

# Knowledge representation for neural circuits subserving saccadic eye movement based on a Brain Information Flow Description

TAWATSUJI Yoshimasa<sup>\*1</sup>, ARAKAWA Naoya<sup>\*2</sup>, YAMAKAWA Hiroshi<sup>\*2,3</sup>

\*1:Global Education Center, Waseda University, \*2:Whole Brain Architecture Initiative, \*3:Tokyo University

<https://wba-initiative.org/en/>

## Introduction

### ■ Aiming the brain-inspired artificial general intelligence

#### - Whole Brain Architecture Approach

1. Develop machine learning modules for parts of the brain (*meso-scopic level*)
2. Integrate the modules to create cognitive architecture

#### - Constructing (Designing and Implementing) brain-inspired AI systems requires neuroscientific knowledge.

➡ **Difficult for developers  
to use neuroscientific knowledge**

### ■ Whole Brain Reference Architecture (WBRA)

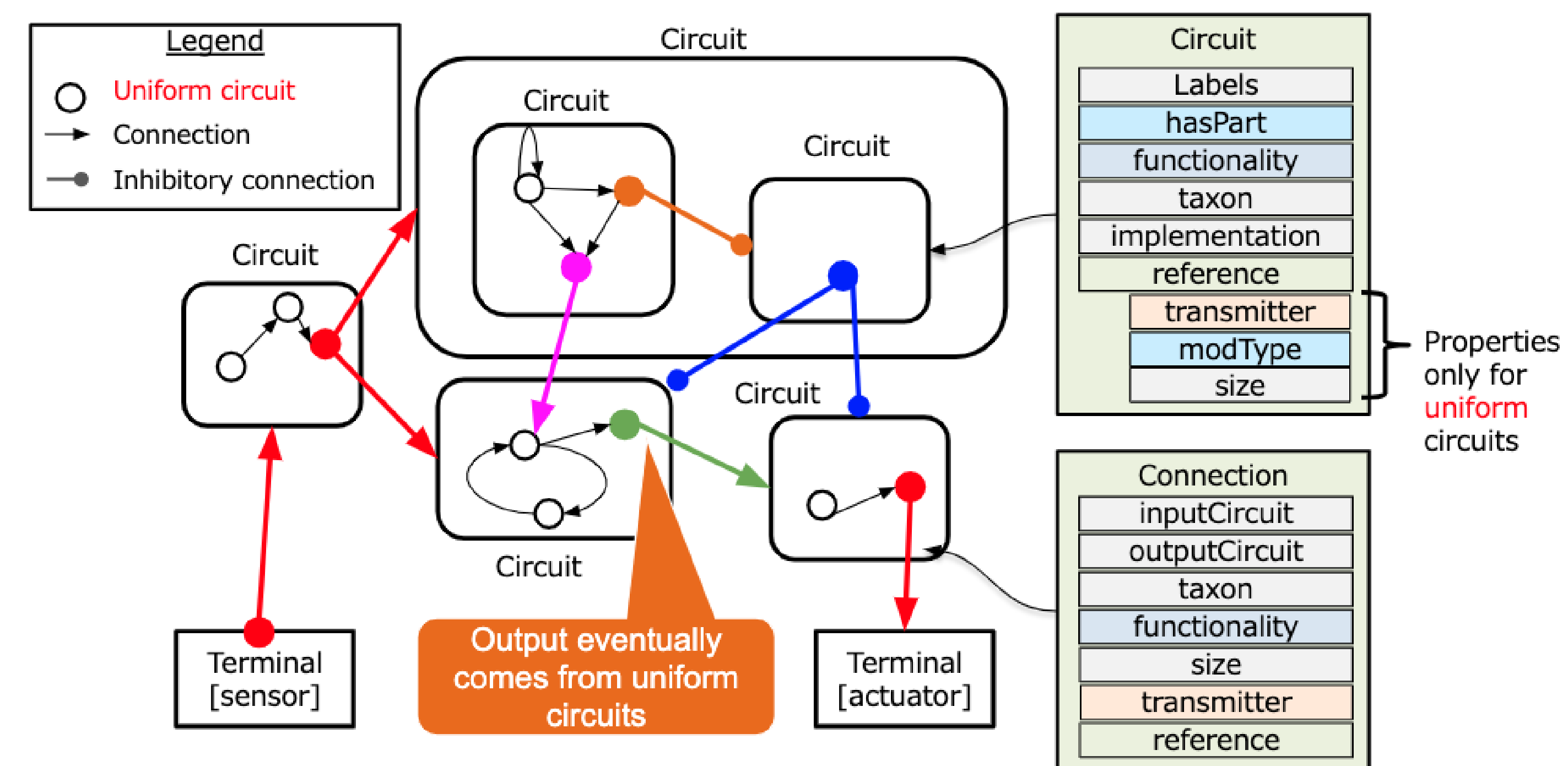
**Static reference model** that contains organized knowledge of whole brain information processing to be specifications for developers

Information about biological plausibility of WBRA  
👉 Poster No.30 (Yamakawa, H. et al.)

