

# **Week 1: Introduction**

**Matthew Caldwell**

**COMP0088 Introduction to Machine Learning • UCL Computer Science • Autumn 2025**

# Course Outline

## 1. Introduction

- 2. Linear Models
- 3. Non-Parametric Models
- 4. Linear Models Revisited
- 5. Neural Networks
- 6. More Neural Networks

Supervised  
Learning

- 7. Clustering & Dimensionality Reduction
- 8. Mixture Models & Expectation Maximisation

Unsupervised  
Learning

- 9. Deep Learning Applications & Pitfalls
- 10. Fun & Games

# Prerequisites

- Linear Algebra
  - Calculus
  - Probability & Statistics
  - Python Programming
- NB: This is not a course in any of these subjects.  
Our focus is **pragmatic**: these are tools we need to get stuff done.

# Format

- Pre-recorded lectures
  - 1–2 hours in ~15 minute chunks
- In person lecture / Q&A
  - Thursday, 15:00–16:30
- In person practical labs
  - Friday 10:00–12:00 / 12:00–14:00
- Optional drop in – “office hour”
  - Friday 15:00–16:00, Hub 4

- Video and slides available the previous week
- Watch at your own pace
- ...but preferably **before** in person sessions

- Ask questions live or in advance on forum
- Latter might get priority

- These are the heart of the module!
- Exercises available the previous week

- One-to-one or small group
- For “private” questions
- Q&A/labs better for most topics

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# Assessment

- Exam (70%)
  - In person
  - 2 hours
  - Closed book but some relevant formulae will be provided
  - Standard calculators only, no computational tools
- Coursework (30%)
  - Jupyter notebook with coding and written answers
  - Individualised data
  - Release 29 October, submission deadline 12 November

# Ethos

- People learn in different ways
- You are responsible for your own engagement
  - If you can't stand to watch the videos, at least read the slides
  - Whatever you do, do it before Thursday
- ML is a practical discipline mediated by programming
  - Doing the practical exercises will really help your understanding
  - If you shun programming you won't get the most from ML and will struggle with the coursework
  - But there is no coding in the exam

## Week 1 Recap

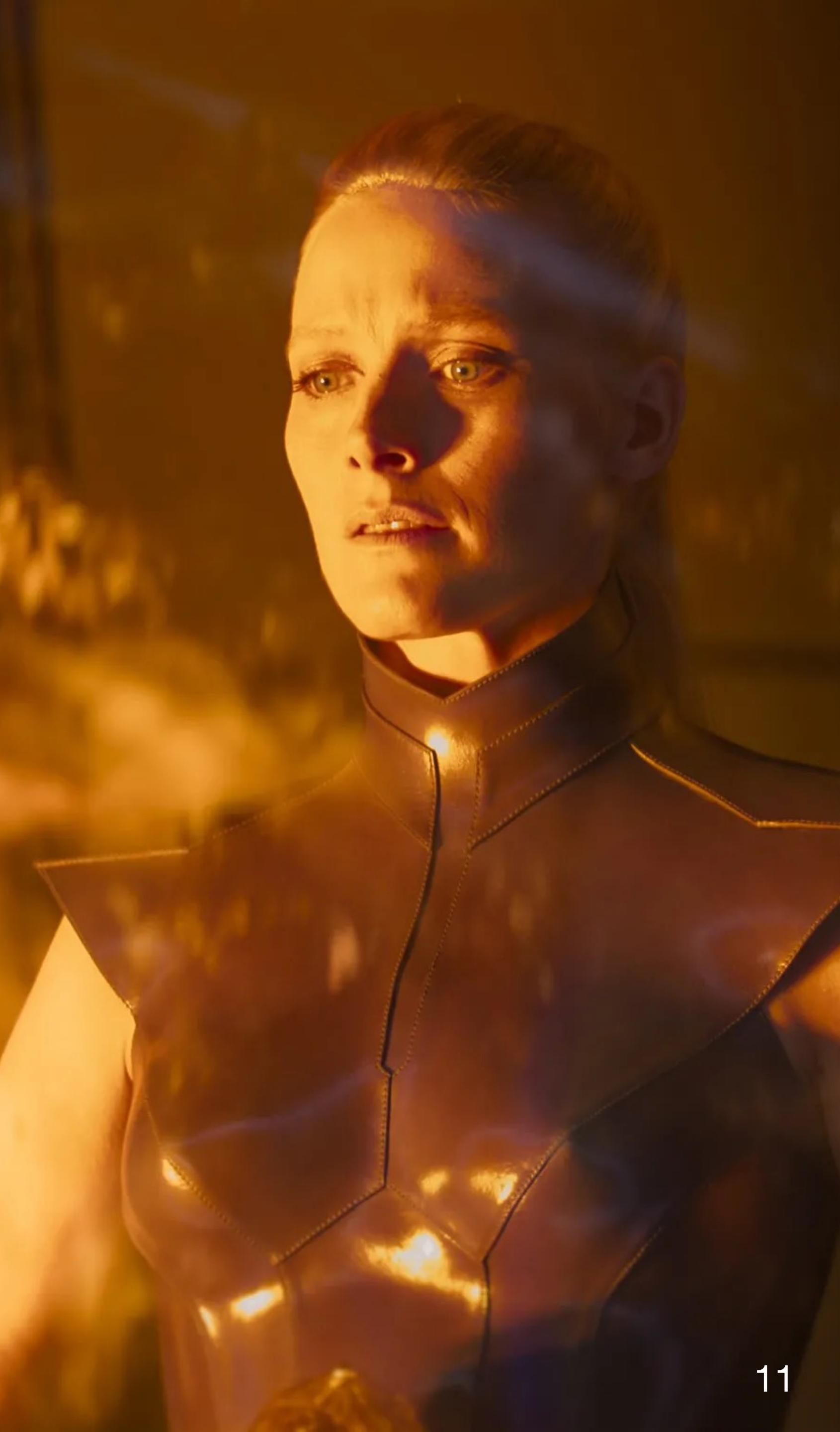
# The Three Laws of Machine Learning

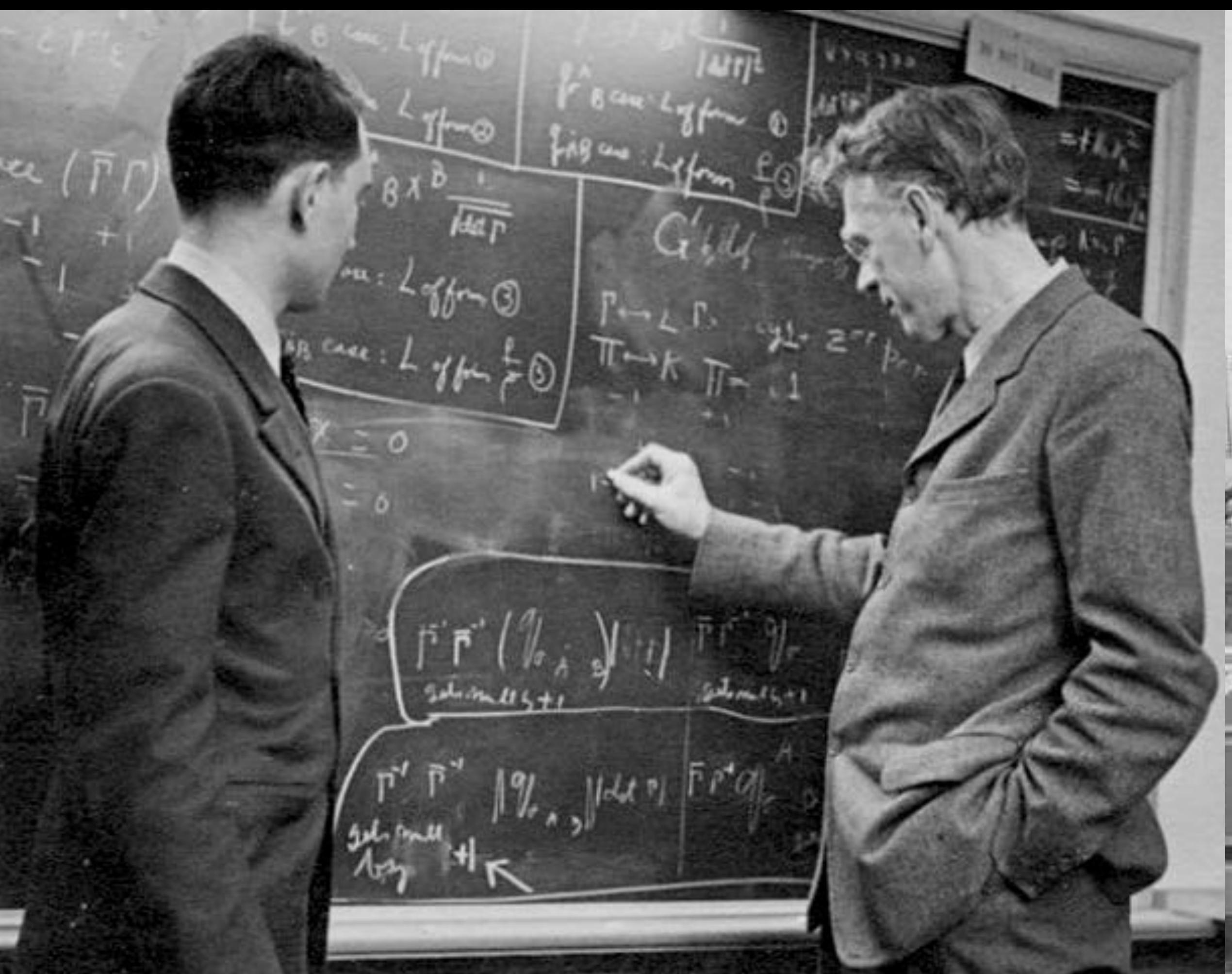
# The Zeroth Law of Machine Learning

**Laws are just models  
and all models are wrong**

The First Law of Machine Learning

**Machine Learning is parameter fitting**





**learn** | lə:n |

verb (past and past participle **learned** | lə:nt, lə:nd | or mainly British **learnt** | lə:nt | ) [with object]

**1** gain or acquire knowledge of or skill in (something) by study, experience, or being taught: *they'd started learning French* | [with infinitive] : *she is learning to play the piano* | [no object] : *we learn from experience.*

- commit to memory: *I'd learned too many grim poems in school.*
- become aware of (something) by information or from observation: [with clause] : *I learned that they had eaten already* | [no object] : *the trading standards office learned of the illegal network.*

**2** archaic or informal teach (someone): 'That'll learn you,' he chuckled | [with object and infinitive] : *we'll have to learn you to milk cows.*

ChatGPT

**Write a limerick about Jeremy Bentham**

**Jeremy Bentham, a thinker so bright,  
In ethics, he shed a clear light.**

**Utilitarian he'd preach,  
The greatest good within reach,  
For happiness, he'd gladly fight!**

MidJourney

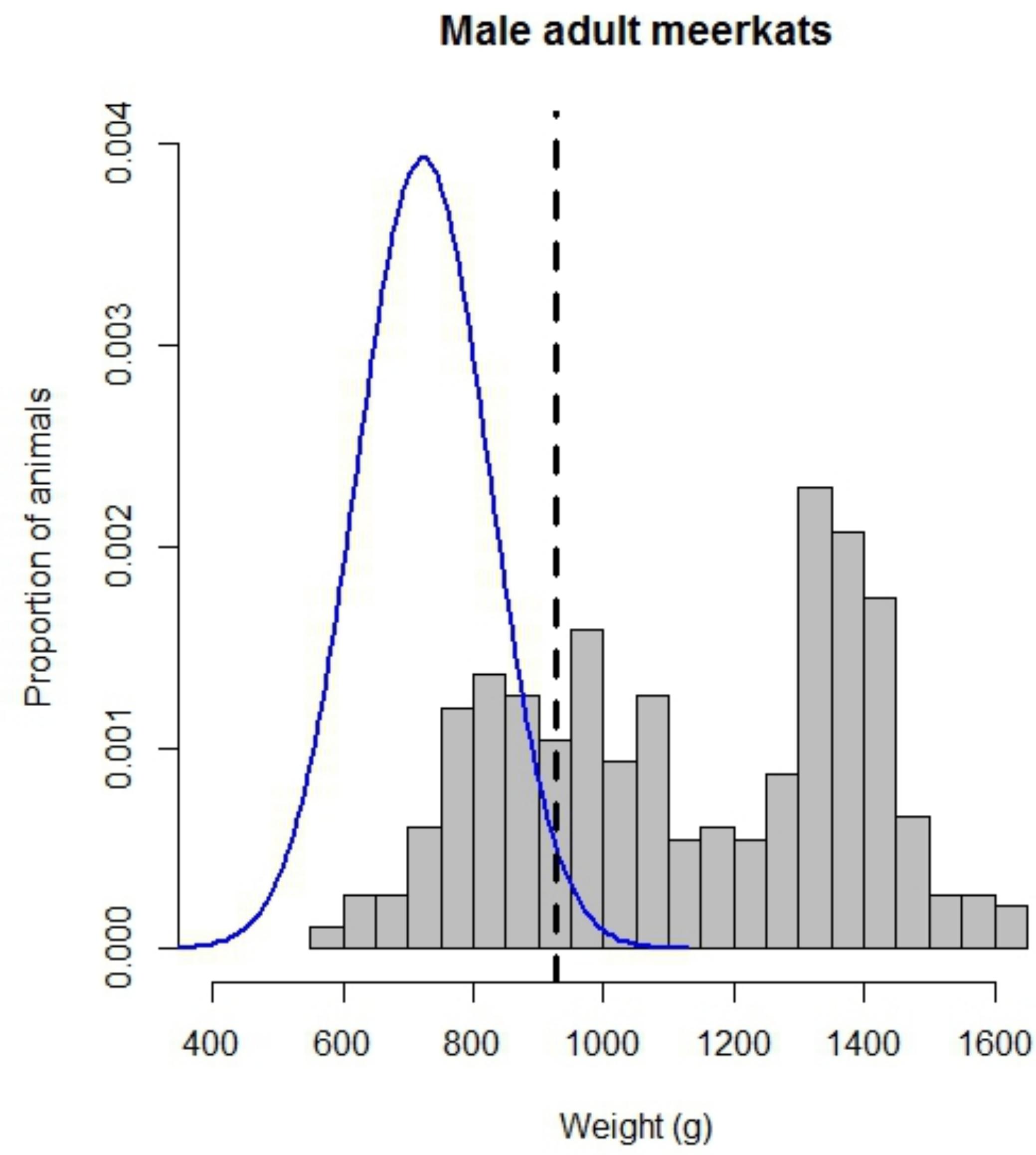
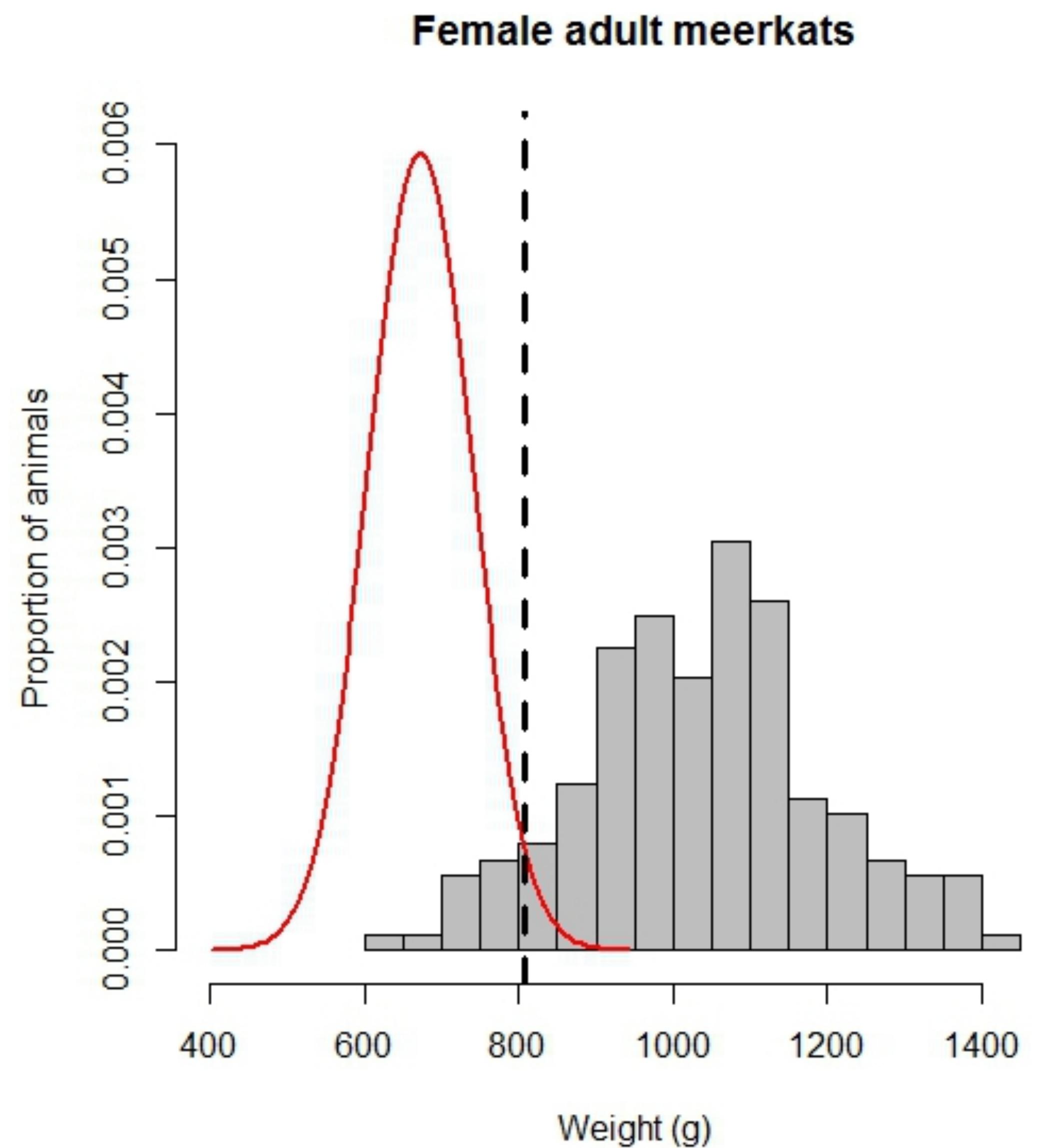
**/imagine Boris Johnson appearing  
on Strictly Come Dancing after  
leaving politics in disgrace**



