Robustness of the neural circuit of working memory to varying stimuli using a dynamical system

Pod: Dryptosaurus Cancan
Group Name: **Micropachy-cephalosaurus**
Group Members:

- Ghanendra Singh
- Fatemeh Ilati
- Phuong Tran
- Truc Ngo

P

Why Study Working Memory?

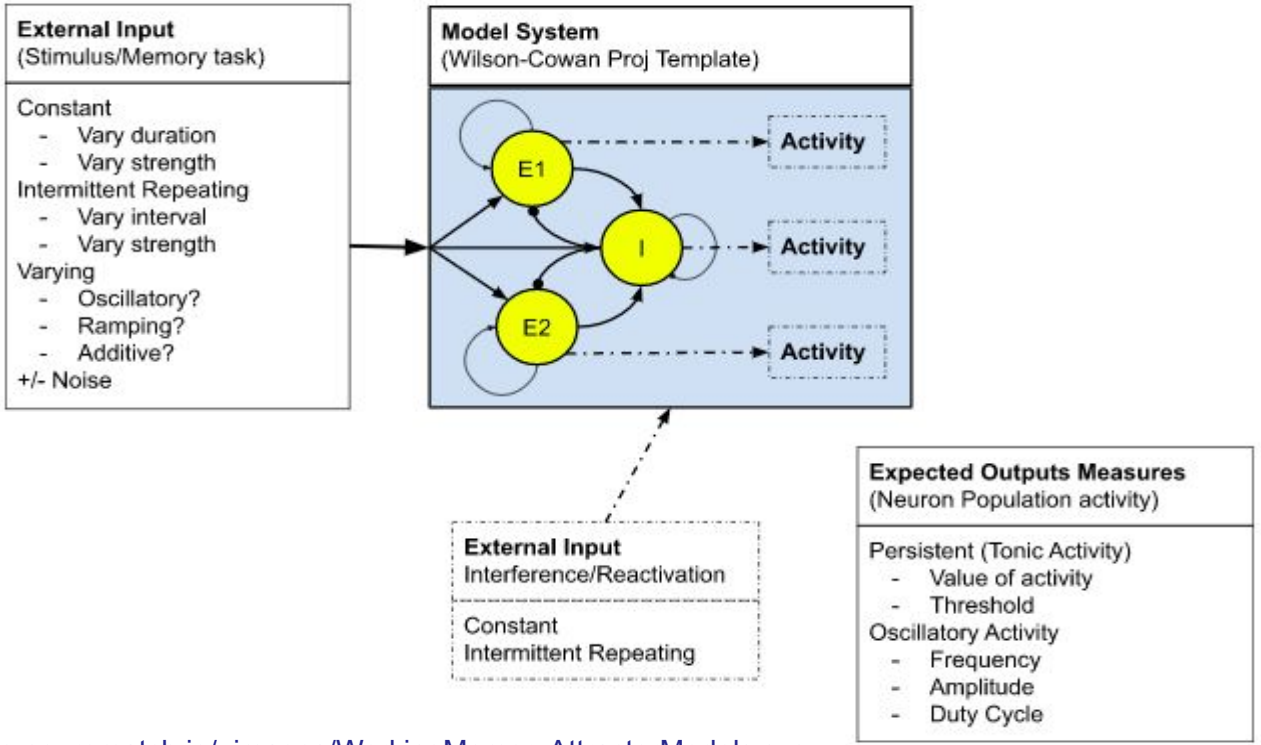
- What is working memory?
  - Temporary
  - Limited capacity
- Experimental recordings of brain activity
  - Persistent neural activity
  - Activity remains for a short period after stimulus removed
  - Then returns to initial state
- How can we explain this activity?
  - Wilson-Cowan-based dynamical system
  - Test with stimuli of varying characteristics (strength, duration, etc.)

Dynamical System and Architecture

Wilson-Cowan based model

Excitatory and Inhibitory populations.

