MANNHEIM BUSINESS SCHOOL

DATA LITERACY & DATA INTUITION:

MAKING SMARTER DECISIONS WITH DATA

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Data Literacy & Data Intuition

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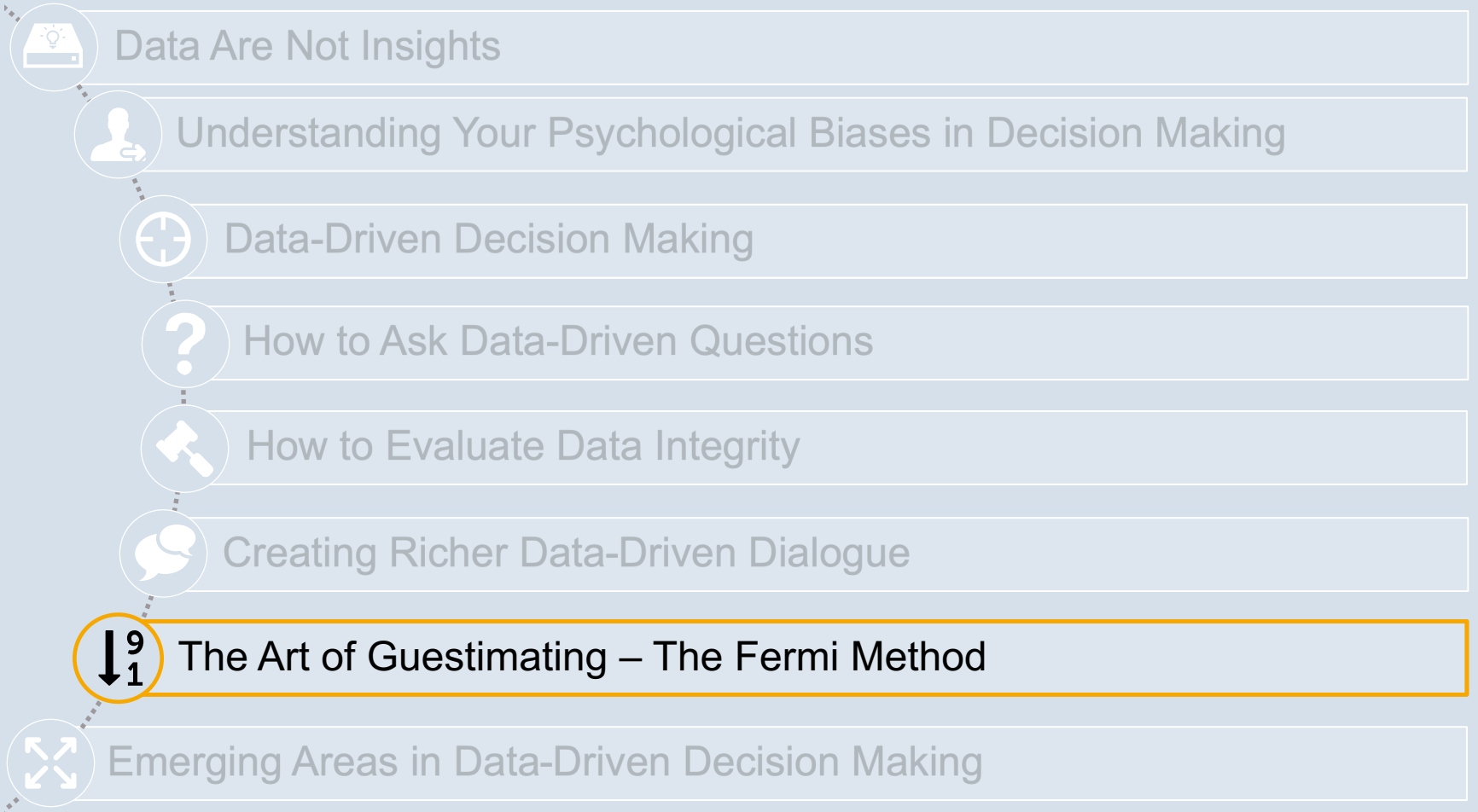