The First Law of Machine Learning

**Machine Learning is parameter fitting**

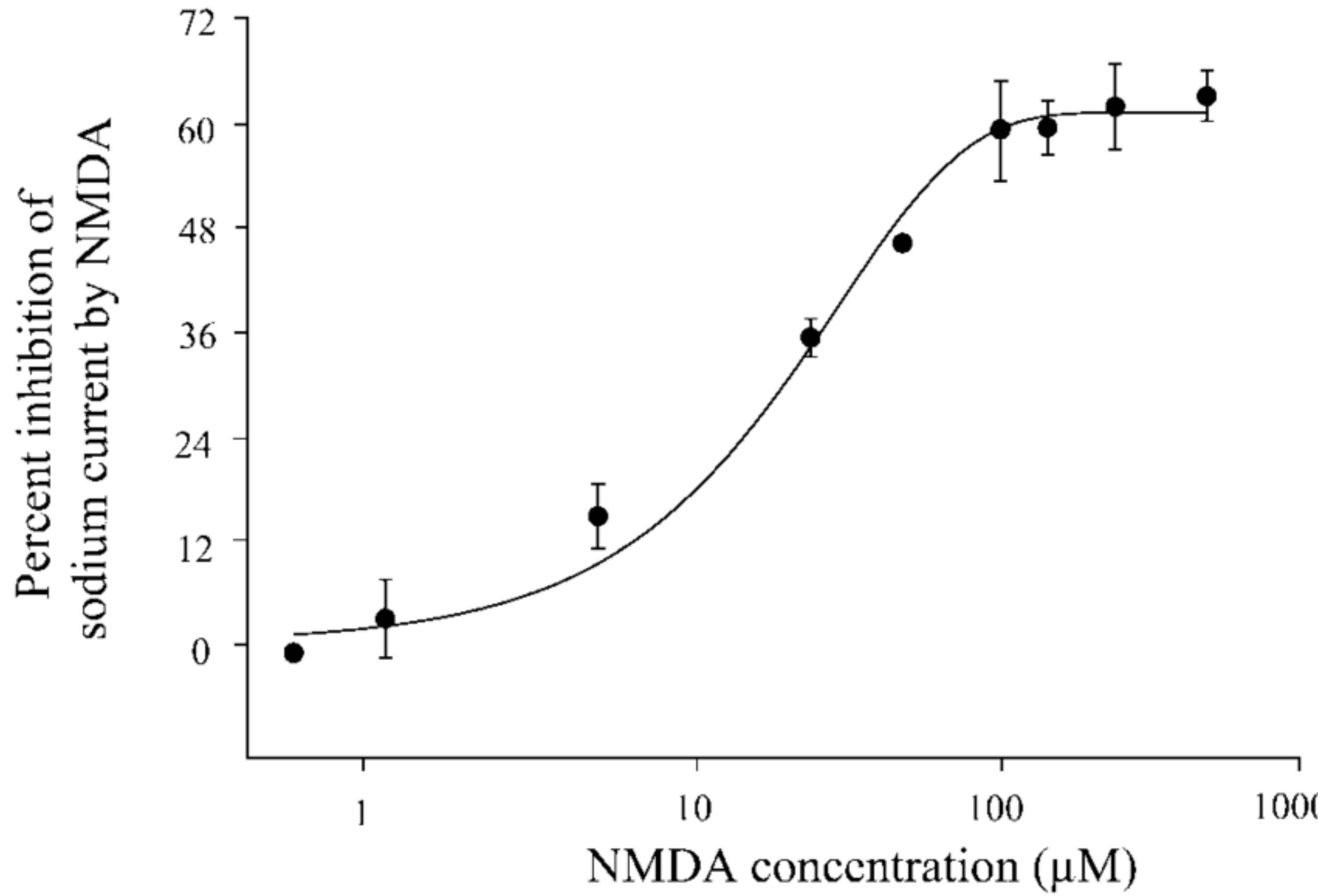


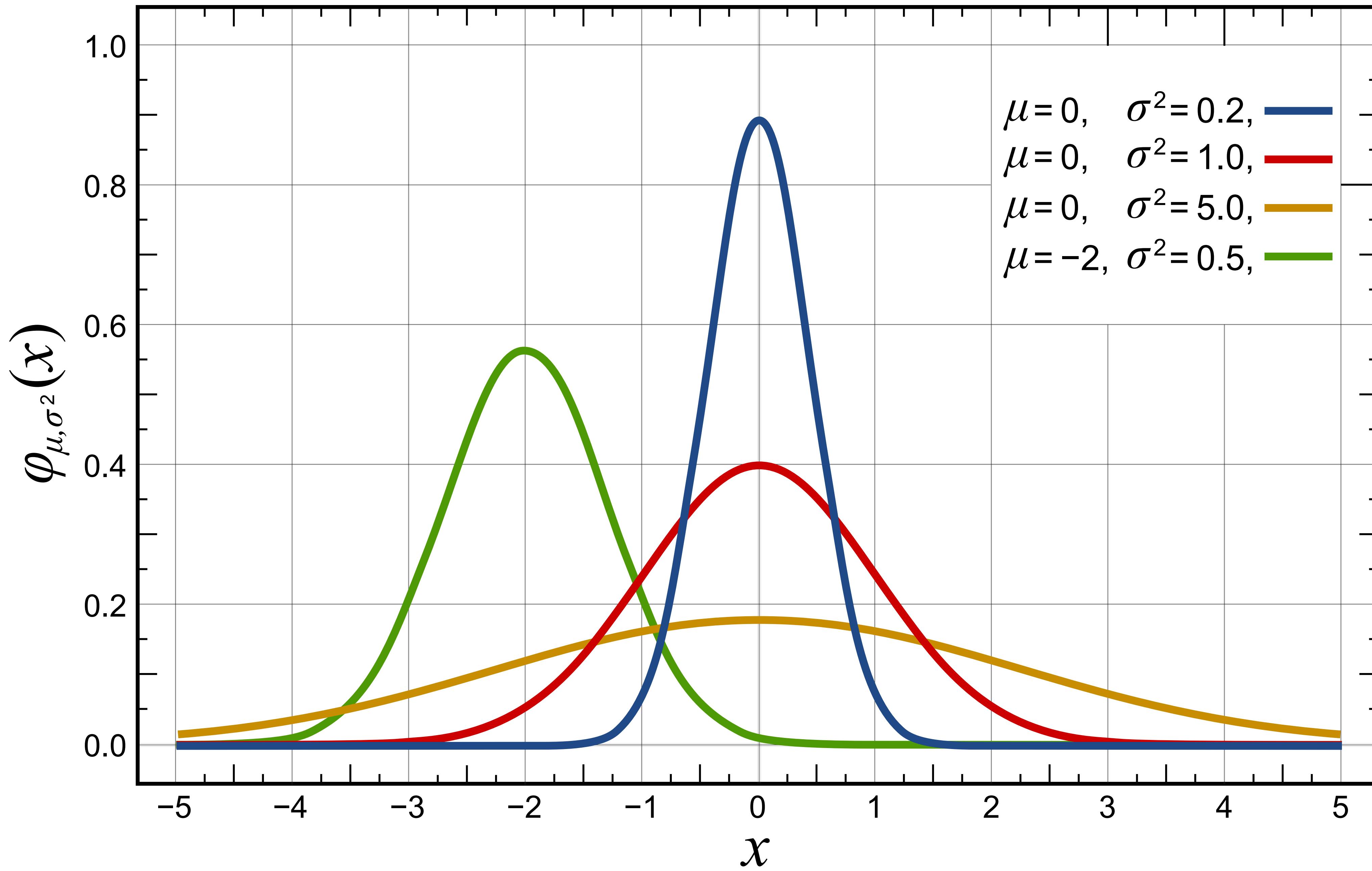


# Higher average incomes are associated with higher life expectancy

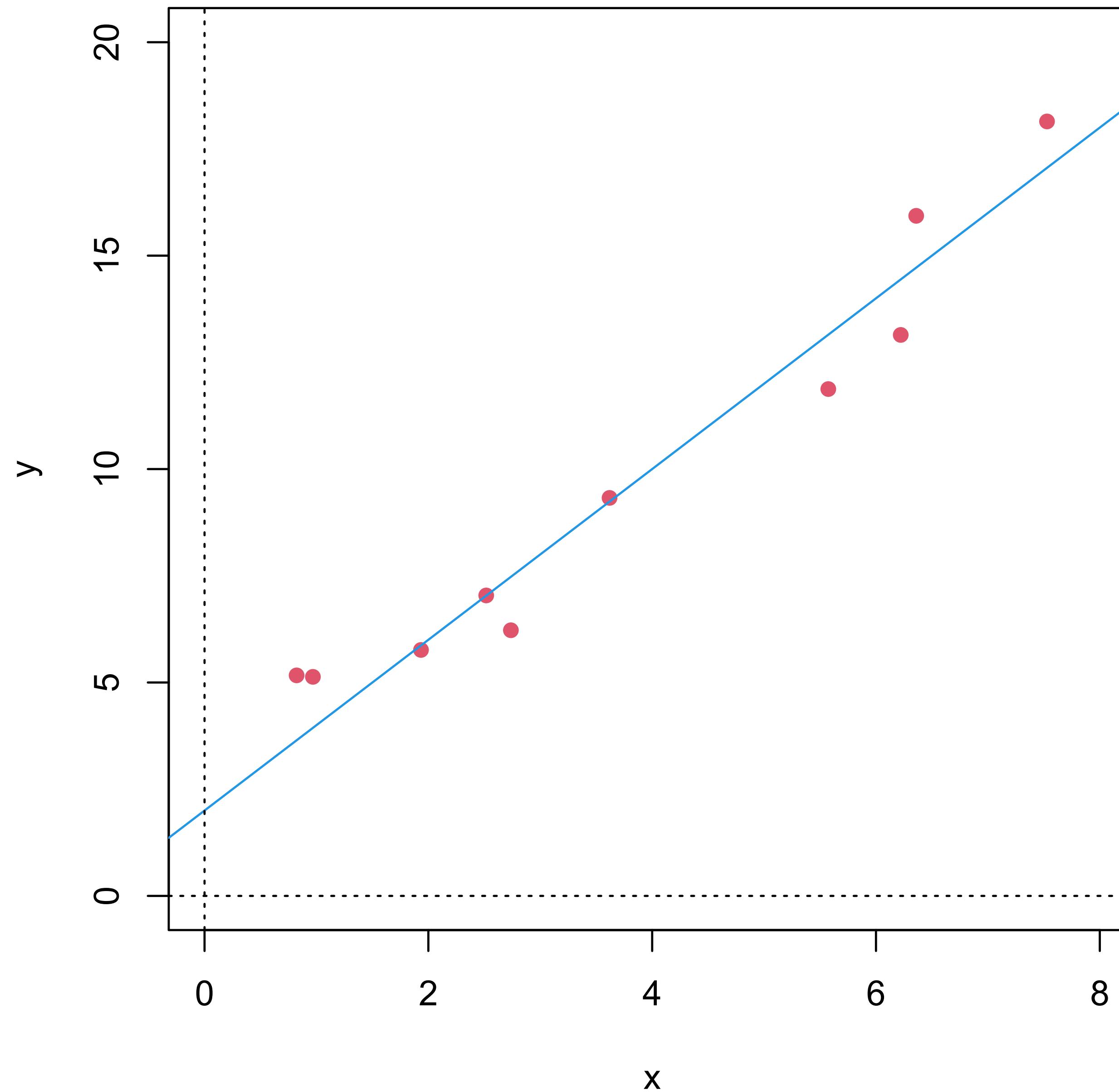
Relationship between life expectancy and net household income for men and women, by neighbourhood: England, 2016–20







