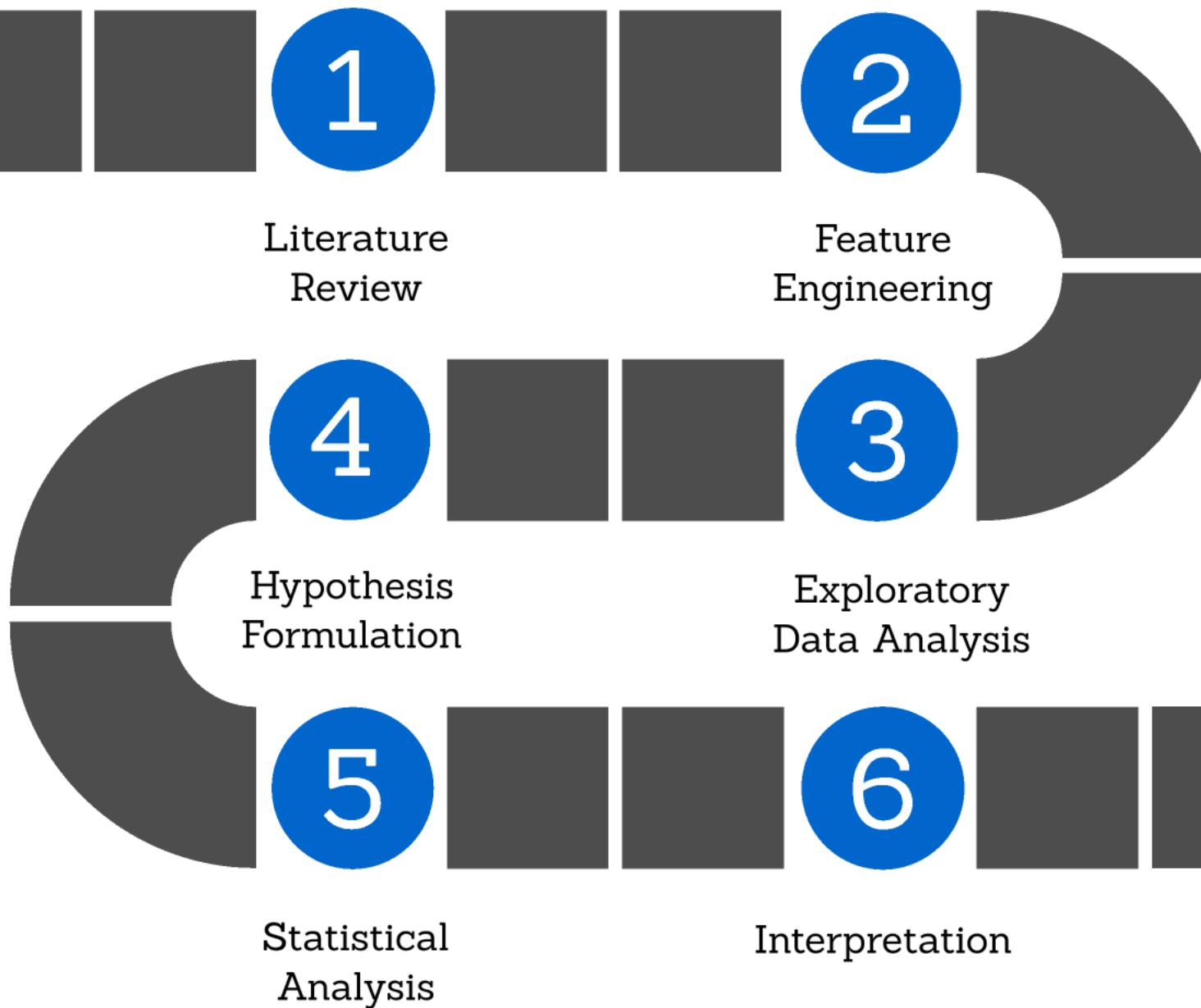


Orientation Selectivity Map in mice



Project participants:

Mohammed Albyoumi
Fatema Darweesh
Rahma Abbas
Shivam Jaiswel
Aditya Agrawal
Argha
Vinayak

Pod name & Group name:

Variraptor Geommu

Literature Review



Brain Maps

Stringer
Dataset

Differences

Brain maps

- 1 Brain Mapping to understand activities and function.
- 2 Maps: Structural, Functional, Connectivity, and Cognitive.
- 3 Functional: Orientation, Retinotopic, Emotional, etc.

Orientation
maps

Orientation Maps

- Reveals the organisation of neural responses to visual stimuli.
- Found in V1
- Significant variation between humans and rodents:
 - Scale and complexity
 - Cortical magnification
 - Binocular vision
 - Visual Activity
- V1 neurons are Orientation Selective

Brain maps

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Orientation
maps

Literature Review



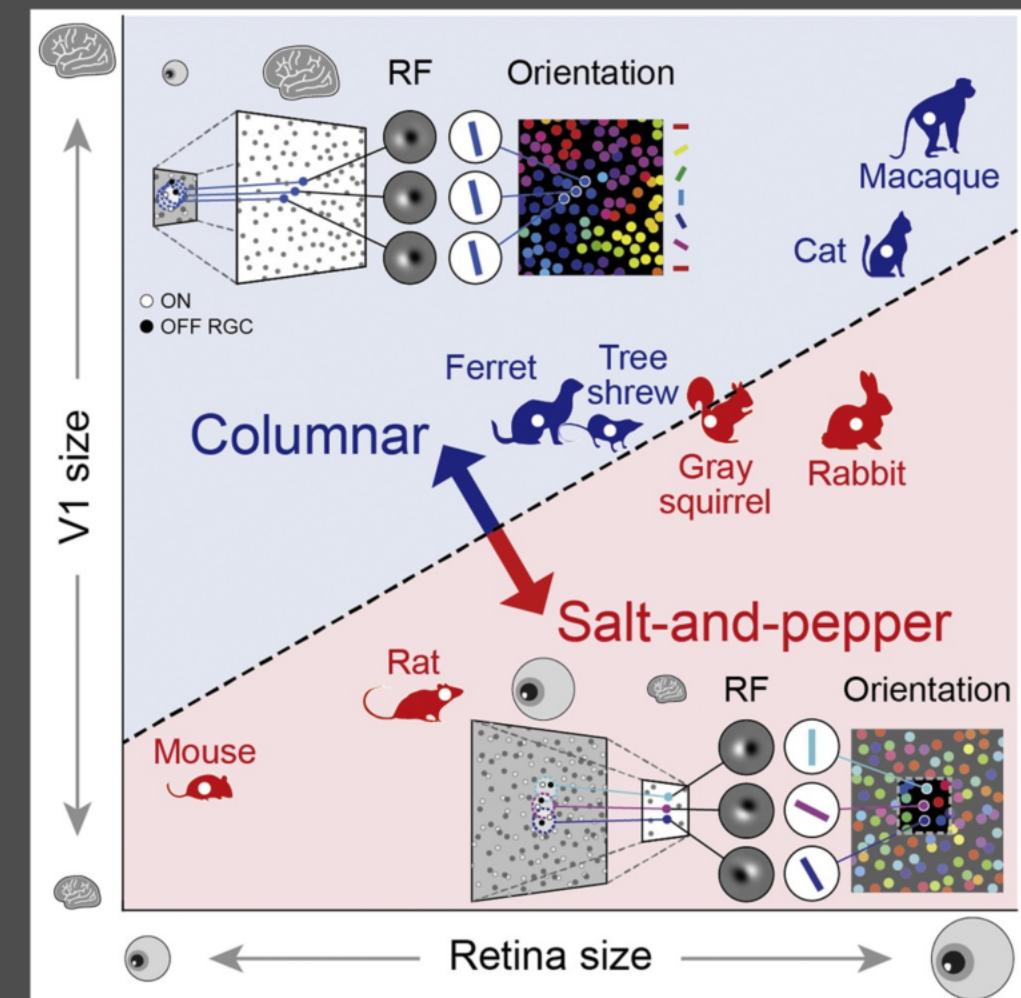
Brain Maps

Stringer
Dataset

Differences

Rodents vs Humans

- Complexity of Orientation selectivity.
- Broad tuning in Rodents.
- Developmental Differences.
- Cortical organisation.
- Still used as animal models



Literature Review



Brain Maps

Stringer
Dataset

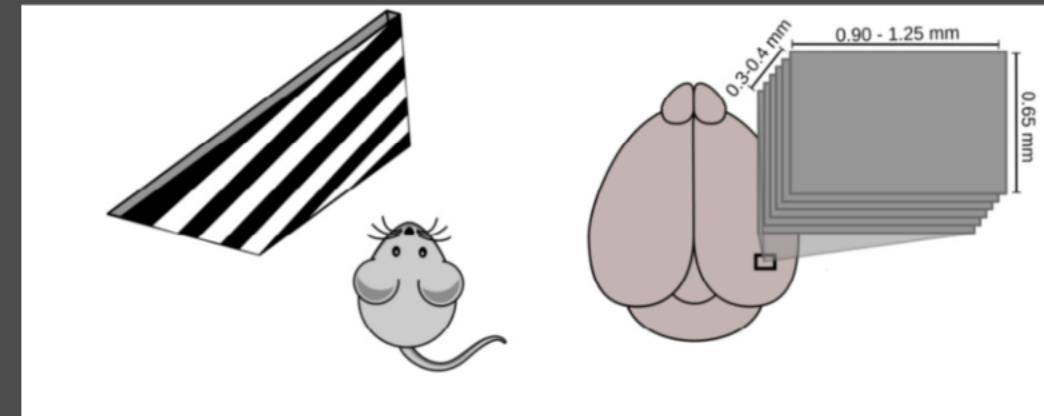
Differences

Stringer Dataset

1 Primary visual cortex in mice

2 20,000+ neural response.

3 Rotating static grating between 0-360 degrees.



Stringer et al., 2021

Ended up with two datasets; Spontaneous behavior, Orientation selectivity.

