Introduction to Linear Algebra in Python

Part II: Matrices

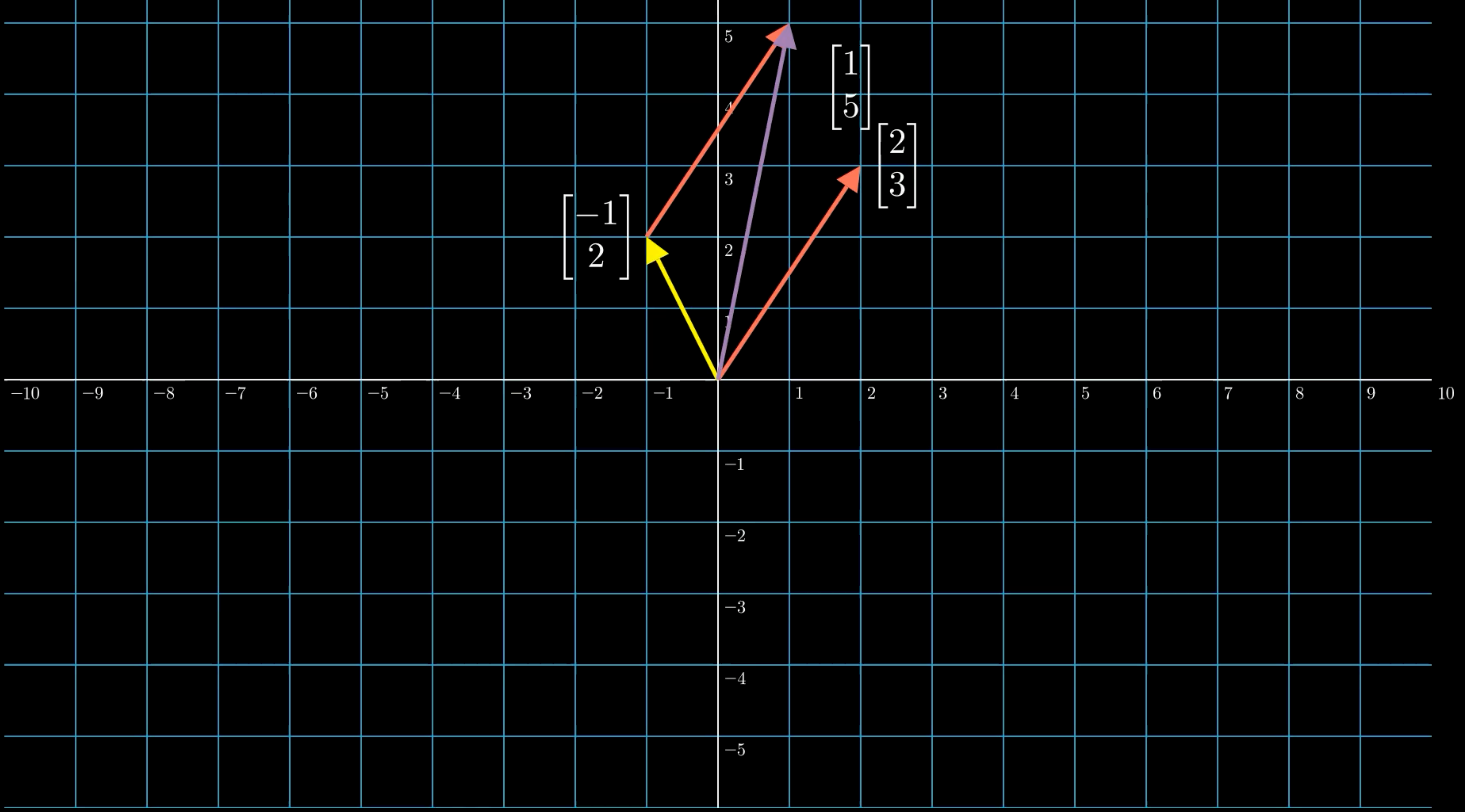
BILD 62

Reminders

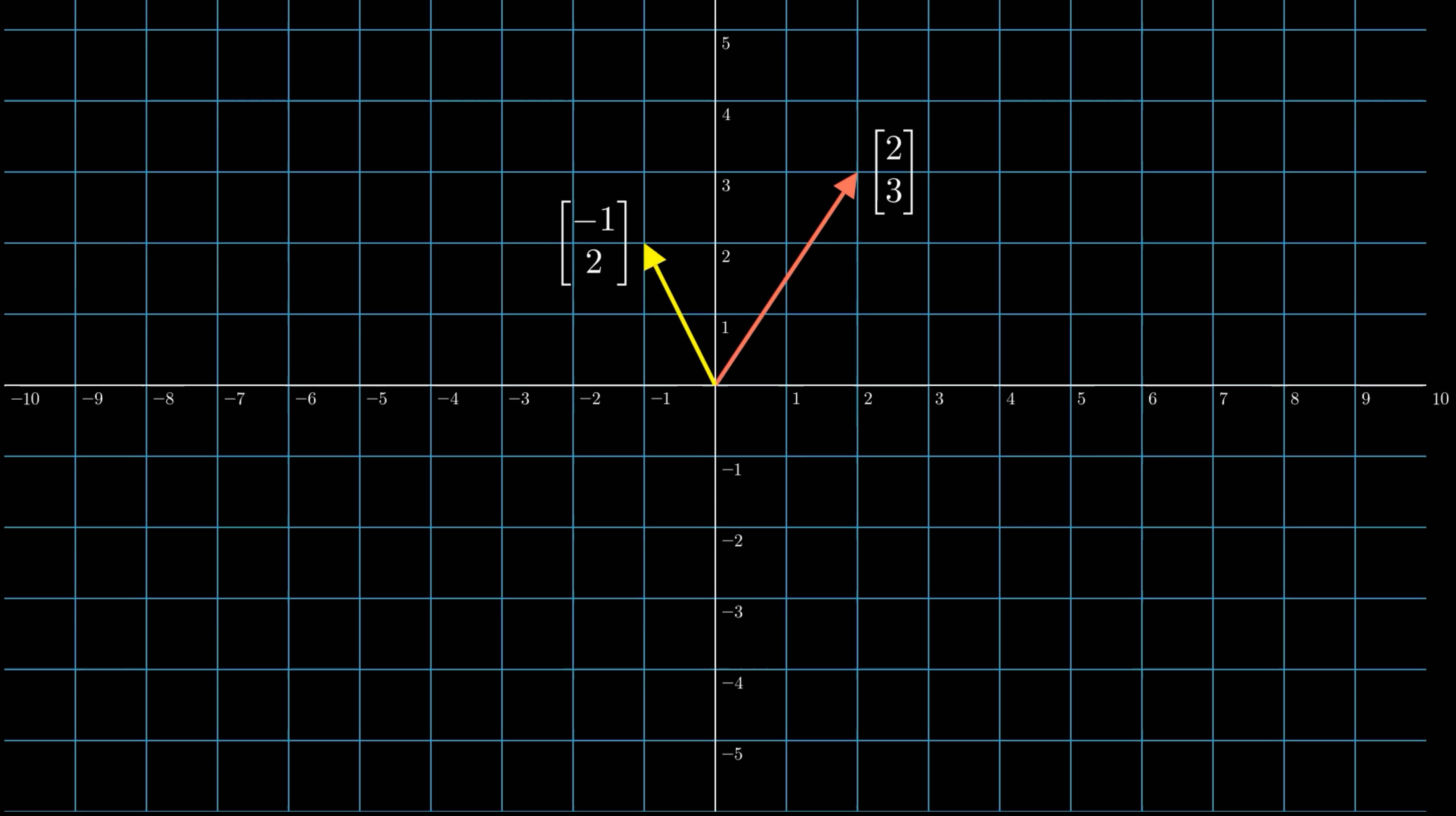
Last time we talked about:

- Different ways to conceptualize a vector, either as a list of numbers of as an arrow in space
- Different operations you can do with vectors (addition, subtraction, scalar multiplication, dot products)