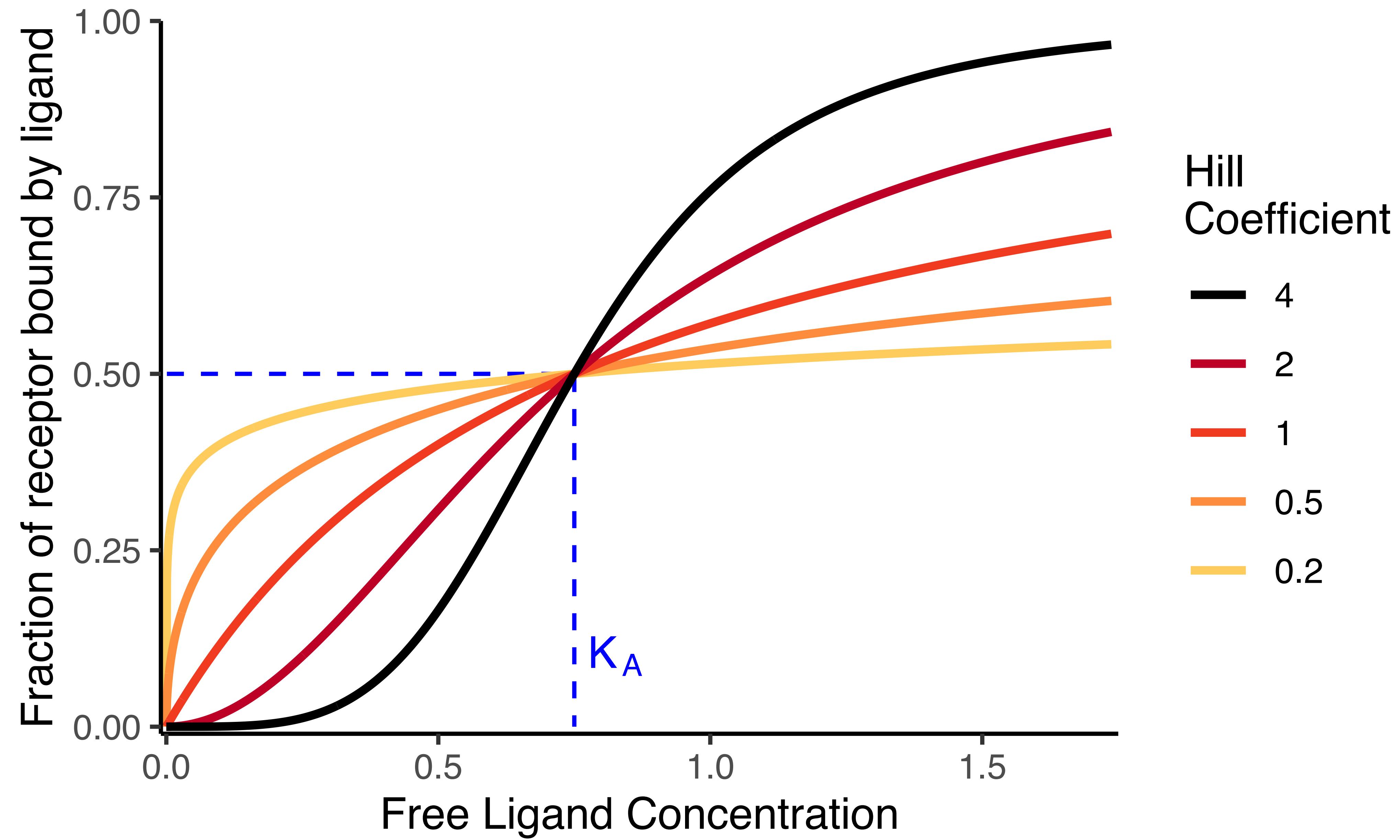
## Simple Linear Model



$$y = ax + b$$

$a \rightarrow \text{slope}$

$b \rightarrow \text{intercept}$

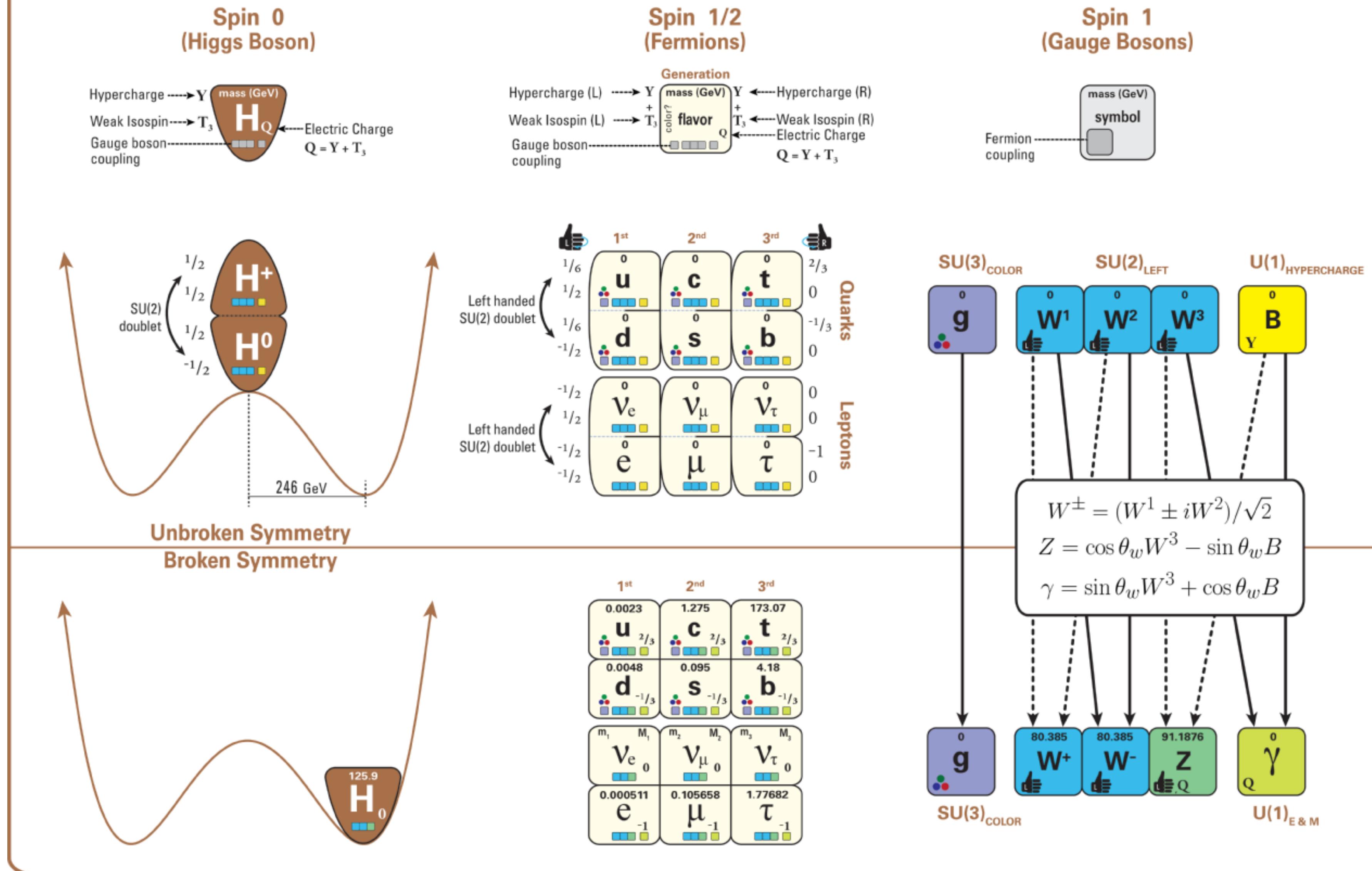


$$C(S_t, t) = N(d_+)S_t - N(d_-)Ke^{-r(T-t)}$$

$$d_+ = \frac{1}{\sigma\sqrt{T-t}} \left[ \ln\left(\frac{S_t}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t) \right]$$