Three Population Model (E1, E2, I)



Ref Project Template: compneuro.neuromatch.io/_images/WorkingMemoryAttractorModels.svg

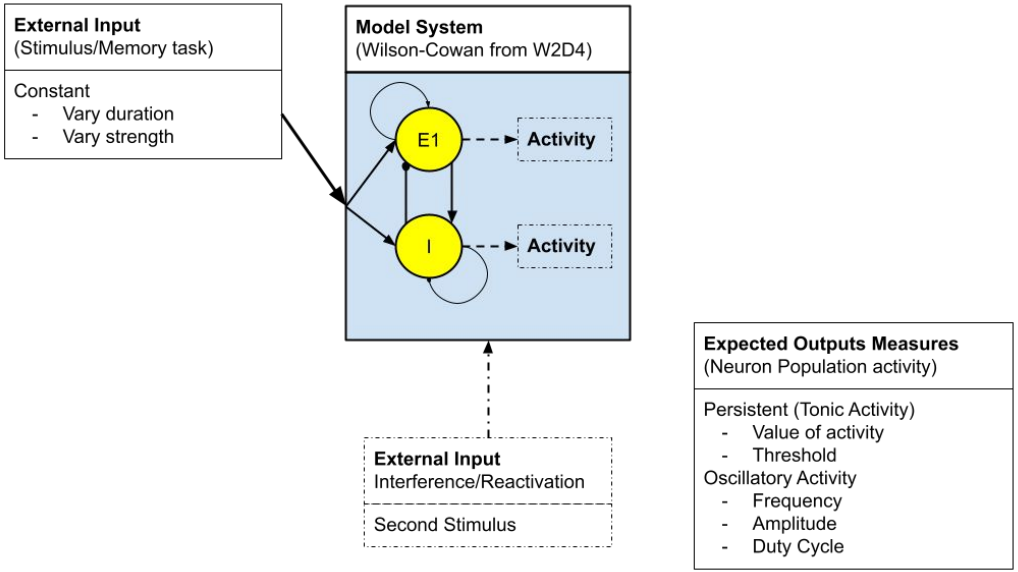
P

Start Simple (2 Population)