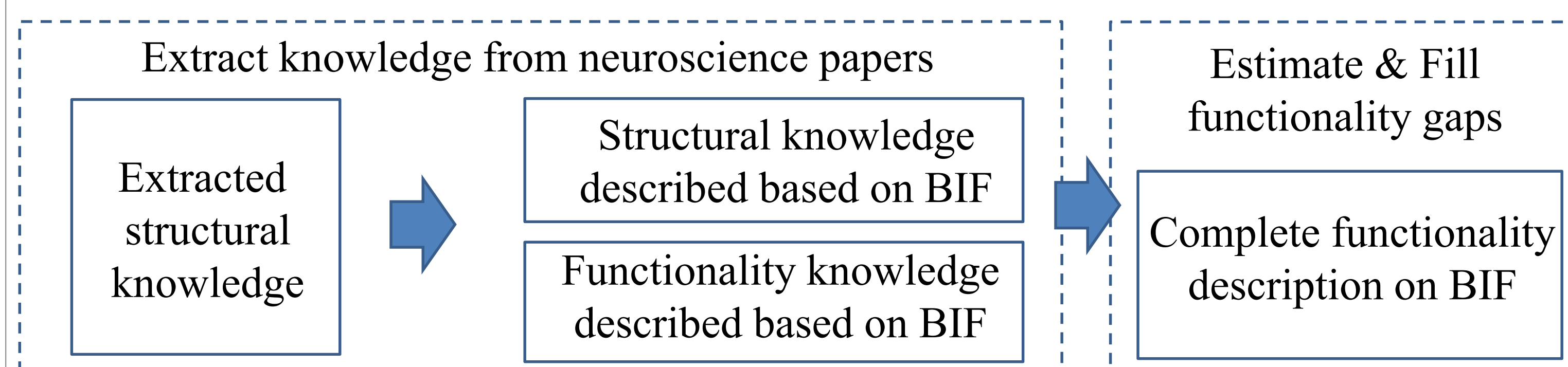
**Note:** Architecture design should be disciplined (not ad hoc) with an ontological perspective.

### ■ The Brain Information Flow (BIF) format

A specification format for WBRA, which can describe information processing of the entire brain in a hierarchical manner.



### ■ Procedure to construct WBRA based on BIF



More information of BIF 👉 Poster No.31 (Sasaki, M. et al.)

## Knowledge representation of eye movement based on BIF

Neural substrates for eye movements are well-investigated

### ■ Extracted knowledge from neuroscience papers of neural substrates for eye movements

- Especially neural substrates of **brainstem** are investigated
- Vertical and horizontal saccadic eye movements
- Smooth pursuit eye movements

### ■ Extracted knowledge based on BIF format

| ID        | names                                         | subClassOf                 | hasParts | functionality           | references     | implementations | uniform | transmitter | modType |
|-----------|-----------------------------------------------|----------------------------|----------|-------------------------|----------------|-----------------|---------|-------------|---------|
| DHBA:SClg | superior colliculus, intermediate grey layer  |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| DHBA:SCIw | superior colliculus, intermediate white layer |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| DHBA:SCD  | superior colliculus, deep layer               | SCD; SCDg                  |          |                         |                |                 | ▼       | ▼           | ▼       |
| DHBA:SCDg | superior colliculus, deep grey layer          |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| DHBA:SCDw | superior colliculus, deep white layer         |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| Pn        | ?                                             | PPRF; dmPMORF; NRI         |          |                         |                |                 | ▼       | ▼           | ▼       |
| PMn       | ?                                             | EBN                        |          | burst neuron            | Sugiuchi, 2011 |                 | ▼       | ▼           | ▼       |
| dmPMORF   | ?                                             |                            |          | inhibitory burst neuron | Sugiuchi, 2011 |                 | ▼       | ▼           | ▼       |
| NRI       | ?                                             |                            |          | omnipause neuron        | Sugiuchi, 2011 |                 | ▼       | ▼           | ▼       |
| FF        |                                               |                            |          | vertical                |                |                 | ▼       | ▼           | ▼       |
| InC       | ?                                             |                            |          | vertical                |                |                 | ▼       | ▼           | ▼       |
| N         | Oculomotor nuclei (RO12)                      | 3N, 4N; 6N                 |          |                         |                |                 | ▼       | ▼           | ▼       |
| 3N        | ?                                             | 3N_IR; 3N_IO; 3N_SR; 3N_MR |          |                         |                |                 | ▼       | ▼           | ▼       |
| 3N_SR     | ?                                             |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| 3N_IR     | ?                                             |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| 3N_MR     | ?                                             |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| 3N_IO     | ?                                             |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| 4N        | ?                                             |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| 6N        | ?                                             |                            |          |                         |                |                 | ▼       | ▼           | ▼       |
| VN        | vestibular nuclei                             |                            |          |                         |                |                 | FALSE   | ▼           | ▼       |

