Data for Brain Reference Architecture of YM24Amygdala

Neural Architecture for Amygdala Fear Conditioning

Yohei Maruyama, Tatsuya Miyamoto, Yoshimasa Tawatsuji, Hiroshi Yamakawa

Objective and Outline

Objective

- To implement the functional expression of **amygdala fear conditioning** in the circuitry, we construct a Function Realization Graph (FRG).
- In this data, we attempted to construct the FRG by using motifs.

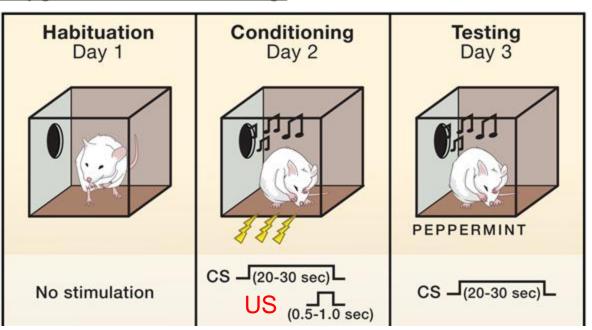
□Outline



- The method used in this data paper differs from the SCID method.
- We construct the FRG from the bottom up by **filling the BIF circuitry with motifs**.

Background of the Data (1/2)

□Amygdala fear conditioning.



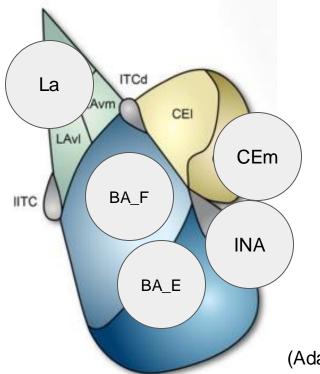
CS:harmless stimulus US: harmful stimulus

 After pairing the CS and US, the CS alone causes a fear response.

(Joshua P._Johansen et al., 2011)

Background of the Data (2/2)

□Amygdala fear conditioning circuitry.



- The amygdala regions closely associated with fear conditioning include the lateral nucleus (La), the basal nucleus (BA), the central nucleus (CEN), and the intercalated cell masses (INA) within the BLA.
- we focus on these regions to construct the BIF and FRG.

(Adapted from Seungho Lee et al., 2013.)

-Data-

BIF and FRG

Overview of the Data and the Constructed BIF

- For this BIF, we have modeled 8 neural nuclei to represent amygdala fear conditioning.
- Modeled 14 connections between these neural nuclei.
- The BIF is constructed based on these neural nuclei and their connections.

Circuits(neural nuclei, 8)

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Overview of the Data and the Constructed BIF

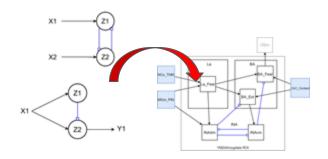
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Overview of the Data and the Constructed FRG

C.Input-Normalization C.Switching C.Input-Normalization -this-1 C.relay -this-1

U.La-Fear U.BA-Ext U.INAdm U.INAvm U.BA-Fear



 We constructed the FRG by exhaustively applying the functions of motifs to the neural nuclei and connections in the BIF.

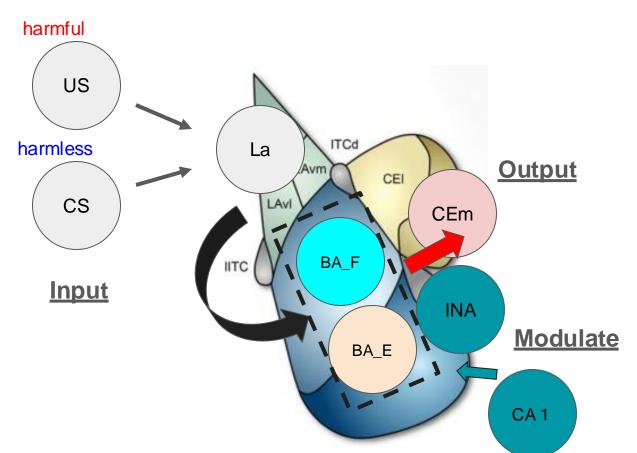
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-METHOD-