Classic Wilson-Cowan

1 Excitatory population

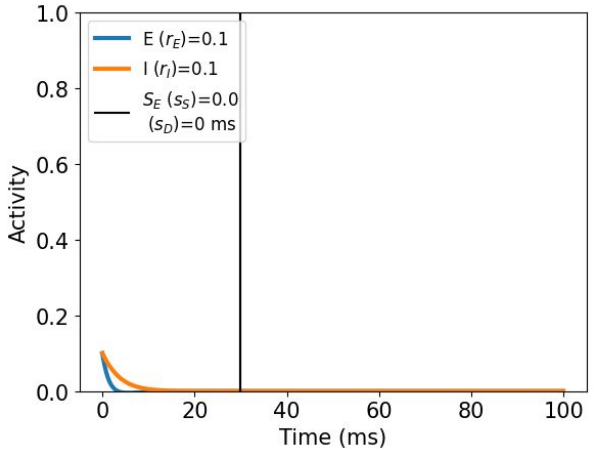
1 Inhibitory population



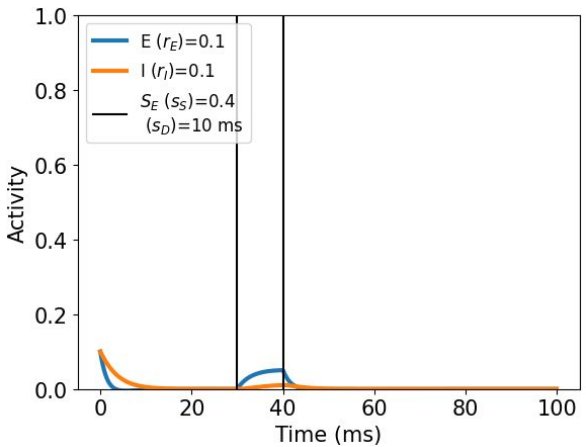
P ->G

Initial Conditions

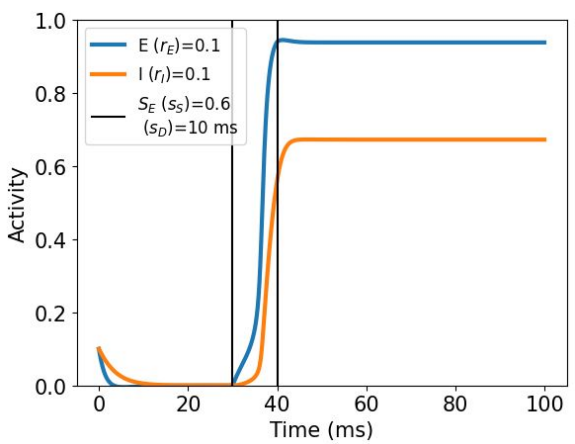
No Stimulus



Weak Stimulus



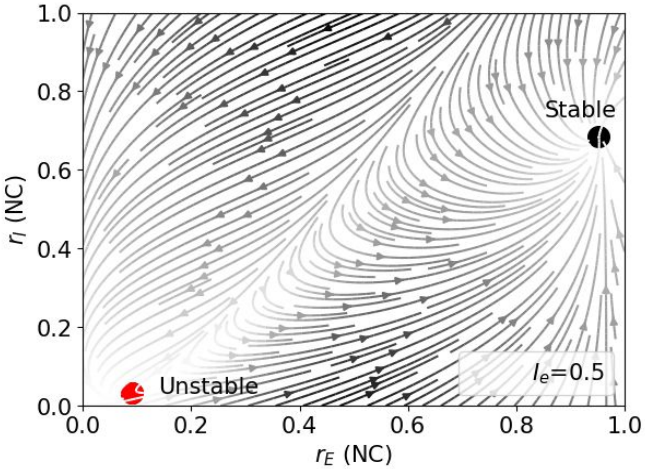
Strong Stimulus



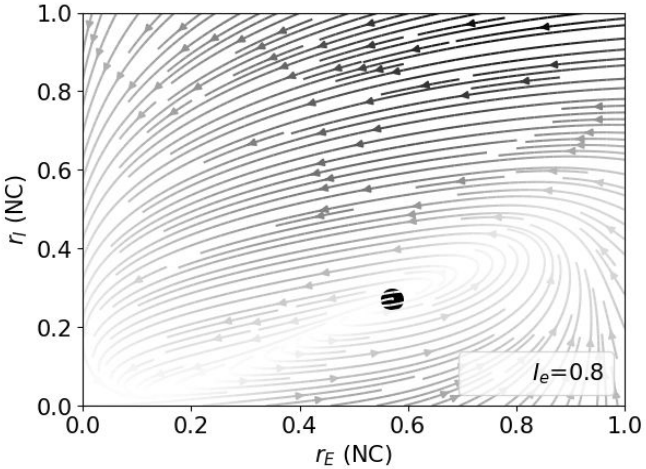
G

State Space

Two states Phase Plane



Oscillatory Phase Plane

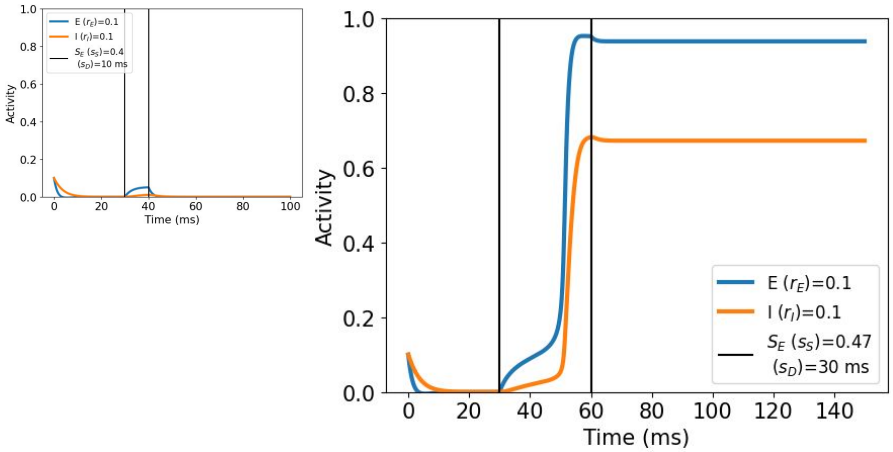


External stimulus leading to state transition from one attractor to another attractor state.