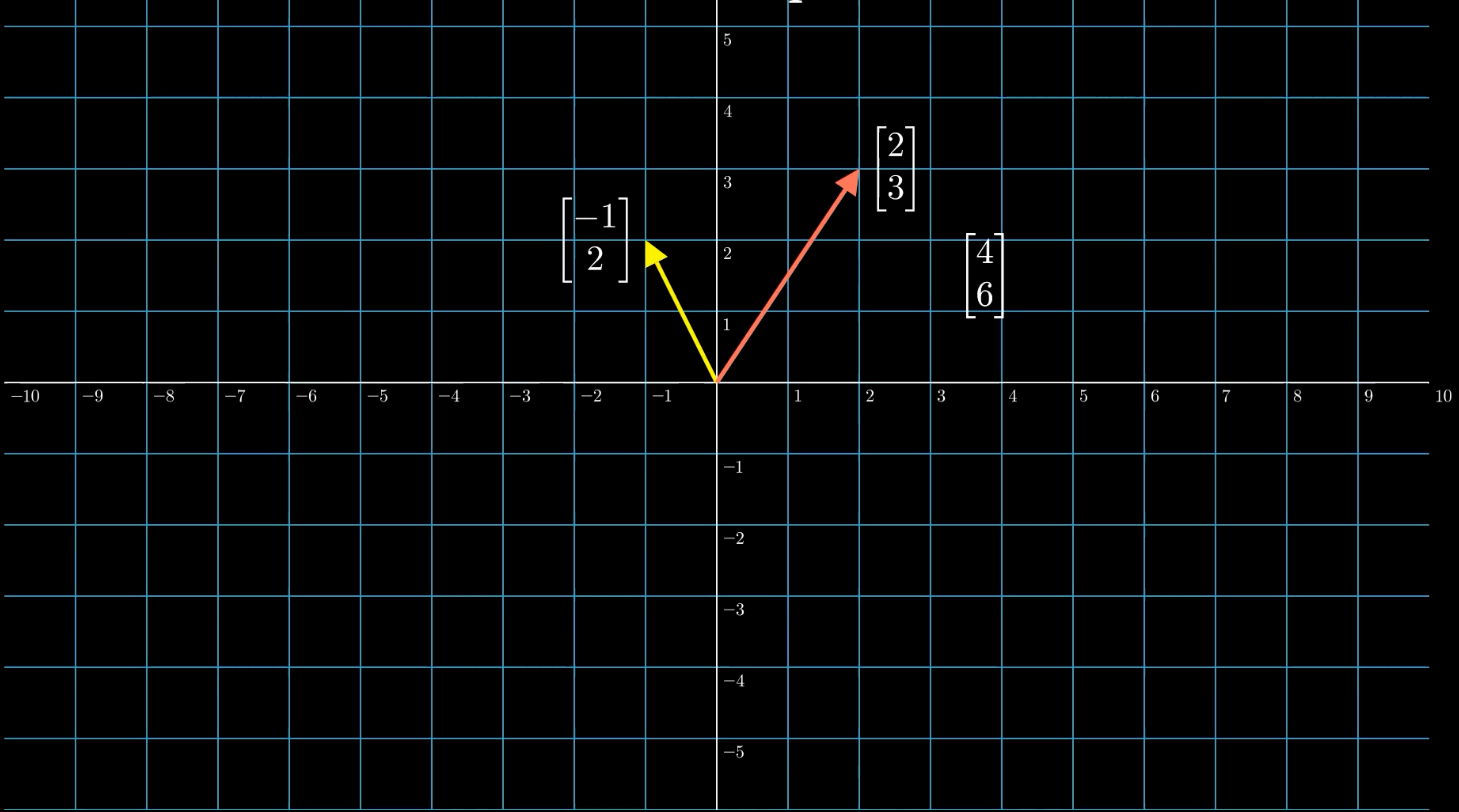
Vector Addition



Vector Subtraction



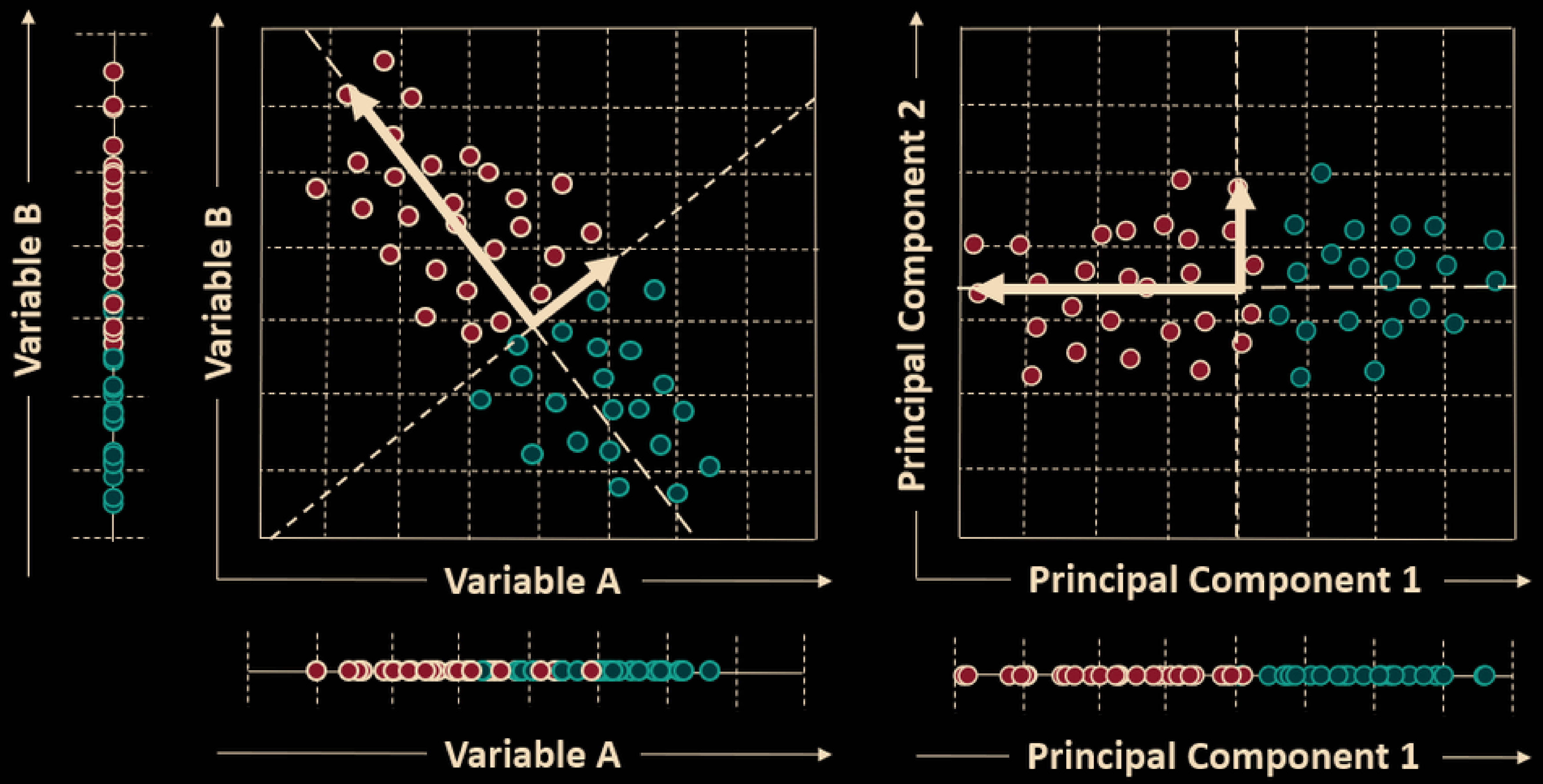
Scalar Multiplication



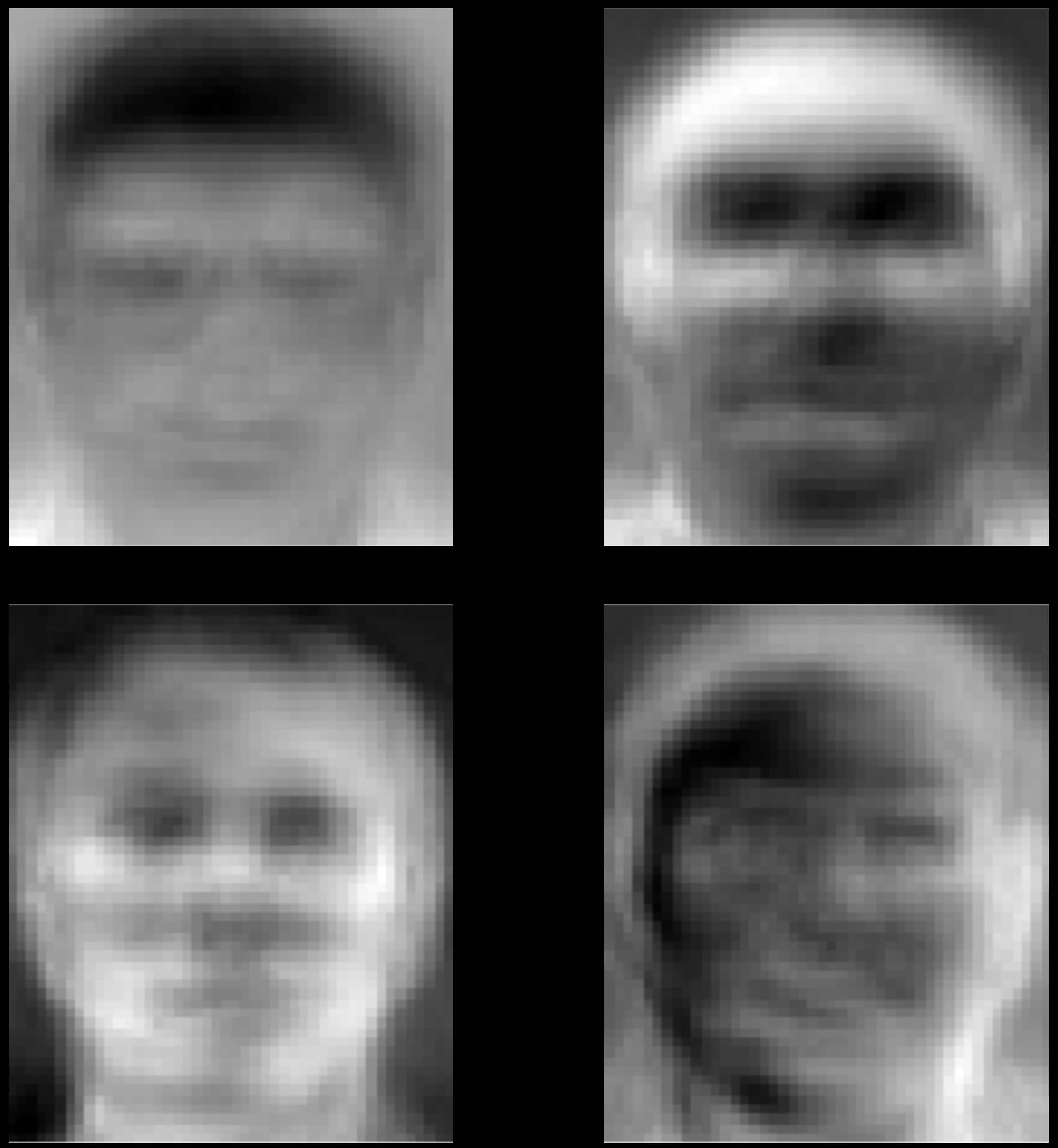
By the end of this lecture, you will be able to:

- Construct and multiply matrices in Python (and by hand)
- Create and manipulate special cases of matrices
- Explain matrices as a linear transformation and relate matrix properties to properties of that linear transformation
- Define what eigenvalues/ eigenvectors are and determine them using Python

What’s the fuss about eigenvectors?



Great video on PCA (video)



Eigenfaces

The example for today's notebook will focus on the visual system — specifically connections from the **retina** to the **LGN**, a visual nucleus in the **thalamus**