Data Creation Process

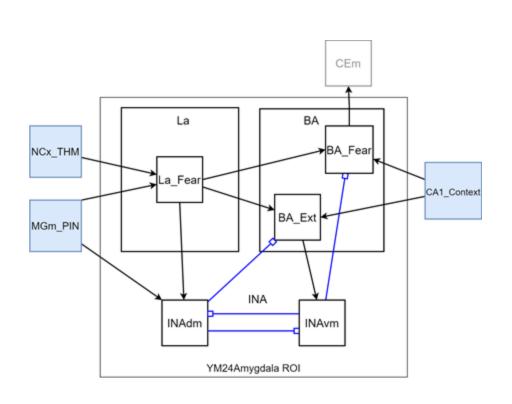
BIF Data and Collection Methods

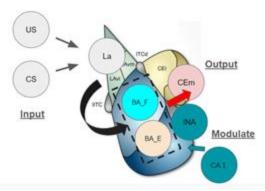


- La receives sensory information (CS and US) and facilitates Hebbian conditioning.
 (Duvarci, S., & Pare, D., 2014)
- LA projects to the BA.
 BA contains BA_Fear (induces fear) and BA_Ext (extinction learning).
 (Amano, T. et al.,,2011)
- BA projects to the **CEm**, which is involved in inducing the fear response. (Duvarci, S., & Pare, D., 2014)
- INA and CA1 serve as modulators of the BA.

(Hagihara,K.M., et al, 2021, Duvarci, S., & Pare, D., 2014, Pitkänen, A. et al, 2000)

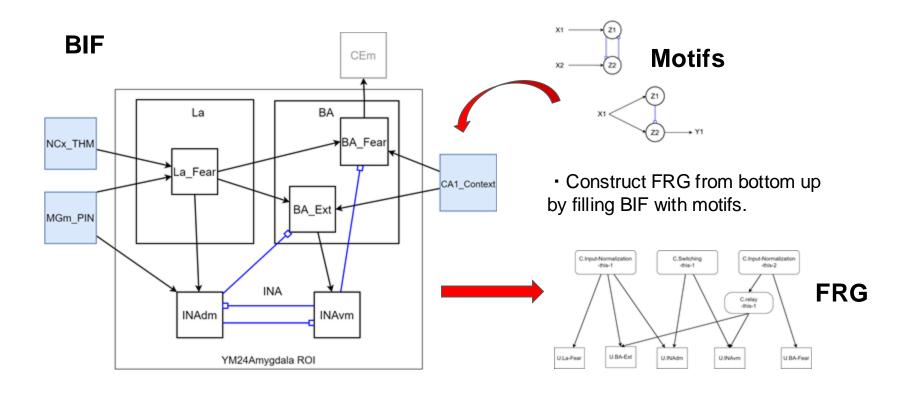
BIF Data and Collection Methods



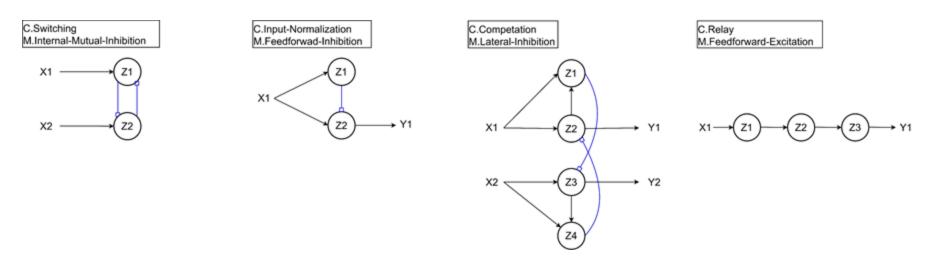


- The BIF constructed with the TM24Amygdala project
- Using this BIF, we construct the FRG.