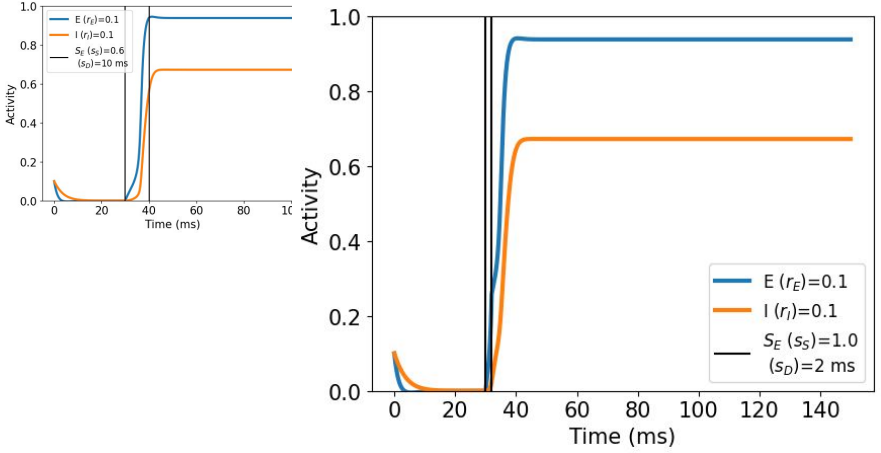
G

Stimulus duration

Weak stimuli strength for longer duration



Strong stimuli strength for short duration

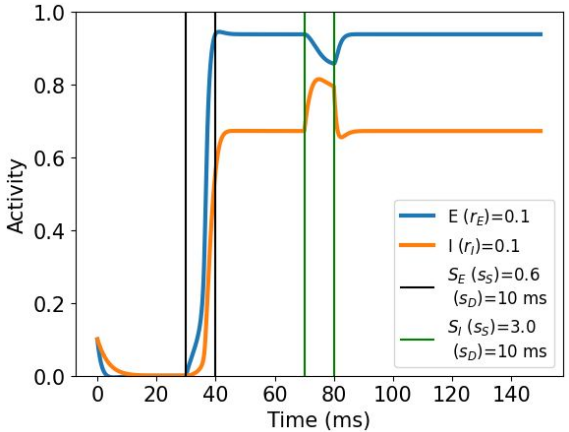


Stimuli duration may influence stimuli threshold required for encoding in WM.

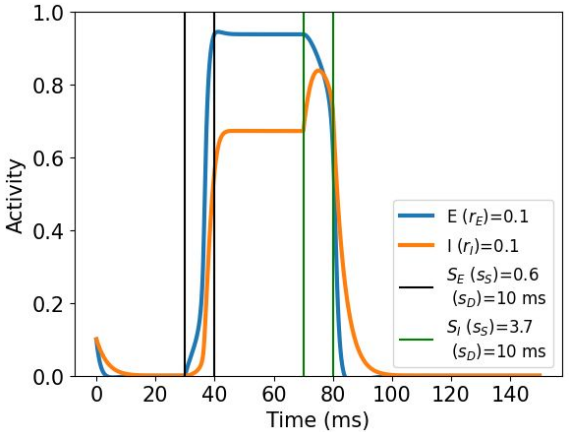
G -> F

Inhibitory Second Stimulus

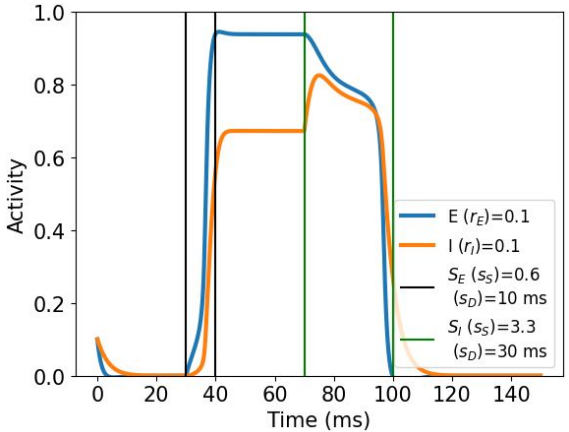
Weak Inhibitory Stimulus



Strong Inhibitory Stimulus



Stimulus Duration



WM recovers from weak external interference whereas not from strong influence.

