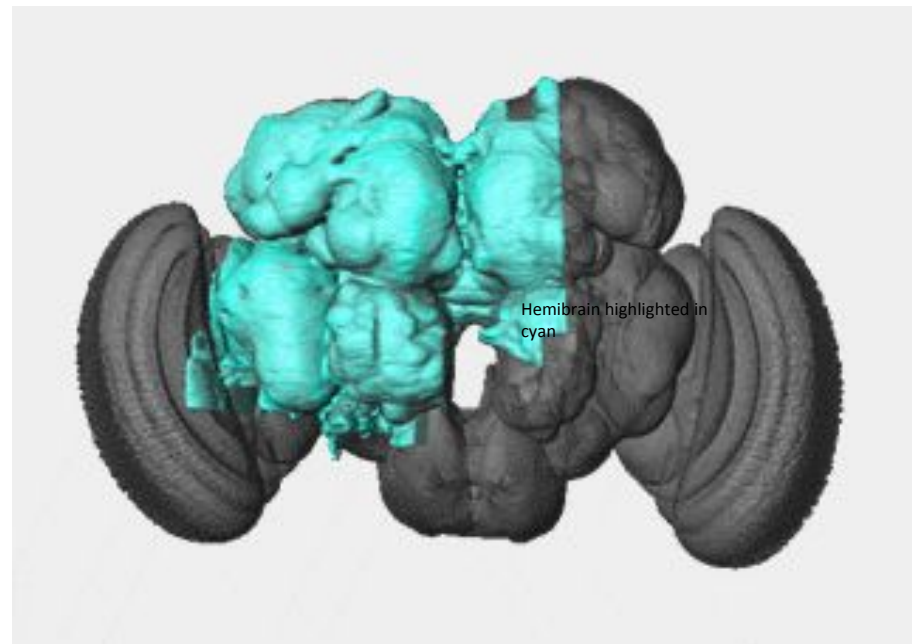


Exploring the Hemibrain

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Introduction



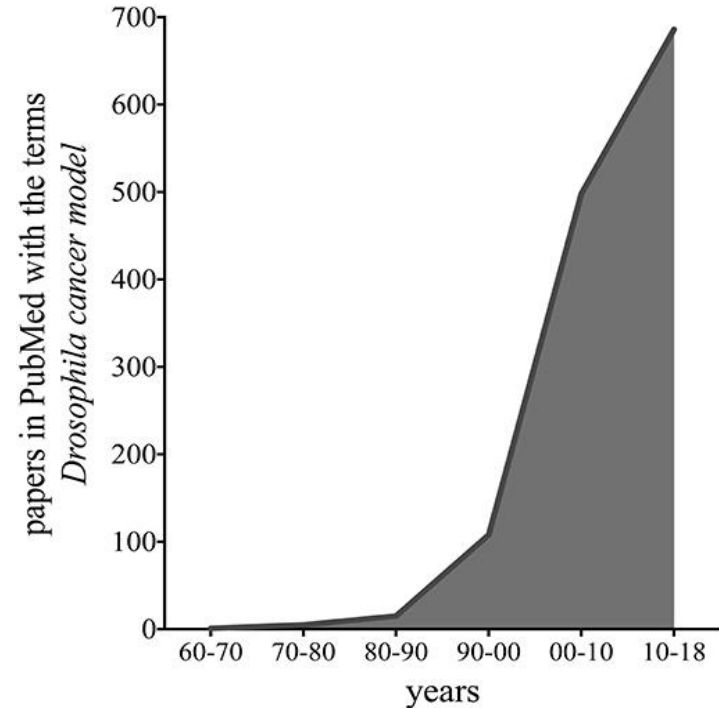
Background - Basic neuron knowledge

Relationship between two neurons: $A \rightarrow B$

- A sends information to B
- Invertebrate Neurons migrate!
- Their body locations don't matter
- Simplified model!

