Data for Brain Reference Architecture of YM24Amygdala

Neural Architecture for Amygdala Fear Conditioning

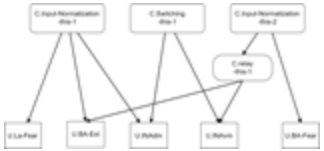
Yohei Maruyama, Tatsuya Miyamoto, Yoshimasa Tawatsuji, Hiroshi Yamakawa

Objective and Outline

□Objective

・To implement the functional expression of **amygdala fear conditioning** in the circuitry, we construct a Function Realization Graph (FRG).

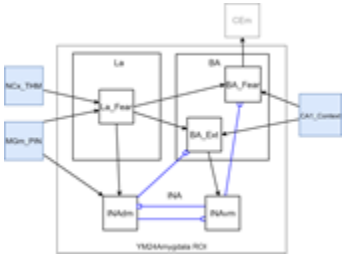
・In this data, we attempted to construct the FRG by using motifs.



□Outline

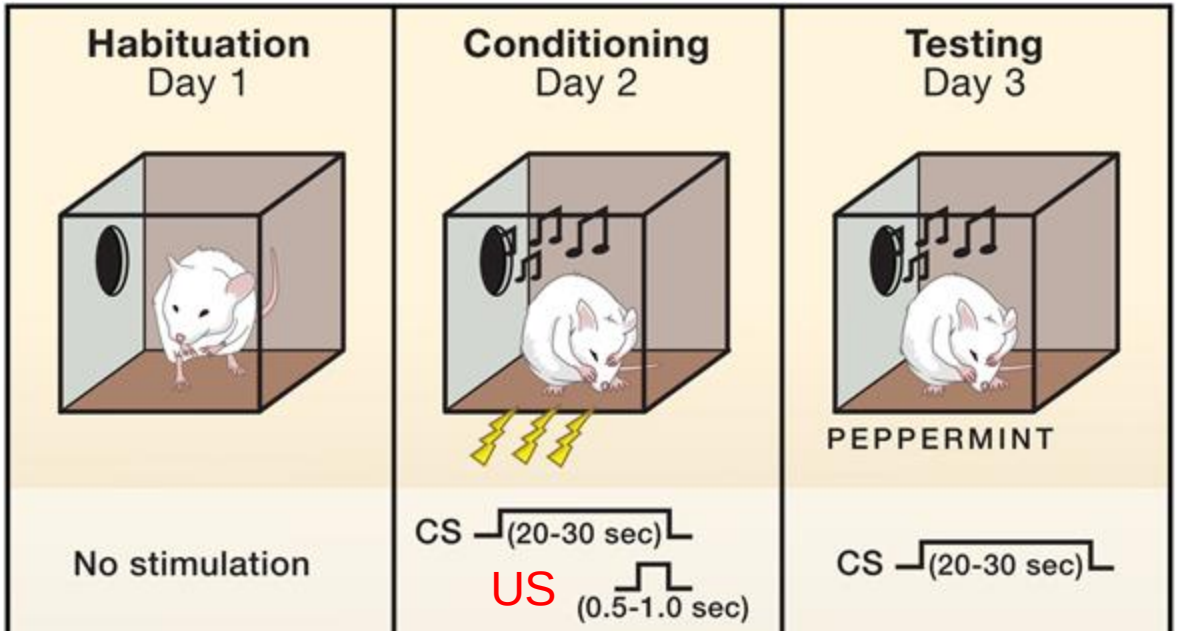
・The method used in this data paper differs from the SCID method.

・We construct the FRG from the bottom up by **filling the BIF circuitry with motifs**.



Background of the Data (1/2)

□Amygdala fear conditioning.



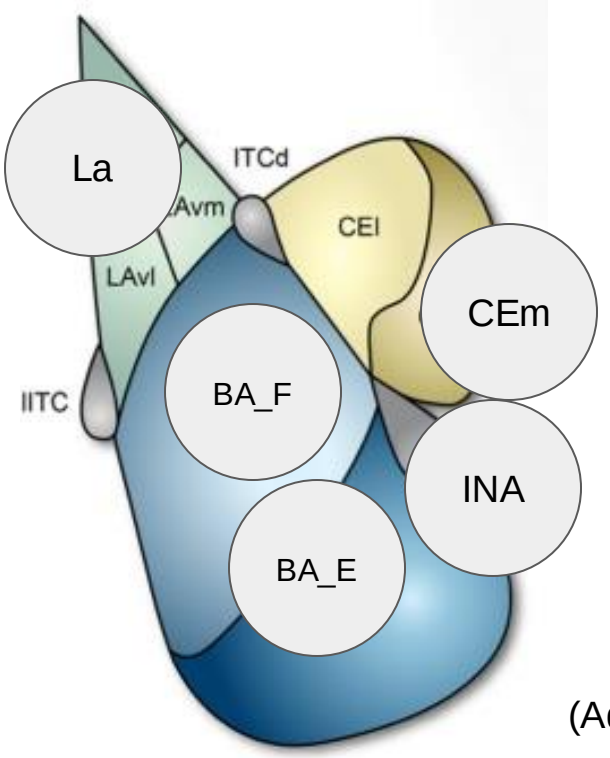
(Joshua P._Johansen et al., 2011)

CS:harmless stimulus
US: harmful stimulus

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

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.