$$d_- = d_+ - \sigma\sqrt{T-t}$$

# The Standard Model of Particle Physics



# ChatGPT:

# ChatGPT: billions of parameters



**ChatGPT: billions of parameters**

**MidJourney:**

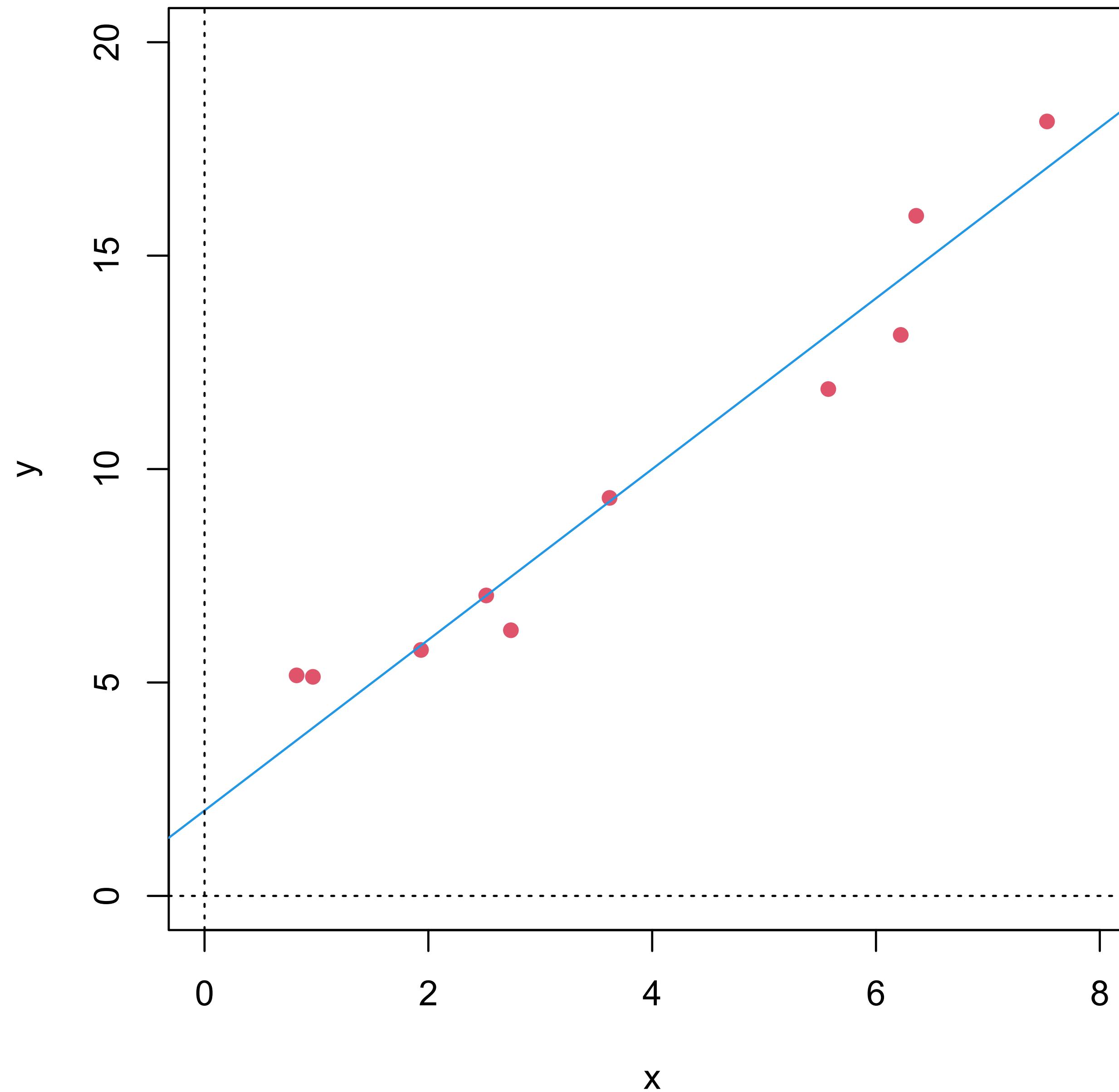
**ChatGPT: billions of parameters**

**MidJourney: ???**

**ChatGPT: billions of parameters**

**MidJourney:  $10^8 - 10^{12}$**

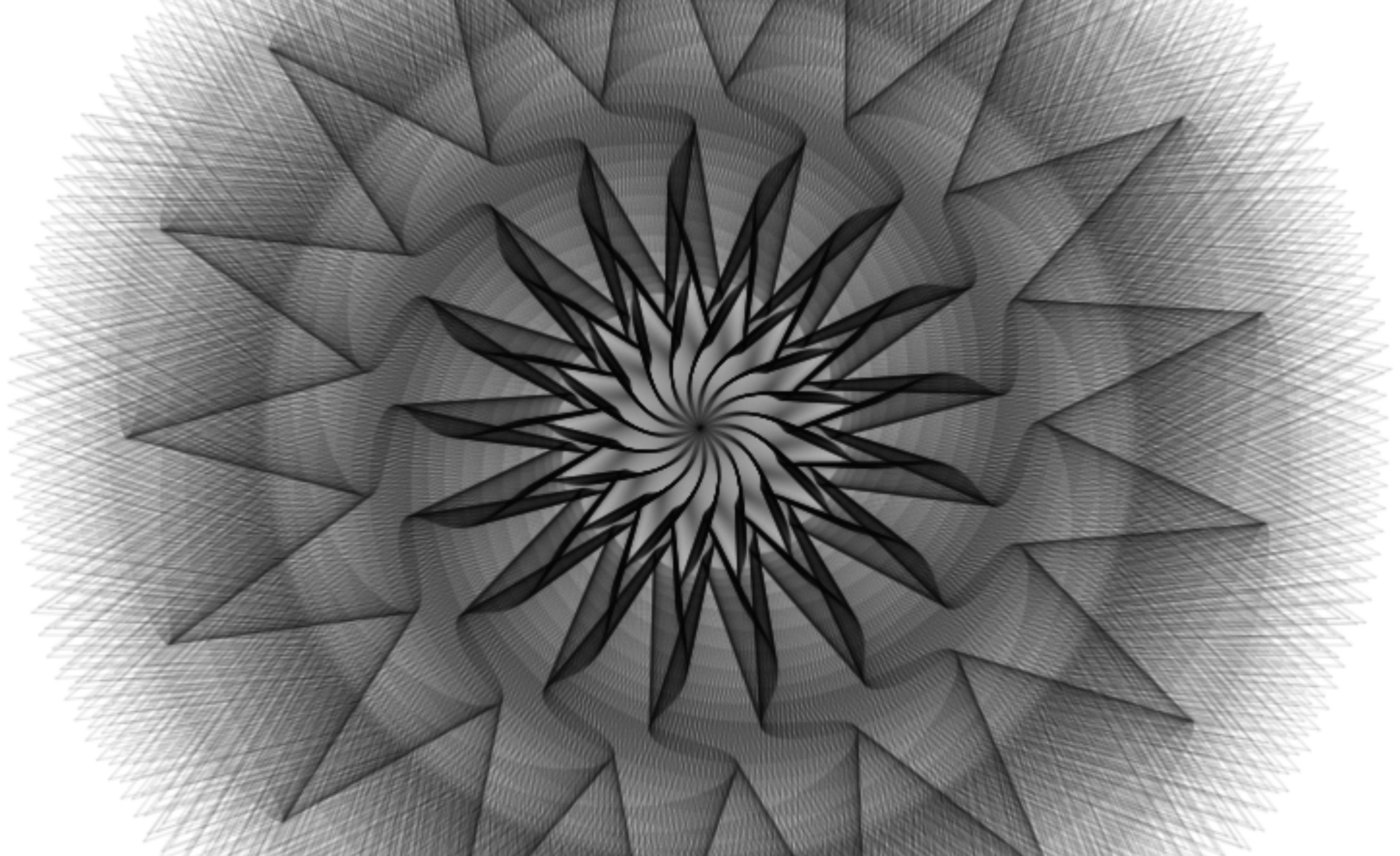
## Simple Linear Model

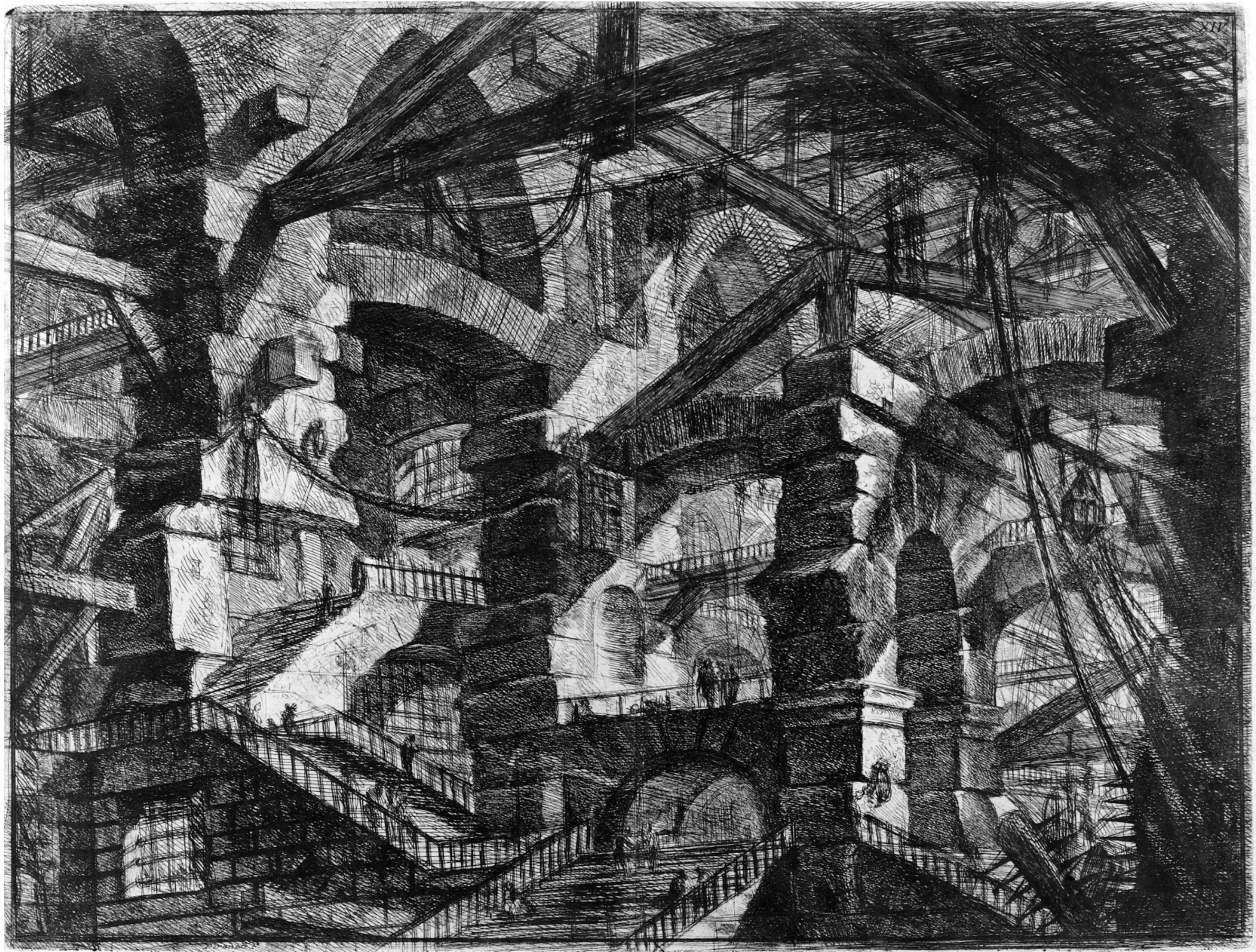


$$y = ax + b$$

$a \rightarrow \text{slope}$

$b \rightarrow \text{intercept}$







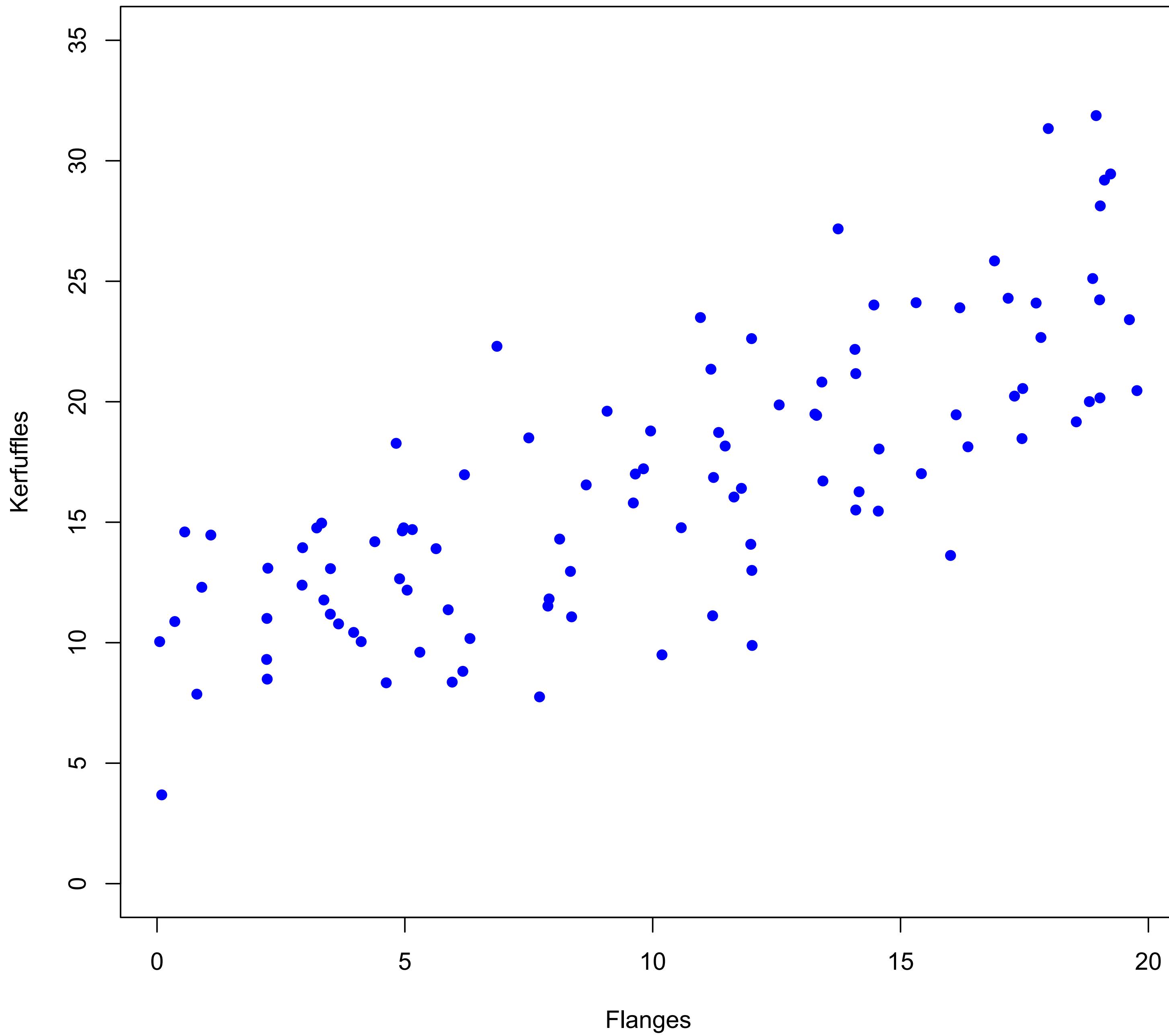
With four parameters I can fit an elephant, and with five I can make him wiggle his trunk

— *John Von Neumann*

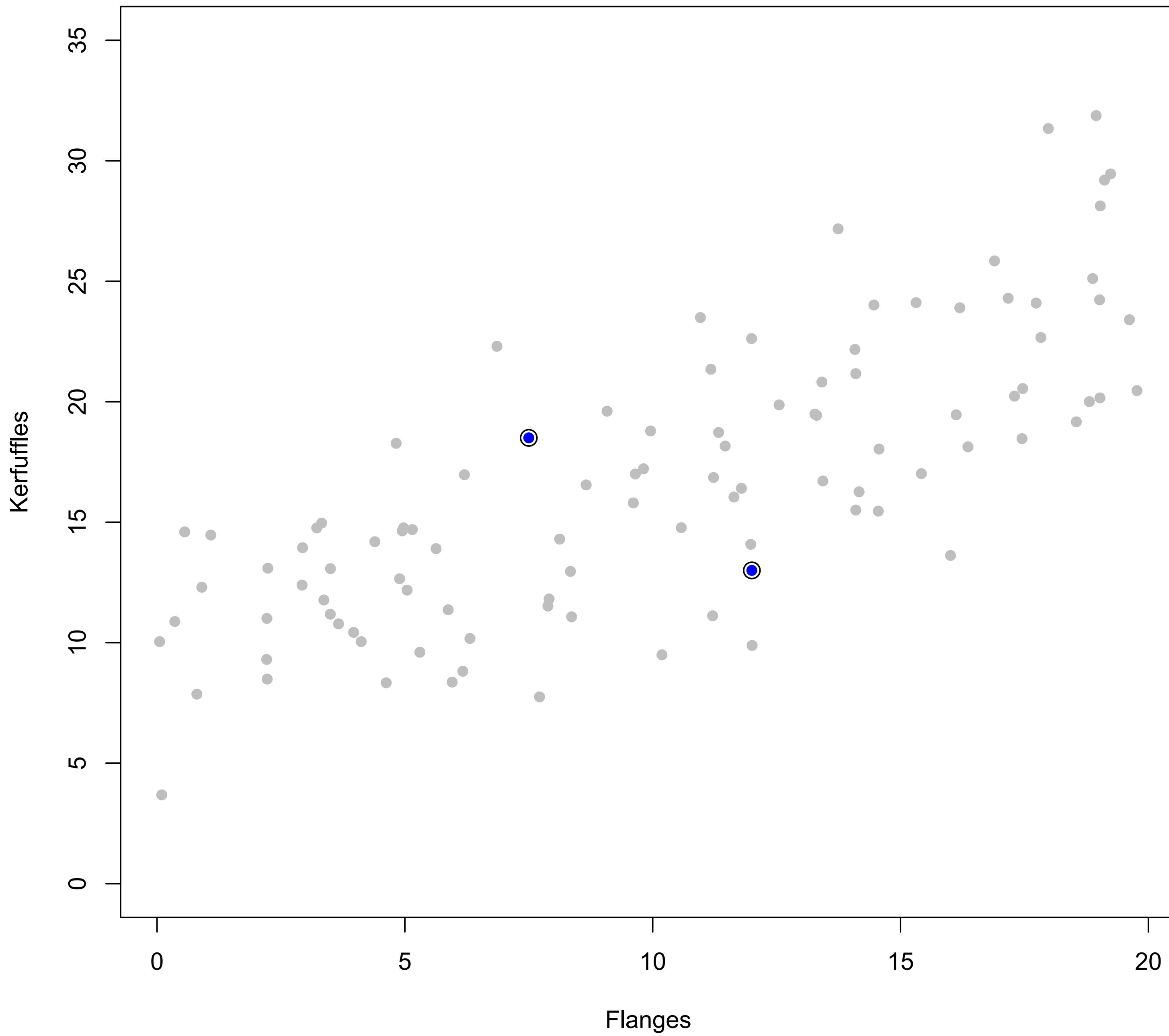
**WHAT IS GOING ON??**

**Is it learning what you *think* it's learning?  
Is it learning what you *want*?**

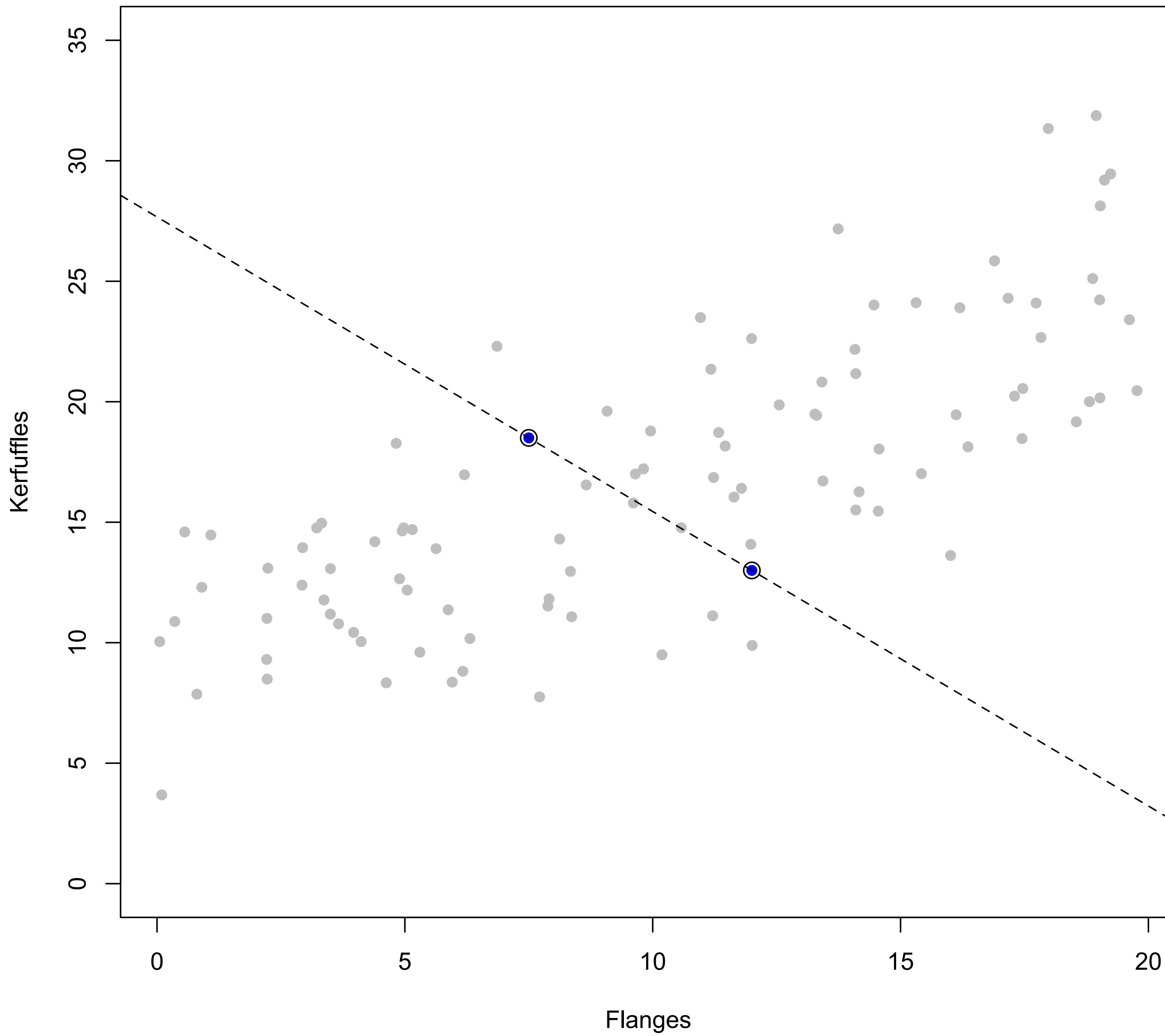
## Kerfuffle-Flange Dependency



## Kerfuffle-Flange Dependency



## Kerfuffle-Flange Dependency



# The Second Law of Machine Learning

## **Generalisation is everything**

**X**

**y**

**x**

**y** ← — — **x**

$$y \equiv f(x)$$

$$y \equiv f(x, \theta)$$

$$L(y, f(x, \theta))$$

$$L(f, \theta, x, y)$$

$$L(f, \theta, \{X[, Y]\})$$

$$\operatorname{argmin}_{\theta} L(f, \theta, \{x, y\})$$

$$\theta^* = \operatorname*{argmin}_{\theta} L(\mathbf{f}, \theta, \{\mathbf{X}, \mathbf{Y}\})$$