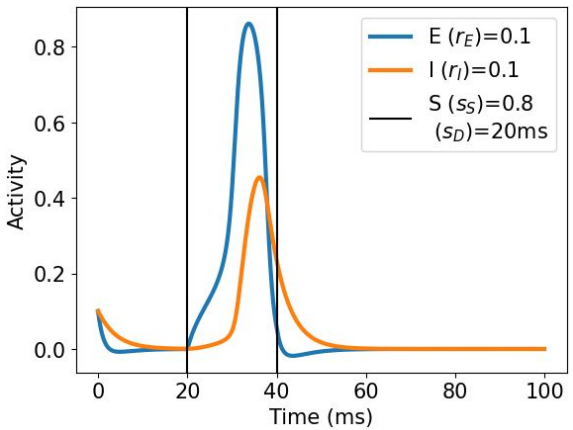
F

Oscillatory State

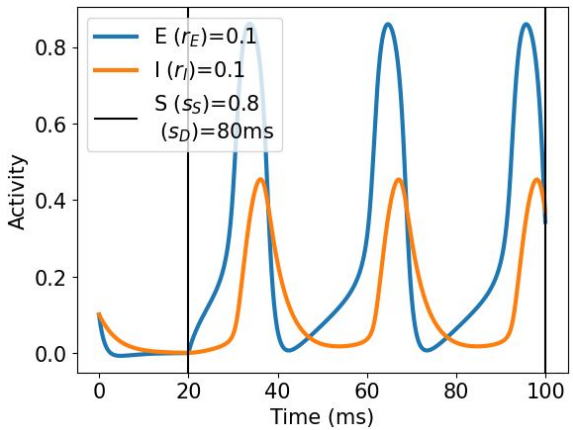
Equilibrium Condition.

Varying the parameter regime of the system.

Pulsed Stimulus



Constant Stimulus

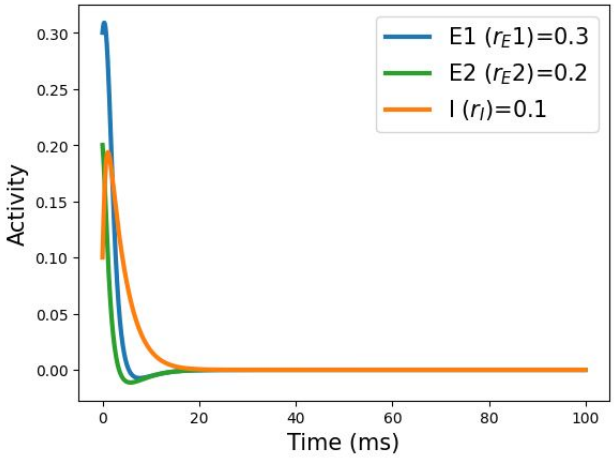


Dynamics oscillates for both E and I units but depends on input.