Literature Review

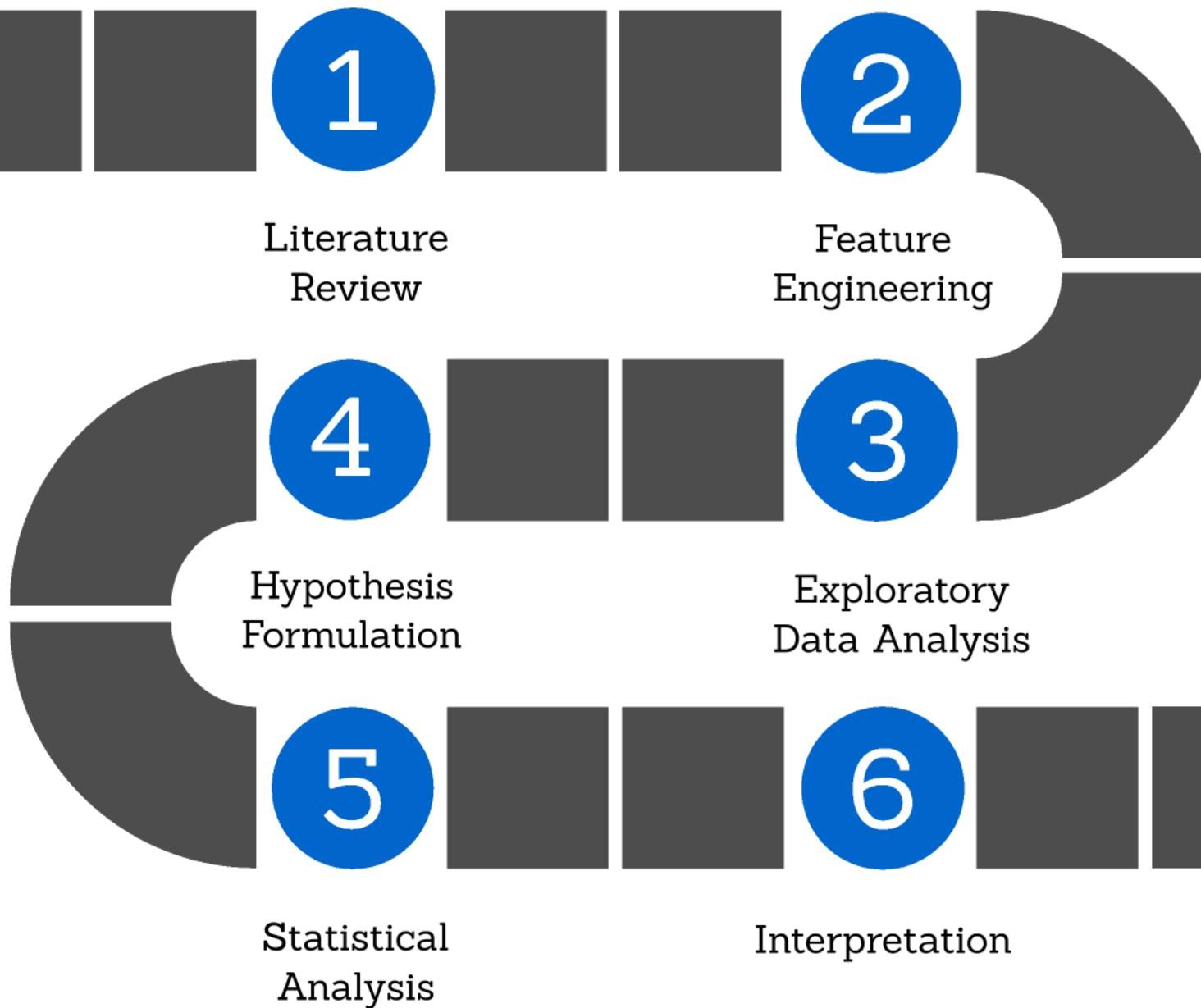


Brain Maps

Stringer
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Differences

Orientation Selectivity Map in mice



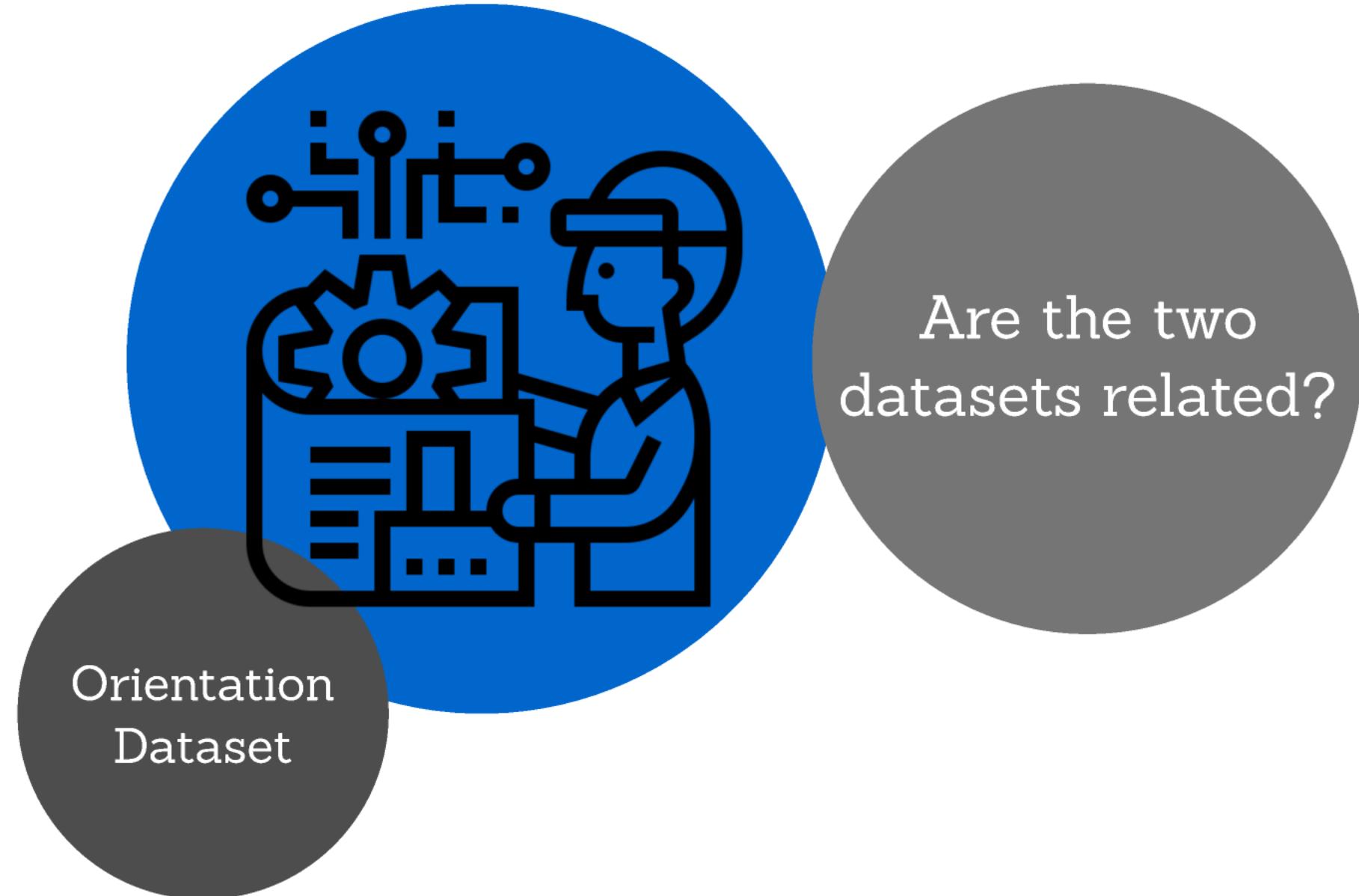
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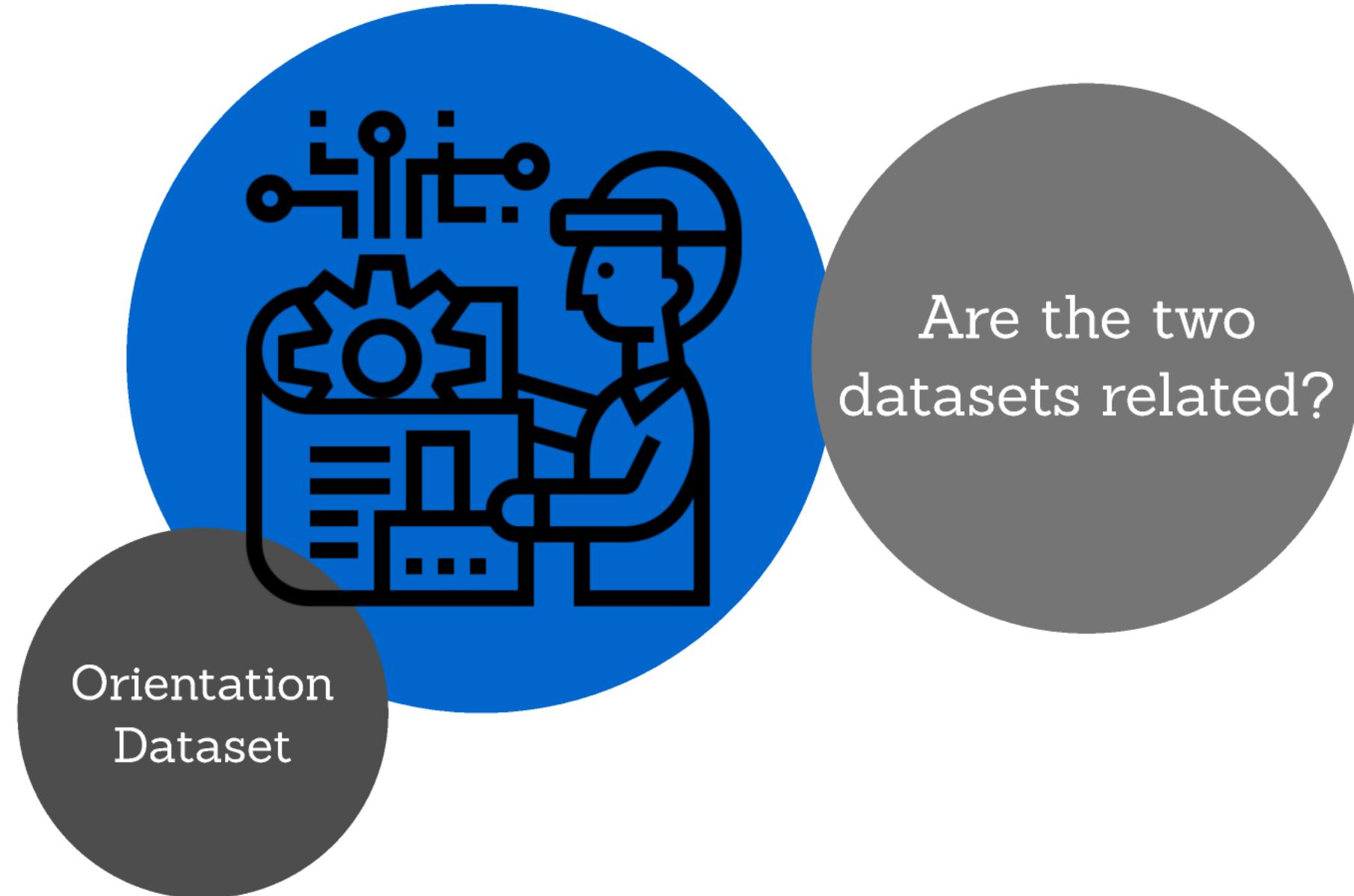
Feature Engineering



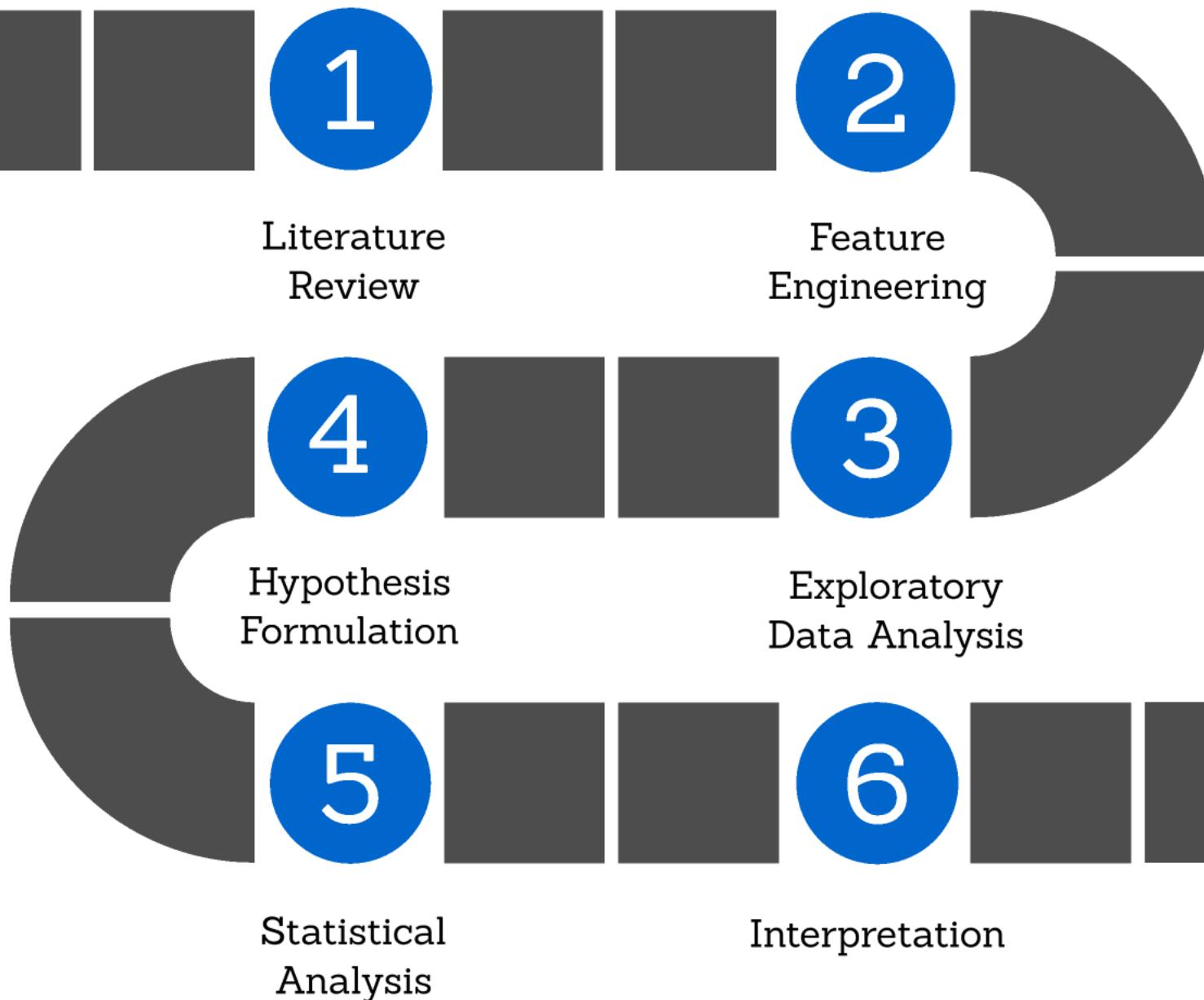
Feature Engineering

- 1 Denoising spontaneous level of activity.
- 2 Neuron response normalized using z-score.
- 3 Converted the orientations from radians to degrees.
- 4 Orientations are binned over trials.
- 5 Neuron response averaged accordingly.

