

Data for Brain Reference Architecture of YM24Amygdala

Neural Architecture for Amygdala Fear Conditioning

Yohei Maruyama, Tatsuya Miyamoto, Yoshimasa Tawatsuji, Hiroshi Yamakawa

Objective and Outline

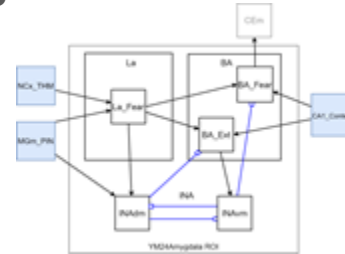
Objective

- 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.



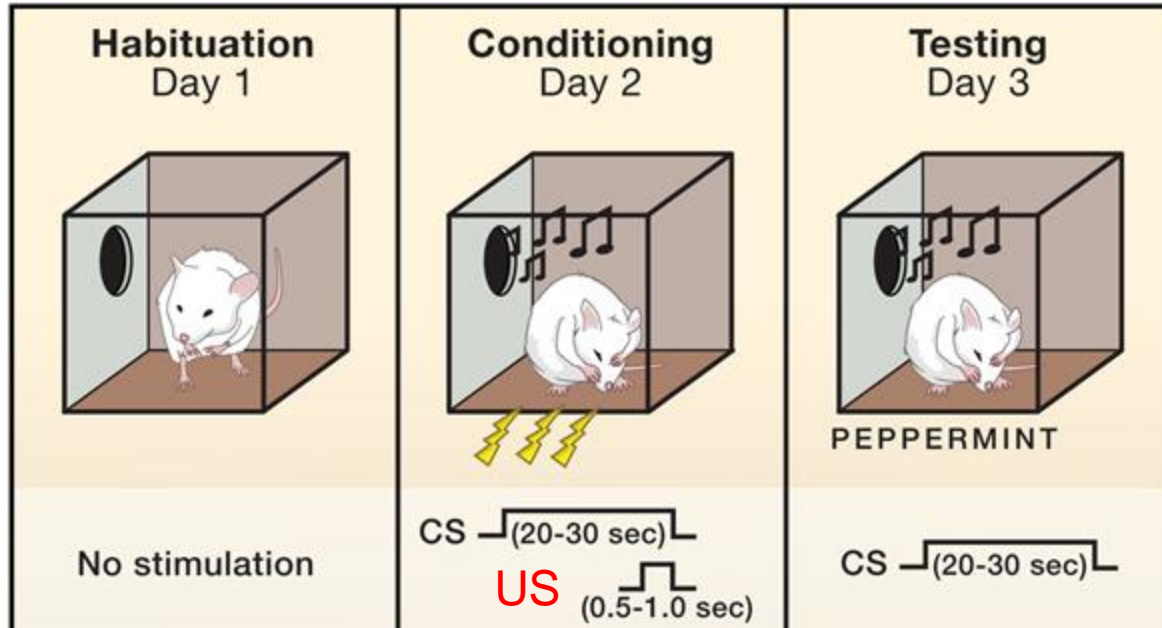
Outline

- 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.

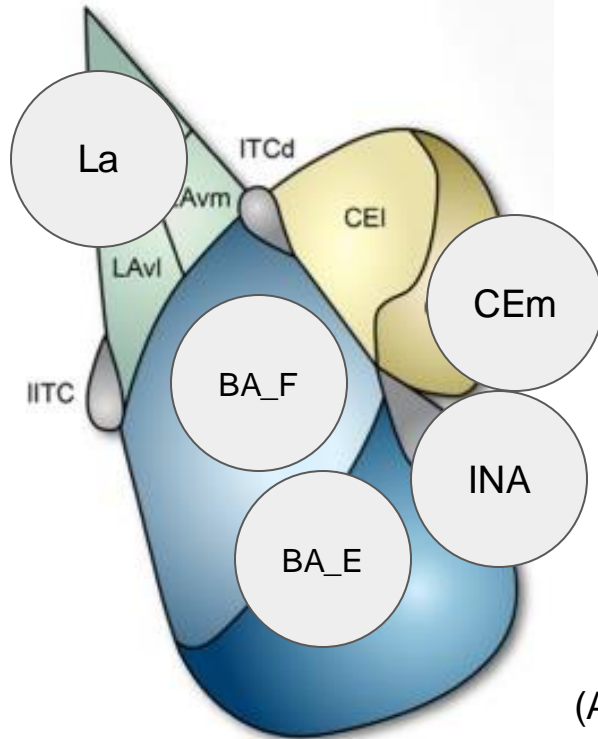


CS: harmless stimulus
US: harmful stimulus

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

Background of the Data (2/2)

□Amygdala fear conditioning circuitry.



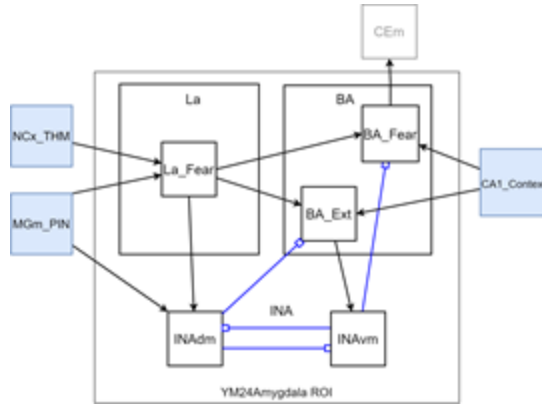
- The amygdala regions closely associated with fear conditioning include the **lateral nucleus (La)**, the **basal nucleus (BA)**, the **central nucleus (CEN)**, and the **intercalated cell masses (INA)** within the BLA.
- we focus on these regions to construct the BIF and FRG.