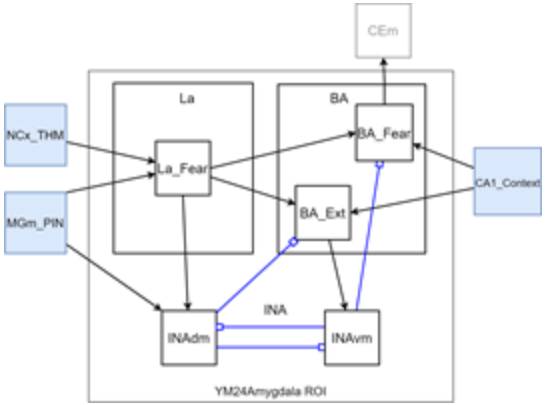
(Adapted from Seungho Lee et al., 2013.)

-Data-

BIF and FRG

Overview of the Data and the Constructed BIF

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)

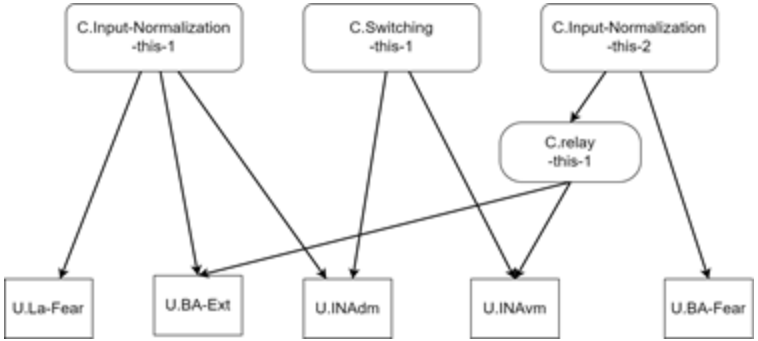
	A	B	C	D	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1	Circuit ID	Source of ID	Names	DHBA: graph_order	Sub-Circuits	Super Class	Uniform	Transmitter	Modulation Type	Size	Output Semantics (0)	Physiological Data	Comments	Contributor	Project ID	WBIF pull request	WBIF copied	Review results	Auto Error Codes
2	YM24Amygdala	[Maruyama, 2024]	ROI of YM24Amygdala	1760.1	La_Fear;BA;INAdm;INAvm;		FALSE							Yoshimasa Tawatsuji	TM24Amygdala			0	
3	NCx_THM	makeshift	Conditioned stimulus of fear conditioning	1760.1	NCx; THM;		TRUE		Excitatory					Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109:Source of ID]
4	MGm_PIN	[Asede, 2022]	Unconditioned stimulus of fear conditioning	1760.1			TRUE		Excitatory					Tatsuya Miyamoto	TM24Amygdala			0	
5	BA	[Duvarci, 2014]	Basal nucleus of Amygdala	1793.2	BA_Fear;BA_Ext;		FALSE							Tatsuya Miyamoto	TM24Amygdala			0	
6	BA_Fear	makeshift	Fear cell of BA	1793.2			TRUE		Excitatory					Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109:Source of ID]
7	BA_Ext	makeshift	Extinction cell of BA	1793.2			TRUE		Excitatory					Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109:Source of ID]
8	INAdm	[Hagihara, 2021]	dorsal cluster of medial ITC	1824.1			TRUE	GABA	Inhibitory					Tatsuya Miyamoto	TM24Amygdala			0	
9	INAvm	[Hagihara, 2021]	ventral cluster of medial ITC	1824.1			TRUE	GABA	Inhibitory					Tatsuya Miyamoto	TM24Amygdala			0	
10	La_Fear	makeshift	fear part of Lateral neucleus of amygdala	1794.1			TRUE							Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109:Source of ID]
11	CA1_Context	makeshift	CA1 resion for Context Information	1619.1			TRUE							Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109:Source of ID]

