Foundations of Data Analysis

Lecture 1: Introduction

Pierre-Simon Laplace (1749–1827)

Births in Paris

1745 - 1770

Births in Paris

1745 - 1770

251,527 Boys

Births in Paris

1745 - 1770

251,527 Boys   241,945 Girls

Are males born at a higher rate than females?

251,527 Boys   241,945 Girls

Some possible statistics

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- **Difference:** +9,582 Boys

Some possible statistics

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- **Difference:** +9,582 Boys
- **Ratio:** 104 Boys to 100 Girls

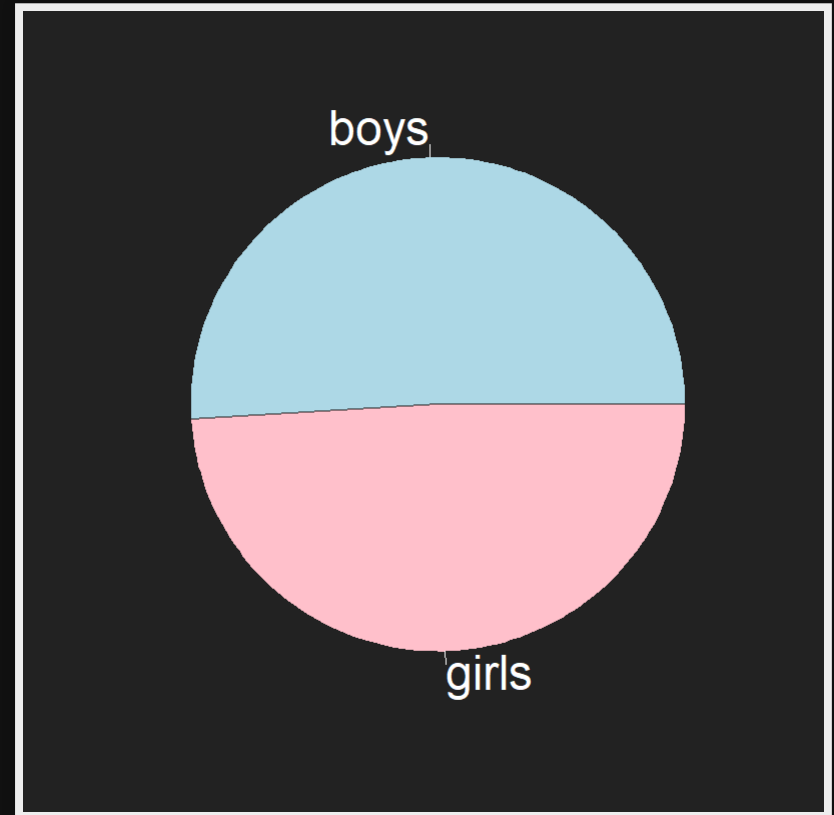# Some possible statistics
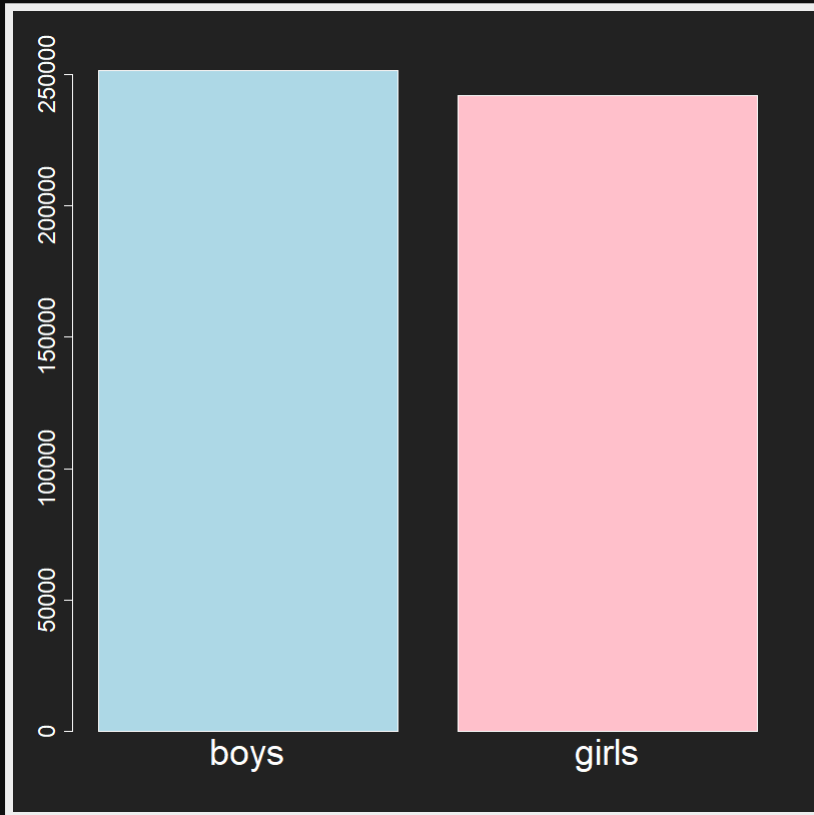
251,527 Boys   241,945 Girls

- **Difference:** +9,582 Boys

- **Ratio:** 104 Boys to 100 Girls

- **Proportion:** 50.97% Boys

Some possible visualizations

251,527 Boys   241,945 Girls

How did Laplace solve this?