(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
	Circuit ID	Source of ID	Names	DHSA: graph_order	Sub-Circuits	Super Class	Uniform	Transmitter	Modulation Type	Size	Output Semantics (S)	Physiological Data	Comments	Contributor	Project ID	WBDF pull request	WBDF copied	Review results	Auto Error Codes
1	YM24Amygdala	[Miyama, 2024]	ROI of YM24Amygdala	1760	La_Fear;BA;INAdm;INAvm		FALSE	-	-	-	-	-		Yoshinasa Tawatsuki	TM24Amygdala				0
2	NCx_THM	makeshift	Conditioned stimulus of fear conditioning	1760.1	NCx_THM		TRUE	-	Excitat ory	-	-	-		Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109 Source of ID]
3	MGm_PIN	[Aaede, 2022]	Unconditioned stimulus of fear conditioning	1760.1			TRUE	-	Excitat ory	-	-	-		Tatsuya Miyamoto	TM24Amygdala				0
4	BA	[Duvvari, 2014]	Basal nucleus of Amygdala	1793.2	BA_Fear;BA_Ext		FALSE	-	-	-	-	-		Tatsuya Miyamoto	TM24Amygdala				0
5	BA_Fear	makeshift	Fear cell of BA	1793.2			TRUE	-	Excitat ory	-	-	-		Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109 Source of ID]
6	BA_Ext	makeshift	Extinction cell of BA	1793.2			TRUE	-	Excitat ory	-	-	-		Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109 Source of ID]
7	INAdm	[Hagihara, 2021]	dorsal cluster of medial ITC	1824.1			TRUE	-	GABA - inhibit ory	-	-	-		Tatsuya Miyamoto	TM24Amygdala				0
8	INAvm	[Hagihara, 2021]	ventral cluster of medial ITC	1824.1			TRUE	-	GABA - inhibit ory	-	-	-		Tatsuya Miyamoto	TM24Amygdala				0
9	La_Fear	makeshift	fear part of Lateral nucleus of amygdala	1794.1			TRUE	-	-	-	-	-		Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109 Source of ID]
10	CA1_Context	makeshift	CA1 resion for Context Information	1619.1			TRUE	-	-	-	-	-		Tatsuya Miyamoto	TM24Amygdala			Warning: 1	1 Warning(s); [109 Source of ID]

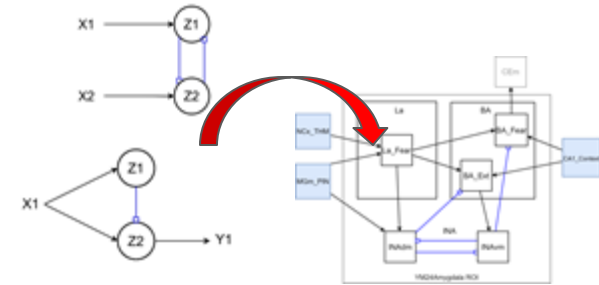
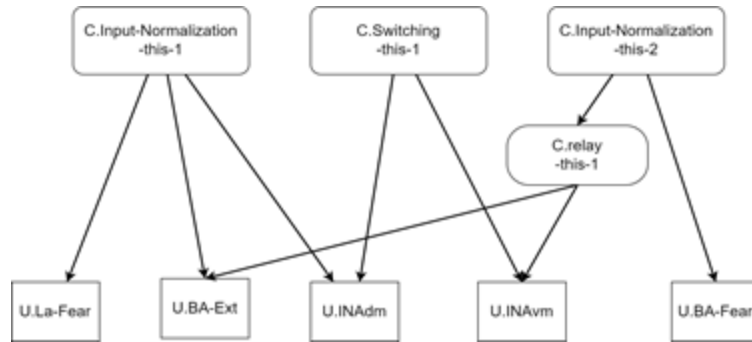
Overview of the Data and the Constructed BIF

Connections (14)