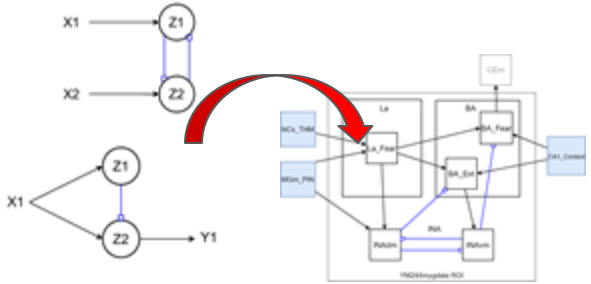
Overview of the Data and the Constructed BIF

Connections (14)

Overview of the Data and the Constructed FRG

FRG





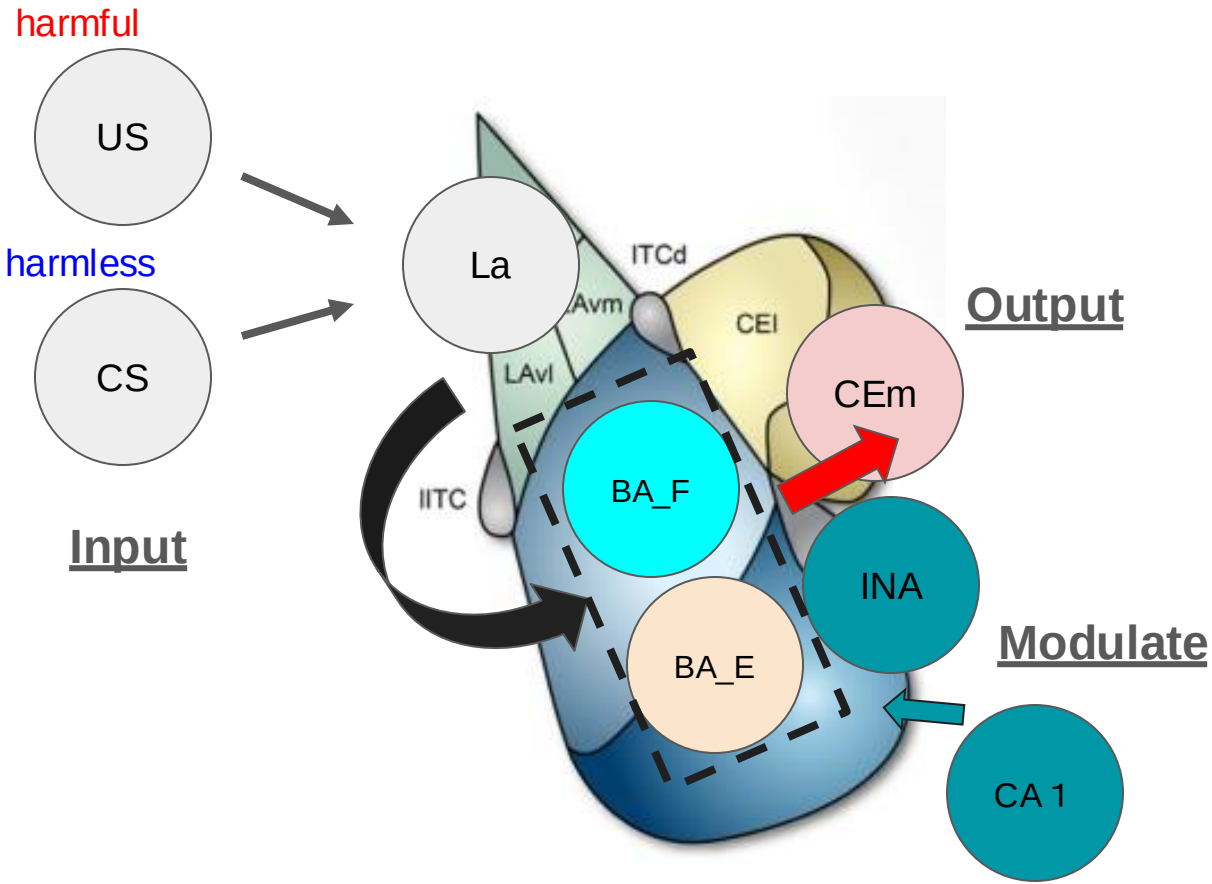
・We constructed the FRG by exhaustively applying the functions of motifs to the neural nuclei and connections in the BIF.