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$\theta > \{X[, Y]\}$

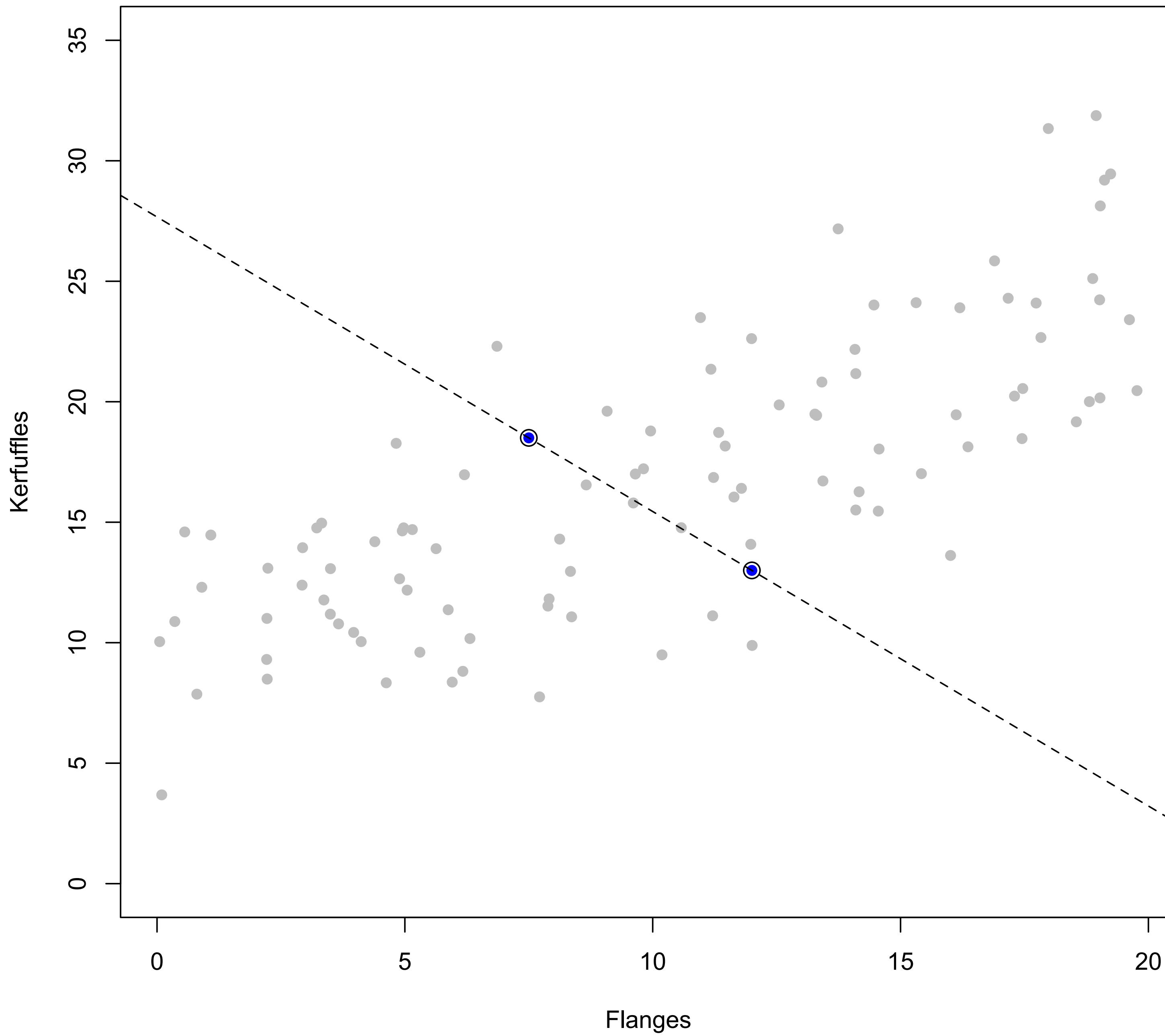
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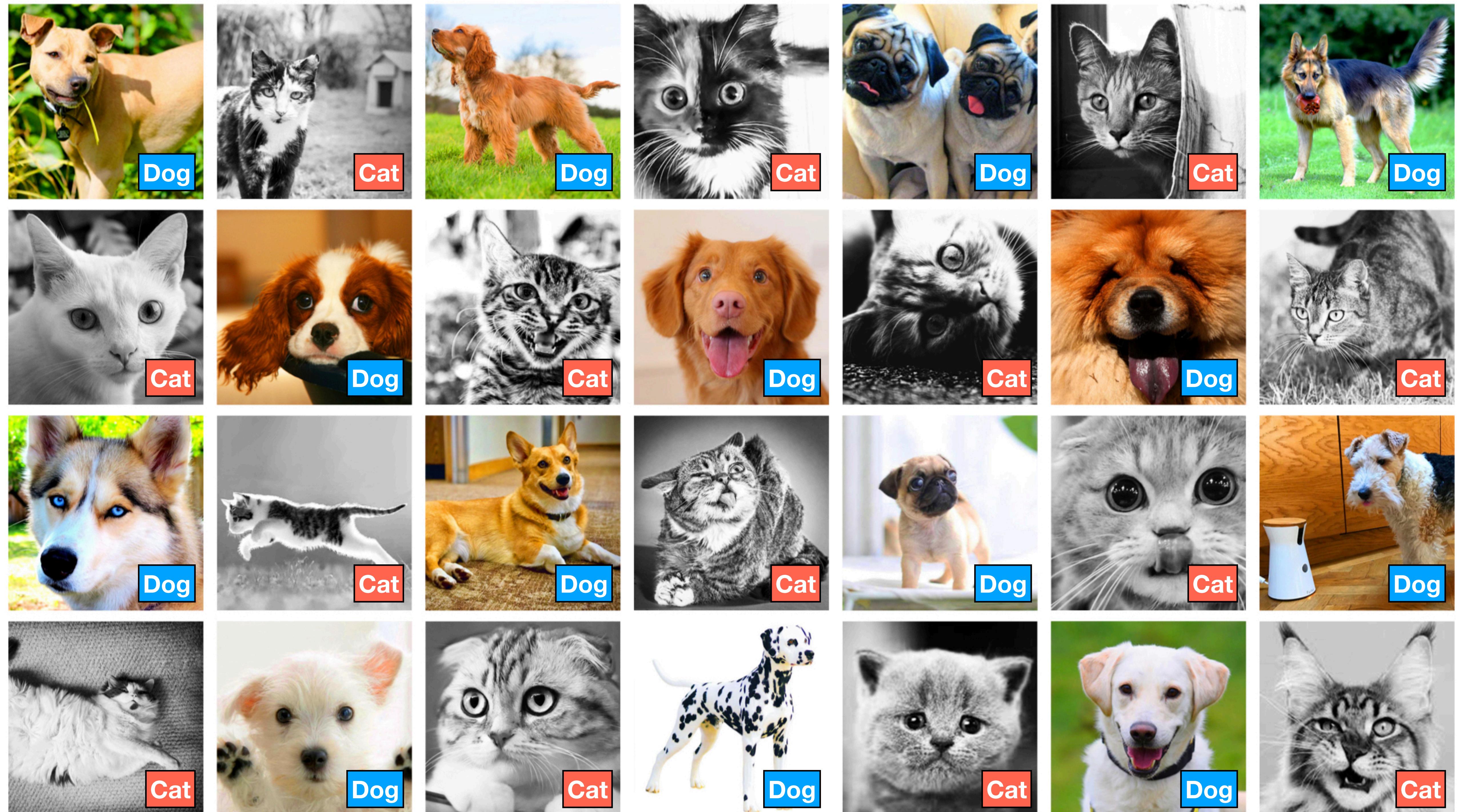