ID	Sender Circuit ID (CID)	ICID relation	Notation of CID in Literature	Receiver Circuit ID (CID)	ICID relation	Notation of CID in Literature	Species	Comments	Reference ID	Taxon	Measurement method	Points on literature	Point on figure	In-depth literature	Doc. Link	Journal names	Literature type	Display string per join	Combined string for search	Reference ID	Source region score	Receiver region score	Journal score	Literature type score	Taxon score	Method score	Credibility rating (CR)	Summarized CR	Revised CR	Summarized Revised CR	Contributor	Project ID	Year
1	NCx_Th_M	-	La_Fear	-	La	-			Pikmen, 2000	Mouse	Unsurveyed		3	DOI	Folia morphol	Review	La_Fear (2000) [Pikmen, 2000]	NCx_Th_M_La_Fear	Pikmen, 2000	1.000	0.700	0.800	0.800	0.5	8.1	0.027	0.027	0.027	0.027	Tatsuya Miyamoto	ThyQ4Amyg data		
2	NCx_R	-	La_Fear	-	La	-			Linka, 2000	Mouse	Axonal tracer		7	DOI	Experimental	Experimental results	La_Fear (2000) [Linka, 2000]	NCx_R_La_Fear	Linka, 2000	1.000	0.700	0.800	1.000	0.5	9.30	0.316	0.316	0.316	0.316	Tatsuya Miyamoto	ThyQ4Amyg data		
3	NCx_R	-	NAdm	-	-	-			Azeidi, 2002	Mouse	Unsurveyed		2	DOI	The Journal of Neuroscience	Review	NAdm (2000) [Azeidi, 2002]	NCx_R_NAadm	Azeidi, 2002	1.000	1.000	0.000	0.000	0.5	8.1	0.000	0.000	0.000	0.000	Tatsuya Miyamoto	ThyQ4Amyg data		
4	LA_Fear	-	La	-	BA_Fear	-	-	-	Duvarci, 2014	Mouse	Unsurveyed		2	DOI	Neuron	Review	BA_Fear (2014) [Duvarci, 2014]	LA_Fear_BA_Fear	Duvarci, 2014	0.700	0.700	0.800	0.800	0.5	8.1	0.019	0.019	0.019	0.019	Tatsuya Miyamoto	ThyQ4Amyg data		
5	LA_Fear	-	La	-	BA_Ect	-	-	-	Duvarci, 2014	Mouse	Unsurveyed		2	DOI	Neuron	Review	BA_Ect (2014) [Duvarci, 2014]	LA_Fear_BA_Ect	Duvarci, 2014	0.700	0.700	0.800	0.800	0.5	8.1	0.019	0.019	0.019	0.019	Tatsuya Miyamoto	ThyQ4Amyg data		
6	LA_Fear	-	La	-	NAdm	-	-	-	Duvarci, 2014	Mouse	Unsurveyed		2	DOI	Neuron	Review	NAdm (2014) [Duvarci, 2014]	LA_FearNAdm	Duvarci, 2014	0.700	1.000	0.800	0.800	0.5	8.1	0.027	0.027	0.027	0.027	Tatsuya Miyamoto	ThyQ4Amyg data		
7	NAdm	-	BA_Ect	-	-	-			Haghighi, 2007	Mouse	Optogenetic		4	DOI	Nature	Experimental results	BA_Ect (1414) [Haghighi, 2007]	NAdm_BA_Ect	Haghighi, 2007	1.000	1.000	0.800	1.000	0.5	8.3	0.143	0.143	0.143	0.143	Tatsuya Miyamoto	ThyQ4Amyg data		
8	NAdm	-	NAdm	-	-	-		Measurement method: anterograde tracing	Haghighi, 2007	Mouse	Anterograde		10	DOI	Nature	Experimental results	NAdm (2007) [Haghighi, 2007] (Measure ment method: anterograde tracing)	NAdmNAdm	Haghighi, 2007	1.000	1.000	0.800	1.000	0.5	8.6	0.288	0.288	0.288	0.288	Tatsuya Miyamoto	ThyQ4Amyg data		
9	NAdm	-	NAdm	-	-	-		Measurement method: anterograde tracing	Haghighi, 2007	Mouse	Retrograde		10	DOI	Nature	Experimental results	NAdm (2007) [Haghighi, 2007] (Measure ment method: anterograde tracing)	NAdmNAdm	Haghighi, 2007	1.000	1.000	0.800	1.000	0.5	8.6	0.475	0.475	0.475	0.475	Tatsuya Miyamoto	ThyQ4Amyg data		
10	NAdm	-	BA_Fear	-	-	-			Haghighi, 2007	Mouse	Optogenetic		4	DOI	Nature	Experimental results	BA_Fear (1414) [Haghighi, 2007]	NAdm_BA_Fear	Haghighi, 2007	1.000	1.000	0.800	1.000	0.5	8.3	0.143	0.143	0.143	0.143	Tatsuya Miyamoto	ThyQ4Amyg data		
11	CA_Ner	-	CA1	-	BA_Fear	-	-	-	Pikmen, 2000	Mouse	Unsurveyed		4	DOI	Folia morphol	Review	BA_Fear (2000) [Pikmen, 2000]	CA1_Connect_A_Fear	Pikmen, 2000	0.700	0.700	0.800	0.800	0.5	8.1	0.019	0.019	0.019	0.019	Tatsuya Miyamoto	ThyQ4Amyg data		
12	CA_Ner	-	CA1	-	BA_Ect	-	-	-	Pikmen, 2000	Mouse	Unsurveyed		4	DOI	Folia morphol	Review	BA_Ect (2000) [Pikmen, 2000]	CA1_Connect_A_Ect	Pikmen, 2000	0.700	0.700	0.800	0.800	0.5	8.1	0.019	0.019	0.019	0.019	Tatsuya Miyamoto	ThyQ4Amyg data		
13	BA_Ect	-	BA	-	NAdm	-	-	-	Duvarci, 2014	Mouse	Unsurveyed		2	DOI	Neuron	Review	NAdm (2014) [Duvarci, 2014]	BA_EctNAdm	Duvarci, 2014	0.700	1.000	0.800	0.800	0.5	8.1	0.027	0.027	0.027	0.027	Tatsuya Miyamoto	ThyQ4Amyg data		
14	BA_Fear	-	BA	-	CEm	-	-	-	Duvarci, 2014	Mouse	Unsurveyed		2	DOI	Neuron	Review	CEm (2014) [Duvarci, 2014]	BA_FearCEm	Duvarci, 2014	0.700	1.000	0.800	0.800	0.5	8.1	0.027	0.027	0.027	0.027	Tatsuya Miyamoto	ThyQ4Amyg data		

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.