Feature Engineering



Orientation Selectivity Map in mice



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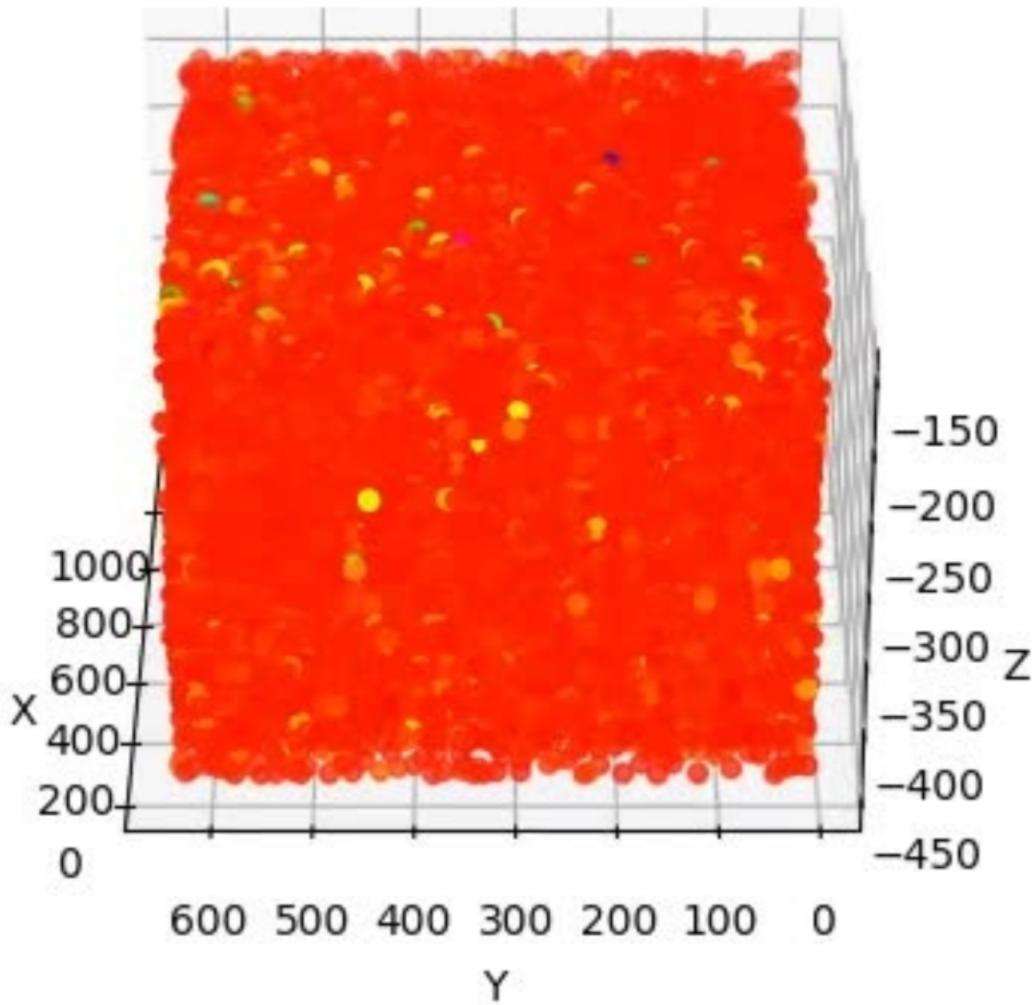
Variraptor Geommu

Exploratory Data Analysis

3D
visualization
of neurons
w.r.t
orientation.

Tunning
curves of
neurons



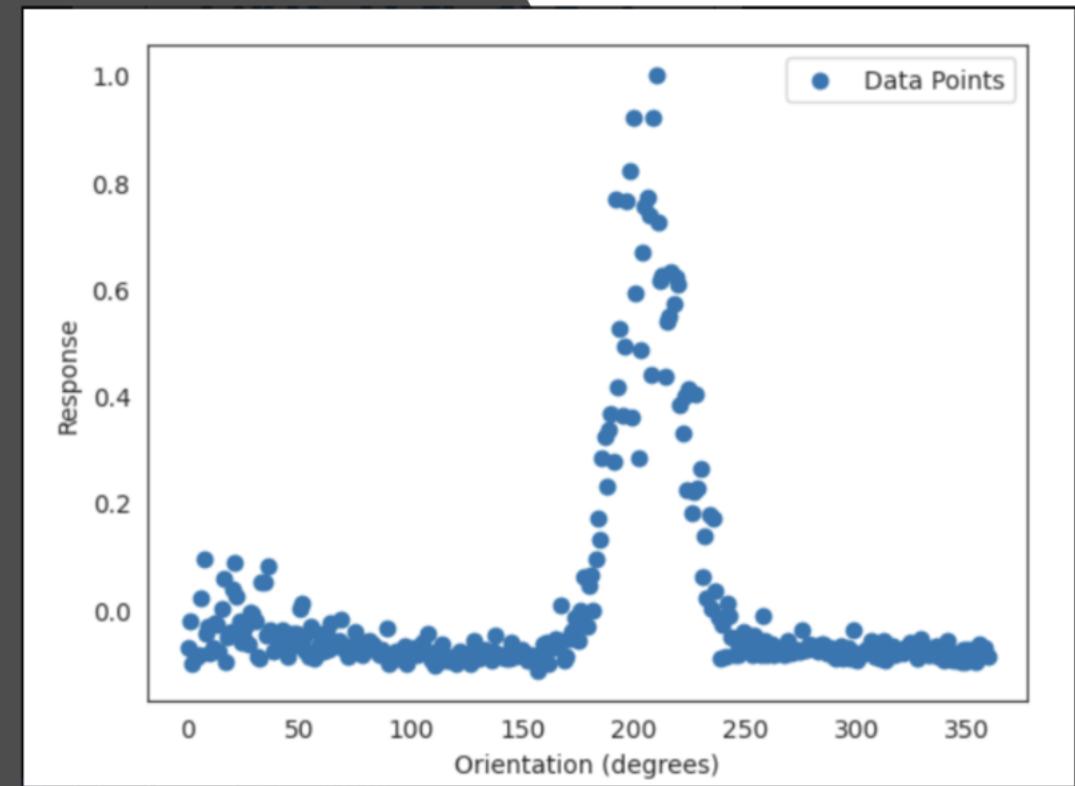
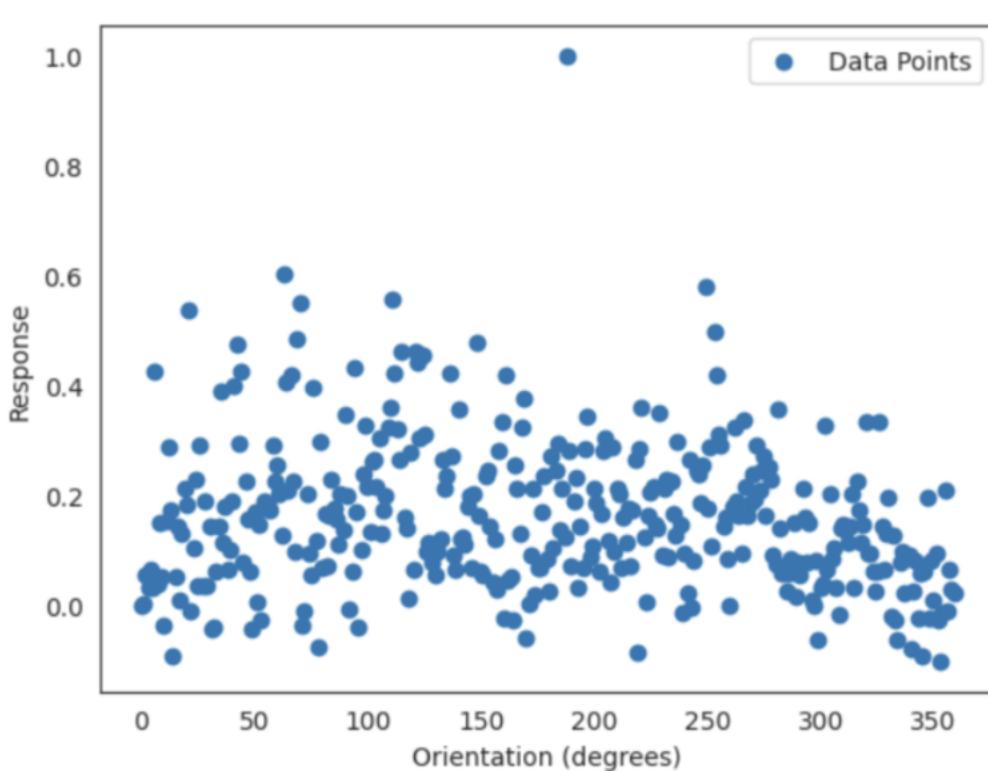


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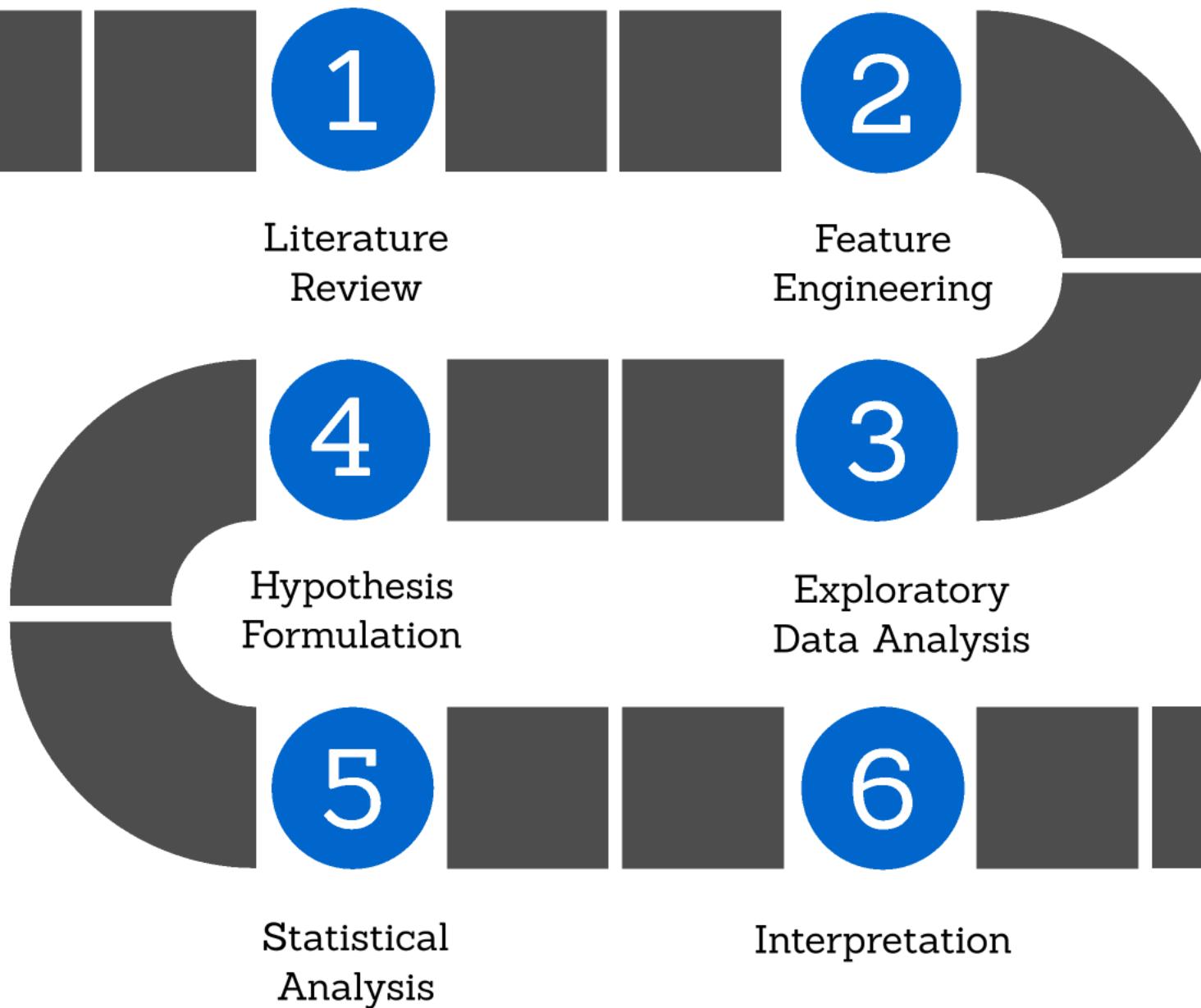
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Hypothesis

The map of the selective neuron in mice V1 is “salt and pepper” and doesn't follow a systematic pattern.



Why mice:

- Due to their convenience size, low cost, amenability to manipulations.
- Many new technologies can be applied on mice but not human.
- Can be parsed to further understand neural circuits, neuron plasticity, and neurological disorders.

Why Orientation:

- Other mammals exhibit very well detailed orientation map in their V1 like cats.
- The architecture of selective neuron in mice is yet to be established.
- Research body argues between no order “salt and pepper”, little order “pinwheels and minicolumn”.

Hypothesis

The map of the selective neuron in mice V1 is “salt and pepper” and doesn't follow a systematic pattern.