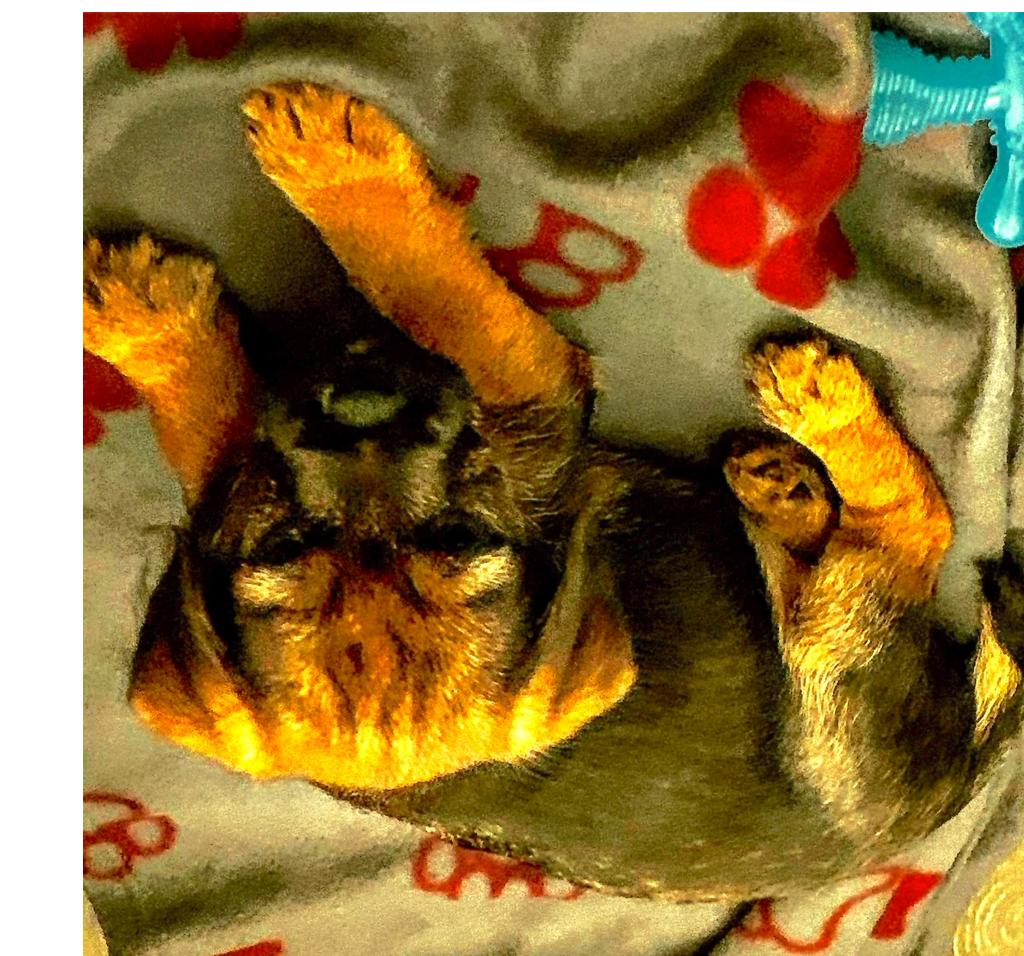
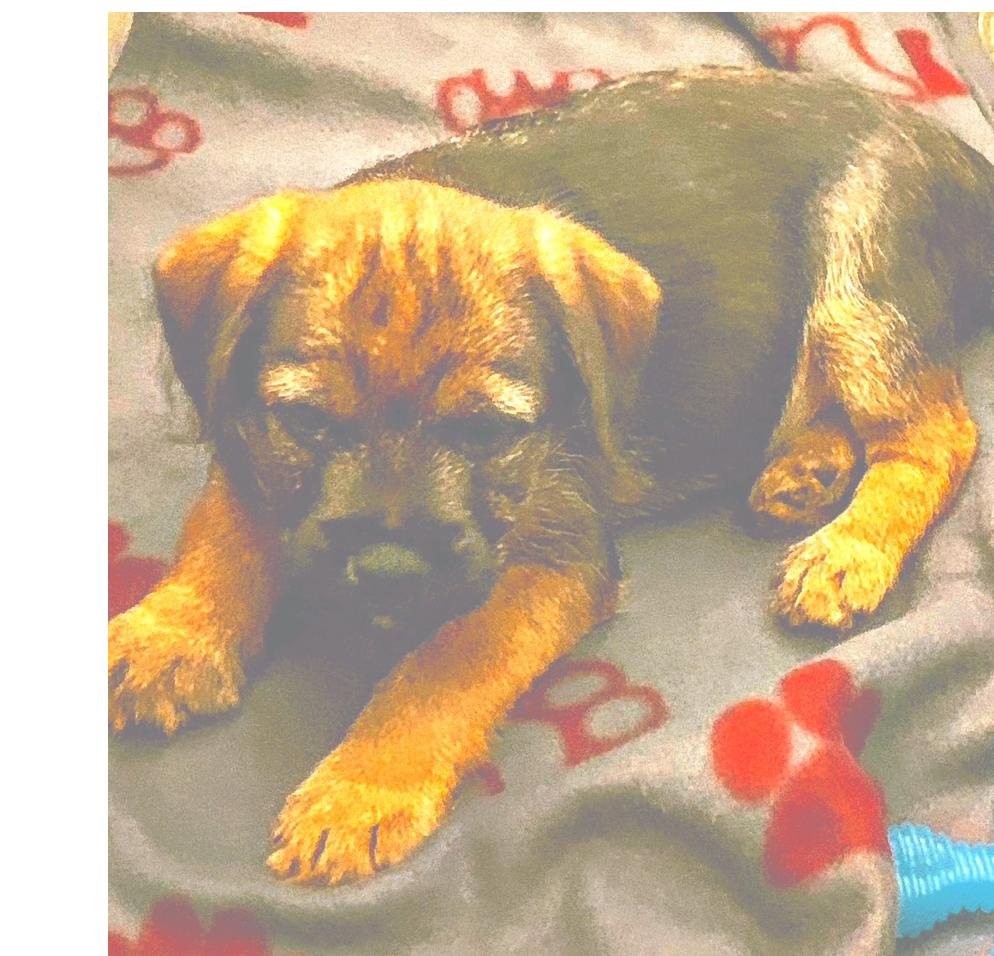
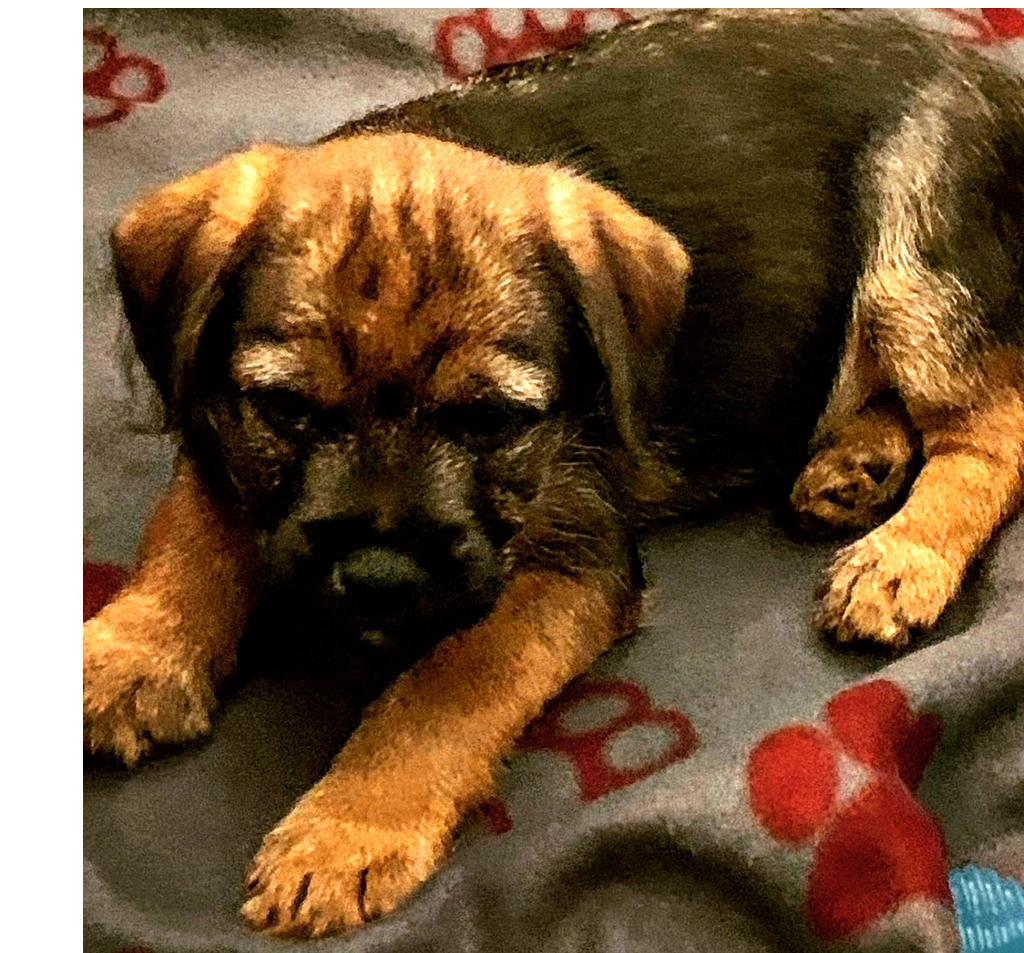
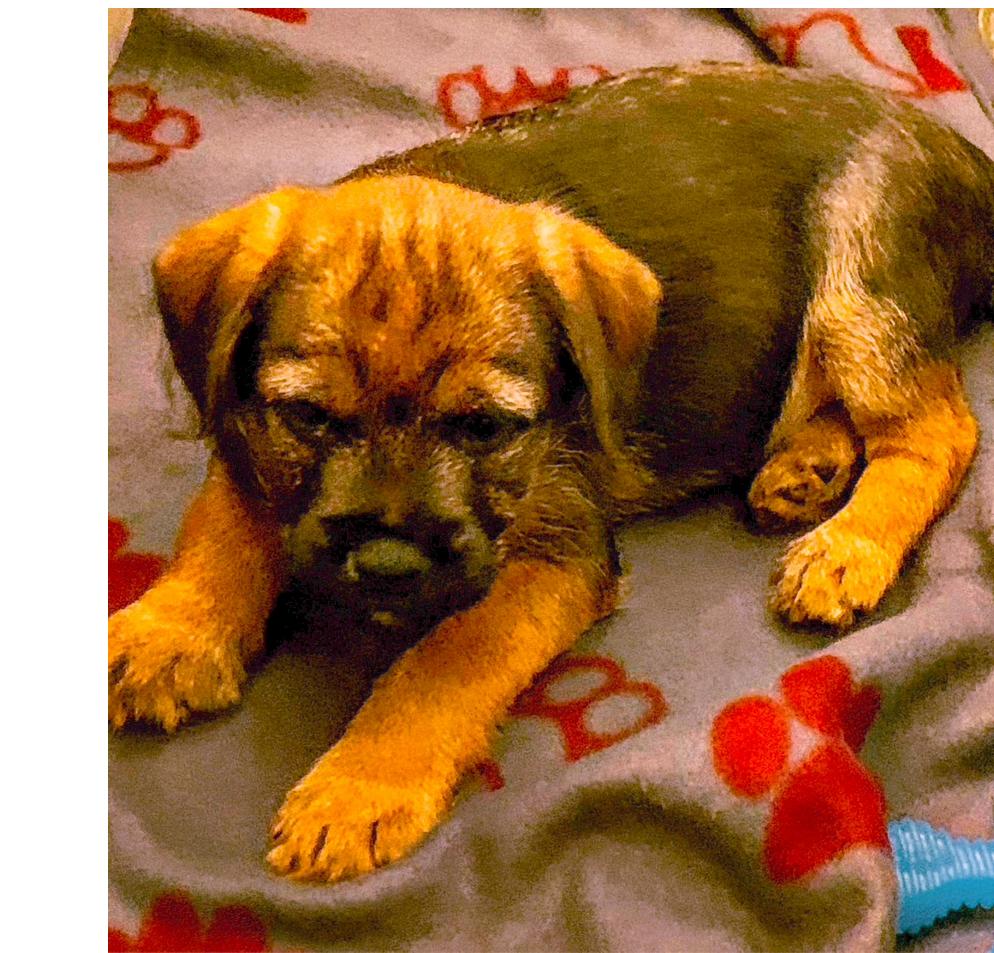
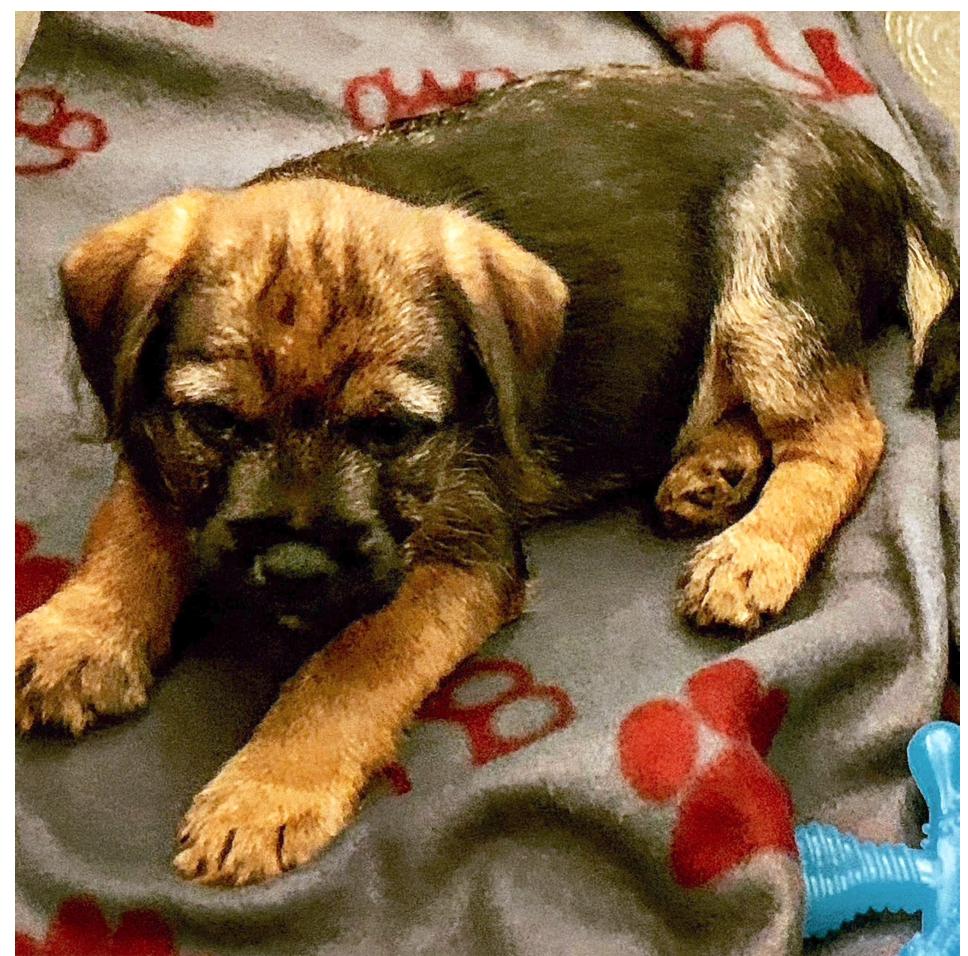
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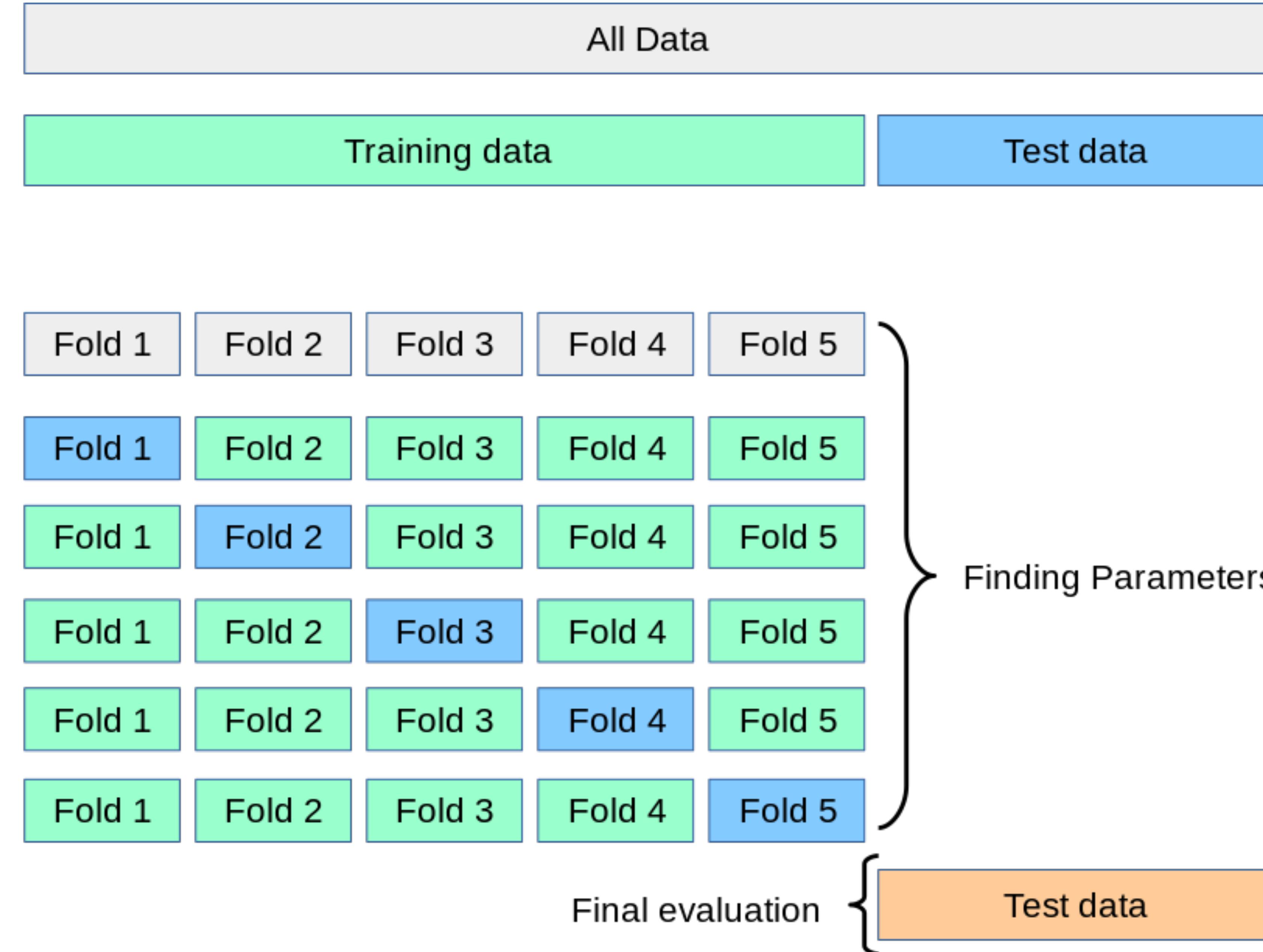
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## Kerfuffle-Flange Dependency