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Conditional Probability that:

rate of boys, θ, is greater than girls,

given

observed data

Answer?

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$$P(\theta > 0.5 \mid \text{data}) = 1 - \epsilon,$$

$$\text{where } \epsilon \approx 1 \times 10^{-42}.$$

What is probability?

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Definition: *Probability* is the study of the mathematical rules that govern random events.

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Informally, a *random event* is an event where we do not know the outcome without observing it.

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Probability tells us what we can say about such events, given our assumptions about the possible outcomes.

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Definition: *Statistics* is the application of probability to the collection, analysis, and description of random data.

Statistics is used to:

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- **Design** experiments

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- **Summarize** data

- **Make conclusions** about the world
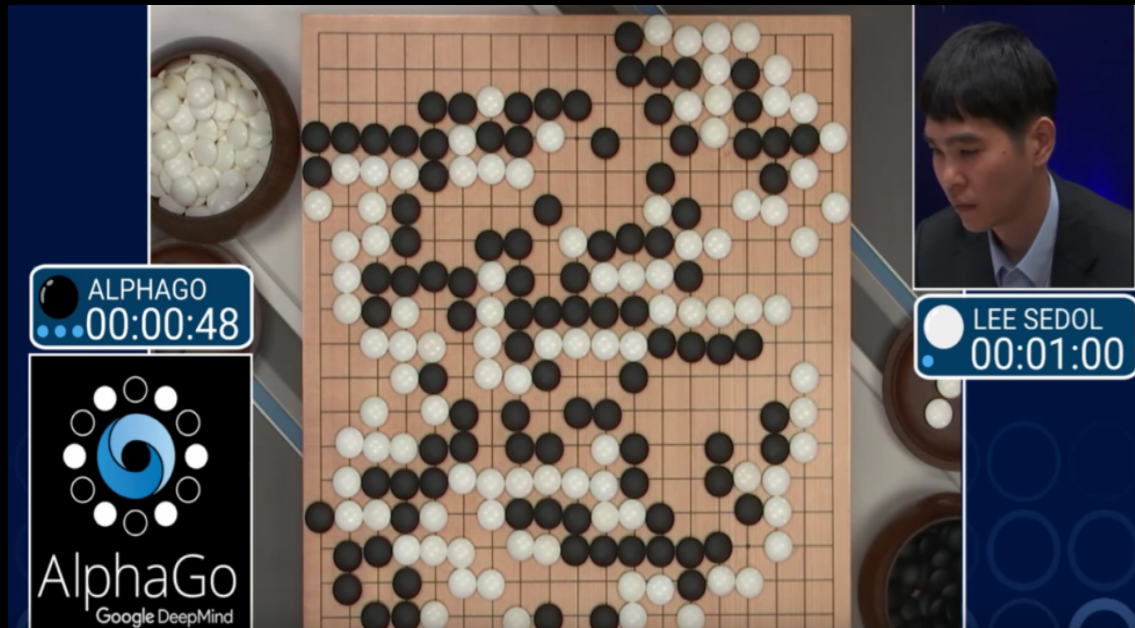
Statistics is used to:

- **Design** experiments

- **Summarize** data

- **Make conclusions** about the world

- **Explore** complex data

What is machine learning?

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Definition: *Machine Learning* builds statistical models of data in order to recognize complex patterns and to make decisions based on these observations.

Machine Learning is Everywhere?

Games

Recommendation system

Assisted driving

Cancer diagnosis

Machine Learning

Statistics

Probability

Linear Algebra

Levels of data analysis expertise

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Levels of data analysis expertise

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2: I understand the math behind the analysis

Levels of data analysis expertise

0: What is data?
1: I know how to run data analysis software
2: I understand the math behind the analysis
3: I'm able to invent new data analysis methods

Why should you know the mathematical foundations?

When machine learning goes wrong

When machine learning goes wrong

Panda (57.7% confidence)

When machine learning goes wrong

Panda (57.7% confidence)   Gibbon (99.3% confidence)