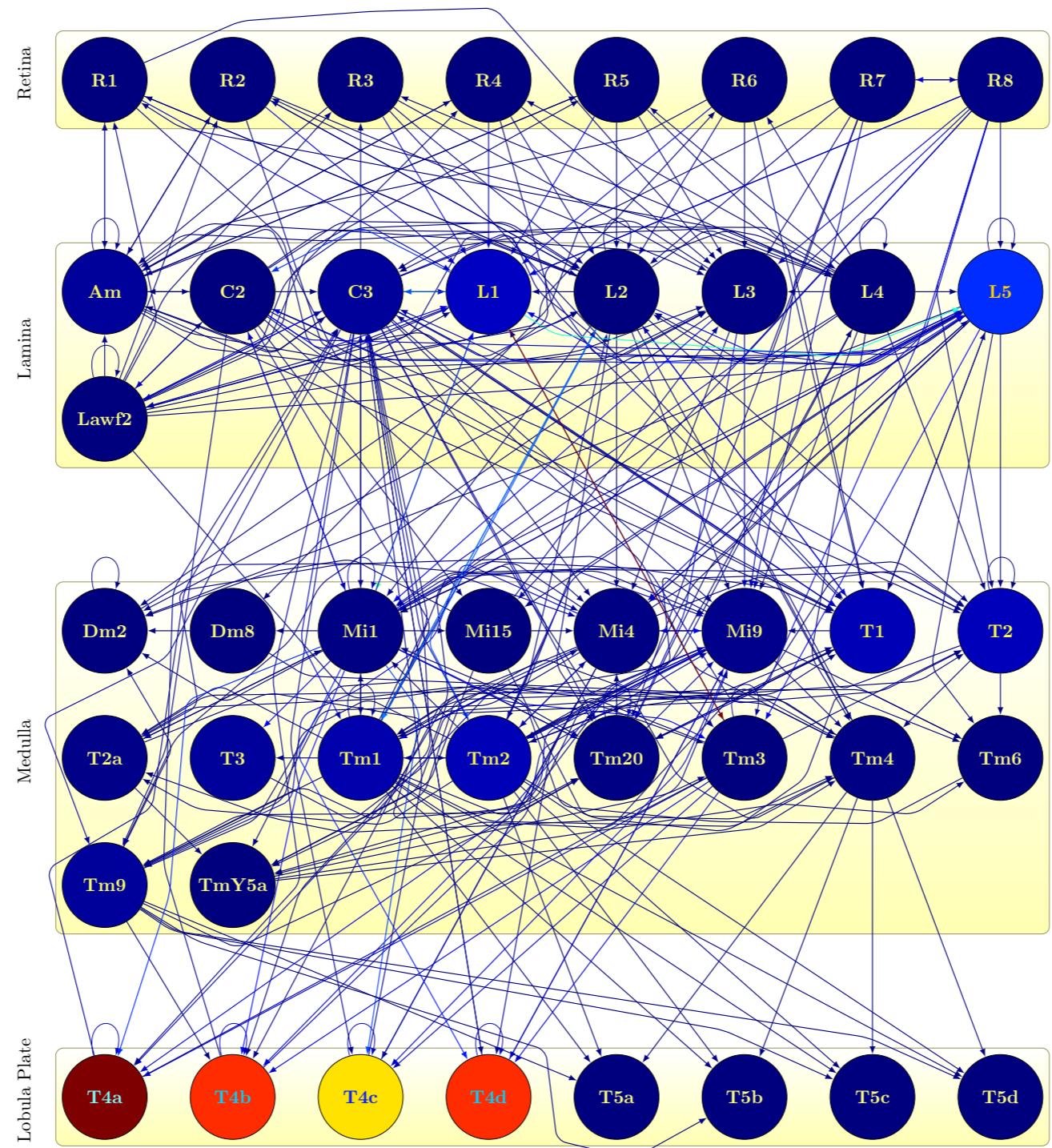
The Fly Visual System



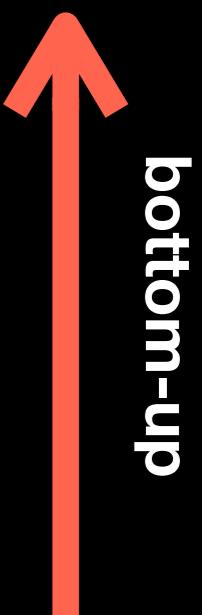
The Fly Visual System







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2022 Fall Course Program