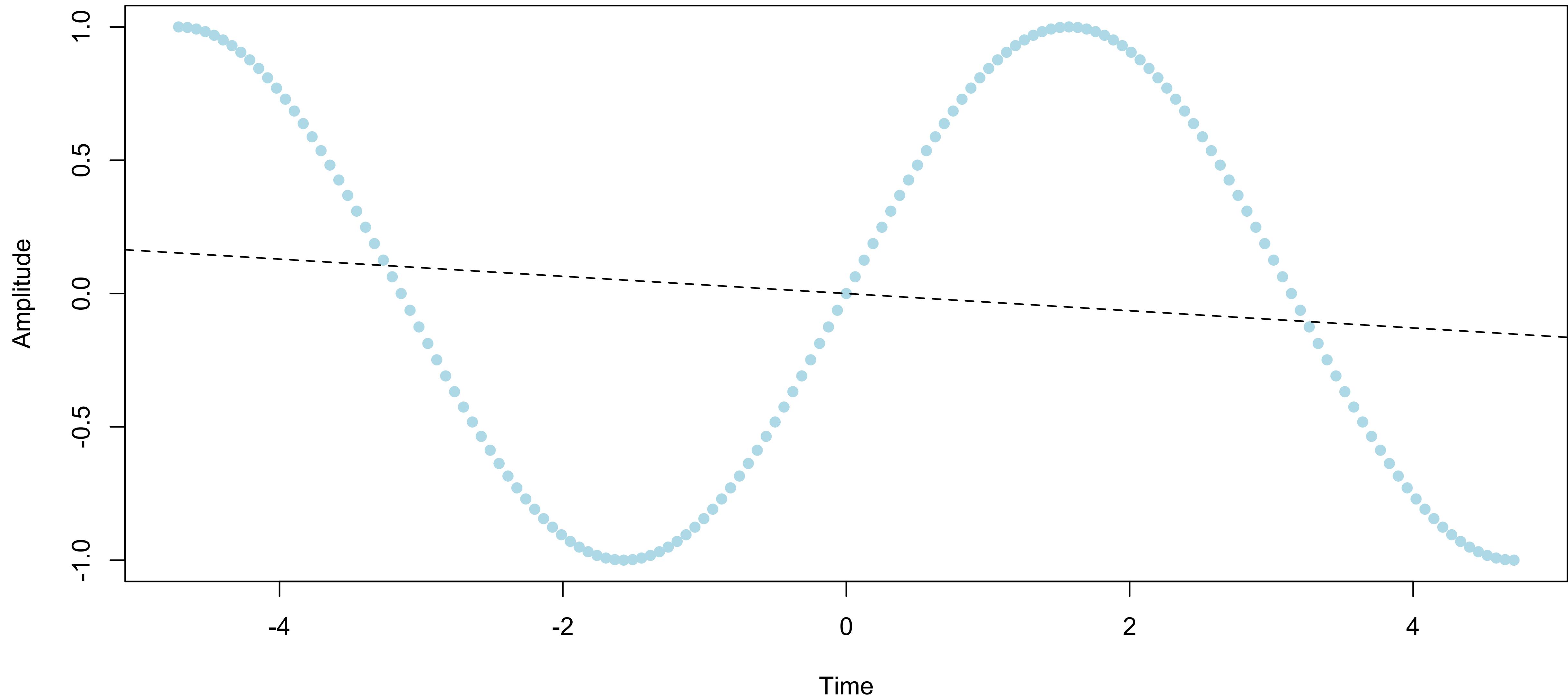




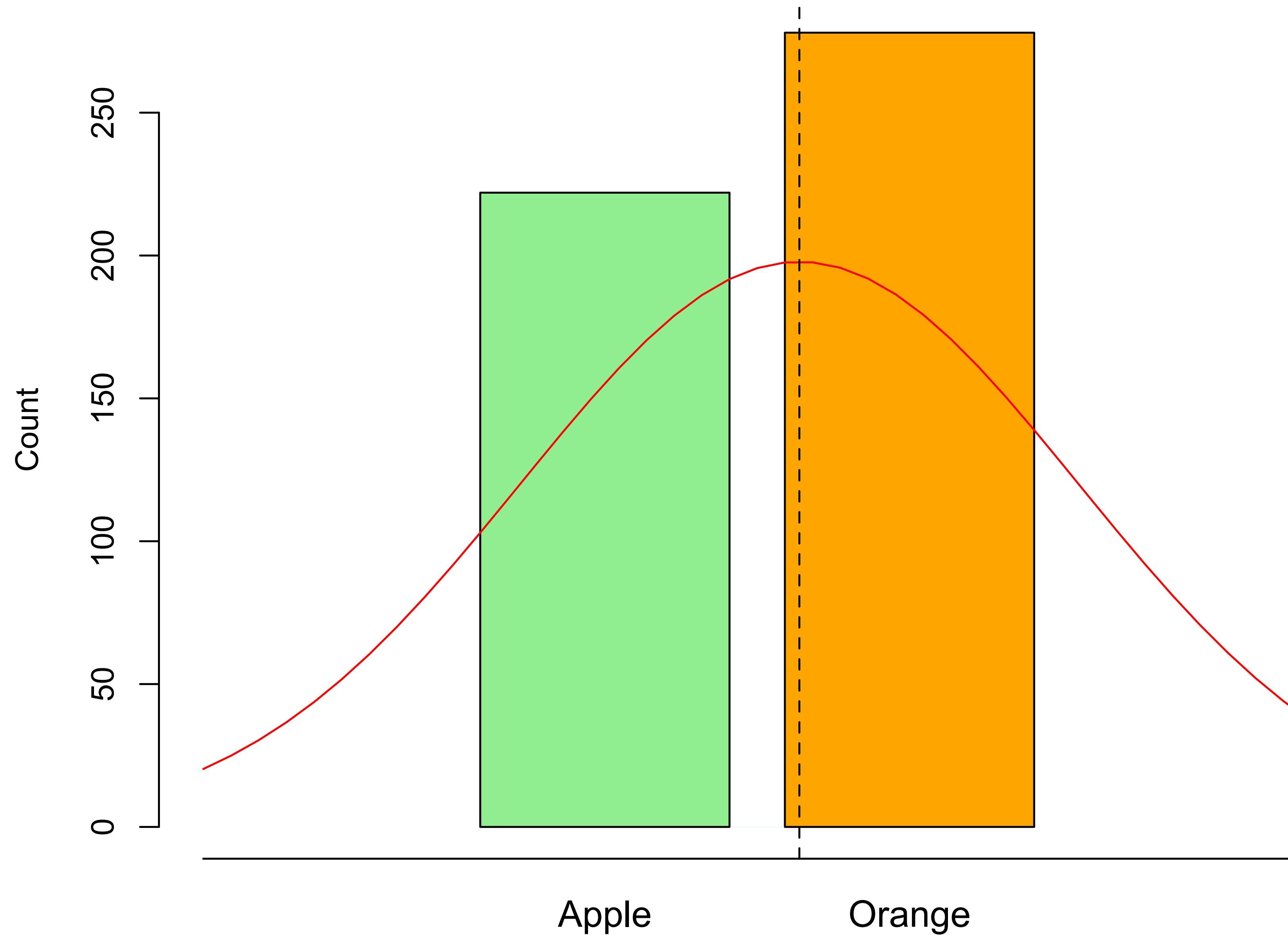




$$\theta^* = \operatorname*{argmin}_{\theta} L(\mathbf{f}, \theta, \{\mathbf{X}, \mathbf{Y}\})$$



## Favourite Fruit



# What's Your Personality Type?

Use the questions on the outside of the chart to determine the four letters of your Myers-Briggs type.  
For each pair of letters, choose the side that seems most natural to you, even if you don't agree with every description.

## 1. Are you outwardly or inwardly focused? If you:

- Could be described as talkative, outgoing
- Like to be in a fast-paced environment
- Tend to work out ideas with others, think out loud
- Enjoy being the center of attention

then you prefer

**E**

Extraversion

- Could be described as reserved, private
- Prefer a slower pace with time for contemplation
- Tend to think things through inside your head
- Would rather observe than be the center of attention

then you prefer

**I**

Introversion

**ISTJ**

Responsible, sincere, analytical, reserved, realistic, systematic. Hardworking and trustworthy with sound practical judgment.

**ISFJ**

Warm, considerate, gentle, responsible, pragmatic, thorough. Devoted caretakers who enjoy being helpful to others.

**INFJ**

Idealistic, organized, insightful, dependable, compassionate, gentle. Seek harmony and cooperation, enjoy intellectual stimulation.

**INTJ**

Innovative, independent, strategic, logical, reserved, insightful. Driven by their own original ideas to achieve improvements.

**ISTP**

Action-oriented, logical, analytical, spontaneous, reserved, independent. Enjoy adventure, skilled at understanding how mechanical things work.

**ISFP**

Gentle, sensitive, nurturing, helpful, flexible, realistic. Seek to create a personal environment that is both beautiful and practical.

**INFP**

Sensitive, creative, idealistic, perceptive, caring, loyal. Value inner harmony and personal growth, focus on dreams and possibilities.

**INTP**

Intellectual, logical, precise, reserved, flexible, imaginative. Original thinkers who enjoy speculation and creative problem solving.

## 2. How do you prefer to take in information? If you:

- Focus on the reality of how things are
- Pay attention to concrete facts and details
- Prefer ideas that have practical applications
- Like to describe things in a specific, literal way

then you prefer

**S**

Sensing

- Imagine the possibilities of how things could be
- Notice the big picture, see how everything connects
- Enjoy ideas and concepts for their own sake
- Like to describe things in a figurative, poetic way

then you prefer

**N**

Intuition

**ESTP**

Outgoing, realistic, action-oriented, curious, versatile, spontaneous. Pragmatic problem solvers and skillful negotiators.

**ESFP**

Playful, enthusiastic, friendly, spontaneous, tactful, flexible. Have strong common sense, enjoy helping people in tangible ways.

**ENFP**

Enthusiastic, creative, spontaneous, optimistic, supportive, playful. Value inspiration, enjoy starting new projects, see potential in others.

**ENTP**

Inventive, enthusiastic, strategic, enterprising, inquisitive, versatile. Enjoy new ideas and challenges, value inspiration.

**ESTJ**

Efficient, outgoing, analytical, systematic, dependable, realistic. Like to run the show and get things done in an orderly fashion.

**ESFJ**

Friendly, outgoing, reliable, conscientious, organized, practical. Seek to be helpful and please others, enjoy being active and productive.

**ENFJ**

Caring, enthusiastic, idealistic, organized, diplomatic, responsible. Skilled communicators who value connection with people.

**ENTJ**

Strategic, logical, efficient, outgoing, ambitious, independent. Effective organizers of people and long-range planners.

## 3. How do you prefer to make decisions? If you:

- Make decisions in an impersonal way, using logical reasoning
- Value justice, fairness
- Enjoy finding the flaws in an argument
- Could be described as reasonable, level-headed

then you prefer

**T**

Thinking

- Base your decisions on personal values and how your actions affect others
- Value harmony, forgiveness
- Like to please others and point out the best in people
- Could be described as warm, empathetic

then you prefer

**F**

Feeling

## 4. How do you prefer to live your outer life? If you:

- Prefer to have matters settled
- Think rules and deadlines should be respected
- Prefer to have detailed, step-by-step instructions
- Make plans, want to know what you're getting into

then you prefer

**J**

Judging

- Prefer to leave your options open
- See rules and deadlines as flexible
- Like to improvise and make things up as you go
- Are spontaneous, enjoy surprises and new situations