Some Sanity Checks before we get started:

- Do our queries match the literature?
- Growing field and unfamiliar dataset
- Cancer researchers have better marketing
- ❖ AL -- MBONS- -> Mushroom body
- ❖ APL regulation of memory
- ❖ Ring neuron innervation is Mutually exclusive



Part 1: NeuPrint Data Summary

Summary Statistics - comparing two versions of the data set

Dataset Version	ROI Min	Percent Completeness Min	ROI Max	Percent Completeness Max
V1.1- Latest	FLA(R)	18.794567%	EBr3am	93.917381%
V1.0.1 - Oldest	EPA(L)	20.558988%	EBr3am	94.22657%

- No change in most complete ROI between data sets but change in lowest completed ROI
- General decrease in mean counts of post/pre synaptic counts between data sets which can be attributed to the addition of more ROIs in the latest update
- The ratio of Post: Pre synaptics sites between datasets remained almost the same at ~6.65
 - Almost always have more postsynaptic sites than presynaptic sites.

Difference in mean percent postsynaptic sites completed between data sets: 3.22%

Difference in mean percent presynaptic sites completed between data sets: 0.028%

Table comparing descriptive stats on each data set

Latest Dataset				
	p_presyn	t_pre	p_postsyn	t_post
count	229.000000	2.290000e+02	229.000000	2.290000e+02
mean	93.442736	9.165484e+04	60.196853	6.044246e+05
std	3.332198	2.164123e+05	20.172745	1.555558e+06
min	81.192053	5.100000e+01	20.558988	1.950000e+02
25%	91.983696	5.226000e+03	44.004432	2.437500e+04
50%	93.942688	1.252800e+04	63.723538	5.465600e+04
75%	95.710166	6.143800e+04	74.094809	3.371190e+05
max	99.854581	1.861182e+06	94.226570	1.356352e+07
Oldest Dataset				
	p_presyn	t_pre	p_postsyn	t_post
count	150.000000	1.500000e+02	150.000000	1.500000e+02
mean	93.415063	1.343923e+05	56.973805	8.942202e+05
std	3.603109	2.573065e+05	24.110162	1.859341e+06
min	81.575311	4.040000e+02	18.794567	2.403000e+03
25%	91.769063	5.898000e+03	32.603004	2.993750e+04
50%	93.964872	3.668650e+04	58.965348	1.664785e+05
75%	96.042271	1.325665e+05	81.910875	8.148918e+05
max	99.854581	1.861218e+06	93.917381	1.357282e+07

Dataset and Clean-up

Neuron dataset was acquired by querying NeuPrint database.

```
QUERY = " MATCH (n :Neuron) RETURN n "
```

Returned results: a dataset of Dictionary structure.

```
len(results) = 186,649
```

Convert Dictionary to Dataframe

The initial dataframe dimension: 186,649 X 245 columns, ROI matrix(230 columns)

Remove Left-side brain neurons. Based on ROIs matrix

Right Brain dataset: 123,494 rows

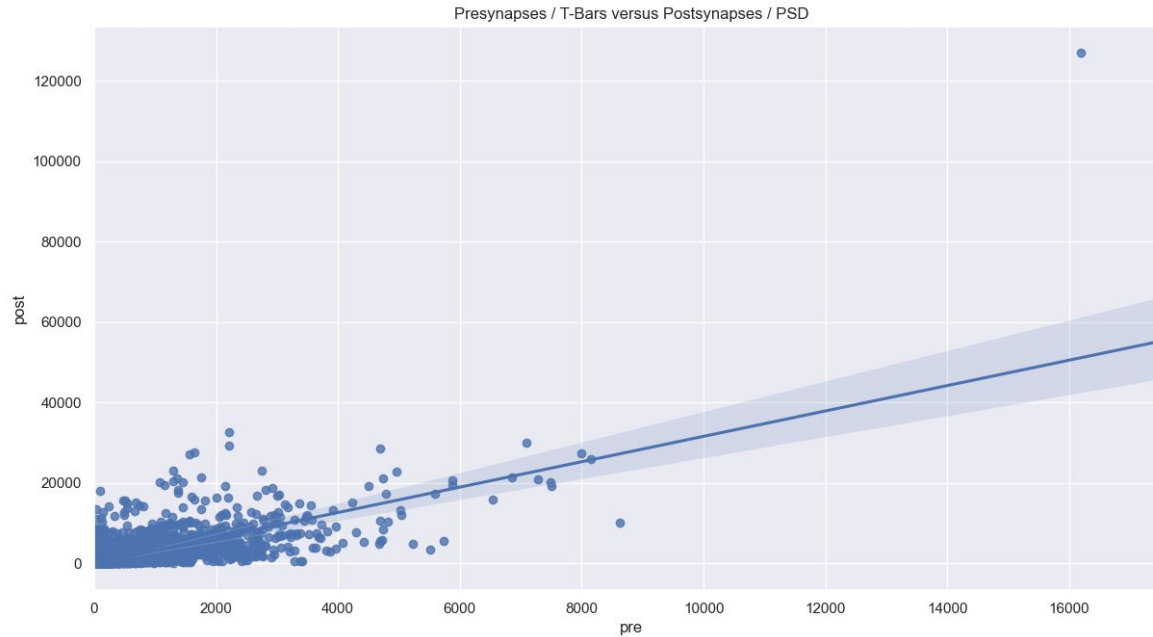
Remove un-traced neurons (including orphans, leaves, segments, etc)