Overview of the Data and the Constructed FRG

-METHOD-

Data Creation Process

BIF Data and Collection Methods



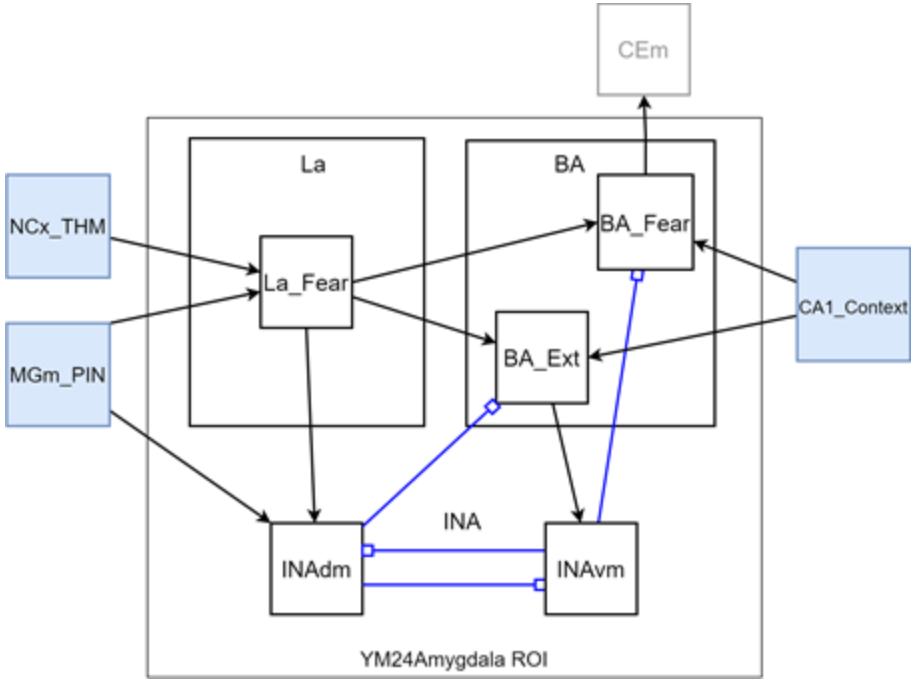
- **La** receives sensory information (CS and US) and facilitates Hebbian conditioning.
(Duvarci, S., & Pare, D., 2014)

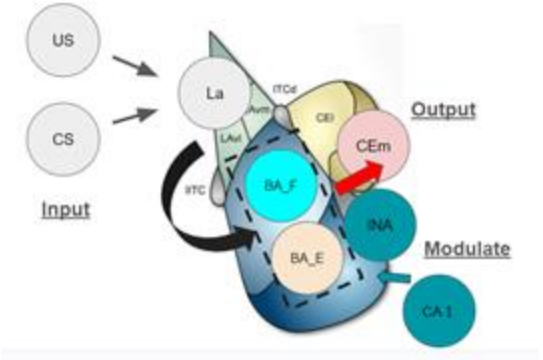
- LA projects to the BA.
BA contains BA_Fear (induces fear) and BA_Ext (extinction learning).
(Amano, T. et al.,,2011)

- 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



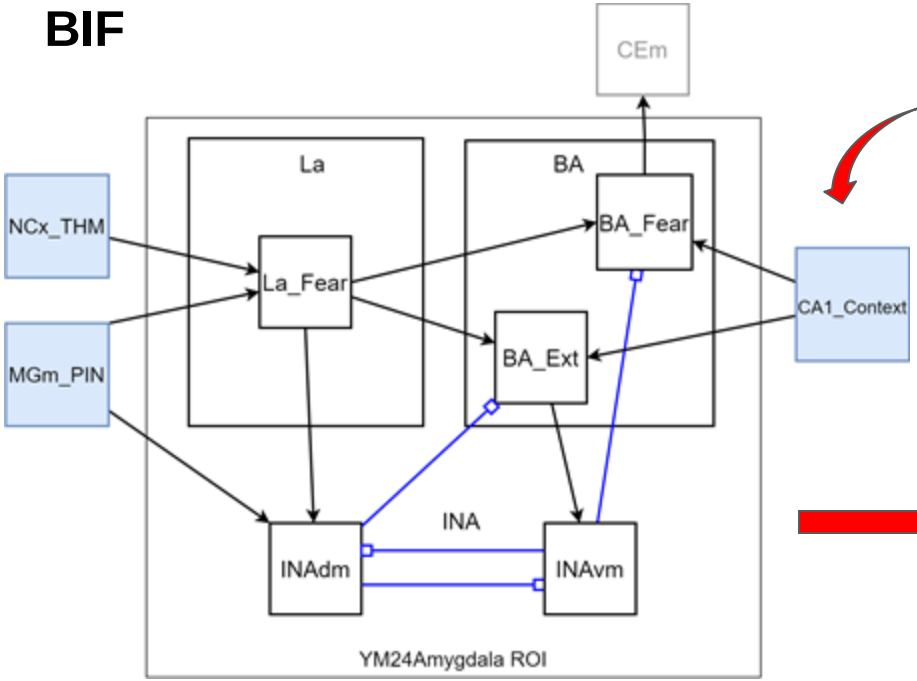


- The BIF constructed with the **TM24Amygdala** project

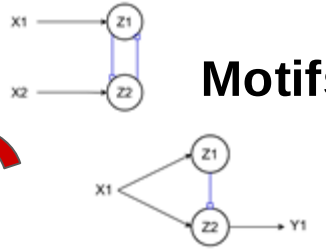
- Using this BIF, we construct the FRG.