Toward the construction of the **FRG** using Motif



Motifs

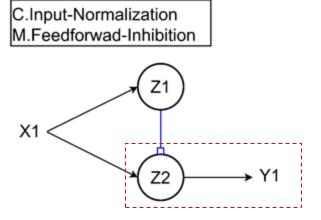


- In this data paper, motifs are collected based on the references cited in the data papers.
- Here are some examples.

<Reference>

- □ Luo, L. (2021). Architectures of neuronal circuits.
- □ Luo, L. (2020). Principles of neurobiology.
- □ Braganza, O., & Beck, H. (2018). The circuit motif as a conceptual tool for multilevel neuroscience.
- □ C. Alex Goddard et al., (2014). Spatially reciprocal inhibition of inhibition within a stimulus selection network in the avian midbrain.

Mechanism and Capability of Motif (example 1/3)



node: Z1, Z2, Z3,.. Input: X1, X2, X3,.. Output: Y1, Y2, Y3,..

black arrow: excitatory signal blue arrow: inhibitory signal

Output amount is adjusted.

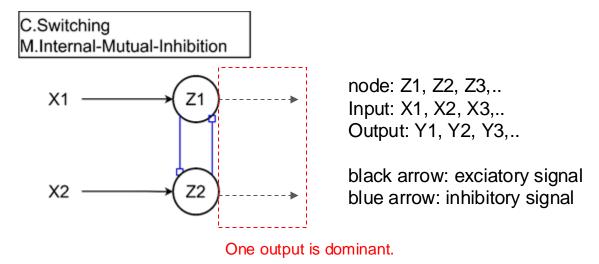
<M: Mechanism_Feedforward Inhibition>

Signals flow feedforward from X1 to the next two nodes. Then, one node inhibits the output of the other node.

<C: Capability_Input Normalization>

The amount of the final output is regulated, indicating that the capability is input normalization.

Mechanism and Capability of Motif (example 2/3)

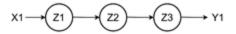


<M: Mechanism_Internal Mutual Inhibition>
The outputs within the motif have a mutual inhibitory relationship (from Z1 and Z2).

<C: Capability_Switching>
Only one output is strengthened, and it switches depending on the input, so the capability is described as switching.

Mechanism and Capability of Motif (example 3/3)

C.Relay M.Feedforward-Excitation



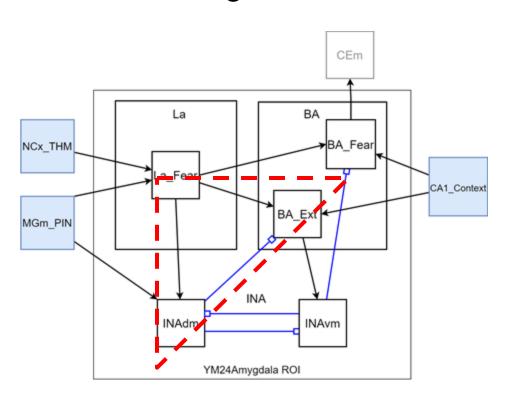
node: Z1, Z2, Z3,.. Input: X1, X2, X3,.. Output: Y1, Y2, Y3,..

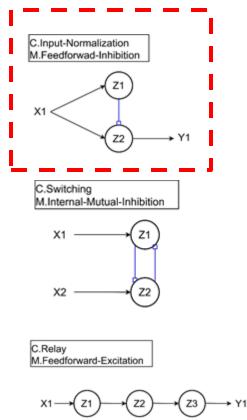
black arrow: exciatory signal blue arrow: inhibitory signal

<M: Mechanism_Feedforward Excitation>
The input from X1 flows straight downstream.