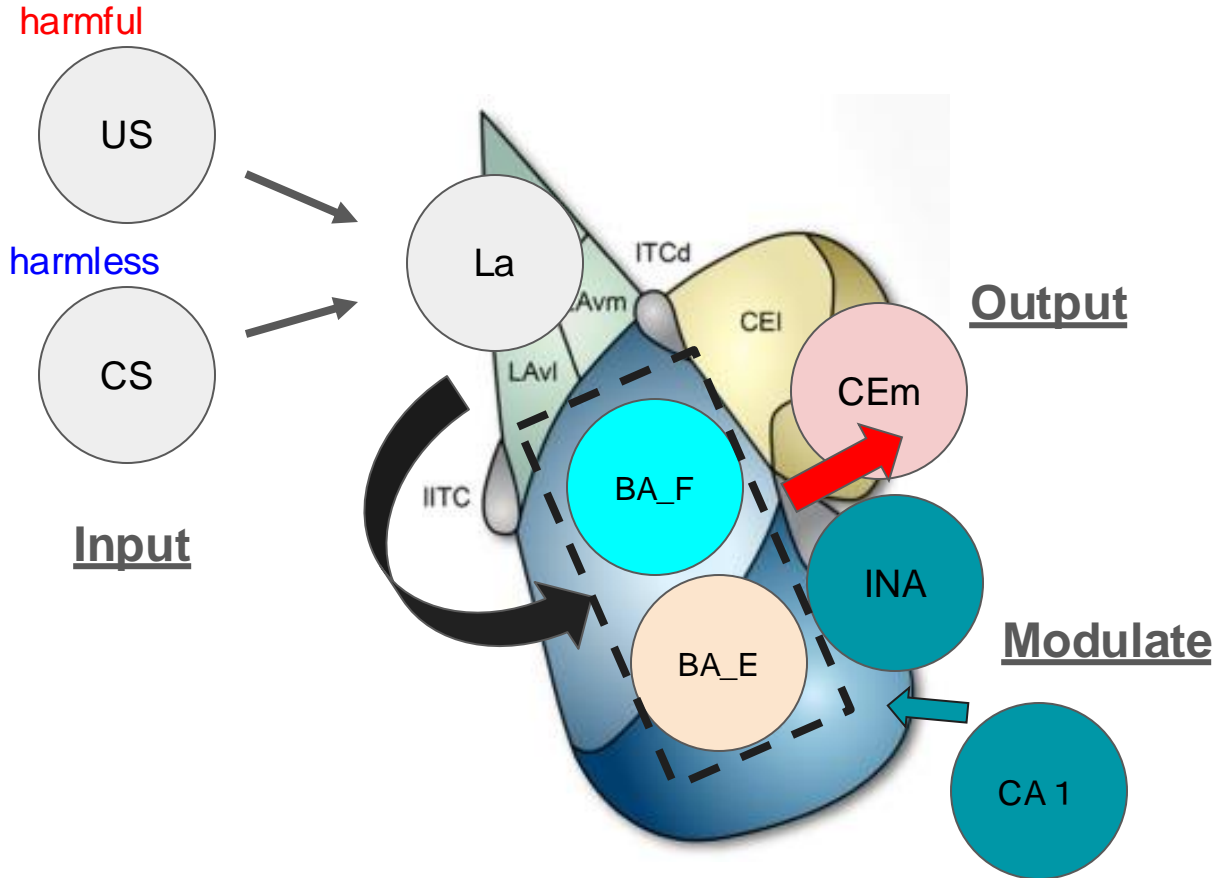
Overview of the Data and the Constructed FRG

Node ID	Activities	Control ID	Precedent Circuits	Precedent Circuits	Uniform Circuits	Output Circuits	Output Circuits	2018 Merged Output Circuits	2018 Merged Output Circuits	2018 Merged Output Circuits	2018 Merged Output Circuits	Interface	Implementation	Capacity: Transition to Implementation	Implementation of Uniform Circuit	Capacity
1	1-1	1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1
2	2-1	2	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1	2-1
3	3-1	3	3-1	3-1	3-1	3-1	3-1	3-1	3-1	3-1	3-1	3-1	3-1	3-1	3-1	3-1
4	4-1	4	4-1	4-1	4-1	4-1	4-1	4-1	4-1	4-1	4-1	4-1	4-1	4-1	4-1	4-1
5	5-1	5	5-1	5-1	5-1	5-1	5-1	5-1	5-1	5-1	5-1	5-1	5-1	5-1	5-1	5-1
6	6-1	6	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1
7	7-1	7	7-1	7-1	7-1	7-1	7-1	7-1	7-1	7-1	7-1	7-1	7-1	7-1	7-1	7-1
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9	9-1	9	9-1	9-1	9-1	9-1	9-1	9-1	9-1	9-1	9-1	9-1	9-1	9-1	9-1	9-1
10	10-1	10	10-1	10-1	10-1	10-1	10-1	10-1	10-1	10-1	10-1	10-1	10-1	10-1	10-1	10-1
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19	19-1	19	19-1	19-1	19-1	19-1	19-1	19-1	19-1	19-1	19-1	19-1	19-1	19-1	19-1	19-1
20	20-1	20	20-1	20-1	20-1	20-1	20-1	20-1	20-1	20-1	20-1	20-1	20-1	20-1	20-1	20-1

-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)