Enrico Fermi and the Fermi-problems

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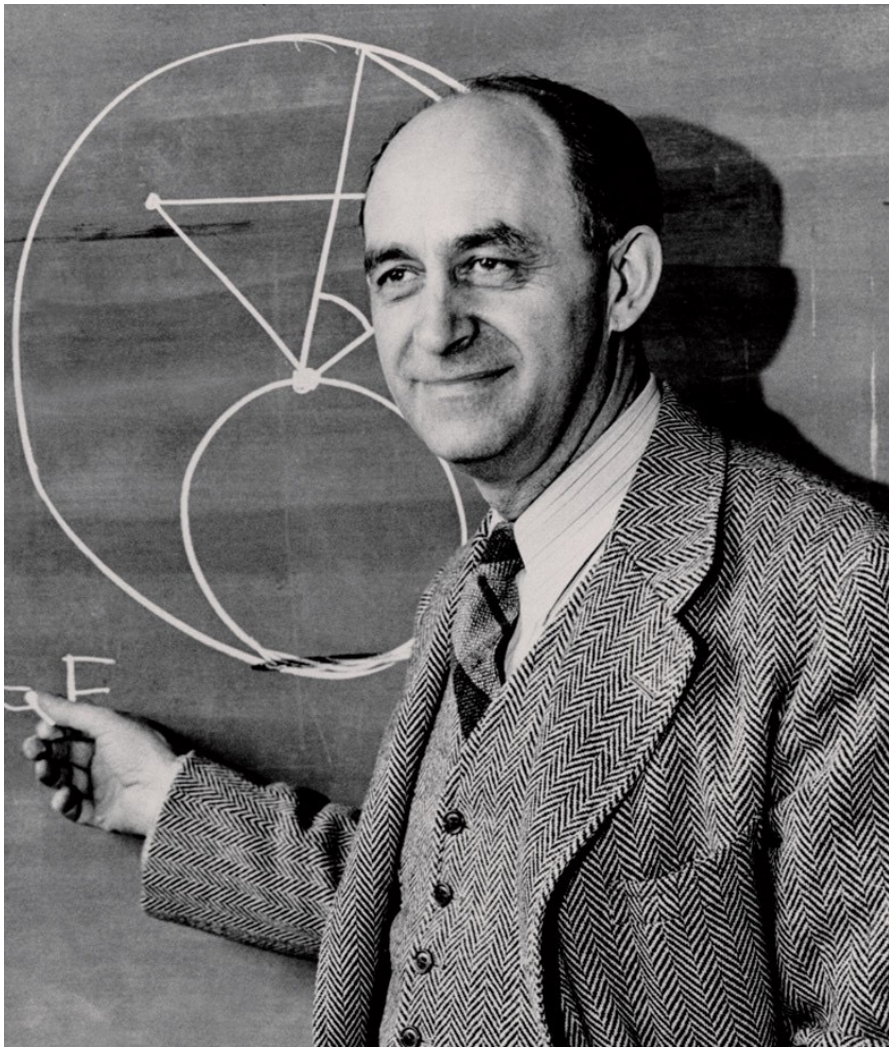
Enrico Fermi

- Italian-American physicist
- Creator of the world's largest first nuclear reactor
- Known for his **ability to make good approximate calculations with little or no actual data**

Fermi problems

- Making **justified guesses** about **quantities** and their **variance** or **lower and upper bounds**



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“How many piano tuners are there in Chicago?” – a Fermi Problem

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We make the following **assumptions/estimations:**

Approximately **5,000,000** people living in **Chicago**.

On average, **two persons** in each household in **Chicago**.

Roughly **one household in twenty** has a piano that is tuned regularly.