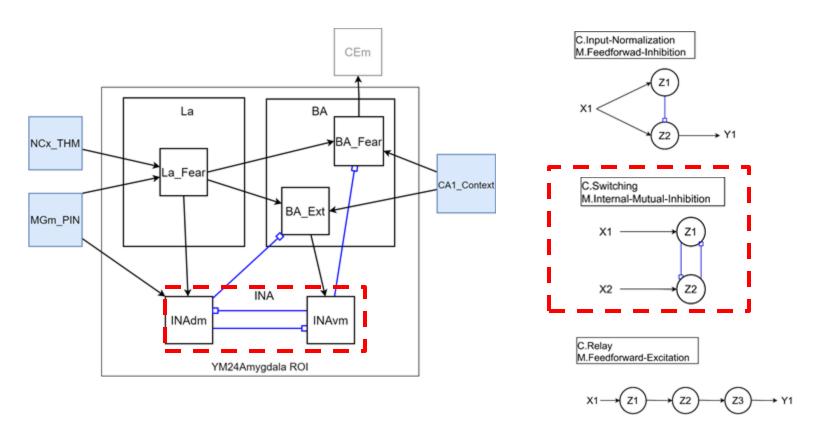
<C: Capability_Relay>
Since the signal is simply passed along, the capability is named "relay."

Exhaustive fitting of Motifs to BIF for FRG construction

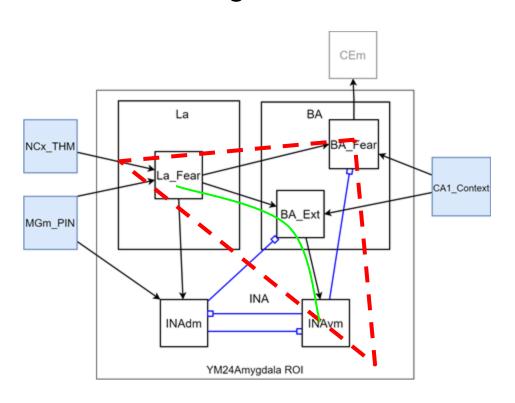


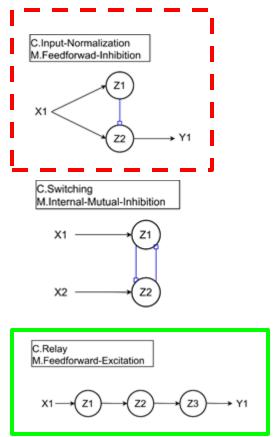


Exhaustive fitting of Motifs to BIF for FRG construction



Exhaustive fitting of Motifs to BIF for FRG construction





Constructed FRG NCx_THM CA1_Context BA Ext MGm_PIN INA. INAdm INAvm C.Input-Normalization C.Switching C.Input-Normalization -this-1 -this-1 -this-2 YM24Amygdala ROI C.relay -this-1 U.BA-Ext U.La-Fear U.BA-Fear U.INAdm U.INAvm

- By applying the motifs and building up their capabilities, the FRG is constructed as follows.
- This time, We described the process of constructing the FRG using motifs and the BIF. Next time, I hope to talk about the significance and details of this FRG.

Dataset Description

3 Dataset Description

Repository location BRA Editorial System (BRAES) https://sites.google.com/wba-initiative.org/braes/data

Object name and versions Please refer to the "Project" sheet in the BRA data for the more detail of data summary.

Table 1: I	3RA DATA S	UMMA	RY
BRA Data			
Object Name	Template	Includ	ling Content(s)
		BIF	HCD/FRG
YM24Amygdala.bra	version 2.0	√	√

Table	2: BRA IMAGE SUMMARY
Graphic Files	: BIF Image, HCD Image, FRG Image
File Type	Object Name
BIF Image	YM24AmygdalaBIF.xml
HCD Image	YM24AmygdalaHCD.xml
FRG Image	YM24AmygdalaFRG.xml

Creation dates 2024-02-08 to 2024-06-30.

Language English.

License The open license under which the data has been deposited (CC-BY 4.0).

Publication date 2024-07-01.

Caveats for Data Usage

- This BRA data focuses on the fear conditioning circuitry of the amygdala.
- The BIF is constructed based on references within the BRA data.
- This data suggests hypothetical FRGs, so careful consideration should be taken when utilizing the data
- The motifs utilized to construct the FRG were organized based on the references cited in this paper.