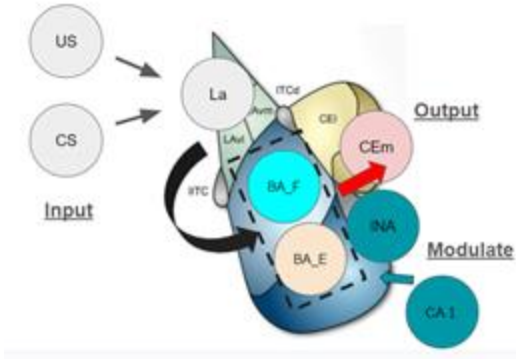
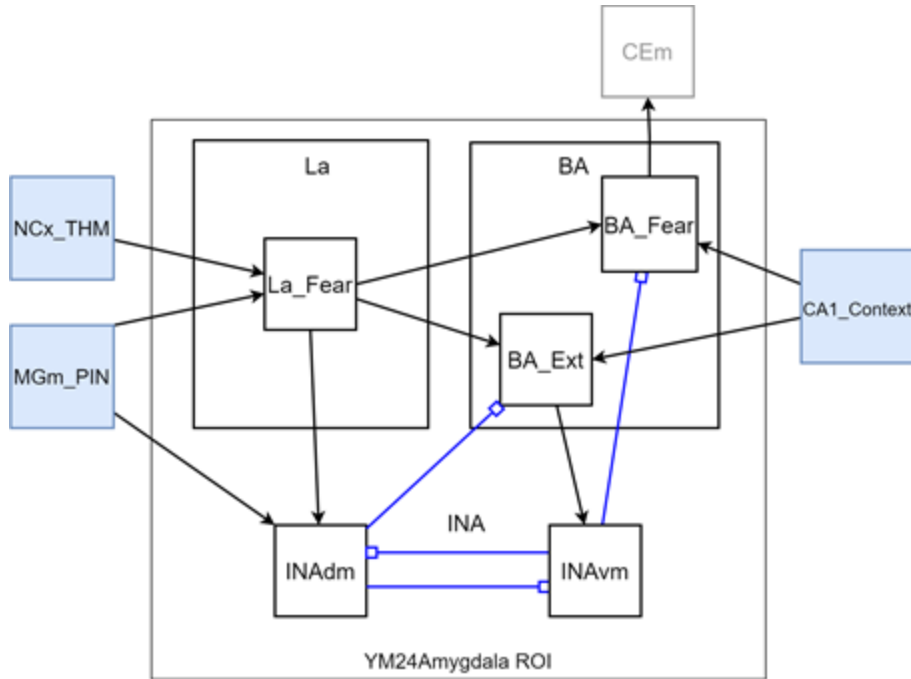
- BA projects to the **CEm**, which is involved in inducing the fear response.

(Duvarci, S., & Pare, D., 2014)

- INA and CA1 serve as modulators of the BA.

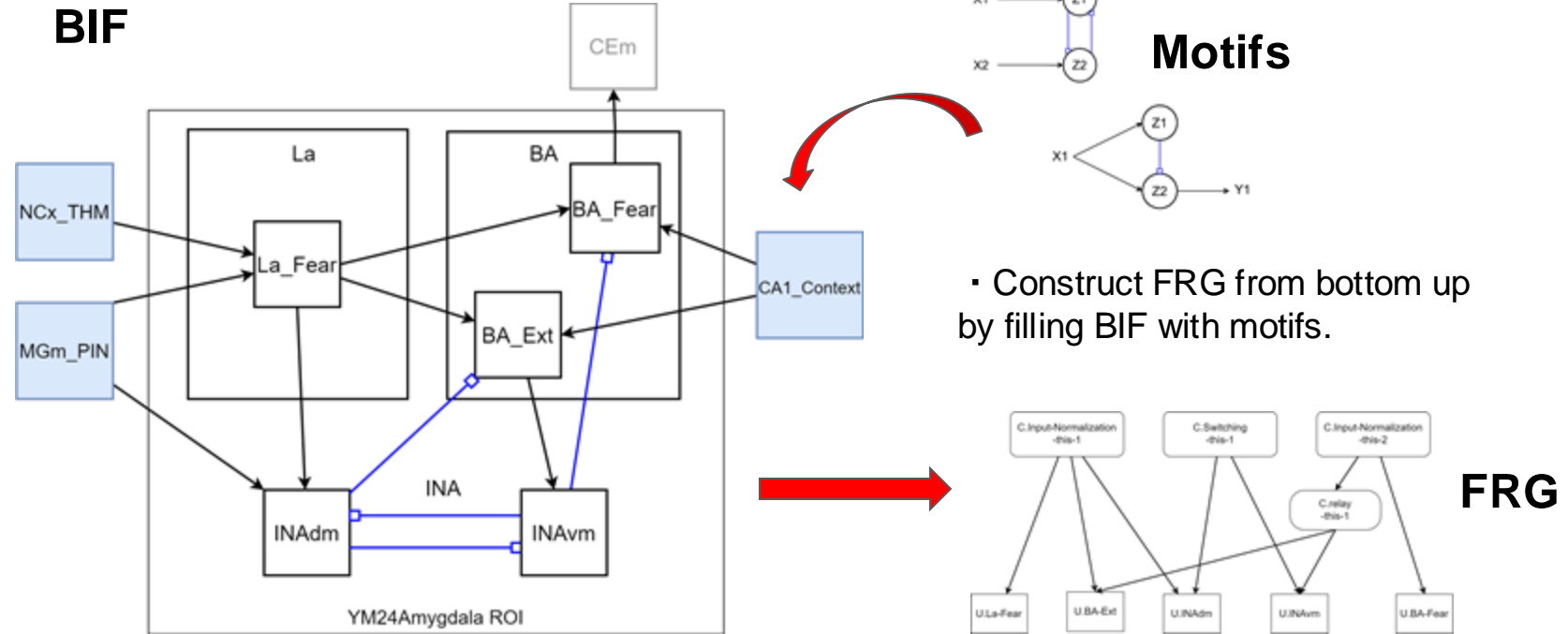
(Hagihara, K.M., et al, 2021, Duvarci, S., & Pare, D., 2014, Pitkänen, A. et al, 2000)