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

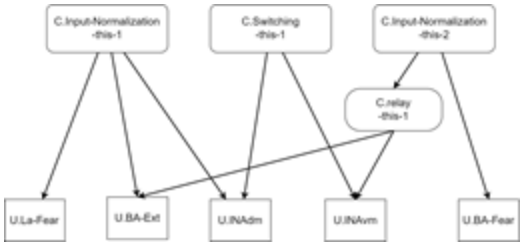
BIF



Motifs

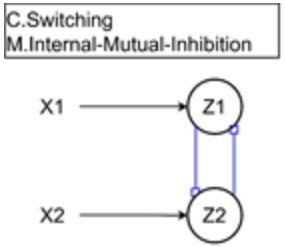


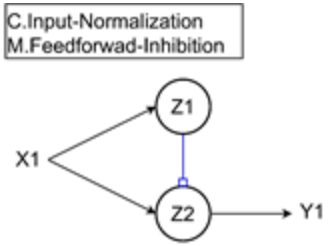
・Construct FRG from bottom up by filling BIF with motifs.

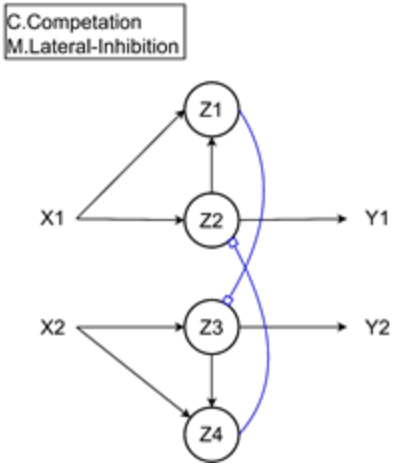


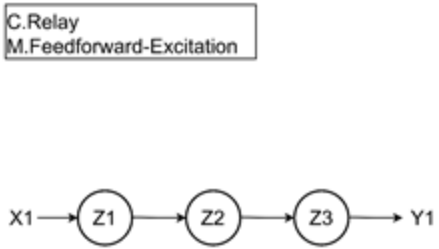
FRG

Motifs







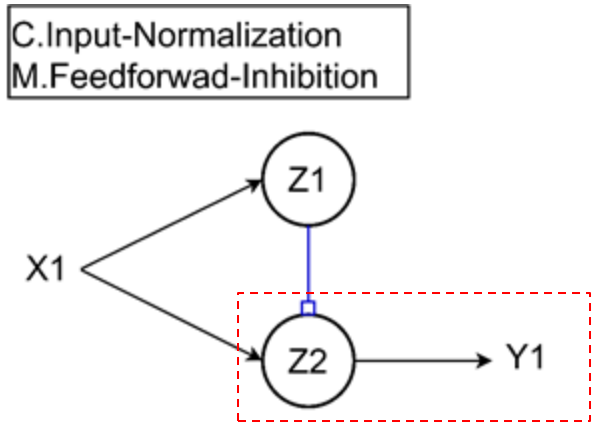


- In this data paper, motifs are collected based on the references cited in the data papers.
- Here are some examples.

<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,..

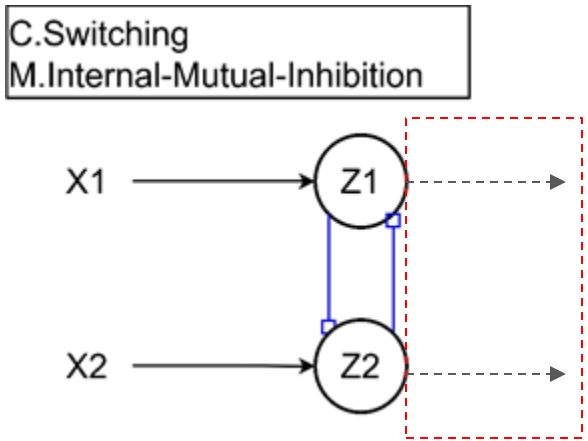
black arrow: excitatory signal
blue arrow: inhibitory signal

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)



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

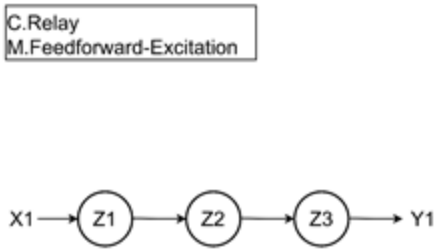
black arrow: exciatory signal
blue arrow: inhibitory signal

One output is dominant.

