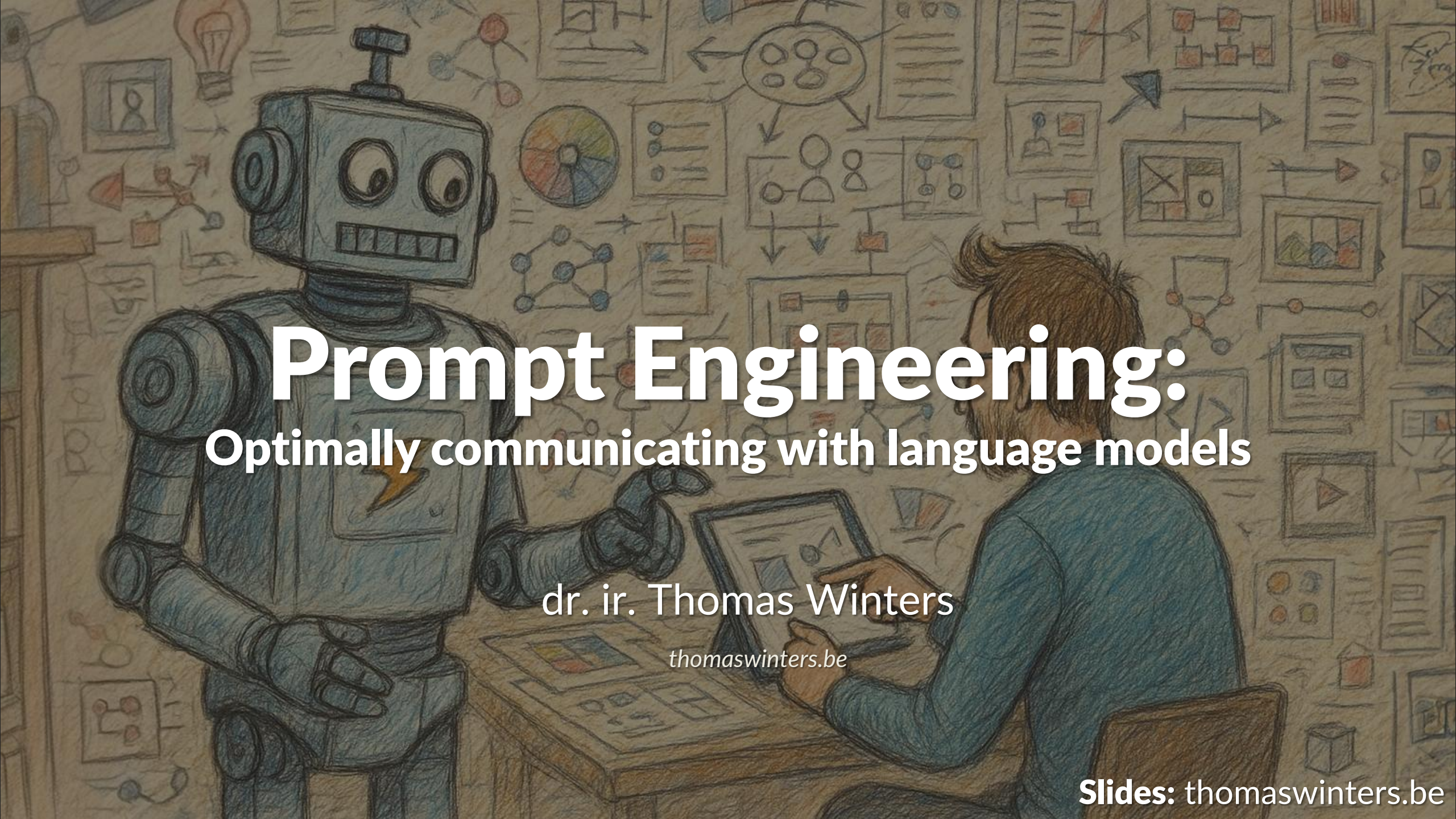


Prompt Engineering:

Optimally communicating with language models

dr. ir. Thomas Winters

thomaswinters.be

Slides: thomaswinters.be

Who has used GPT/Gemini/Copilot…?



Who has used GPT to solve an actual need (work, personal...)?



Who found task that GPT can’t do?