Final dataset: 20,026 rows:

Summary Statistics

- There are 20,026 completed neurons on the right side of the hemibrain
- The average number of ROIs per neuron is: 10
 - * Body ID 1418618235 has 117 ROIs passing through
 - * Body ID 356131764 has 1 ROI passing through

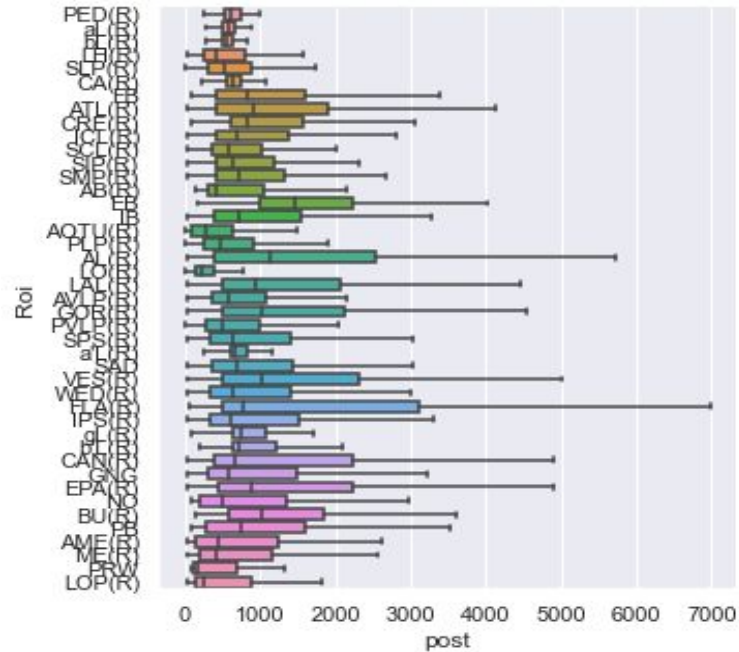
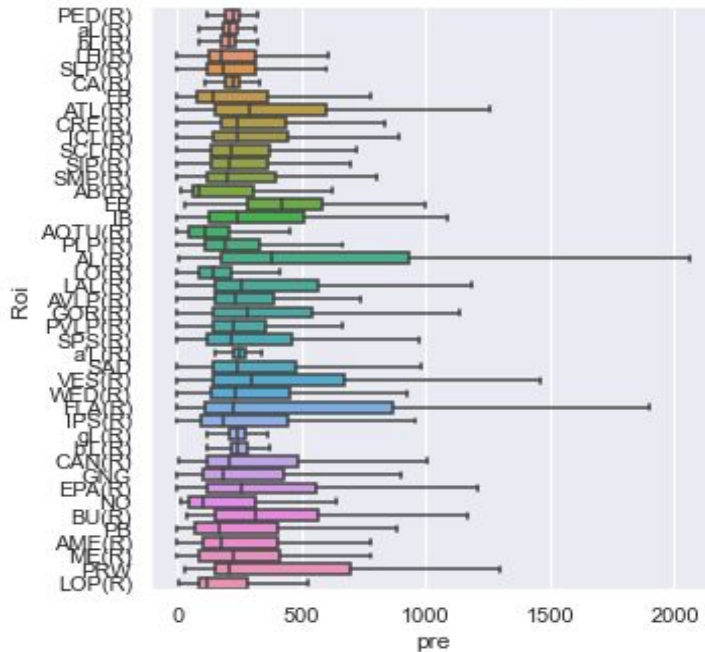
Presynapses/T-Bars VS. Postsynapses/PSD