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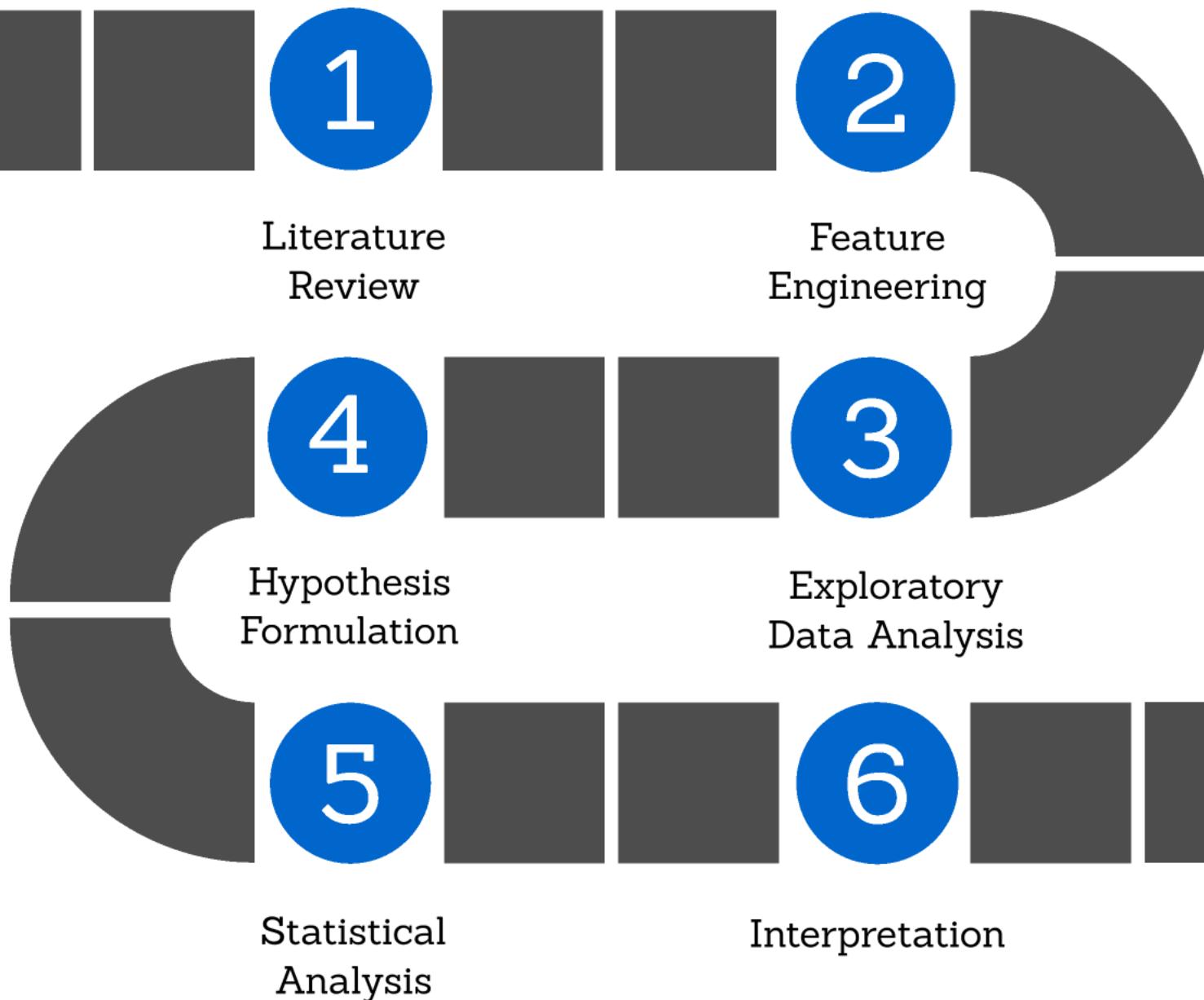
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Orientation Selectivity Map in mice



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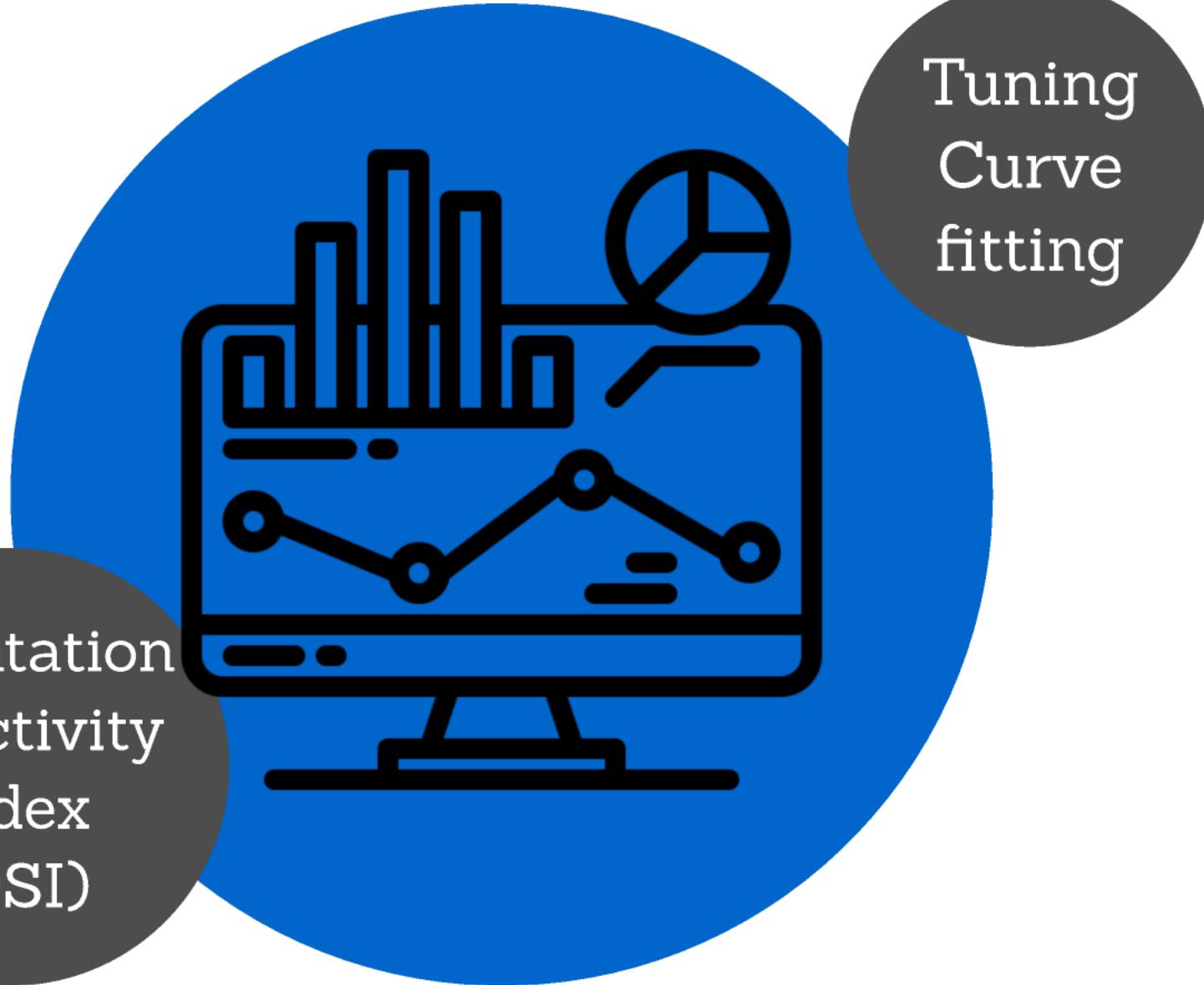
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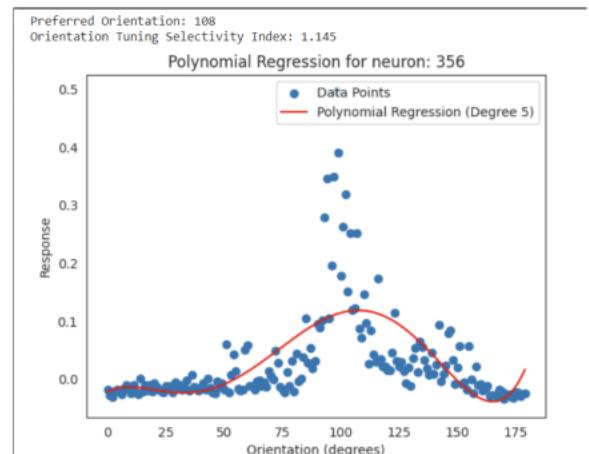
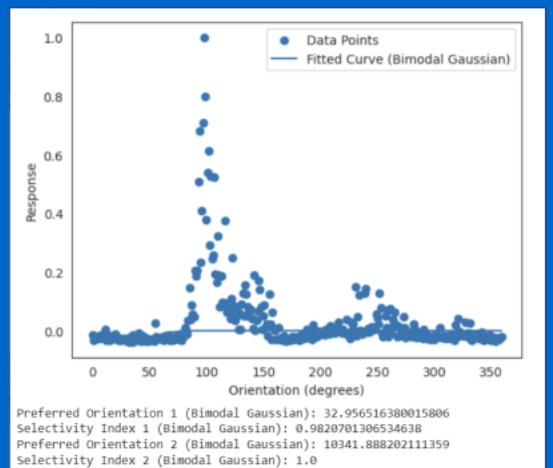
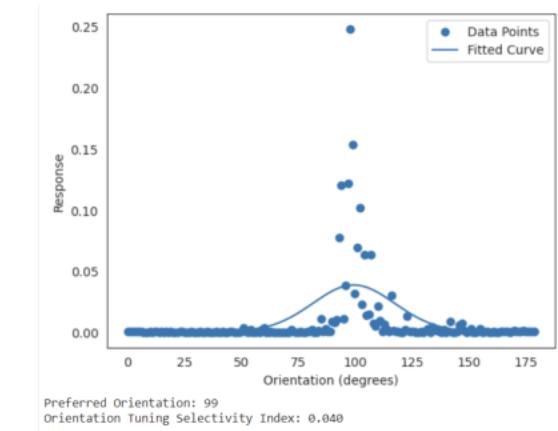
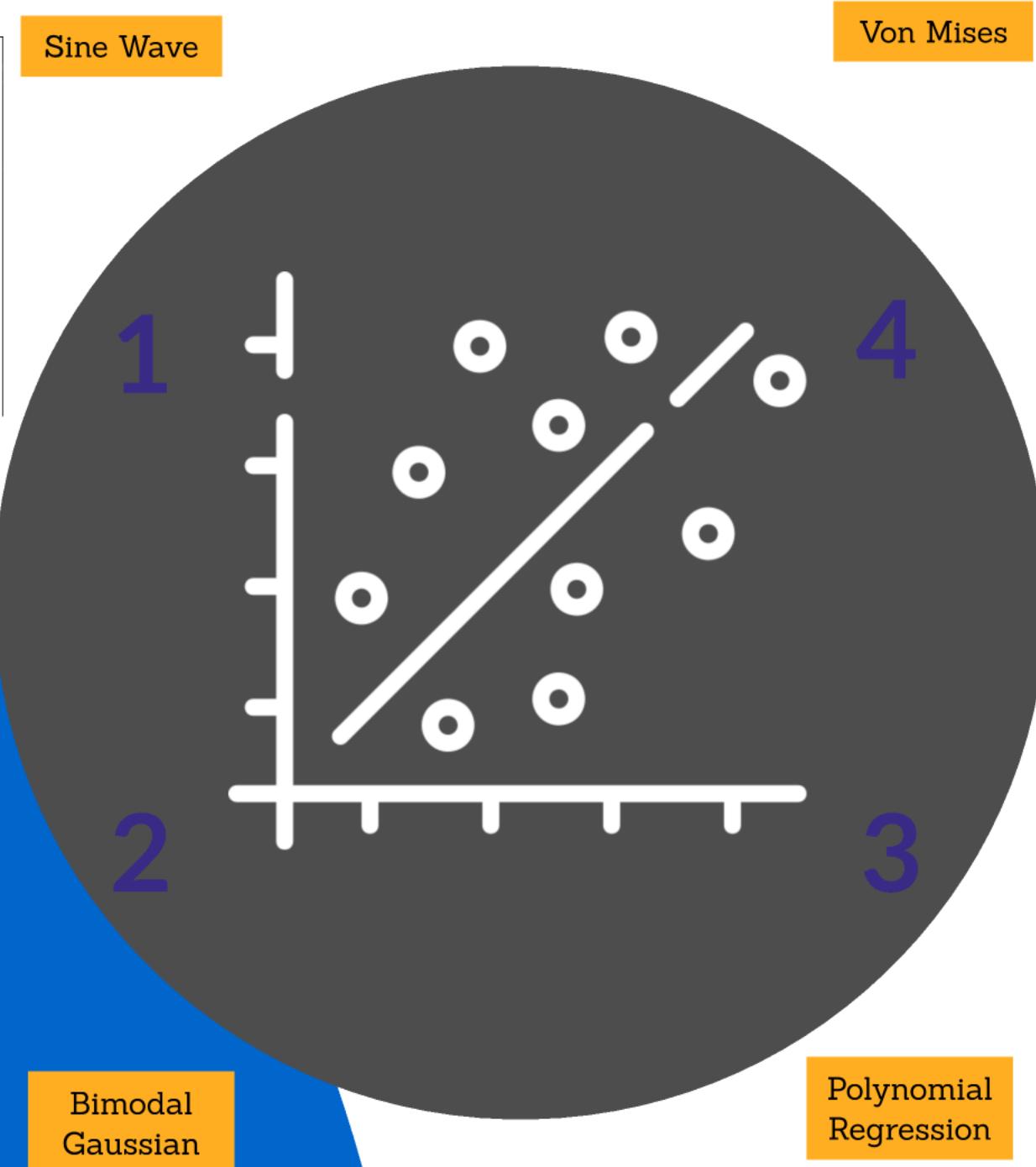
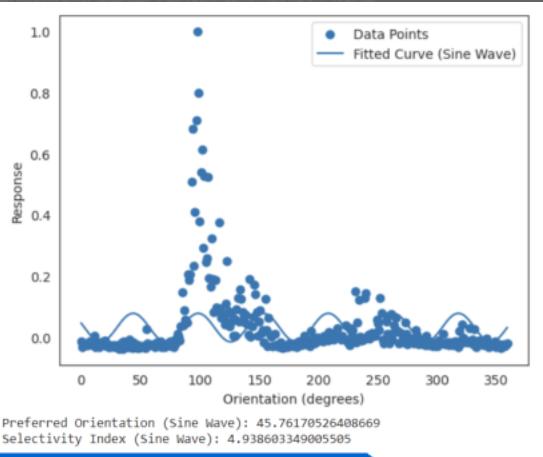
Pod name & Group name:

Variraptor Geommu

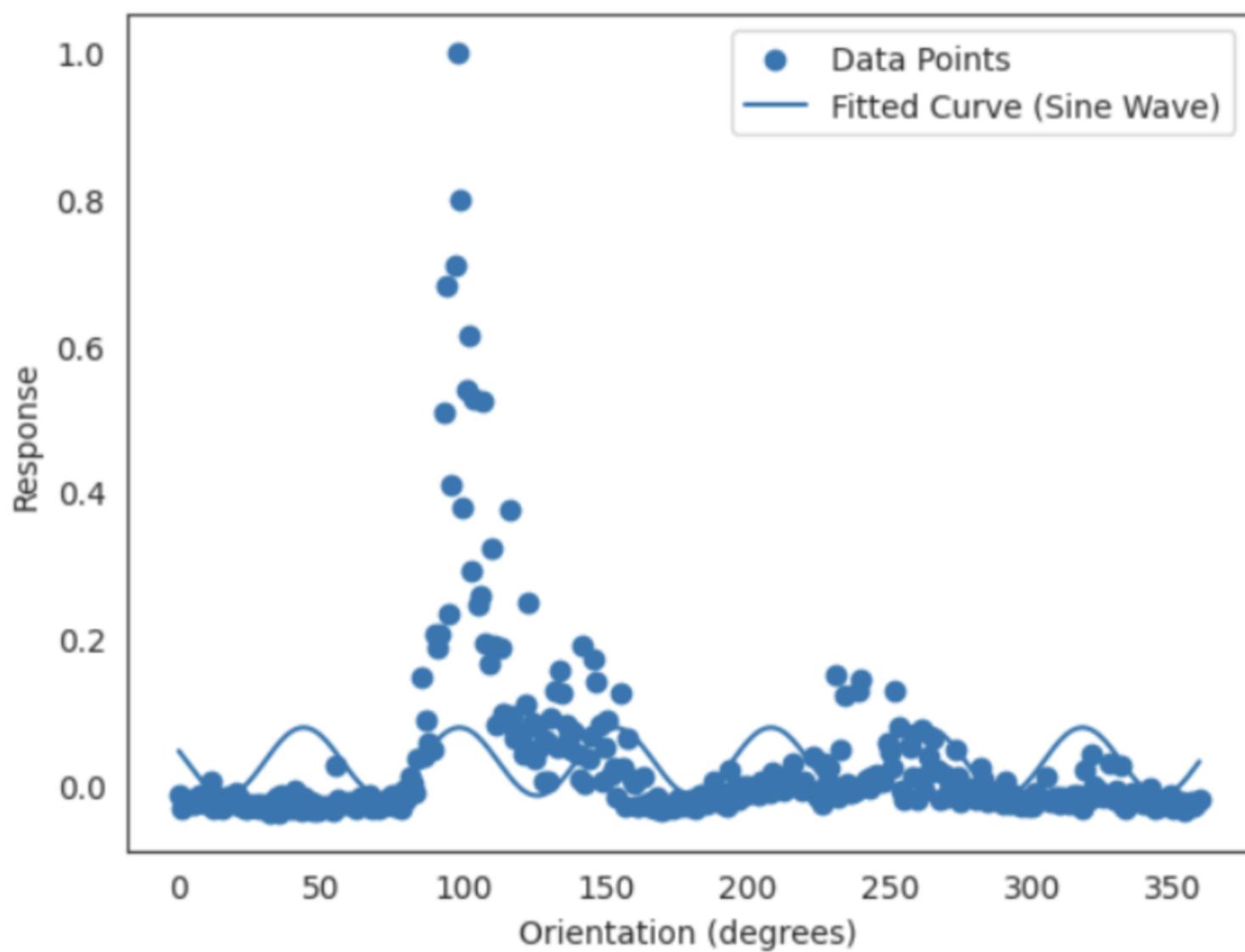
Statistical Analysis

Orientation
Selectivity
Index
(OSI)



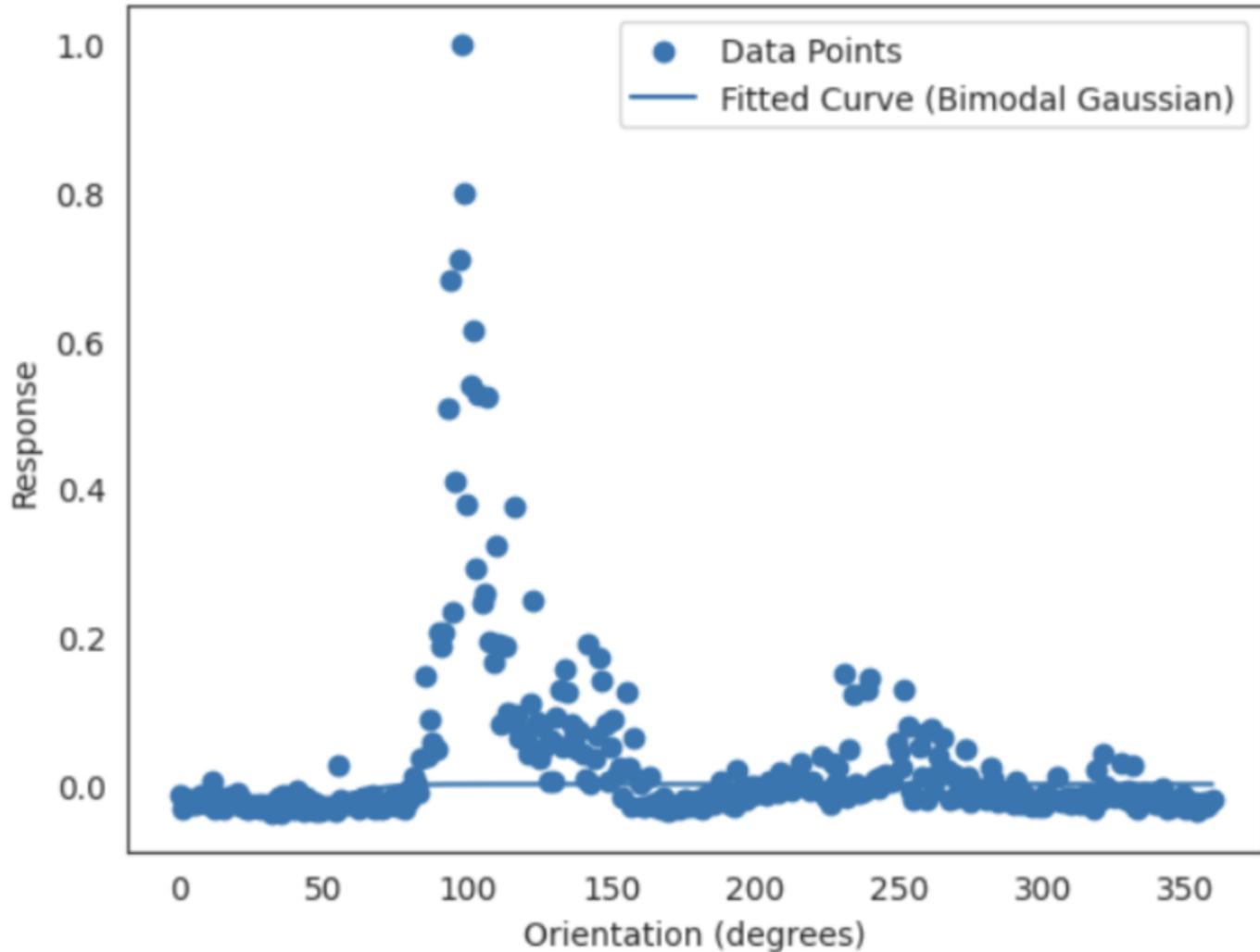


Sine Wave



Preferred Orientation (Sine Wave): 45.76170526408669
Selectivity Index (Sine Wave): 4.938603349005505