The retina *projects* to the LGN

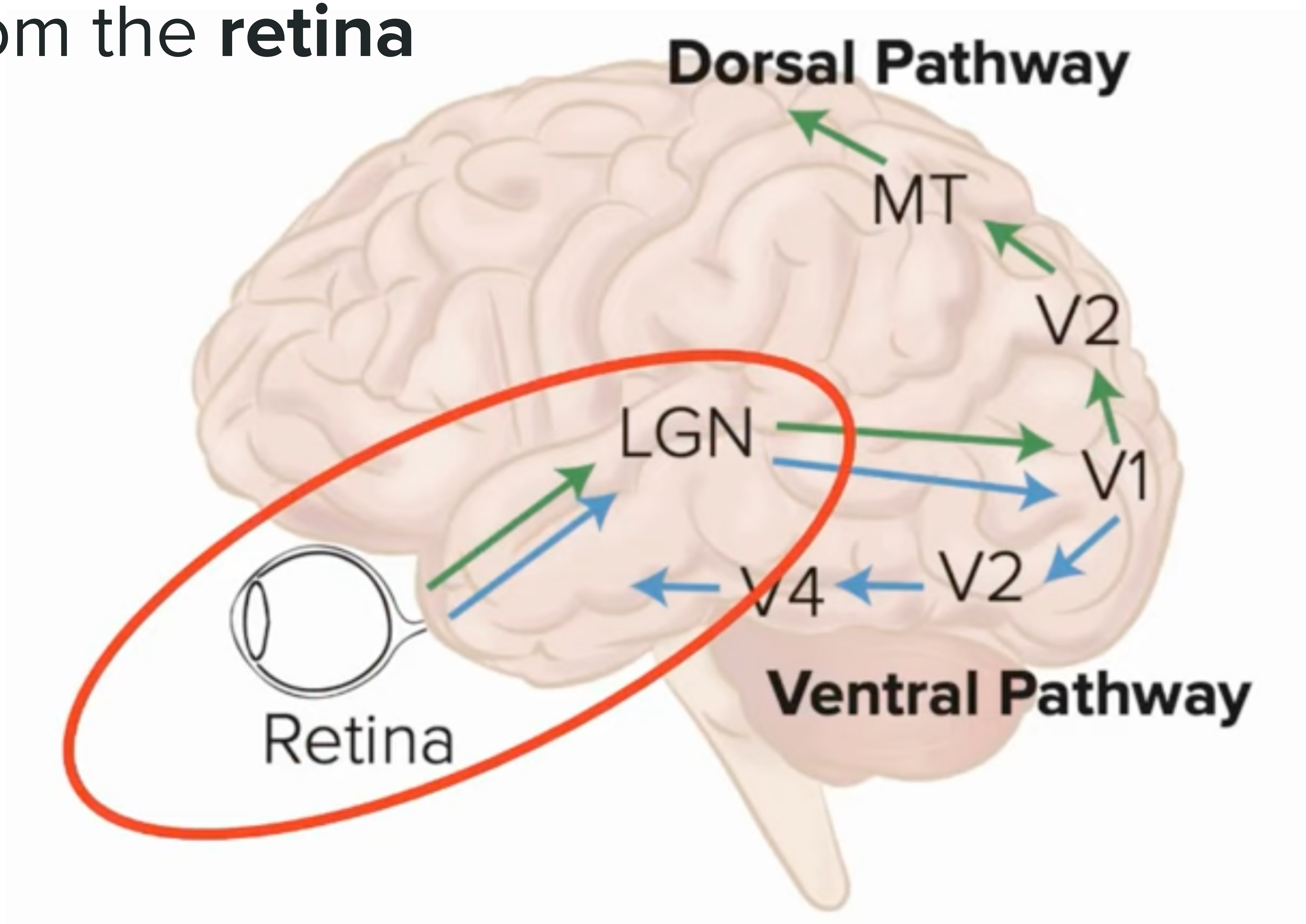
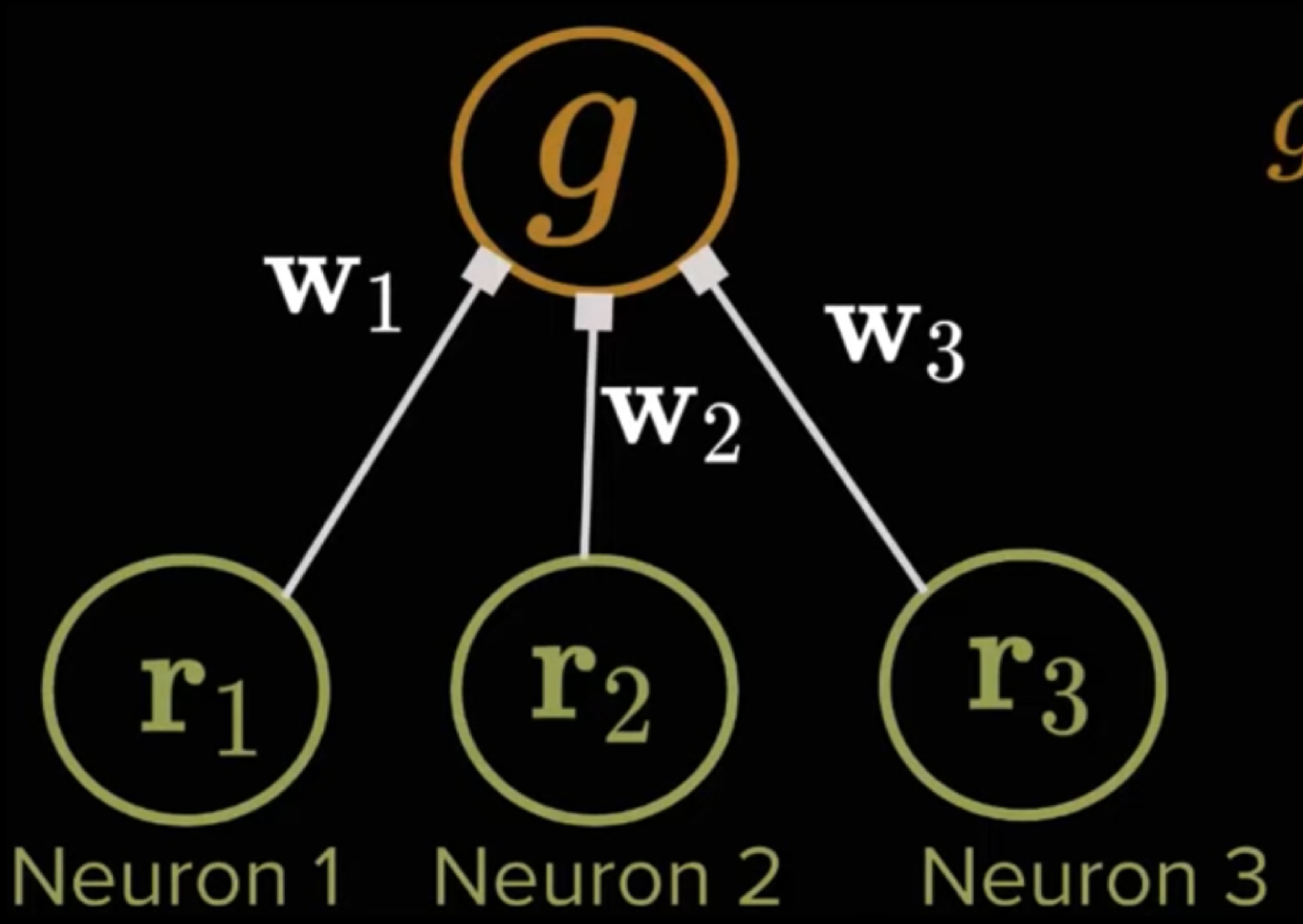