Summary Statistics - MBONs

- There are 64 MBONs on the right side of the hemibrain
- The average number of ROIs for MBONs is 23, while the average number of ROIs for all right side neurons is 10
- The average number of presynapses is 890 (>281)
- The average number of postsynapses is 10,307(>857)

Pre and post synapses in primary ROIs



Connectivity of Primary ROIs

Relationship between neurons:

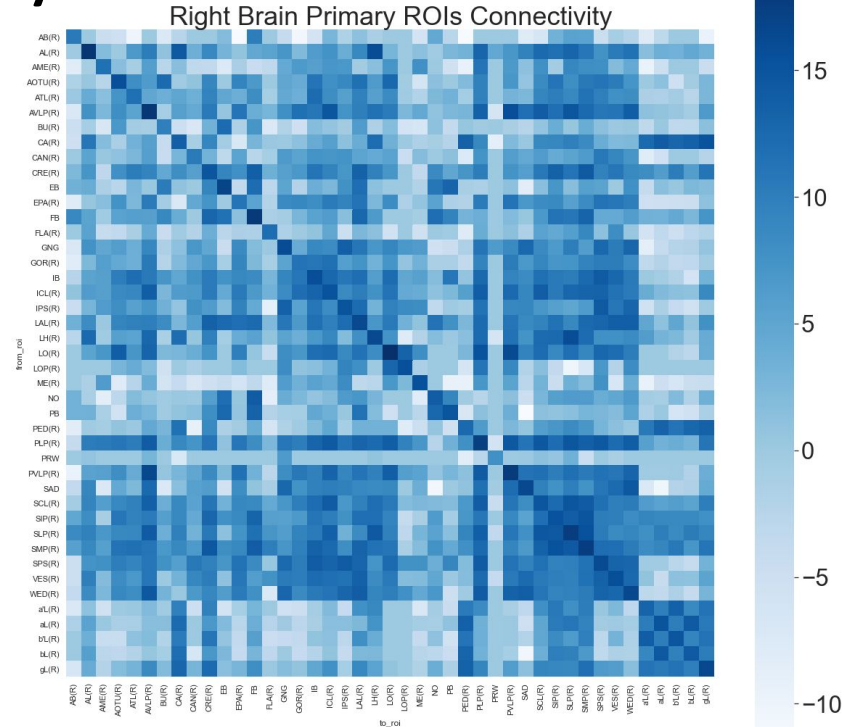
```
fetch_roi_connectivity(format='pandas')
```

pre-computed connectivity statistics between primary ROIs in the dataset

```
In [3]: RightBrain.head(20)
```

```
Out [3]:
```

	from_roi	to_roi	count	weight
25	AB(R)	AB(R)	112	10.591788
26	AB(R)	AL(R)	1	0.059706
27	AB(R)	AME(R)	1	-4.564785
28	AB(R)	AOTU(R)	1	-5.142958
30	AB(R)	ATL(R)	1	-10.221587
32	AB(R)	BU(R)	3	-7.226553
33	AB(R)	CA(R)	1	-2.564785
35	AB(R)	CRE(R)	11	-0.014807
36	AB(R)	EB	18	1.807405
37	AB(R)	EPA(R)	1	-11.647908