<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)



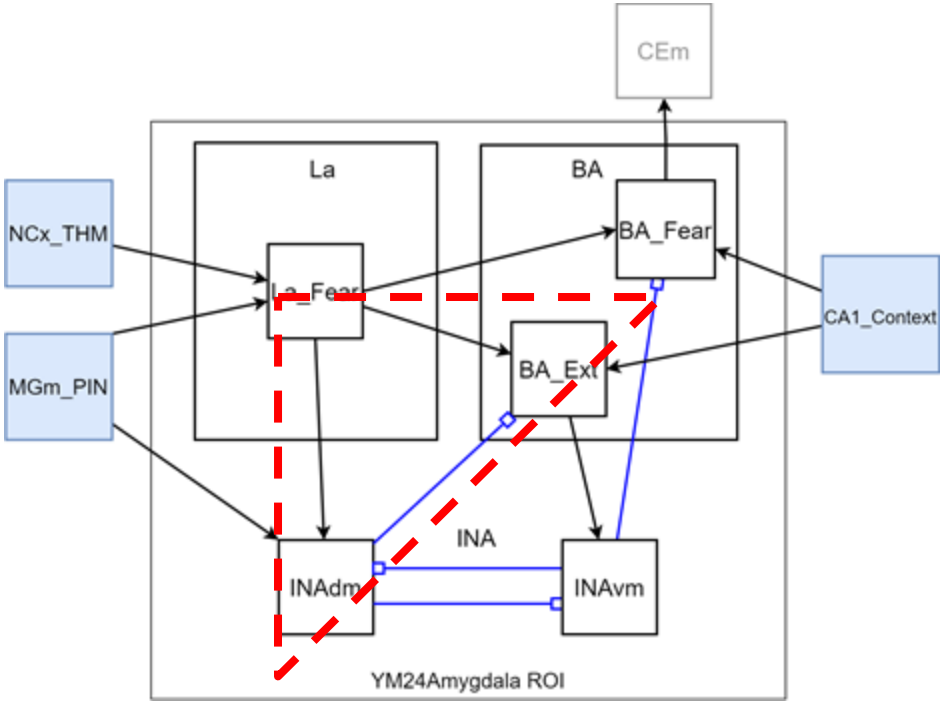
node: Z1, Z2, Z3,..
Input: X1, X2, X3,..
Output: Y1, Y2, Y3,..

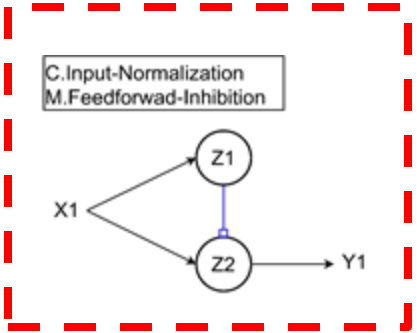
black arrow: exciatory signal
blue arrow: inhibitory signal

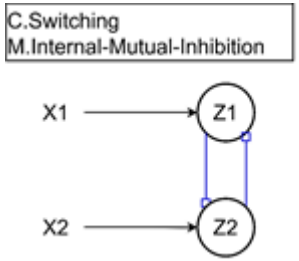
<M: Mechanism_Feedforward Excitation>
The input from X1 flows straight downstream.

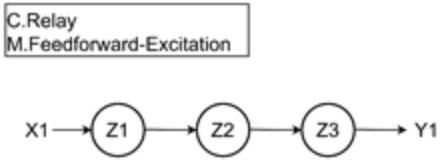
<C: Capability_Relay>
Since the signal is simply passed along, the capability is named "relay."