Pianos are tuned on average about **once per year**.

It takes a piano tuner about **two hours** to tune a piano

Each piano tuner works **eight hours** in a day, **five days** in a week, and **50 weeks** in a year.

“How many piano tuners are there in Chicago?” – a Fermi Problem

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Number of pianos tunings in Chicago in a single year:

(5,000,000 persons in Chicago) / (2 persons/household) × (1 piano/20 household) × (1 piano tuning per piano per year)
= 125,000 piano tunings per year in Chicago.

The average piano tuner performs:

(50 weeks/year)×(5 days/week)×(8 hours/day)×(1 piano tuning per 2 hours per piano tuner)
= 1000 piano tunings per year per piano tuner.

This gives us:

(125,000 piano tuning per year in Chicago) / (1000 piano tunings per year per piano tuner)
= 125 piano tuners in Chicago.

„How many hairs are present on your head?“ – a Fermi Problem

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150 hairs per **square cm**

50% of our head is **covered** with hear

Radius (head) ~ 10 cm
- 0.5 * (4*π*r^2) = 200* π = 628 cm^2

Calculation:
- 628 * 150 = 94,200

The Fermi Method – How Does It Work?

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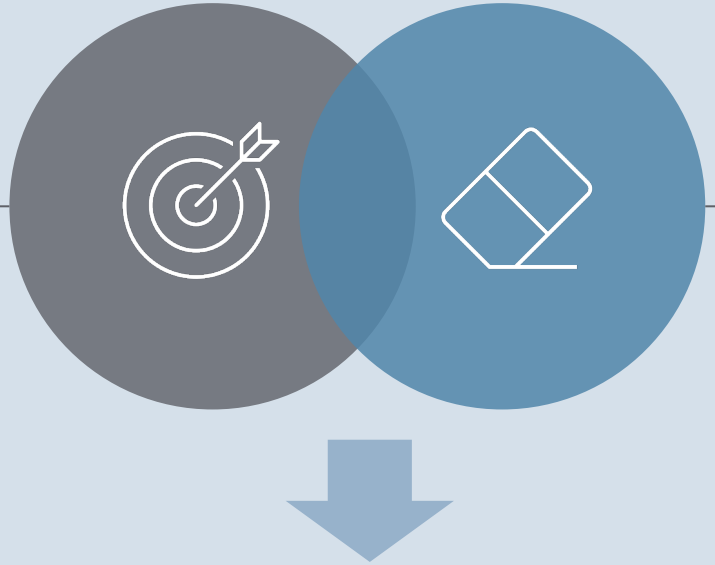
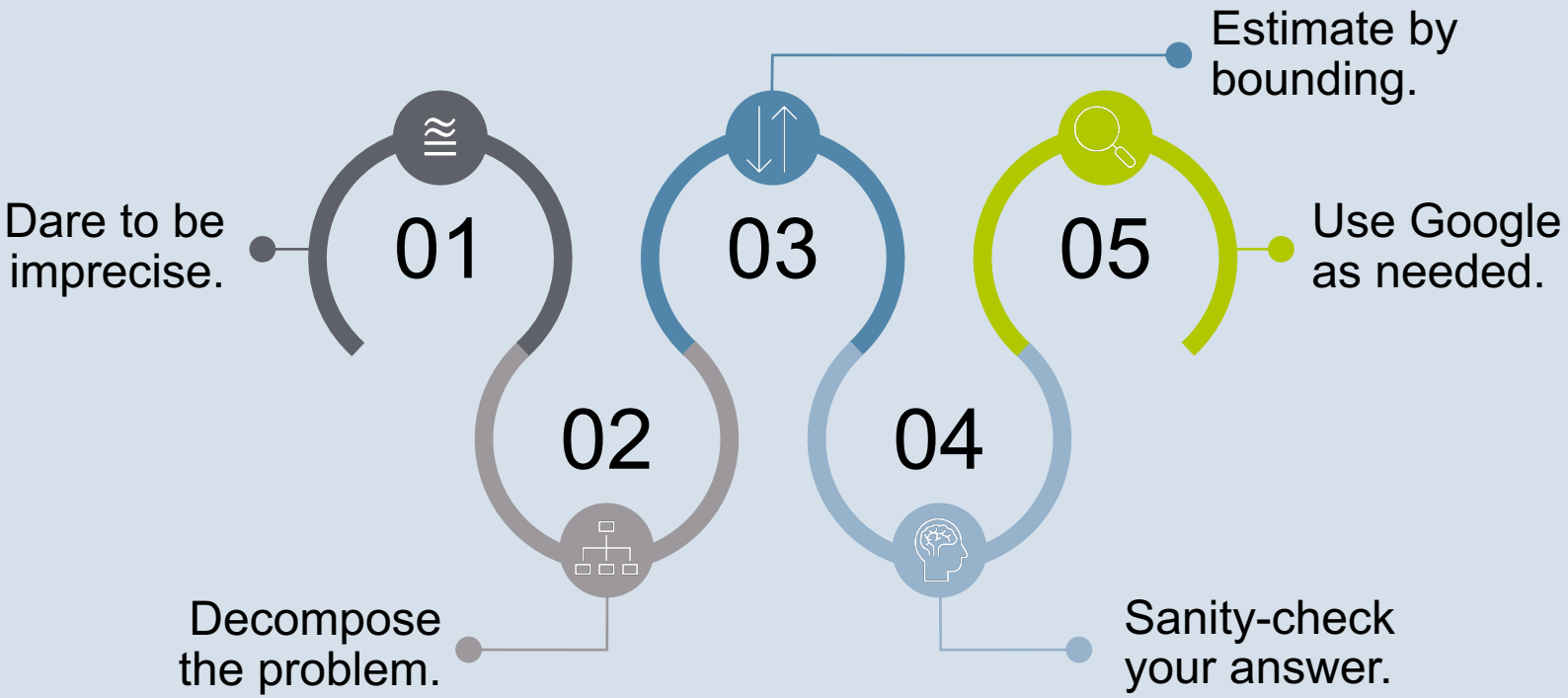
Estimations of individual terms are often **close to correct.**