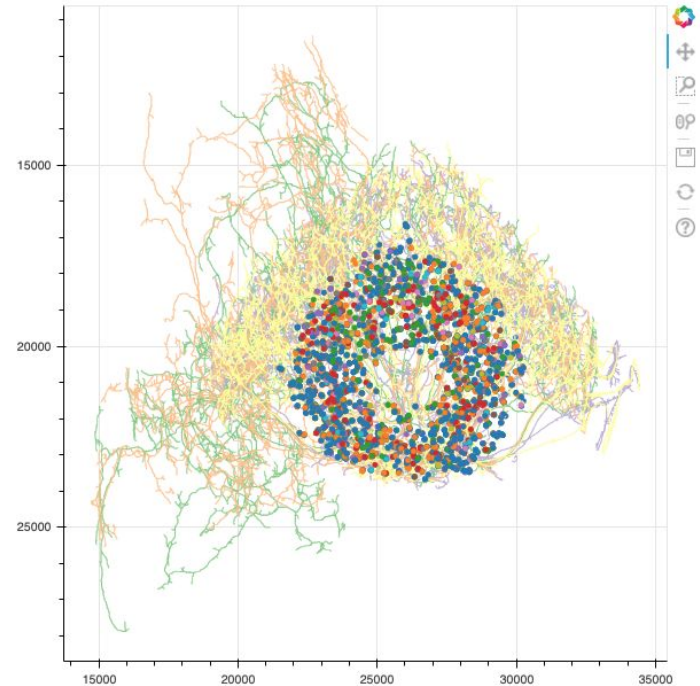
Skeleton Graph

- Visualize the 3D physical location of neurons and synapses in the brain in a 2D plot

Neuron/Synapse Criteria:

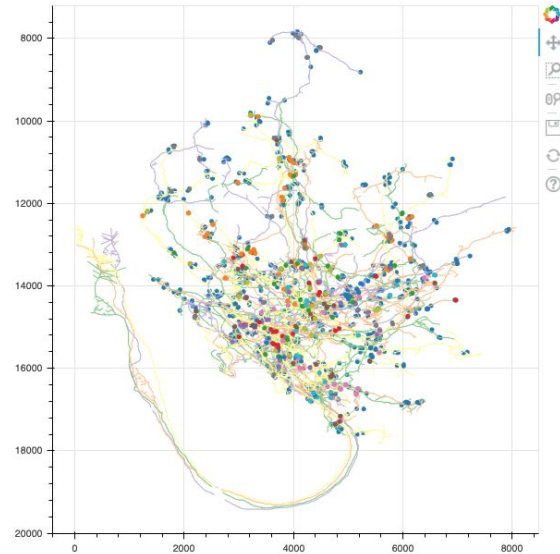
ROIs: EB

Cell Type: FB4Y

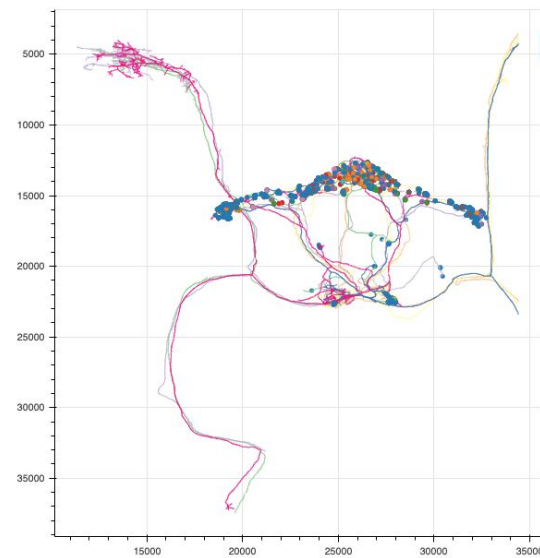


Visually trace connections in the brain

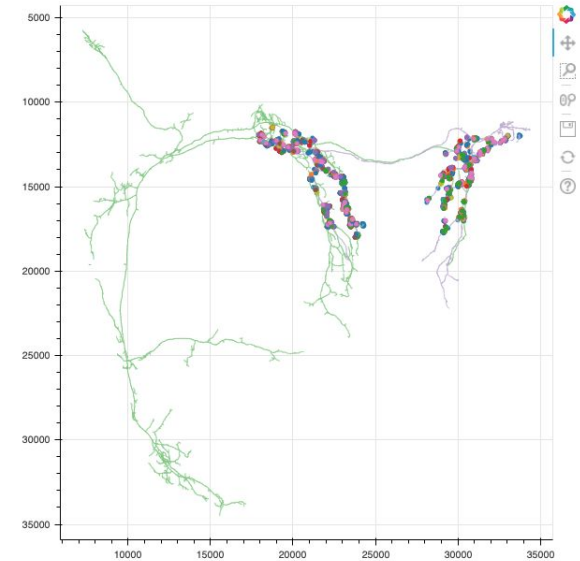
Neuron/Synapse Criteria:
ROIs: LH(R)
Cell Type: LHAV4g2