BIF Data and Collection Methods



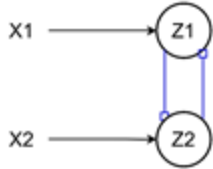
- The BIF constructed with the **TM24Amygdala** project
- Using this BIF, we construct the FRG.

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

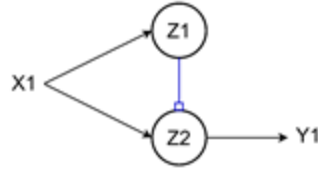


Motifs

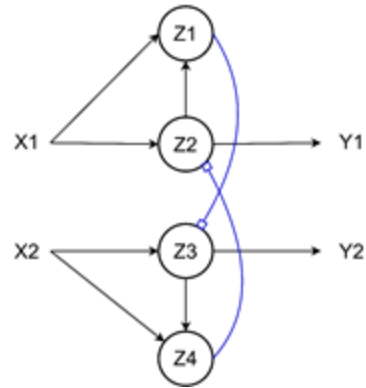
C.Switching
M.Internal-Mutual-Inhibition



C.Input-Normalization
M.Feedforward-Inhibition



C.Competition
M.Lateral-Inhibition



C.Relay
M.Feedforward-Excitation



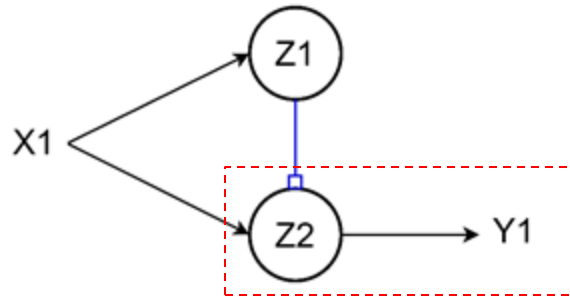
- In this data paper, motifs are collected based on the references cited in the data papers.
- Here are some examples.

<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)

C.Input-Normalization
M.Feedforward-Inhibition



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

black arrow: excitatory signal
blue arrow: inhibitory signal

<M: Mechanism_Feedforward Inhibition>

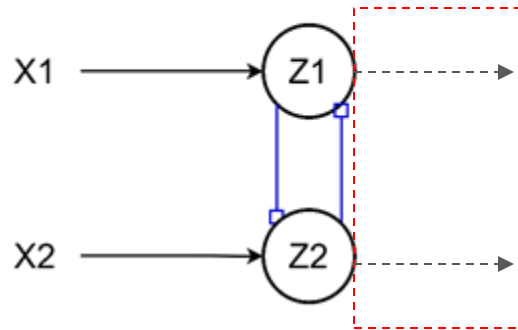
Signals flow feedforward from X1 to the next two nodes. Then, one node inhibits the output of the other node.

<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)

C.Switching
M.Internal-Mutual-Inhibition



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

black arrow: excitatory 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)

C.Relay
M.Feedforward-Excitation



node: Z1, Z2, Z3,..

Input: X1, X2, X3,..

Output: Y1, Y2, Y3,..

black arrow: excitatory signal

blue arrow: inhibitory signal

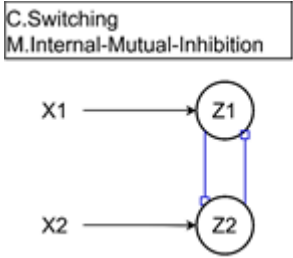
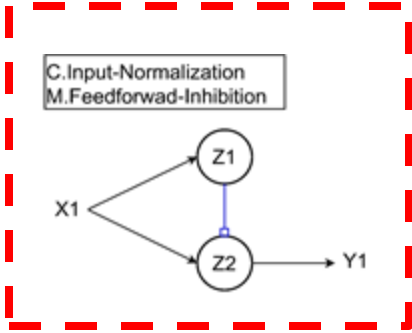
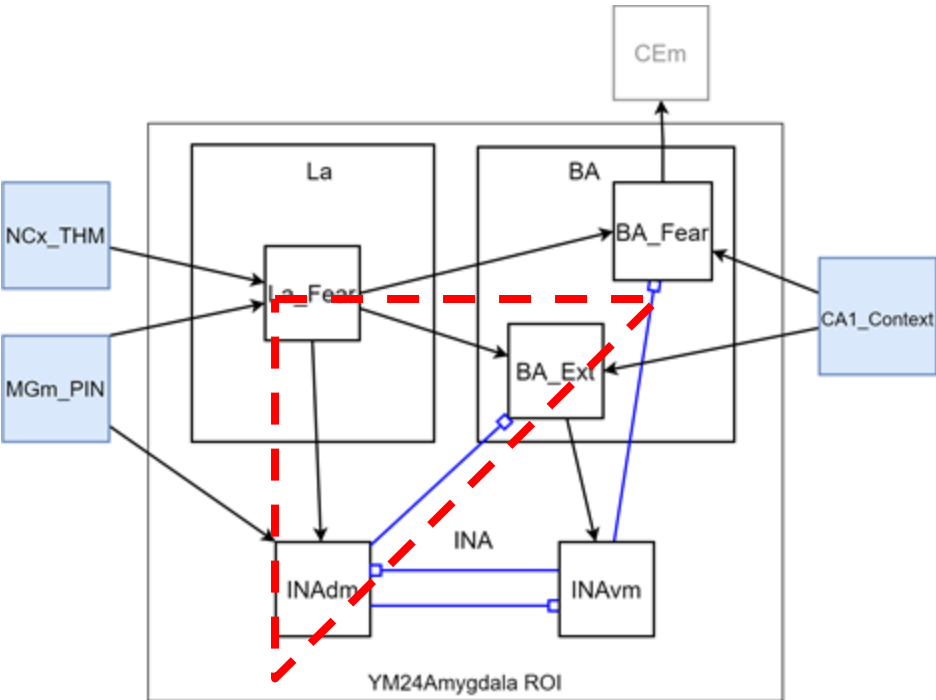
<M: Mechanism_Feedforward Excitation>