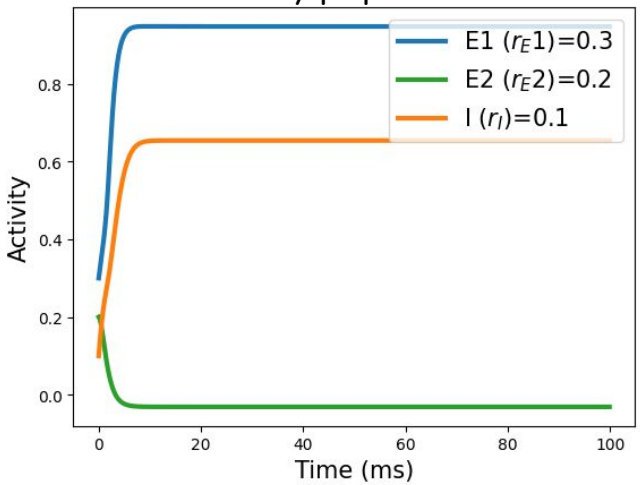
F

2 excitatory and 1 inhibitory population

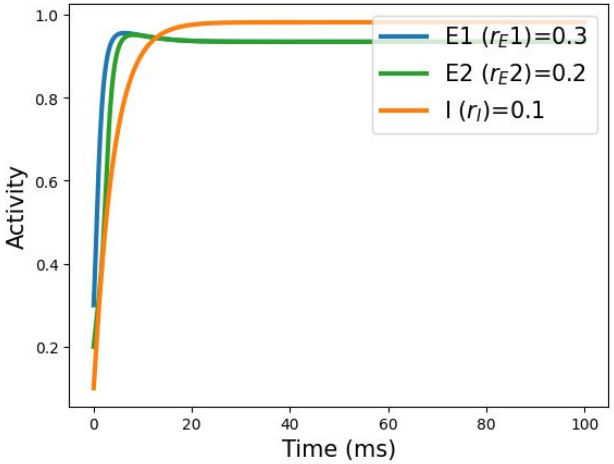
No external input



External input to excitatory populations



Increasing strength

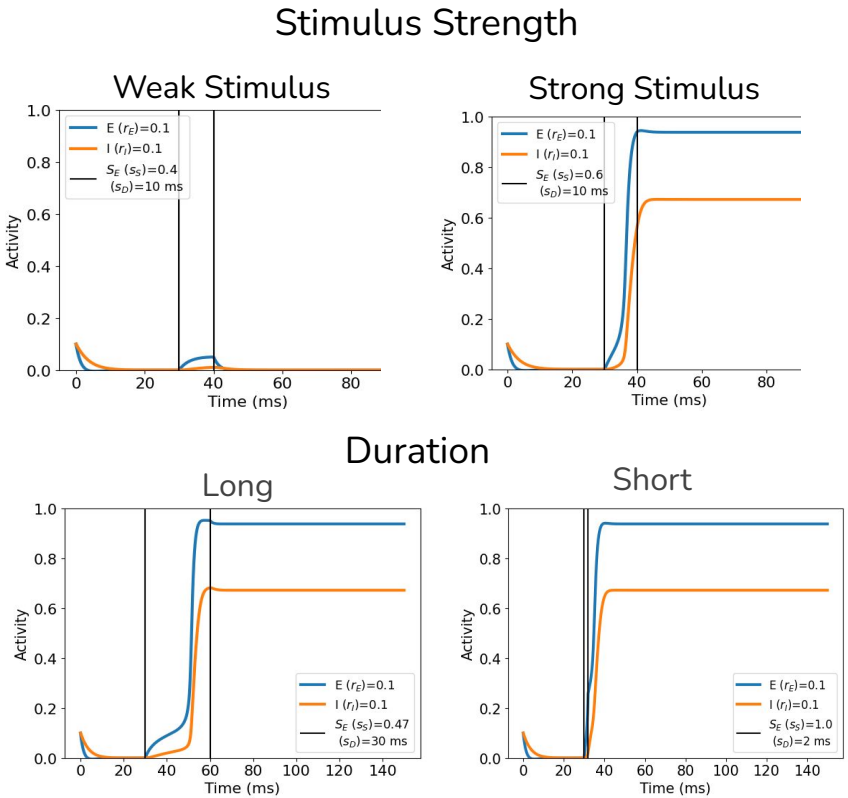


External input resulting in state transitions.

F -> T

Summary

- Dynamical system is a potential model for describing neuronal activity changes that have been observed experimentally
- Characteristics of stimuli seem to influence working memory.



T

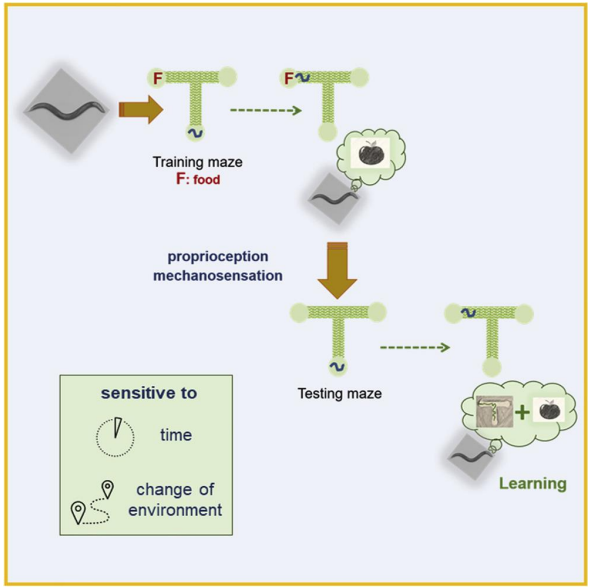
Next Steps

- Further explore the oscillatory (limit cycle) state
- Introduce stimuli to the 3-population model
- Vary other stimuli characteristics.
- Fit model to with experimental data from different organisms.

T

Comparison with simple model system

C. elegans can locate food in T-shaped mazes and, following that experience, learn to reach a specific maze arm. C. elegans learning inside the maze is possible after a single training session, it resembles **working memory**, and it prevails over conflicting environmental cues.



Ref: [Caenorhabditis elegans learning in a structured maze is a multisensory behavior]

T

Thanks

- Nadav
- Bennet