Neuron/Synapse Criteria:
ROIs: FB
Cell Type: SAF



Neuron/Synapse Criteria:
ROIs: ATL(R), ATL(L)
Cell Type: ATL014



Our Approach

Created a SkeletonGraph class that accepts a “cell type” string and a list of ROIs as parameters

Automatically generates and returns a scatter plot of the tbar synapse connections, and the associated neurons overlaid on a skeleton graph plot of the neurons.

Heavily Utilized the neuprint-Python API

- Fetch_synapses, fetch_synapse_connections, fetch_neurons, merge_neuron_properties, fetch_skeleton

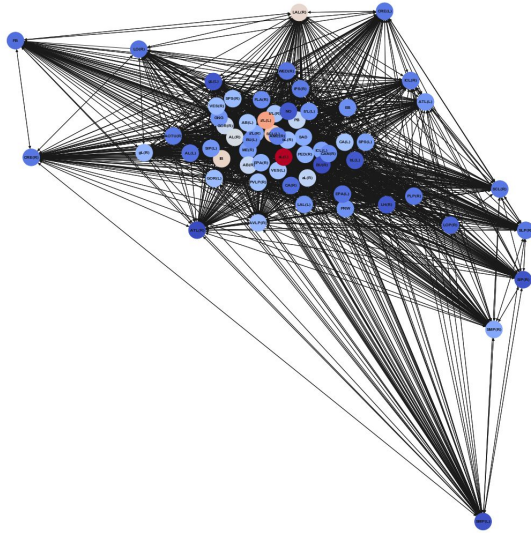
Extending Our Class: Cell Type of the Day

- Pulls the current day's 'Cell Type of the Day' information via the `fetch_daily_type` API call
- Creates an instance of the Skeleton Visualization class that plots the skeleton graph for all neurons of that cell type.