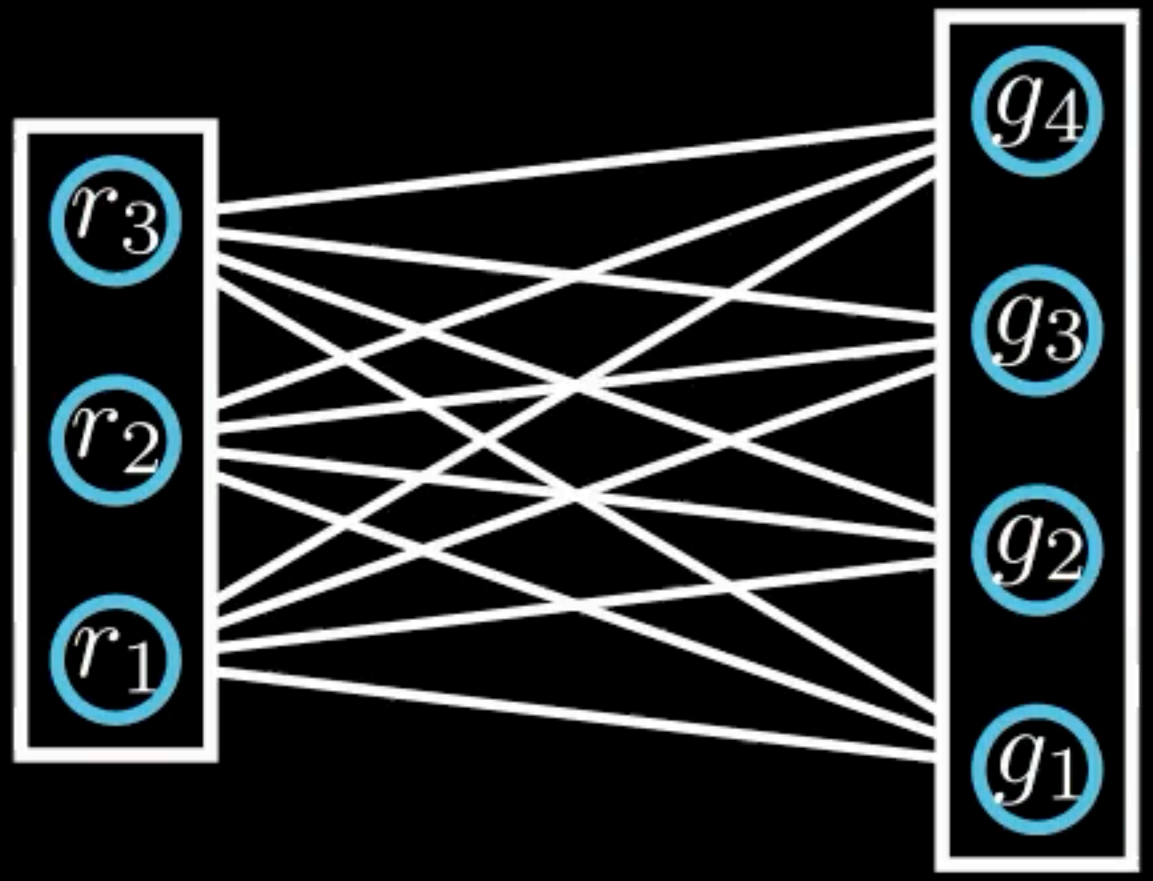
Image: Neuromatch Academy

We can describe LGN activity as an equation,
summing the weights (w) * activities (r) of each retina neuron.