Exhaustive fitting of Motifs to BIF for FRG construction

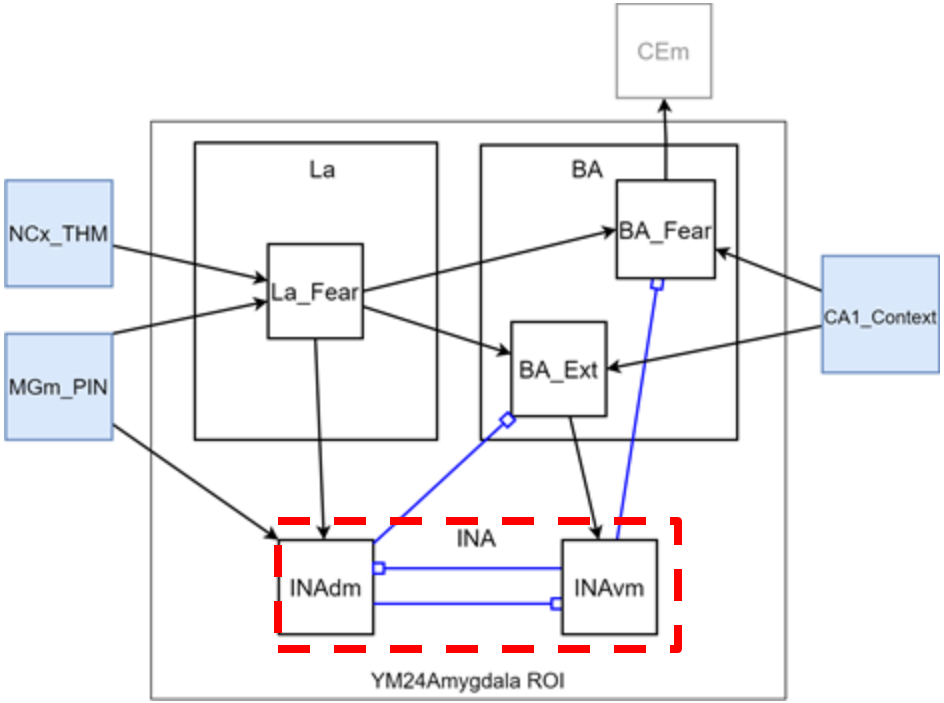


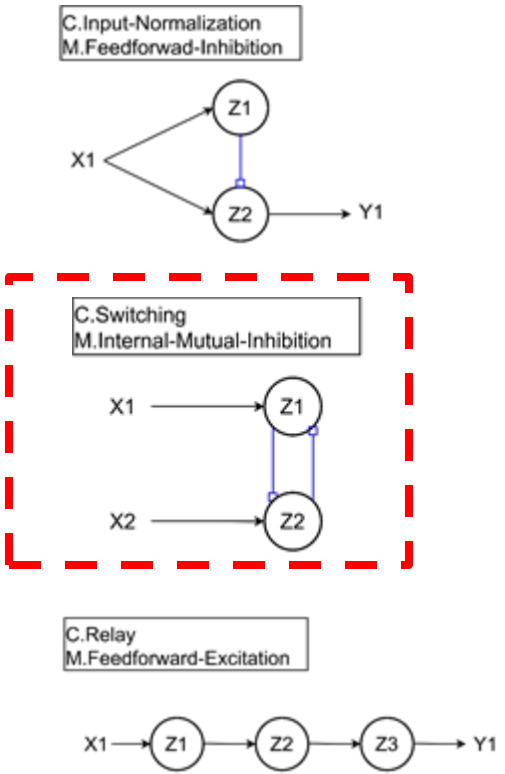




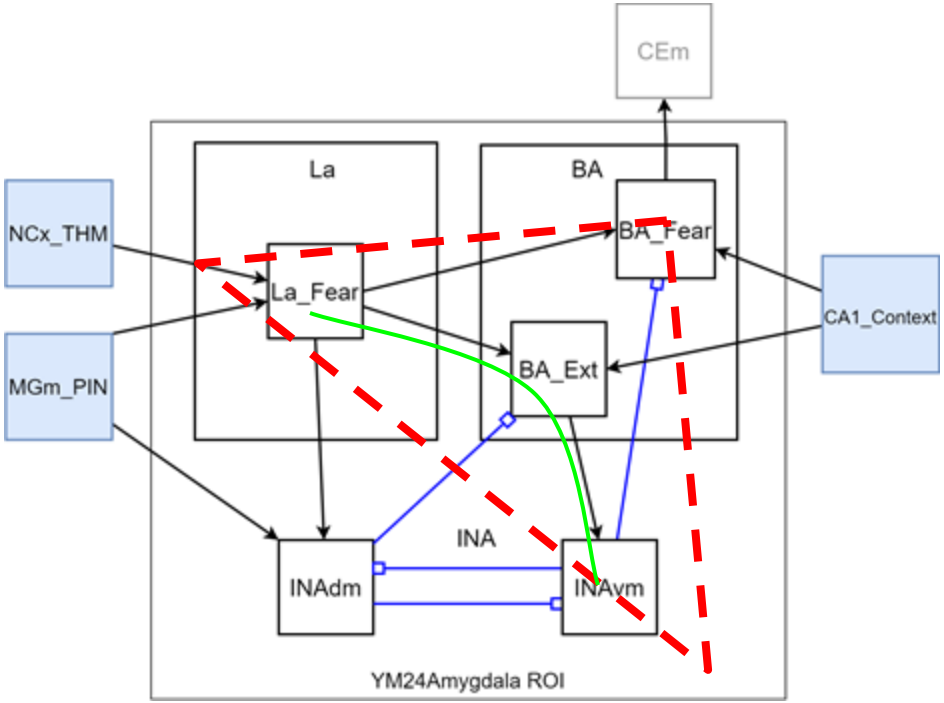


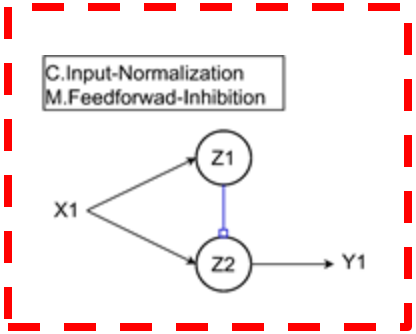
Exhaustive fitting of Motifs to BIF for FRG construction

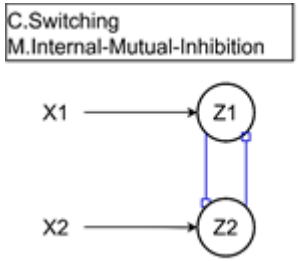


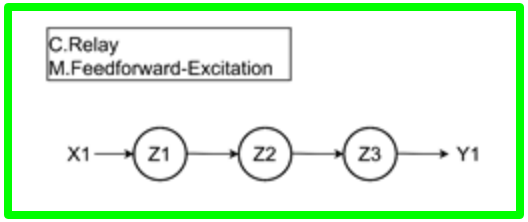