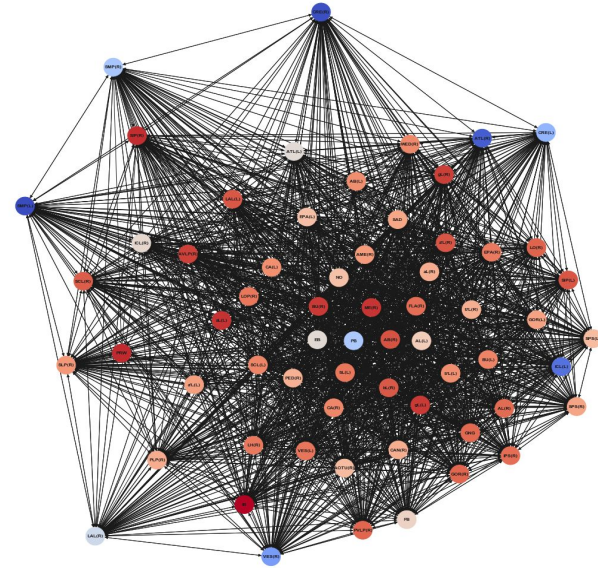
Part 2: Dataset Analysis

Number of Connections vs Weight

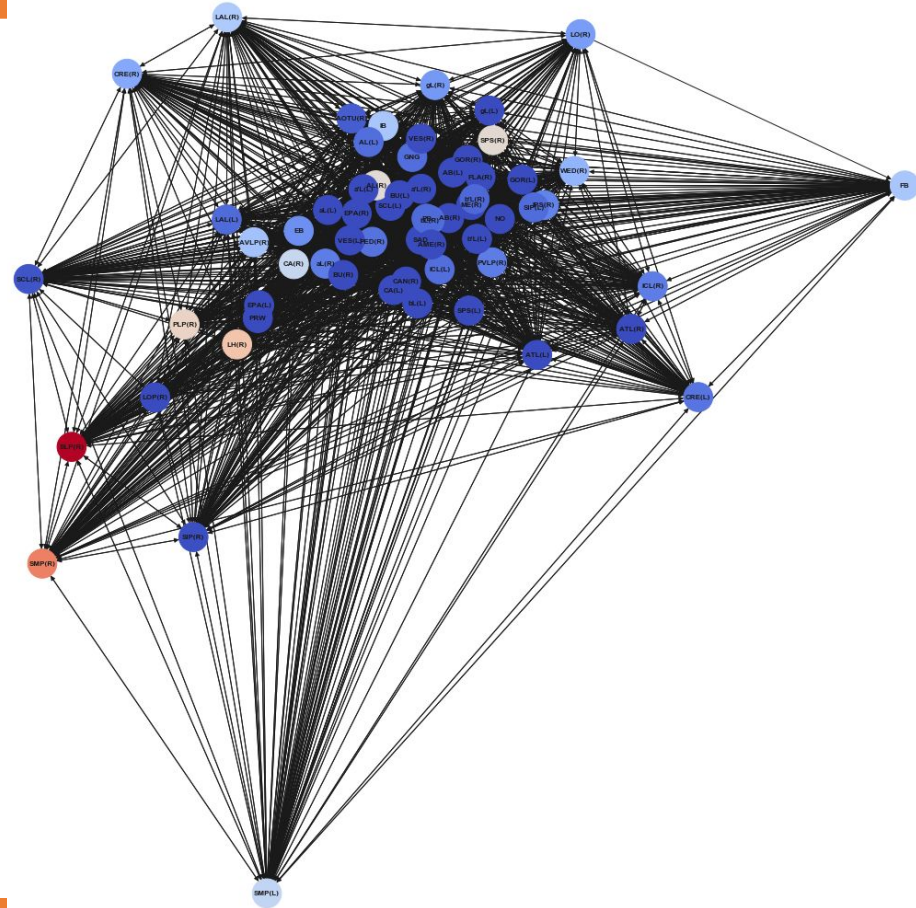
Local Reach by weight



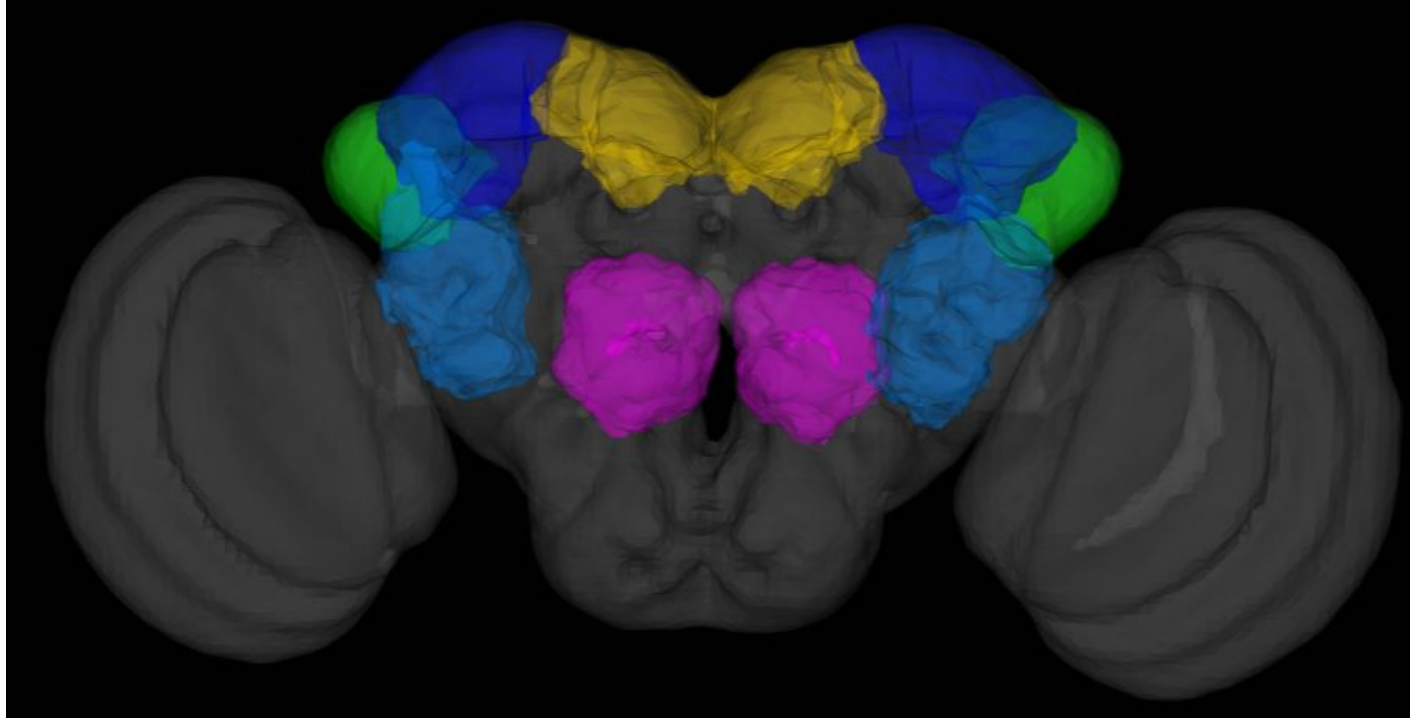
Local Reach by connectivity



Betweenness

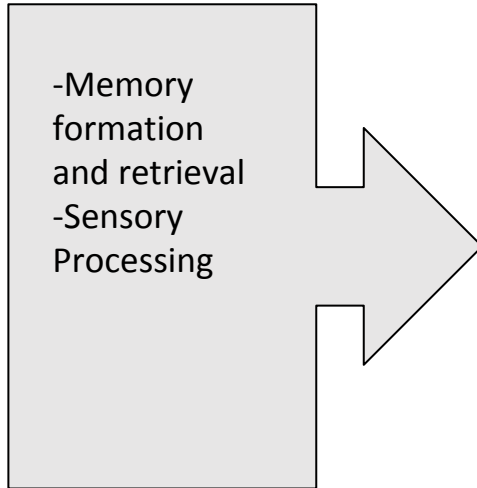


What does this look like in the brain?

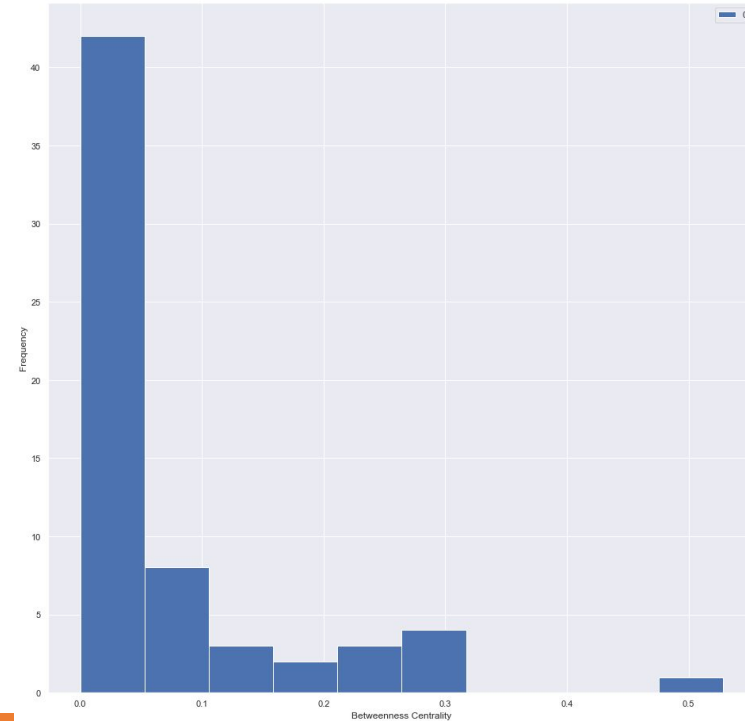


Eigencentrality for Weight

Poorly Defined



SAD	0.528454
a'L(R)	0.315810
gL(R)	0.300056
AB(L)	0.296509
NO	0.295431
EPA(L)	0.259042
aL(R)	0.236455
b'L(L)	0.220793
GOR(L)	0.204093
PB	0.162846



So what are these things we found?

- local reaching: memory
- eigencentality and betweenness centrality:
 - “Terra incognita” -Janelia
 - Possible centers for the control of learning and complex social behavior
 - Poorly characterized and under increasing recent scrutiny