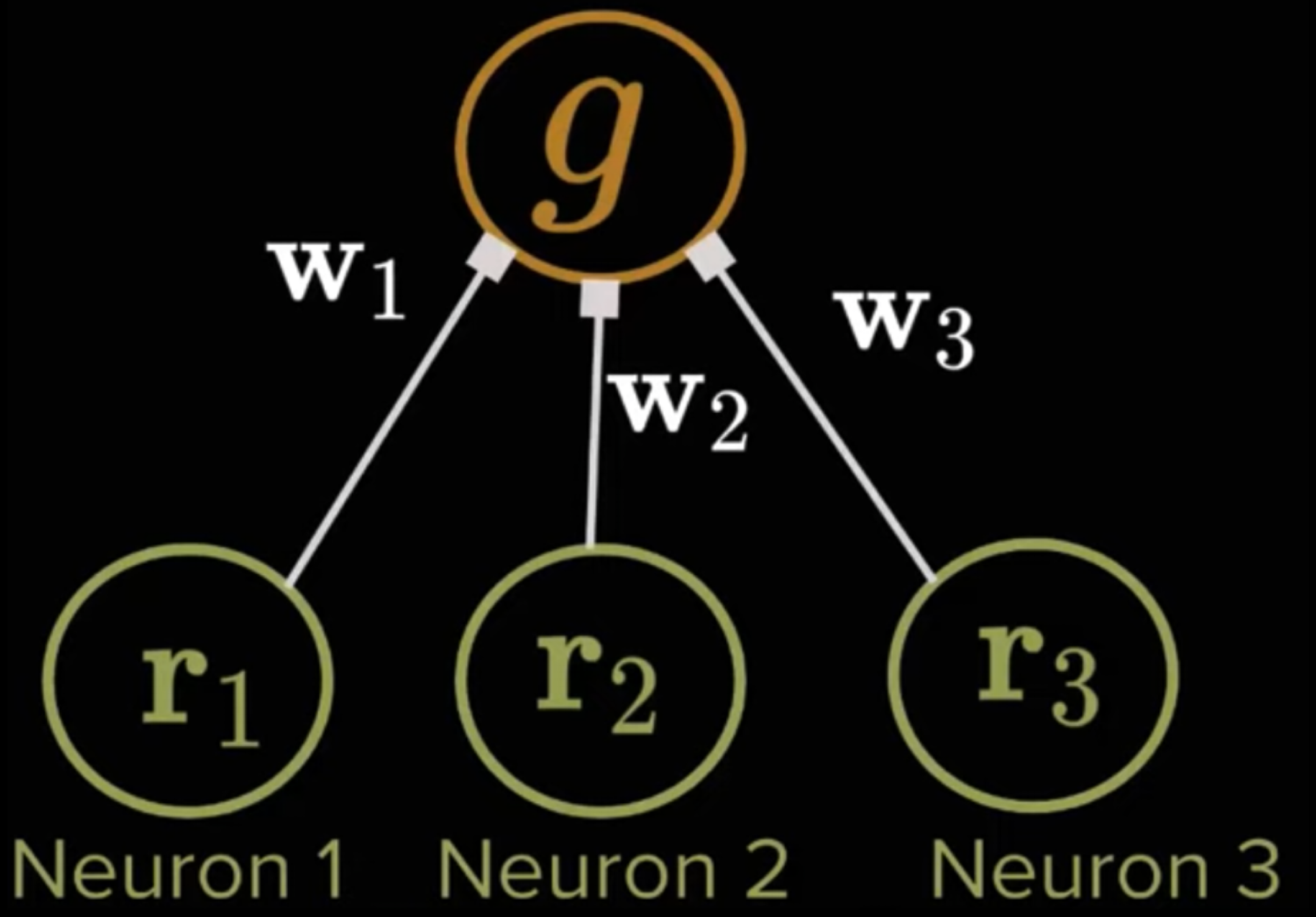


$$g = w_1 r_1 + w_2 r_2 + w_3 r_3$$

We can call
this a
weighted sum

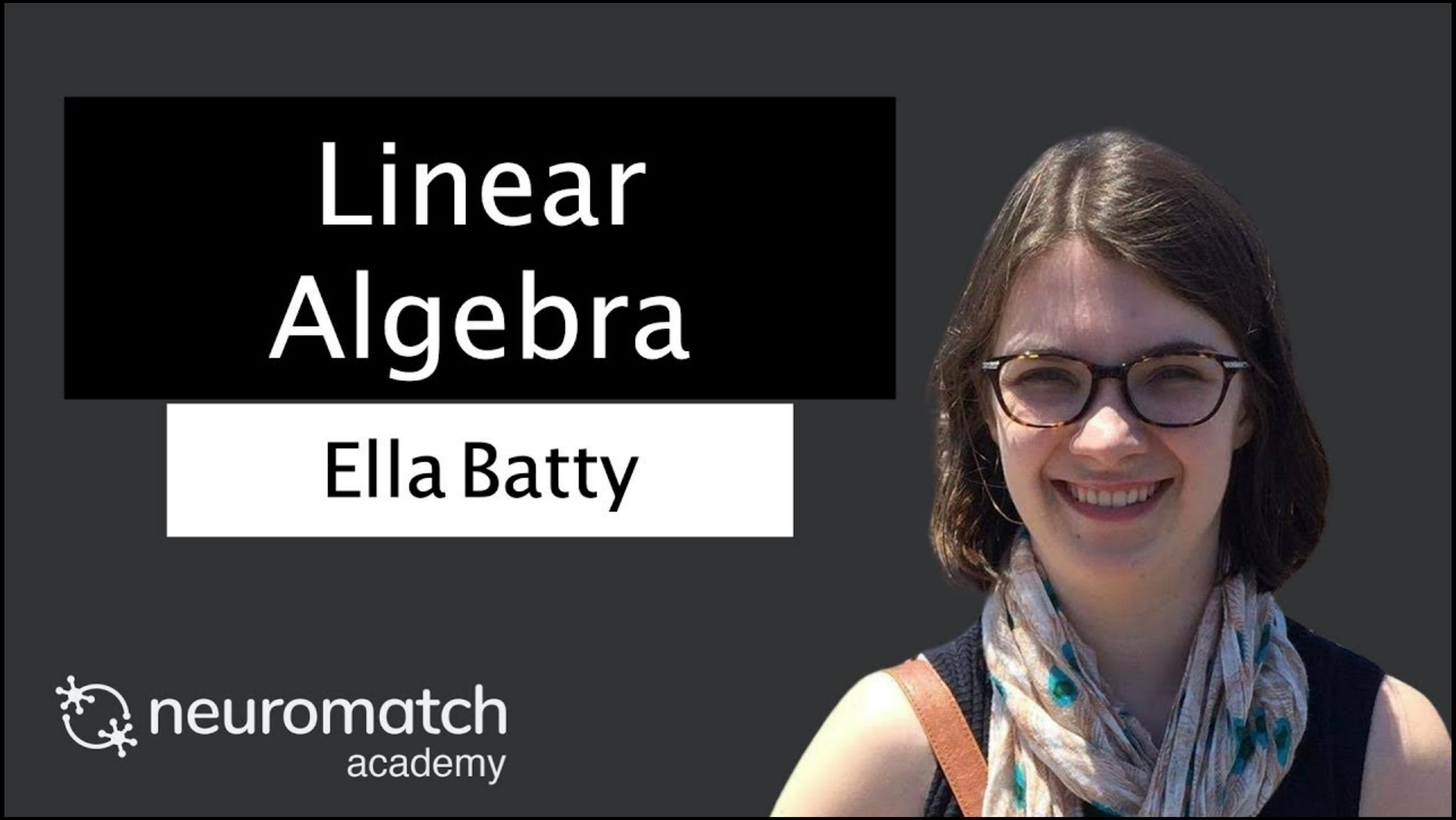

r_3
r_2
r_1
g_4
g_3
g_2
g_1

We can simplify this by using vectors, and computing the dot product.