The input from X1 flows straight downstream.

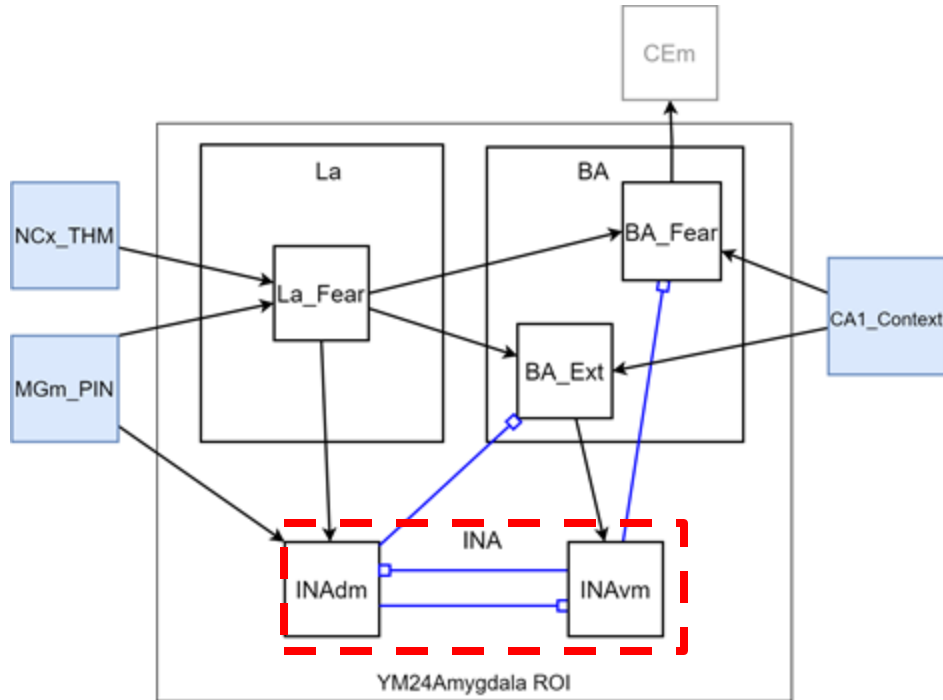
<C: Capability_Relay>

Since the signal is simply passed along, the capability is named "relay."

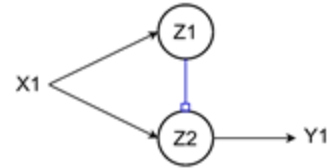
Exhaustive fitting of Motifs to BIF for FRG construction



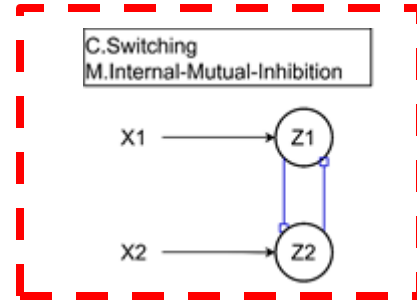
Exhaustive fitting of Motifs to BIF for FRG construction