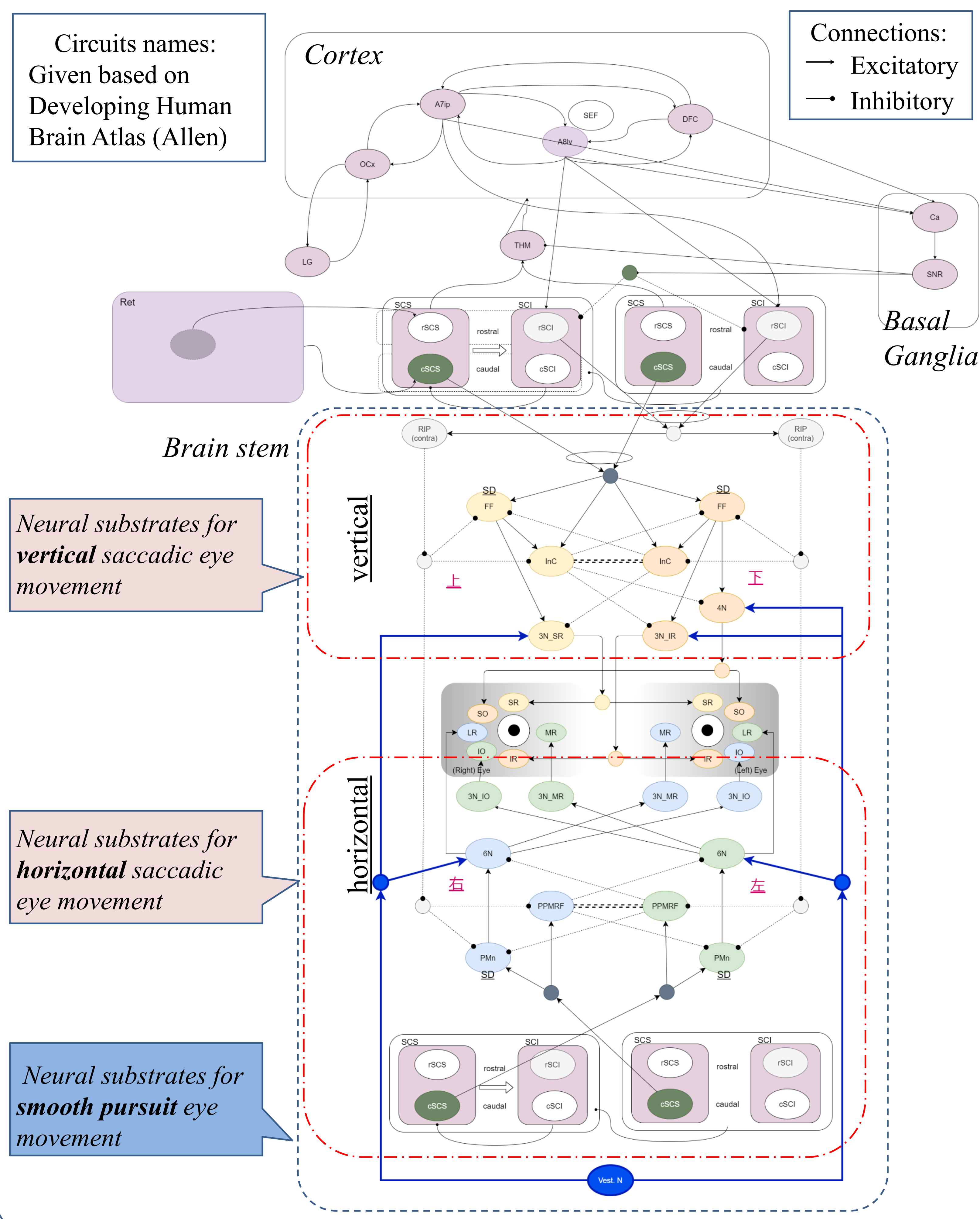
## Summary and Future works

### ■ Summery: The neural substrates of eye movements are arranged clearly with BIF format

### ■ Working on: To estimate and fill functionality gaps (e.g. FF, PMn) (to be presented on Technical Committee NC in Japanese)

### ■ Future Work: To sophisticate BIF from perspective of Device Ontology

### Structural knowledge extracted from previous studies



Neural substrates for  
**vertical** saccadic eye movement

Neural substrates for  
**horizontal** saccadic eye movement

Neural substrates for  
**smooth pursuit** eye movement