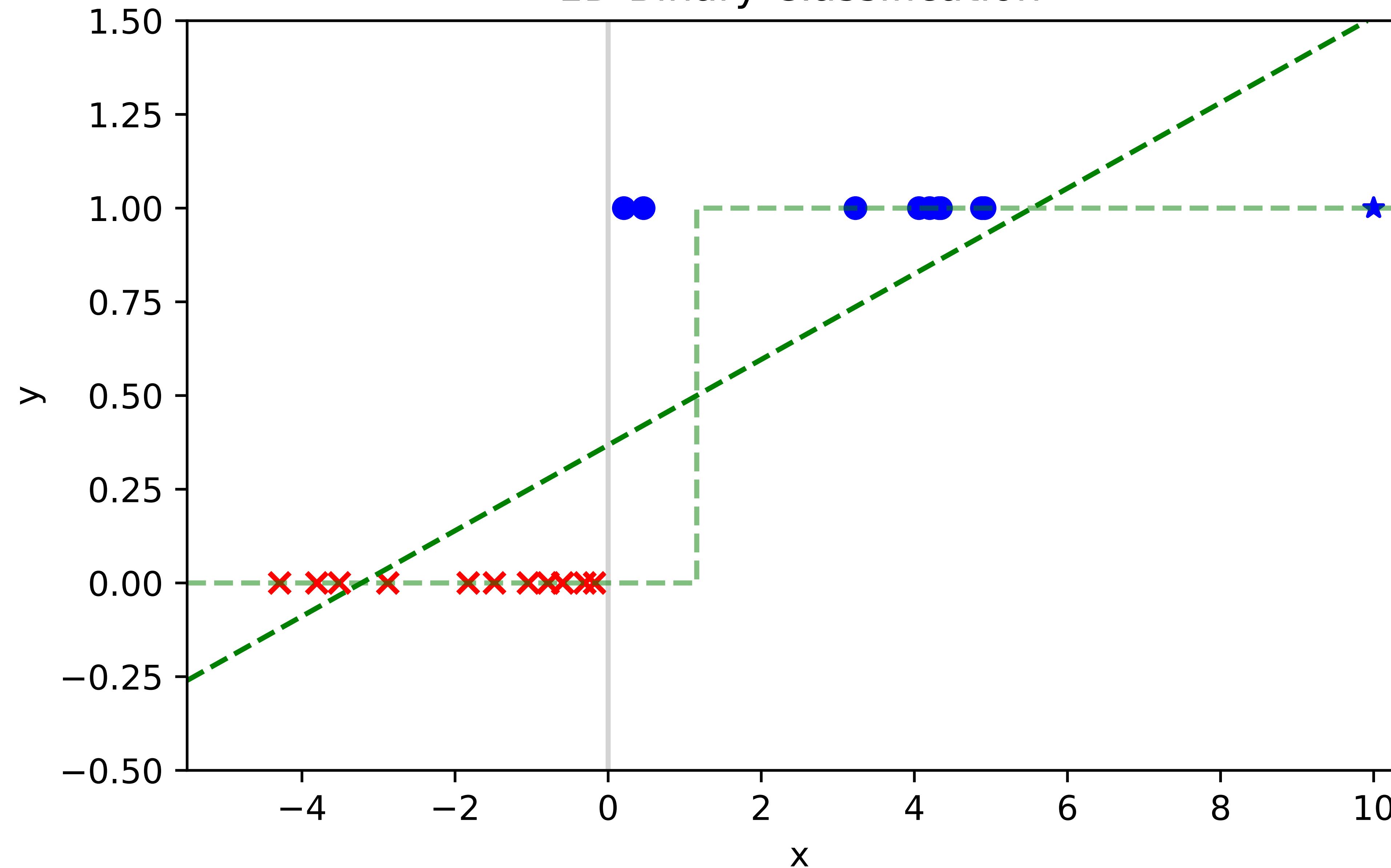
then you prefer

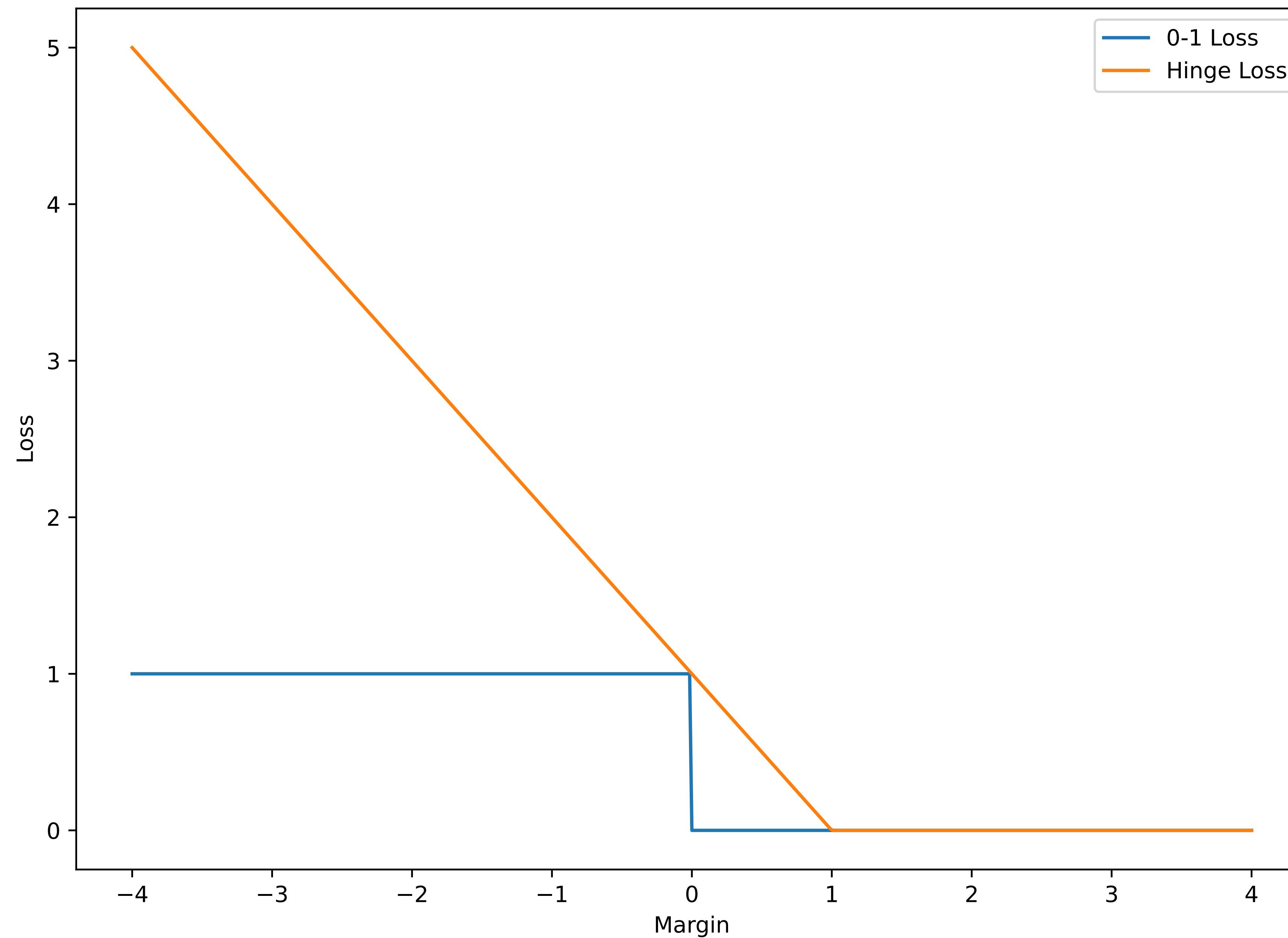
**P**

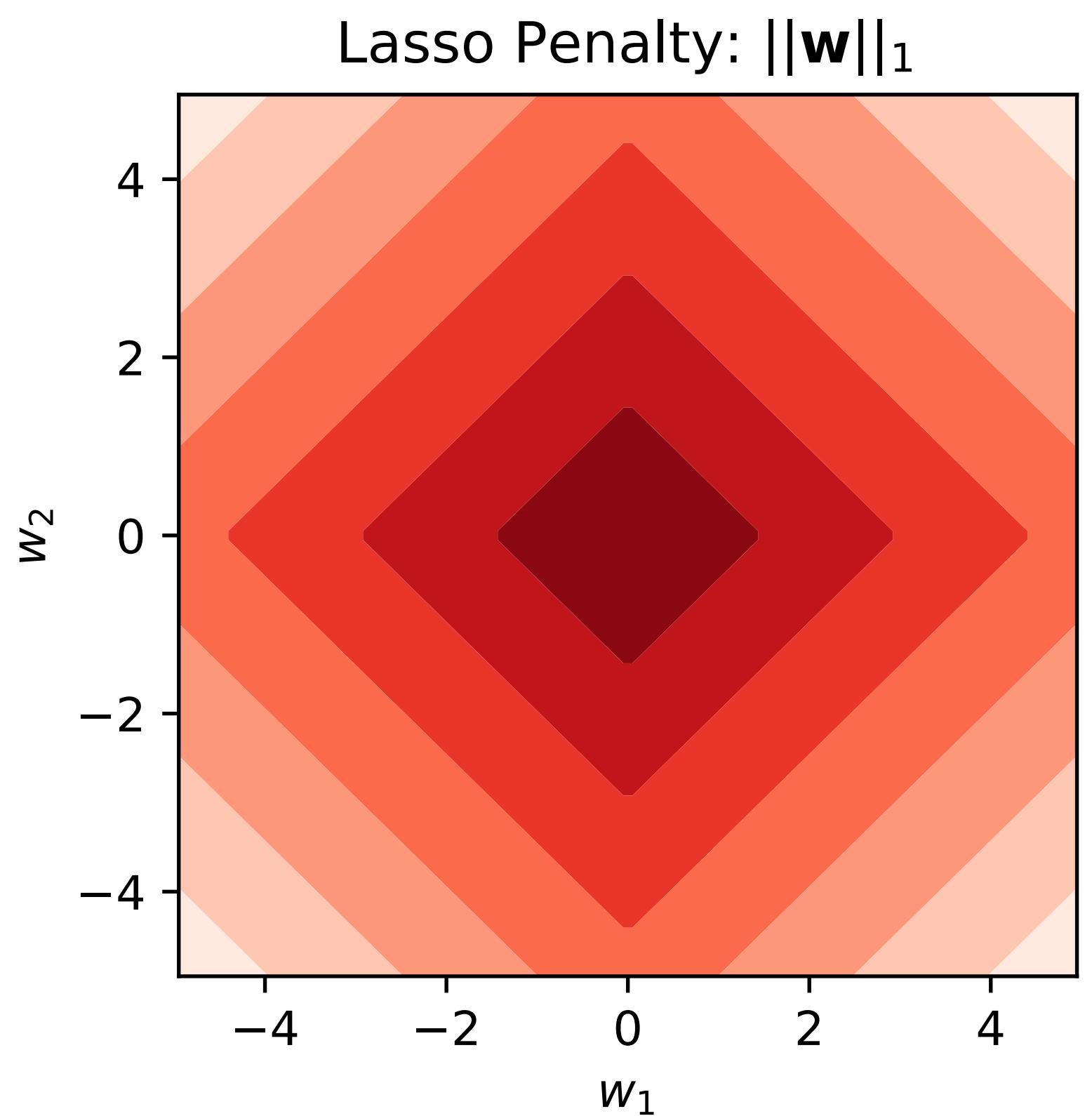
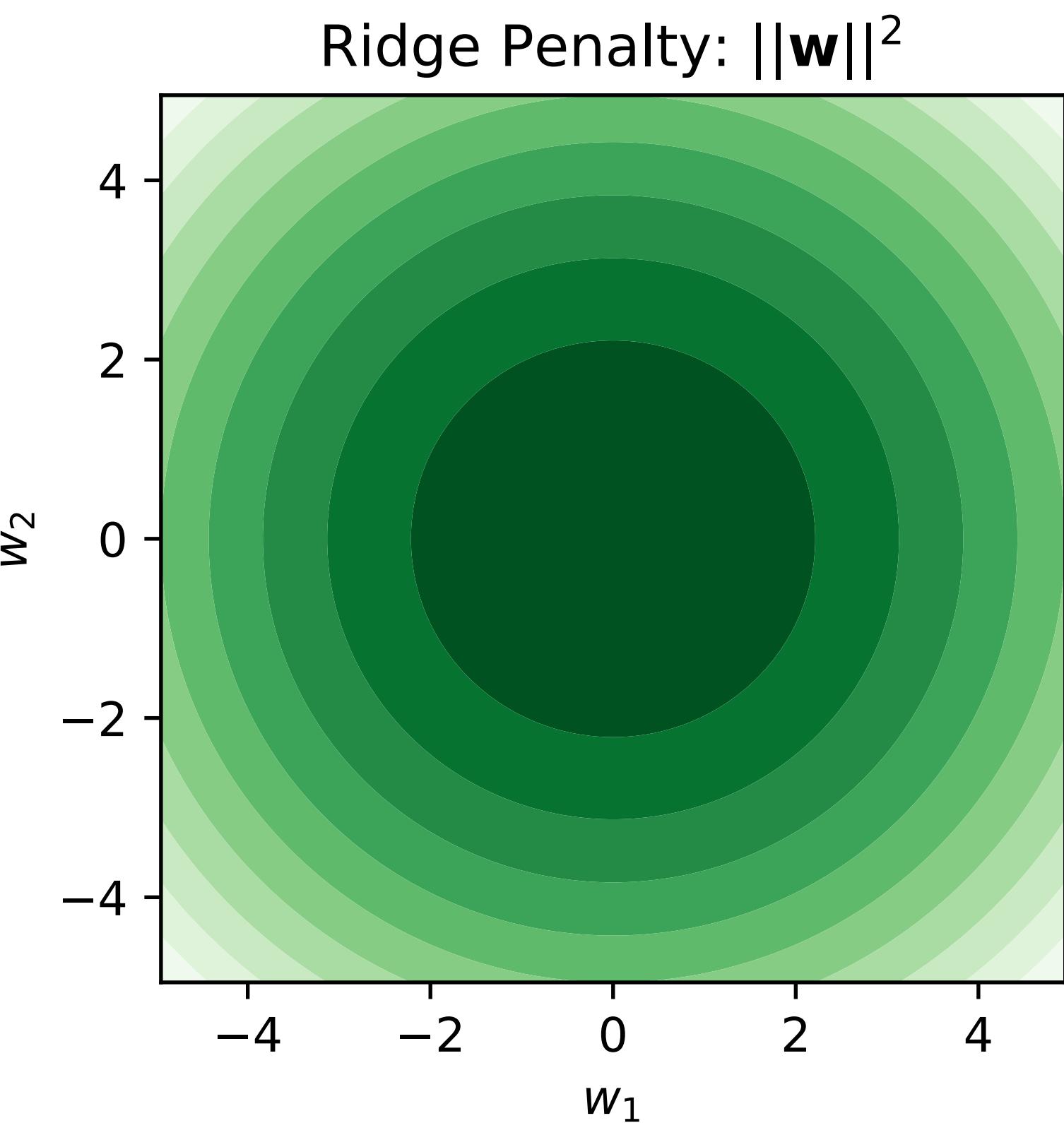
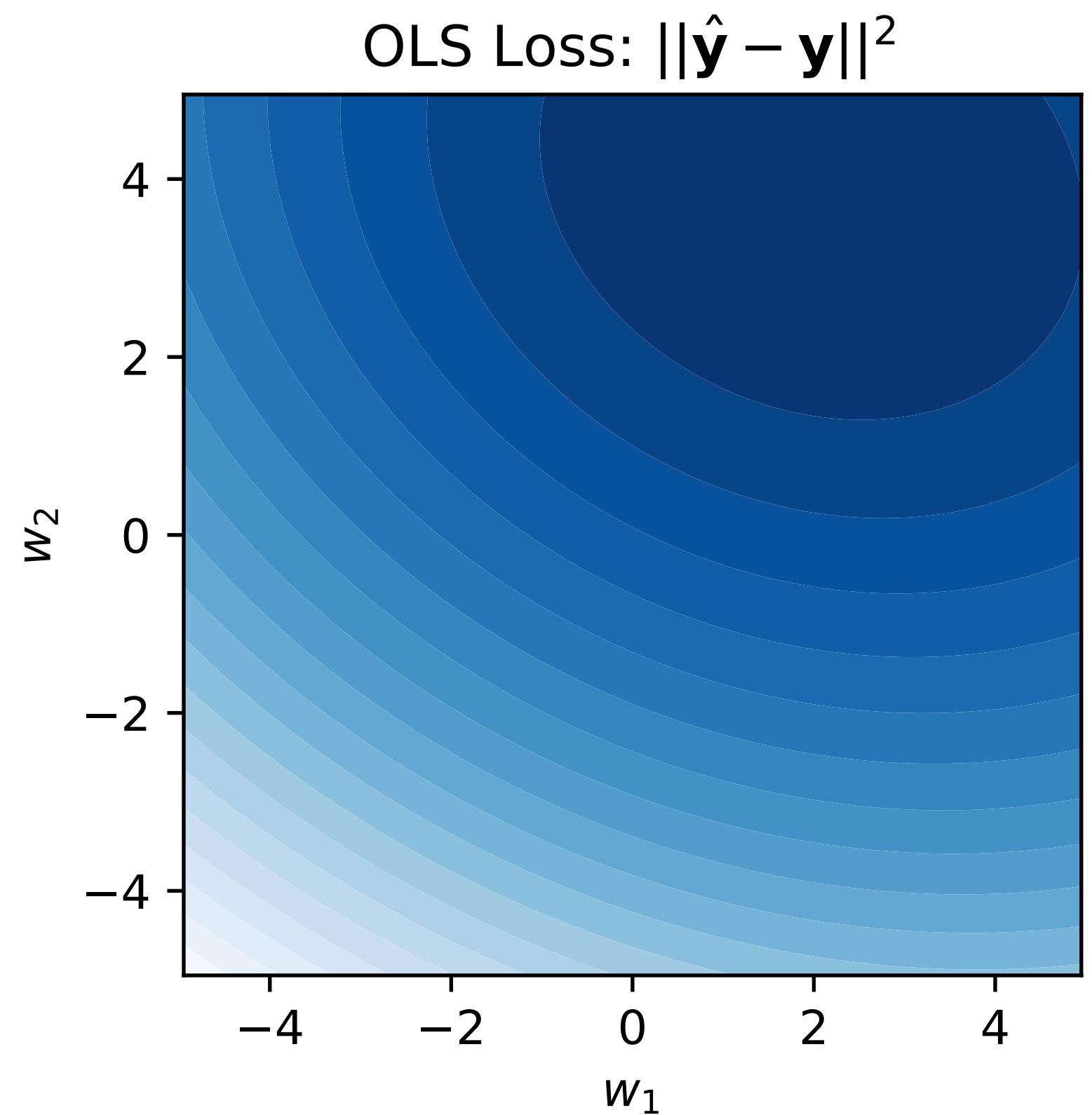
Perceiving

$$\theta^* = \operatorname*{argmin}_{\theta} L(\mathbf{f}, \theta, \{\mathbf{X}, \mathbf{Y}\})$$

# 1D Binary Classification









The Third Law of Machine Learning

**Machine Learning is not magic**





THIS IS YOUR MACHINE LEARNING SYSTEM?

YUP! YOU POUR THE DATA INTO THIS BIG  
PILE OF LINEAR ALGEBRA, THEN COLLECT  
THE ANSWERS ON THE OTHER SIDE.

WHAT IF THE ANSWERS ARE WRONG?

JUST STIR THE PILE UNTIL  
THEY START LOOKING RIGHT.





# **Questions?**

# Next: Linear Models