1

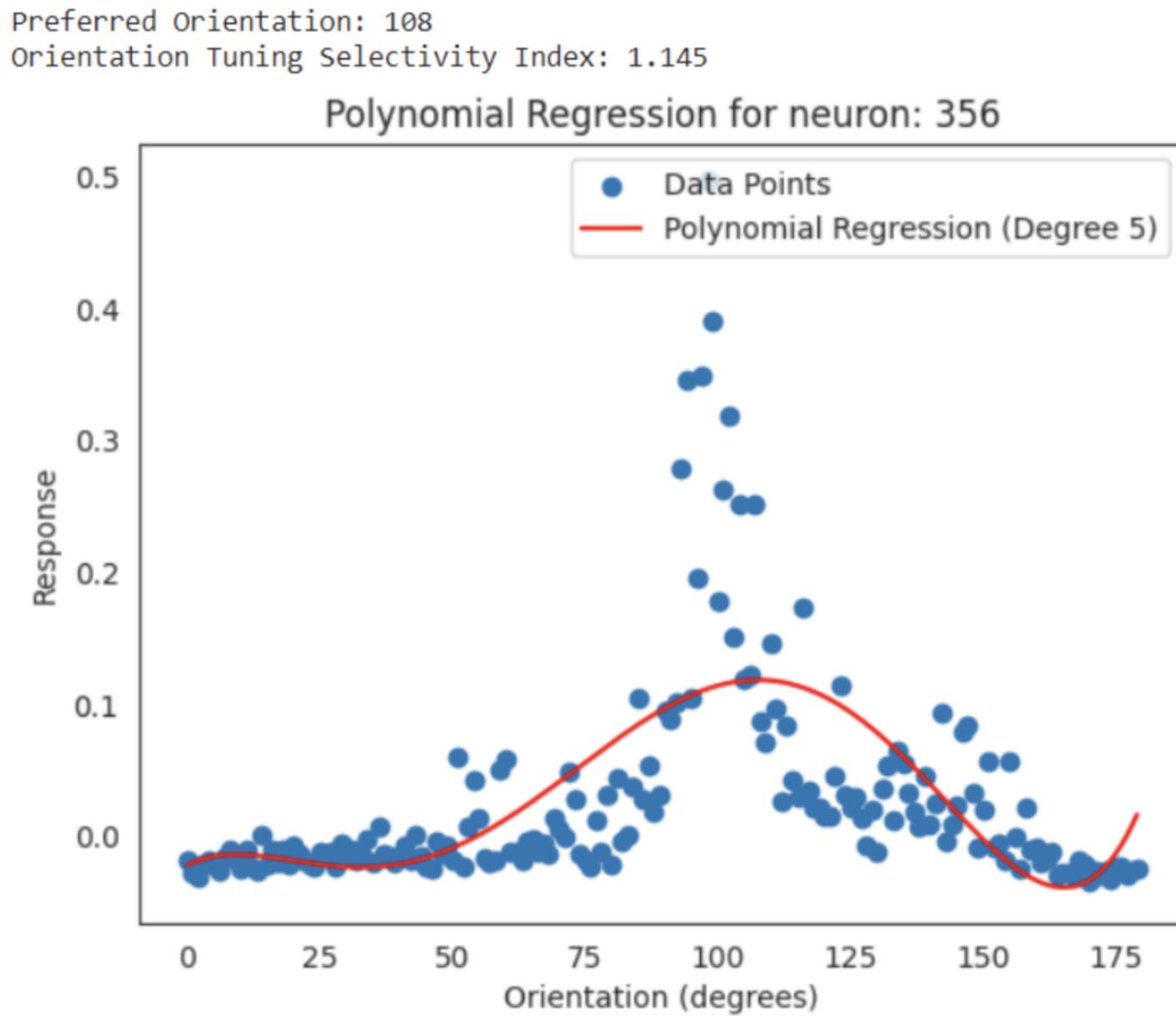


2

Bimodal Gaussian

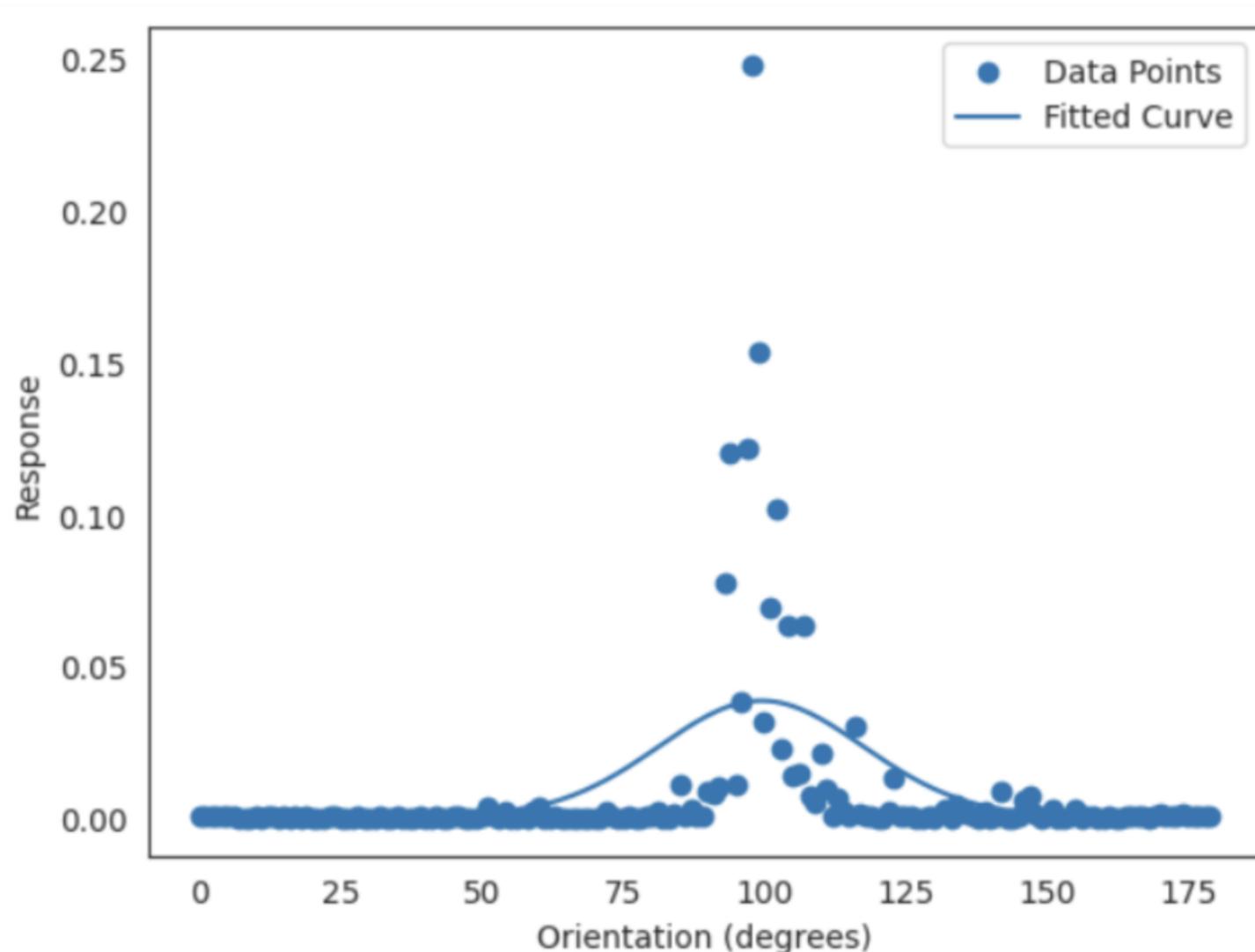
Polynomial Regression

3



Von Mises

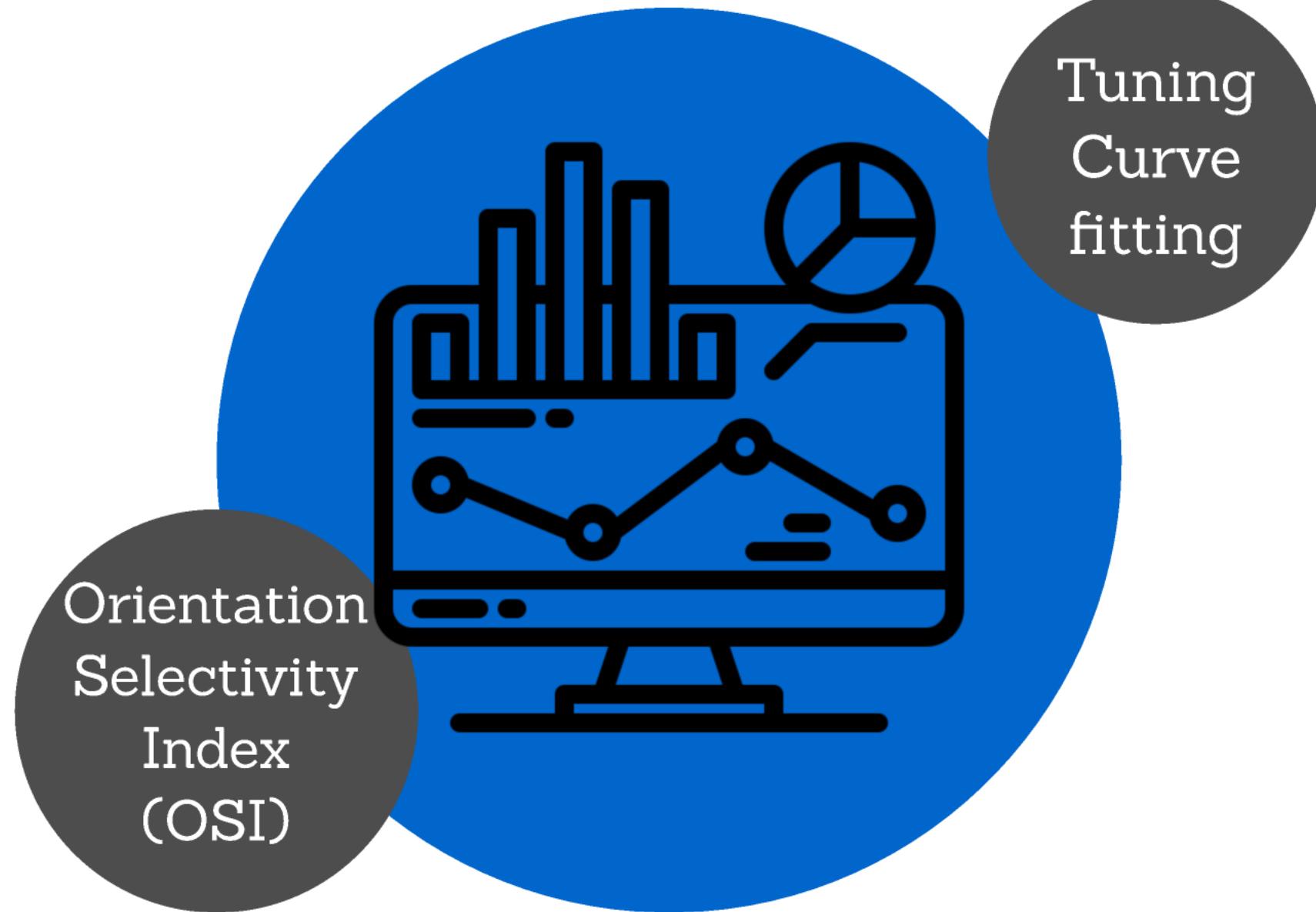
4



Preferred Orientation: 99

Orientation Tuning Selectivity Index: 0.040

Statistical Analysis



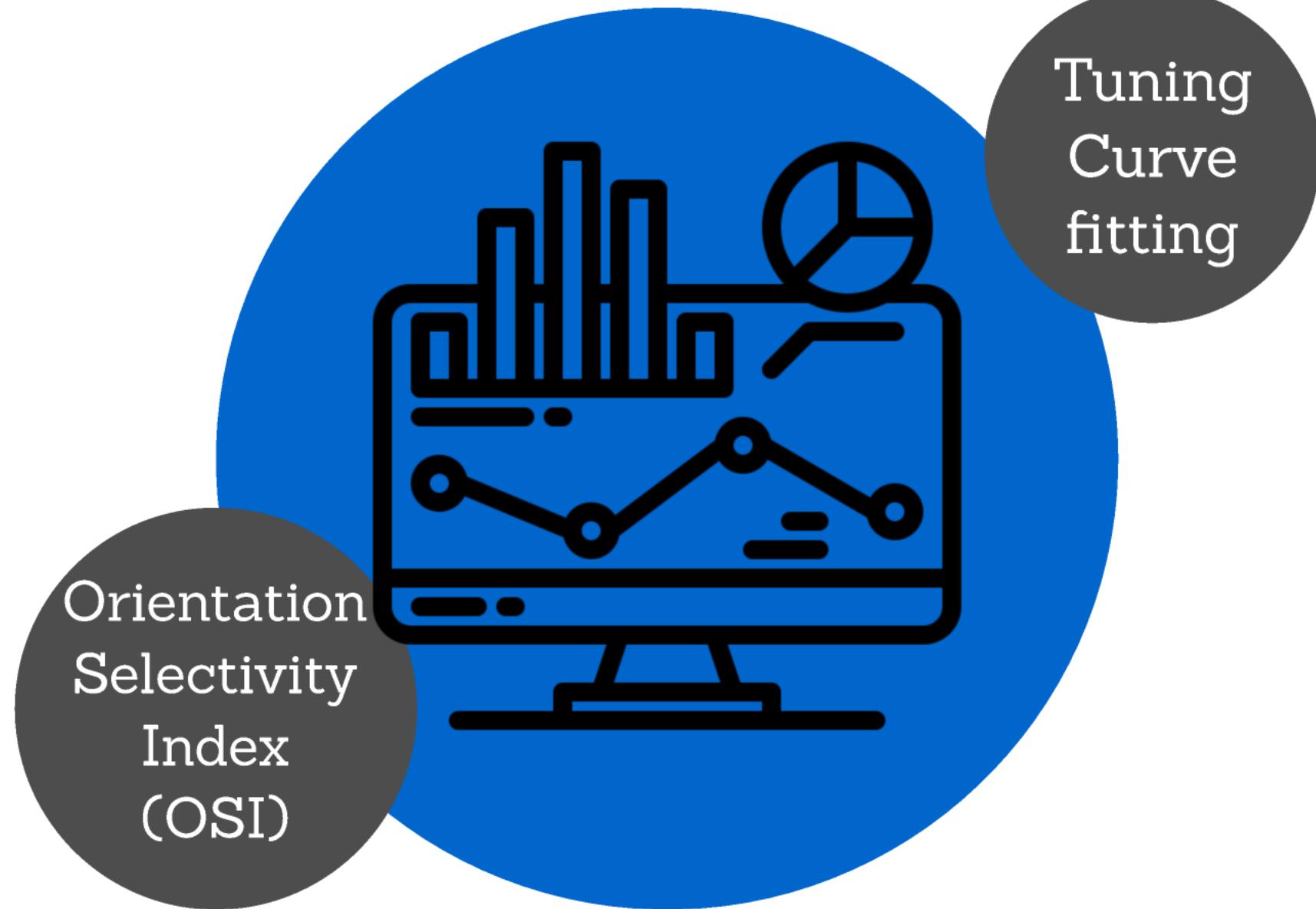
Orientation Selectivity Index (OSI)

Where R_{pref} is the response of neuron to the preferred angle, R_{orth} is the response of neuron at the pref angle + 90.