Exhaustive fitting of Motifs to BIF for FRG construction

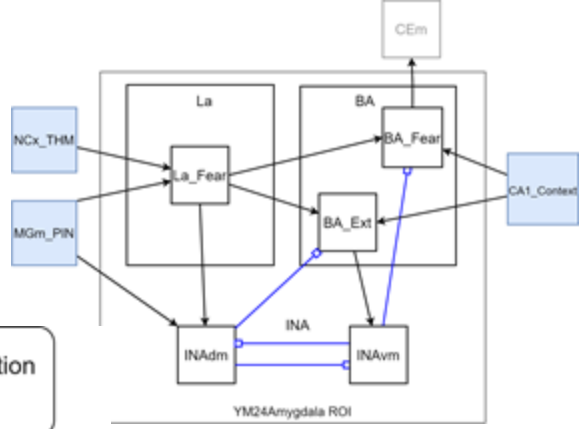


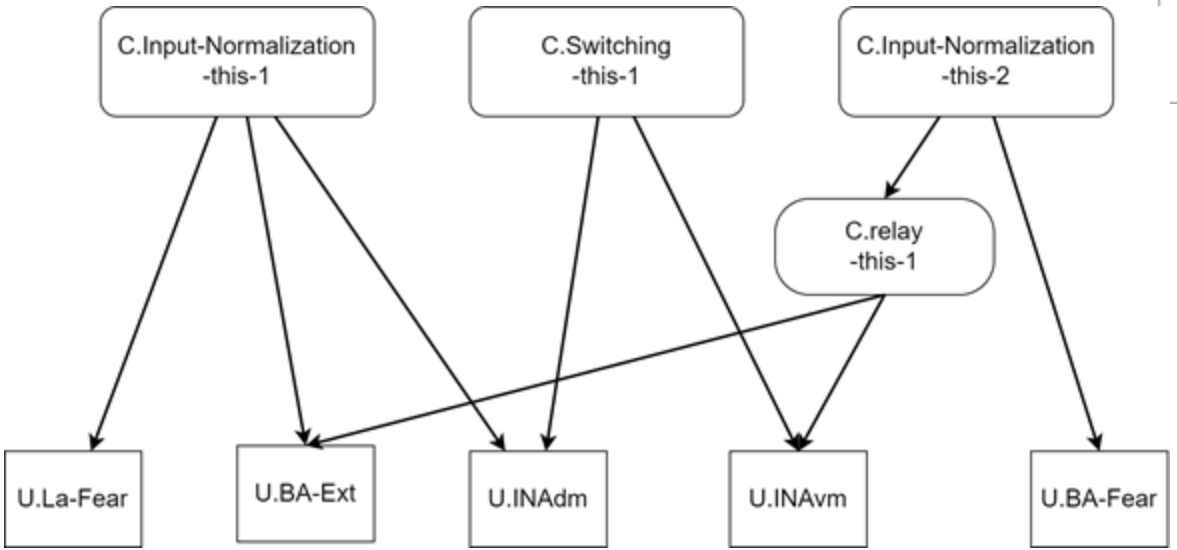






Constructed FRG





- 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: BRA DATA SUMMARY

BRA Data			
Object Name	Template	Including 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.