Overestimates and underestimates **cancel each other out**.

There is **no consistent bias.**

The Fermi Method – Estimation Tips



The Fermi Method – Estimation Tips: Estimate by Bounding (Example)

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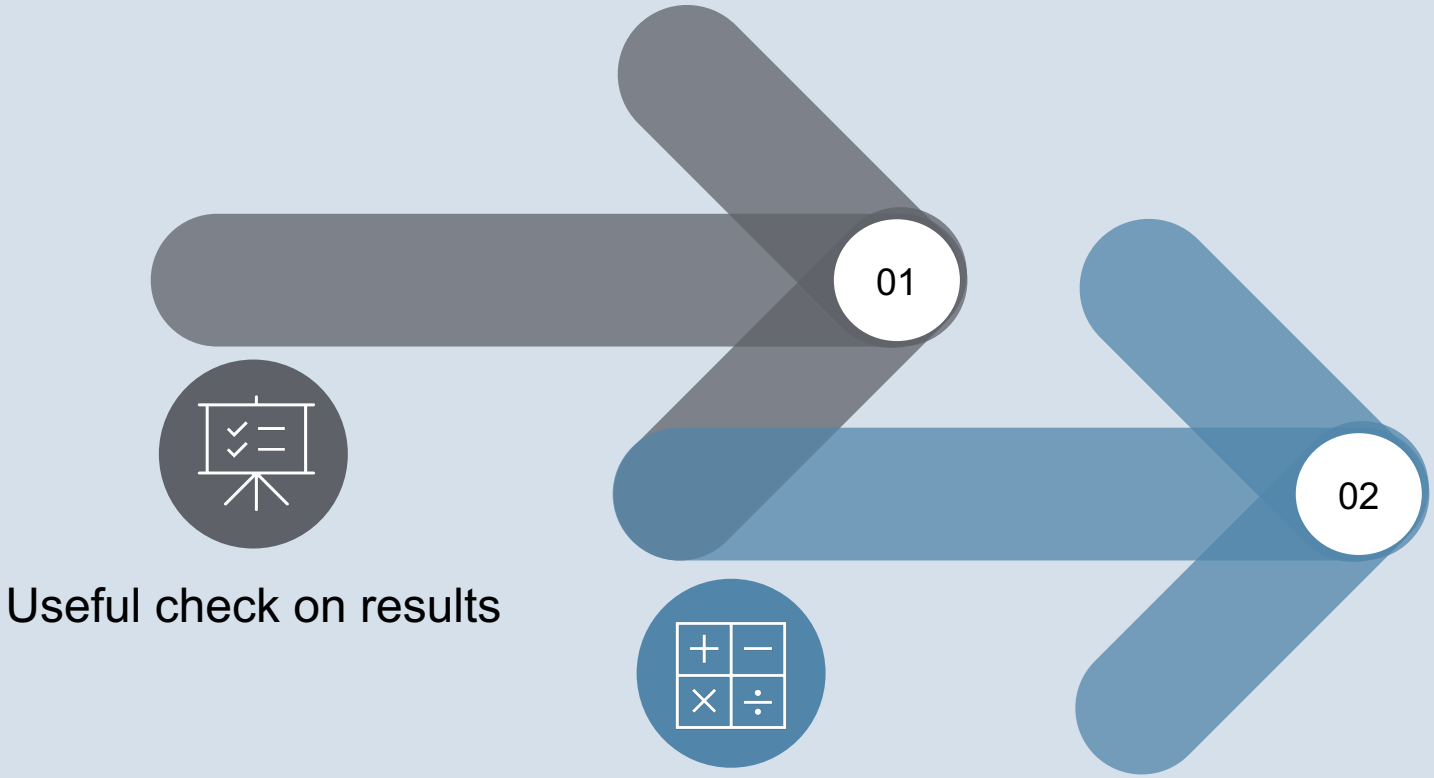
How much time per day does the average 15-year-old watch TV?

- Rough estimation: Between 2 minutes and 400 minutes
- Use the **approximate geometric mean (AGM)** (approximate square root of the product of the upper and lower bounds)
- What is the AGM of 2 and 400?
  - → $2 = 2 \times 10^0$ and $400 = 4 \times 10^2$
  - Average of the coefficients (2 and 4) is 3
  - Average of exponents is (0 and 2) 1
  - **AGM = $3 \times 10^1 = 30$** *(precise geometric mean 28.28)*

If the sum of exponents is an odd number: Round the resulting exponent down and multiply the final answer by three.

Fermi Estimation Failure Modes

The Fermi Method – Advantages



„How many new passenger cars are sold each year in the USA?“ - Exercise

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Approach #1: Car dealerships

1 How many new cars does a dealership sell per month?
- More than 5, less than 50
- AGM is 15

2 How many counties are there in the US?
- More than 300, less than 20,000
- AGM is 2,500

3 How many towns of 10,000 people or more are there per county?
- More than 10, less than 5,000
- AGM is 300

4 How many car dealerships are there in cities of 10,000 or more people?
- More than 2, less than 30
- AGM is 7.5

→ (15 x 12) x 7.5 x 300 x 2,500 = 1,012,500,000

?

„How many new passenger cars are sold each year in the USA?“ - Exercise

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Approach #1: Population in the USA

~ 330 million people live in the US

~ 110 million people own cars

Lifetime of a car ~ 15 years
1/15 bought a car in the last year

110 million / 15 = 7.33 million new cars sold

Actual number (Google 2021) = 3.34 million