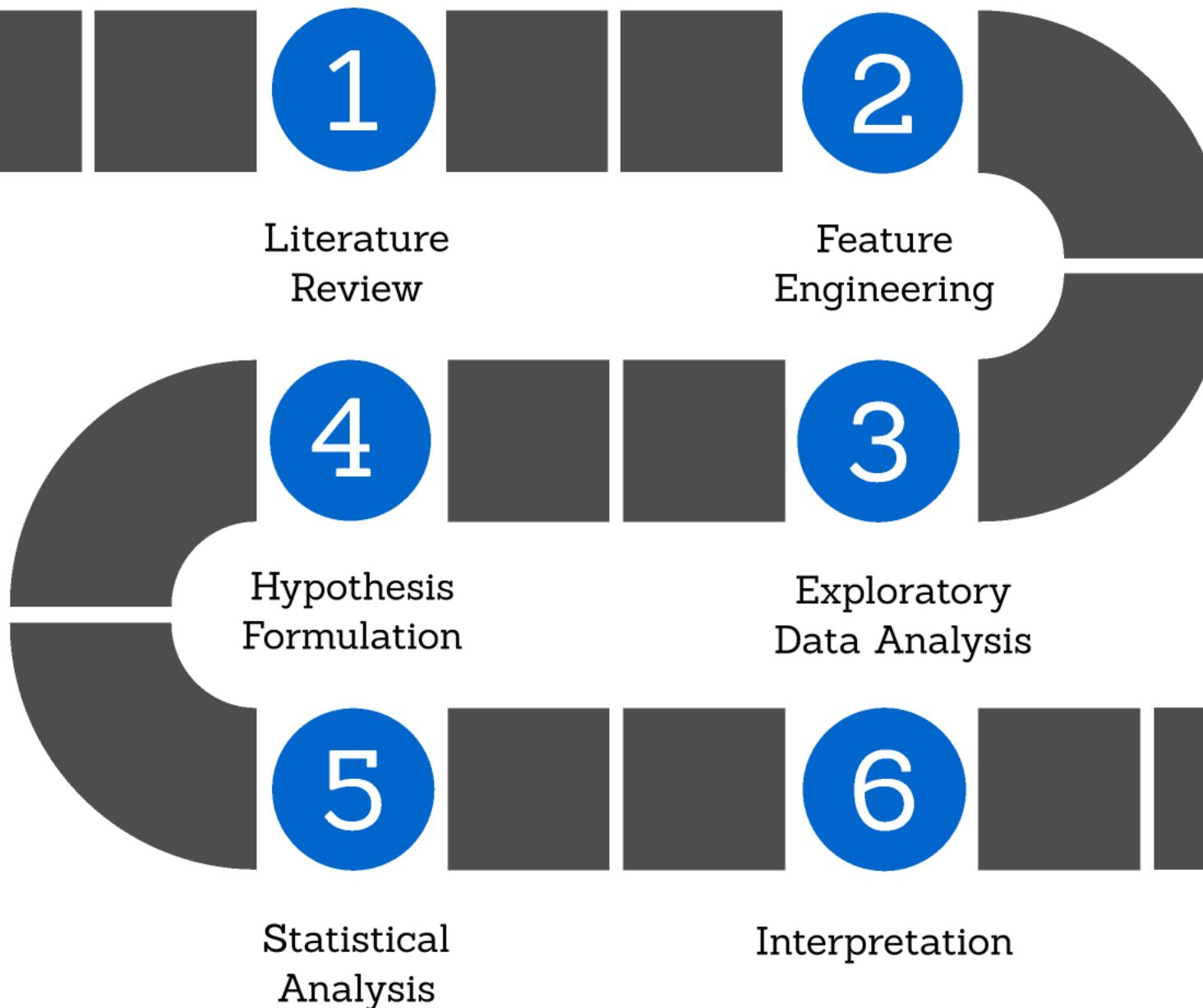
Preferred degree, due to the nature of von mises function, the preferred degree would be the peak or the trough of the fitted curve which is calculated implicitly.

$$OSI = \frac{(R_{pref} - R_{orth})}{(R_{pref} + R_{orth})}$$

Statistical Analysis



Orientation Selectivity Map in mice



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Pod name & Group name:

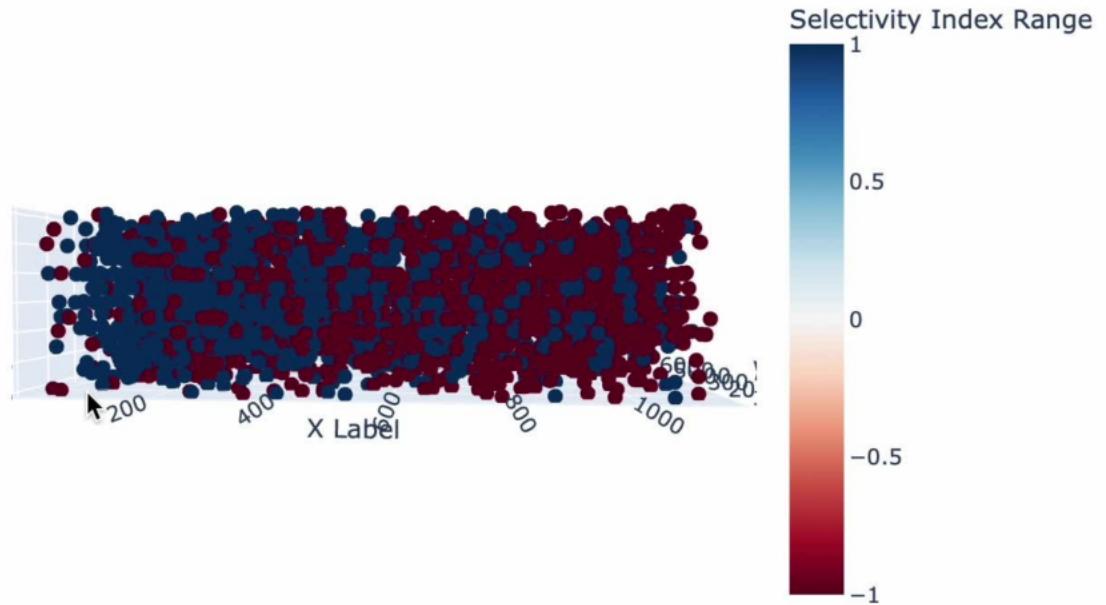
Variraptor Geommu

Interpretation

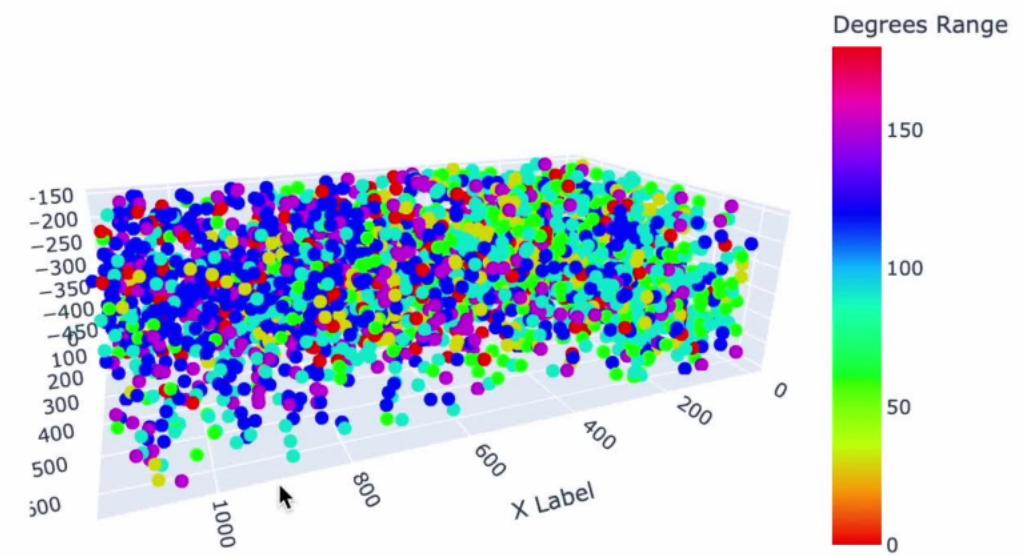
Orientation
Maps

Spatial
Analysis

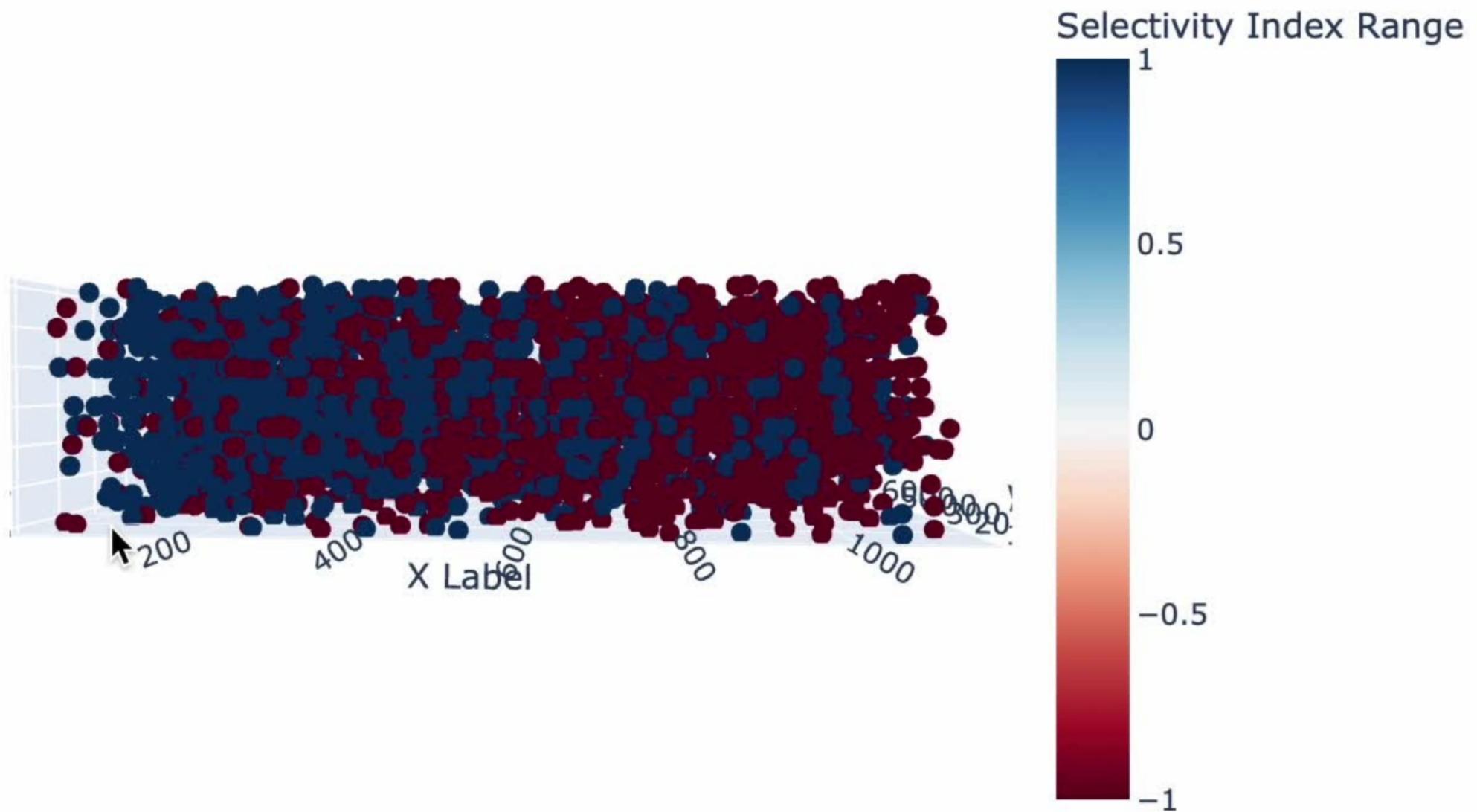
Selectivity Index neurons



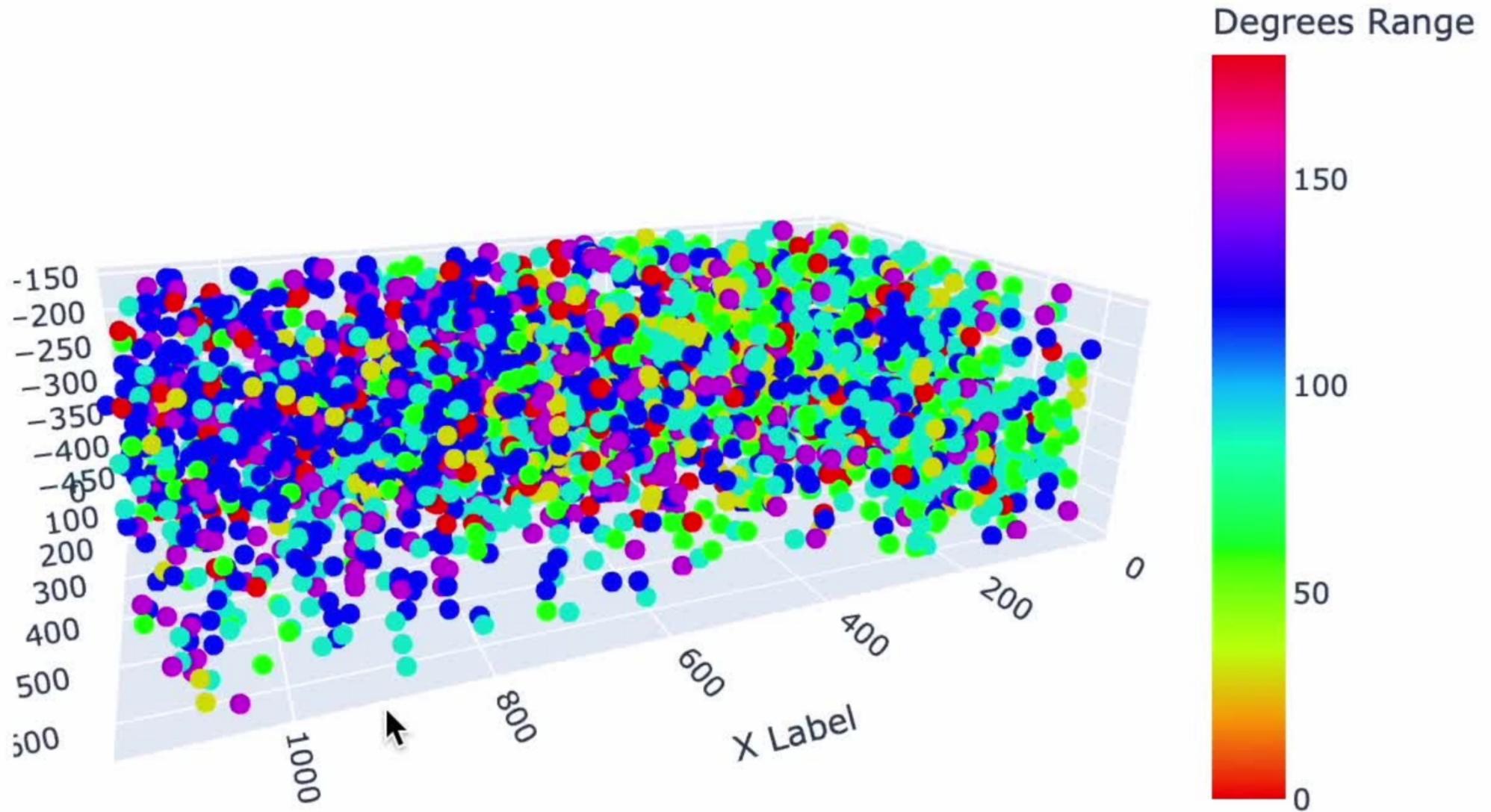
Orientation Selectivity Map



Selectivity Index neurons



Orientation Selectivity Map



Interpretation

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Linear Regression Model:

- Mean Squared Error (MSE) ≈ 0.45
 - R-squared $\approx 10\%$

Ordinary Least Square (OLS):

```

=====
                         OLS Regression Results
=====
Dep. Variable: preferred_degrees_all   R-squared:      0.071
Model:           OLS                     Adj. R-squared:  0.070
Method:          Least Squares        F-statistic:    75.06
Date:            Thu, 27 Jul 2023     Prob (F-statistic): 8.63e-47
Time:             22:24:43           Log-Likelihood: -15171.
No. Observations: 2962                  AIC:         3.035e+04
Df Residuals:    2958                  BIC:         3.037e+04
Df Model:        3
Covariance Type: nonrobust
=====
              coef    std err      t      P>|t|      [0.025      0.975]
-----
const       71.6071    3.346    21.400    0.000      65.046    78.168
360 → x    0.0333    0.002    14.764    0.000      0.029    0.038
361 → y   -0.0087    0.004    -2.110    0.035     -0.017   -0.001
362 → z   -0.0038    0.008    -0.448    0.654     -0.020    0.013
-----
Omnibus:            60.288   Durbin-Watson:      2.016
Prob(Omnibus):      0.000     Jarque-Bera (JB): 33.147
Skew:               0.043     Prob(JB):        6.34e-08
Kurtosis:            2.489     Cond. No.:      3.34e+03
=====

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified
[2] The condition number is large, 3.34e+03. This might indicate that there are strong multicollinearity or other numerical problems.

```

```

=====
                         OLS Regression Results
=====
Dep. Variable: selectivity_indices   R-squared:      0.115
Model:                 OLS            Adj. R-squared: 0.114
Method:                Least Squares F-statistic:    127.6
Date:        Thu, 27 Jul 2023   Prob (F-statistic): 9.64e-78
Time:        22:25:32           Log-Likelihood: -2993.3
No. Observations: 2962          AIC:                  5995.
Df Residuals:    2958          BIC:                  6019.
Df Model:             3
Covariance Type: nonrobust
=====

      coef  std err      t      P>|t|      [0.025      0.975]
=====
const     -0.2820    0.055    -5.143    0.000    -0.389    -0.174
360 → x    0.0007  3.69e-05    19.171    0.000     0.001    0.001
361 → y   -0.0002  6.73e-05    -2.670    0.008    -0.000   -4.77e-05
362 → z    0.0002    0.000     1.288    0.198   -9.37e-05    0.000
=====

Omnibus:            2060.030   Durbin-Watson:       1.966
Prob(Omnibus):      0.000     Jarque-Bera (JB): 171.823
Skew:               0.021     Prob(JB):        4.89e-38
Kurtosis:            1.821     Cond. No.       3.34e+03
=====

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified
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```

OLS Regression Results

Dep. Variable:	preferred_degrees_all	R-squared:	0.071			
Model:	OLS	Adj. R-squared:	0.070			
Method:	Least Squares	F-statistic:	75.06			
Date:	Thu, 27 Jul 2023	Prob (F-statistic):	8.63e-47			
Time:	22:24:43	Log-Likelihood:	-15171.			
No. Observations:	2962	AIC:	3.035e+04			
Df Residuals:	2958	BIC:	3.037e+04			
Df Model:	3					
Covariance Type:	nonrobust					
	coef	std err	t	P> t	[0.025	0.975]
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Kurtosis:	2.489	Cond. No.	3.34e+03			

Notes:

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OLS Regression Results

Dep. Variable:	selectivity_indices	R-squared:	0.115			
Model:	OLS	Adj. R-squared:	0.114			
Method:	Least Squares	F-statistic:	127.6			
Date:	Thu, 27 Jul 2023	Prob (F-statistic):	9.64e-78			
Time:	22:25:32	Log-Likelihood:	-2993.3			
No. Observations:	2962	AIC:	5995.			
Df Residuals:	2958	BIC:	6019.			
Df Model:	3					
Covariance Type:	nonrobust					
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362 → z	0.0002	0.000	1.288	0.198	-9.37e-05	0.000
Omnibus:	2060.030	Durbin-Watson:	1.966			
Prob(Omnibus):	0.000	Jarque-Bera (JB):	171.823			
Skew:	0.021	Prob(JB):	4.89e-38			
Kurtosis:	1.821	Cond. No.	3.34e+03			

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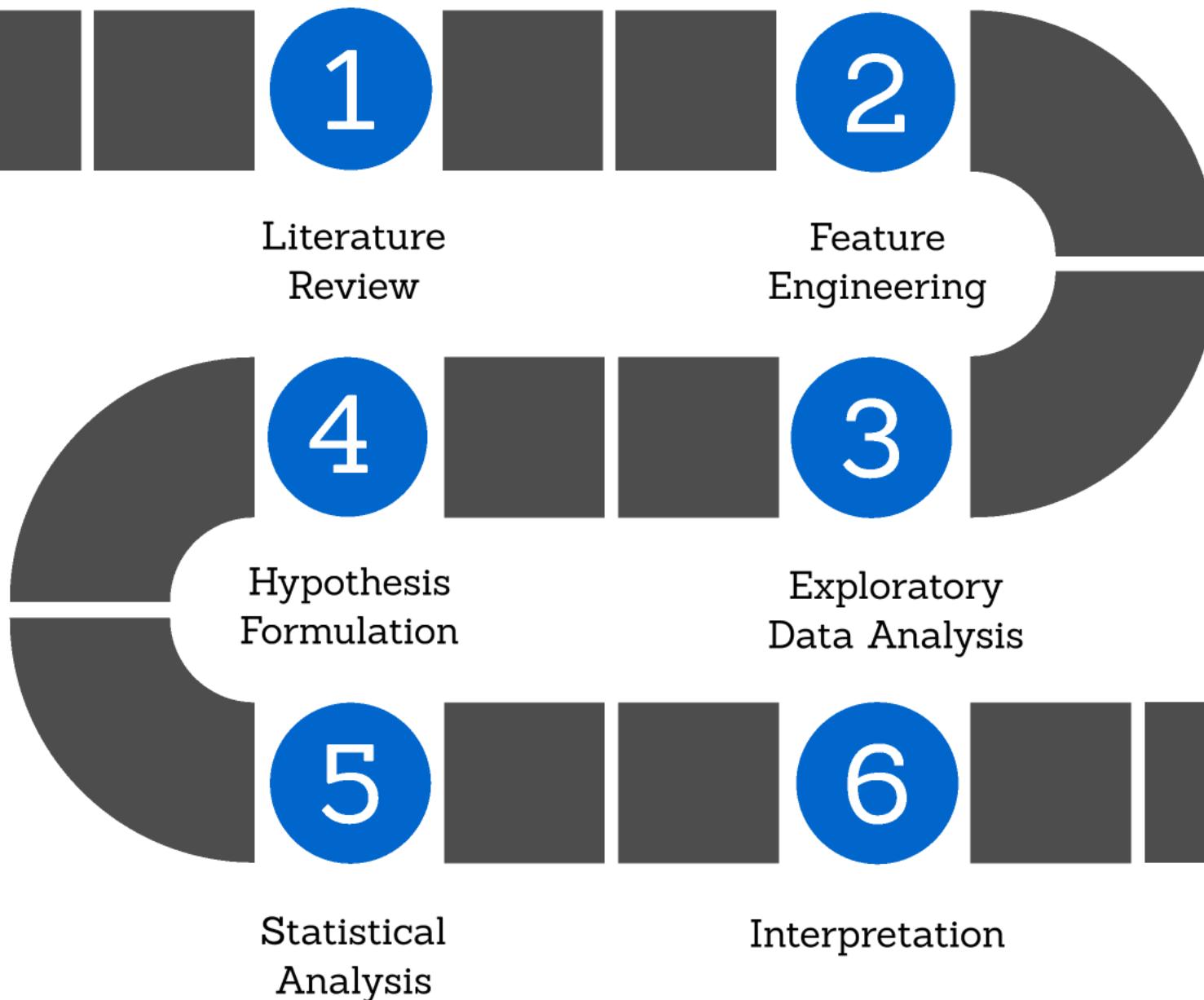
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Further Work



More fitting testing, double von mises,
Difference of Guassian.



Further spatial analysis, DBSCAN.



Locomotion and V1.

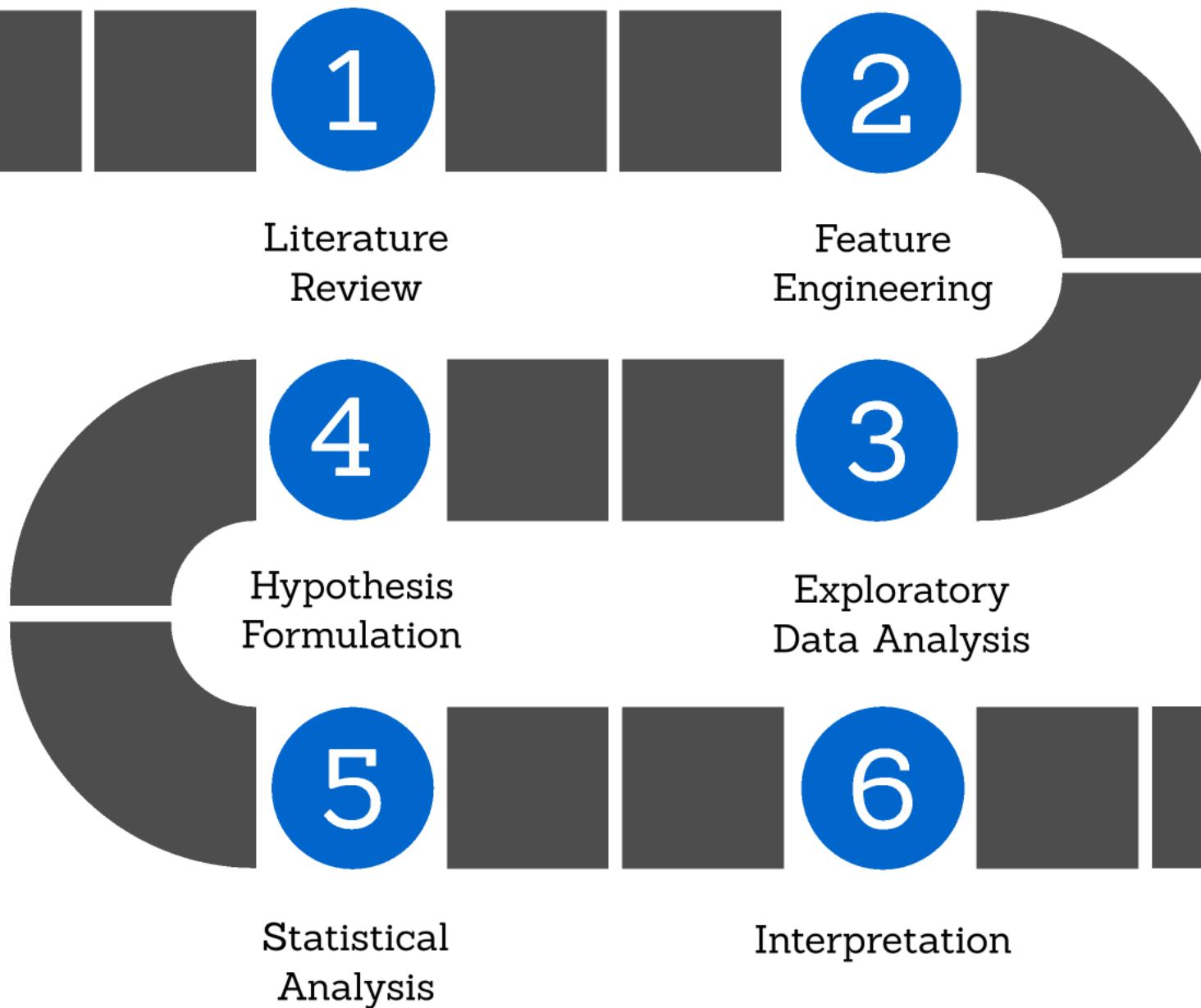


Recreate expirments using virtual
mouse, virtual stimuli.



Different Dataset, Different
Experiment.

Orientation Selectivity Map in mice



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