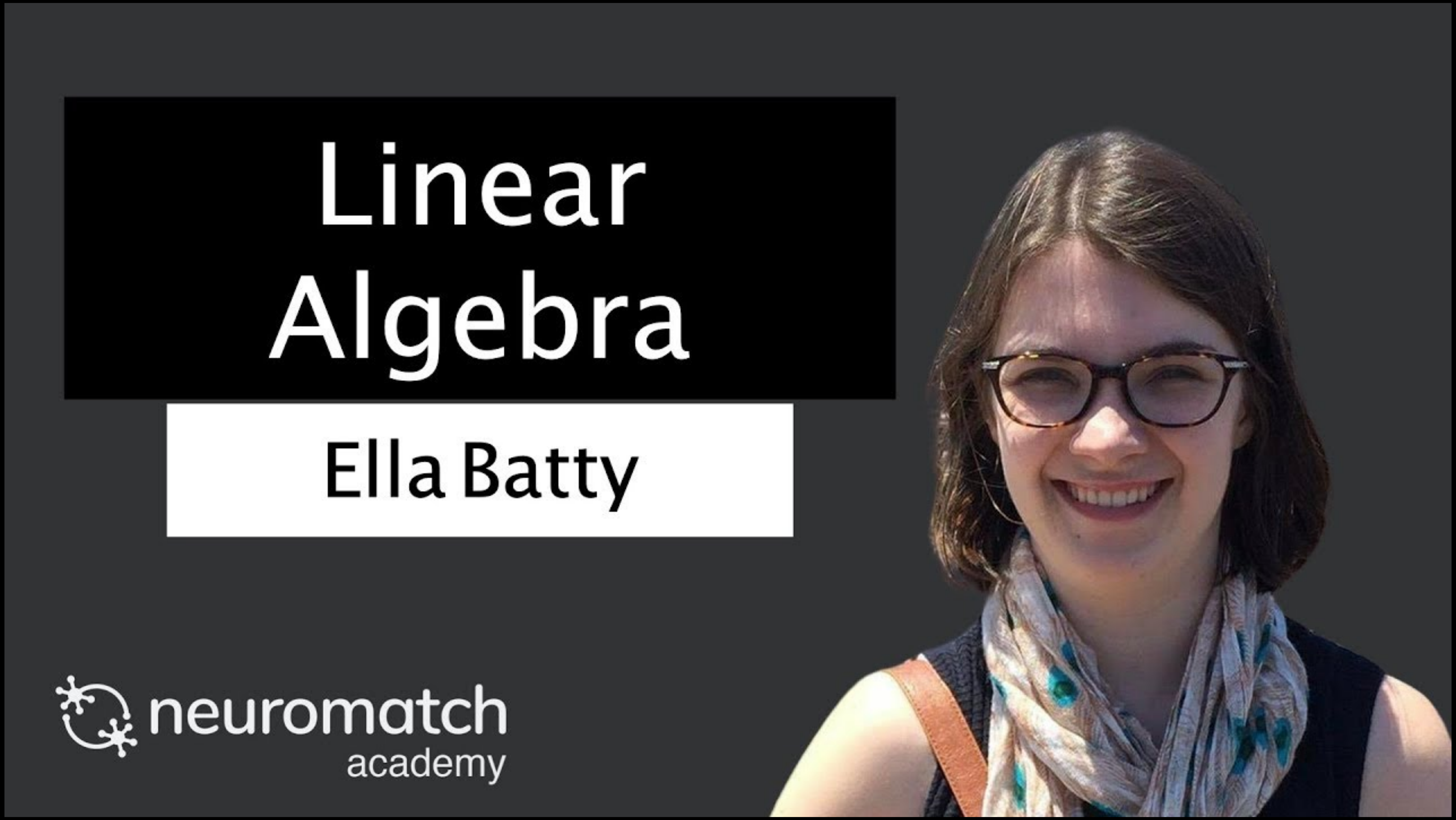
$$\mathbf{w} = \begin{bmatrix} \mathbf{w}_1 \\ \mathbf{w}_2 \\ \mathbf{w}_3 \end{bmatrix} \qquad \mathbf{r} = \begin{bmatrix} \mathbf{r}_1 \\ \mathbf{r}_2 \\ \mathbf{r}_3 \end{bmatrix}$$

$$\begin{aligned} g &= \mathbf{w} \cdot \mathbf{r} \\ &= \mathbf{w}_1\mathbf{r}_1 + \mathbf{w}_2\mathbf{r}_2 + \mathbf{w}_3\mathbf{r}_3 \end{aligned}$$



Building a model of neural connections using linear equations

Let’s try this in the notebook.



Thinking about the computations as linear transformations of matrices

Additional resources

https://www.youtube.com/watch?v=Ene_TYyTdNM — modeling neural connections as vectors and dot product review

http://matrixmultiplication.xyz/ — awesome visualization of matrix multiplication!

Essence of linear algebra - YouTube