C.Input-Normalization
M.Feedforward-Inhibition



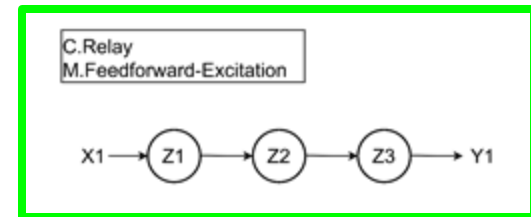
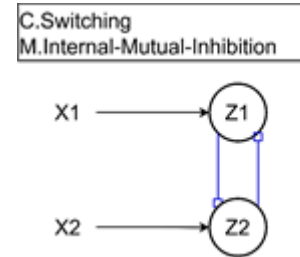
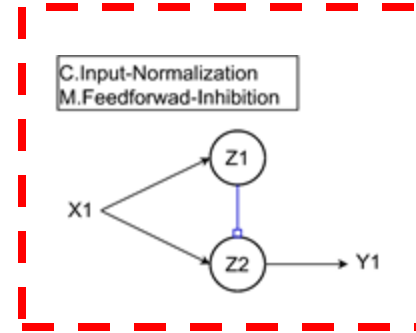
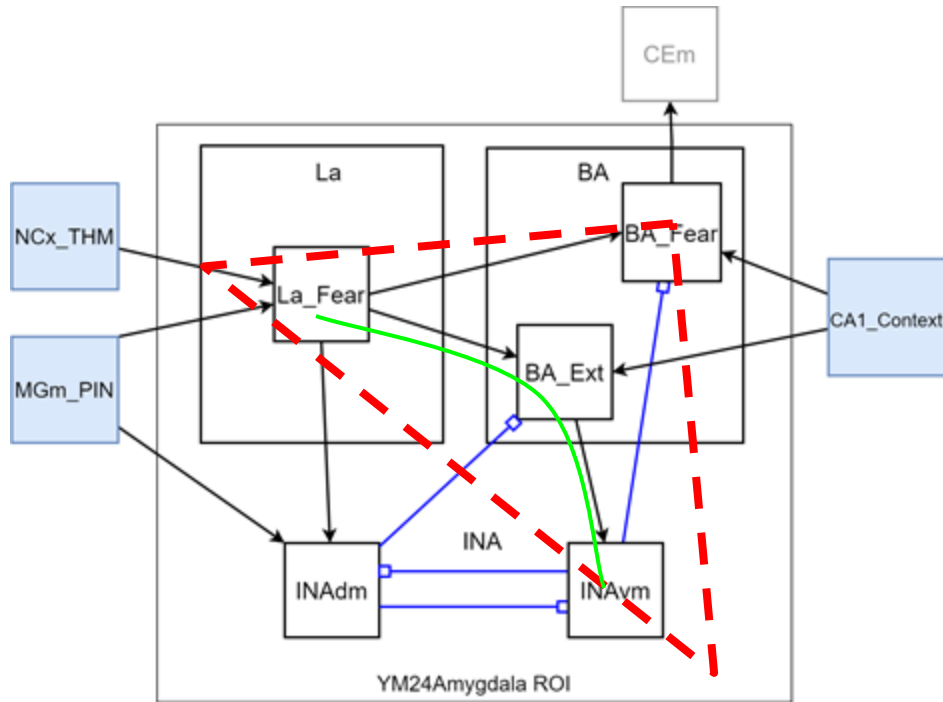
C.Switching
M.Internal-Mutual-Inhibition



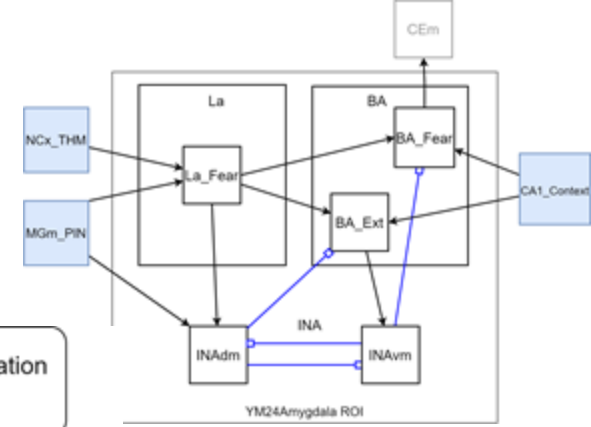
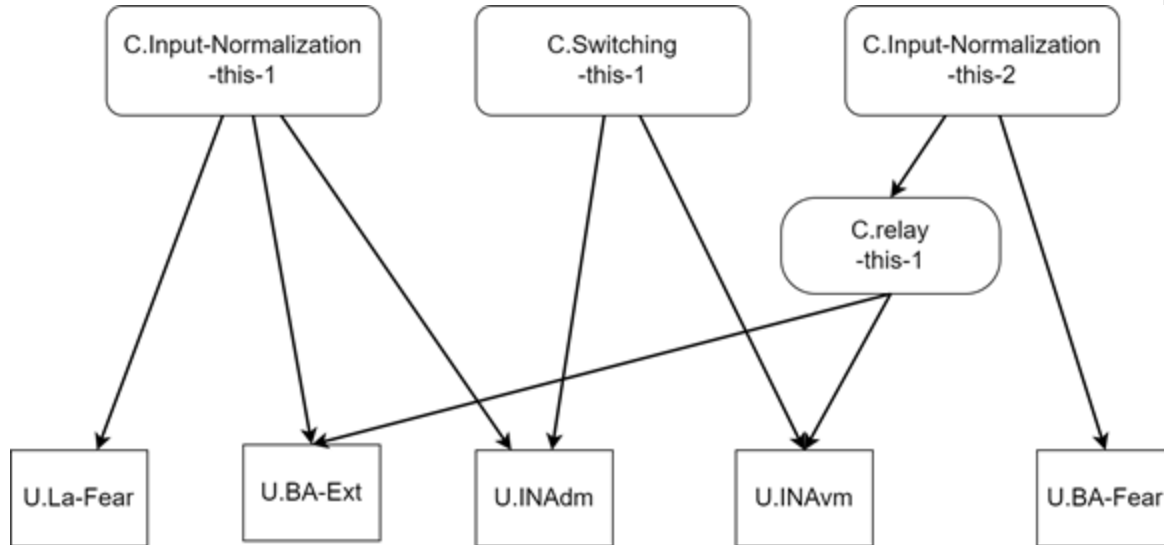
C.Relay
M.Feedforward-Excitation



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	<i>version 2.0</i>	√	√

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.

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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.