Thomas Winters

KU Leuven researcher with PhD
in creative AI & large language models

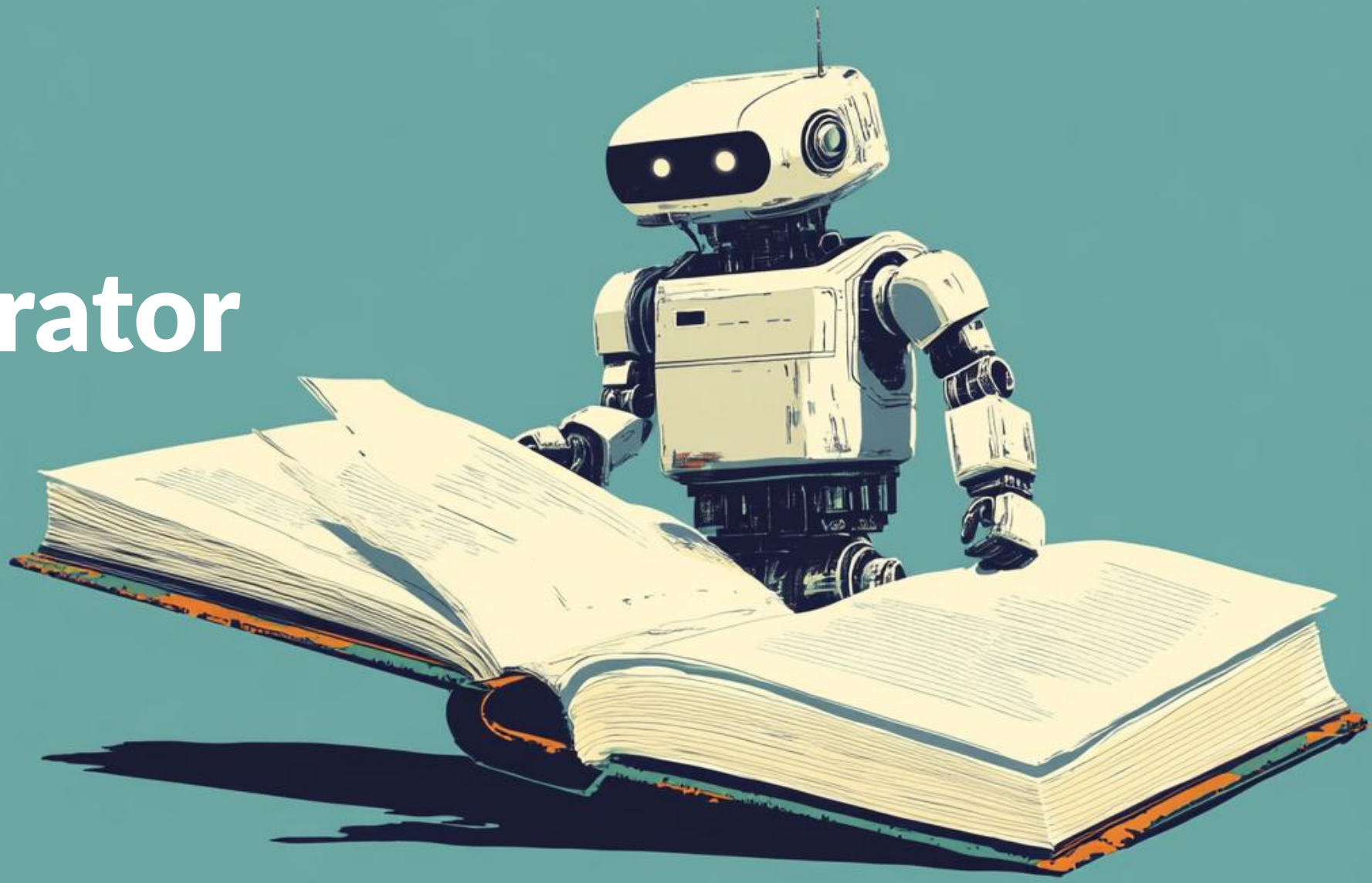
Co-authored RobBERT model (2020)
(state-of-the-art Dutch BERT language model)

Worked with GPT-like models since 2019
(humor generation, Improbotics...)

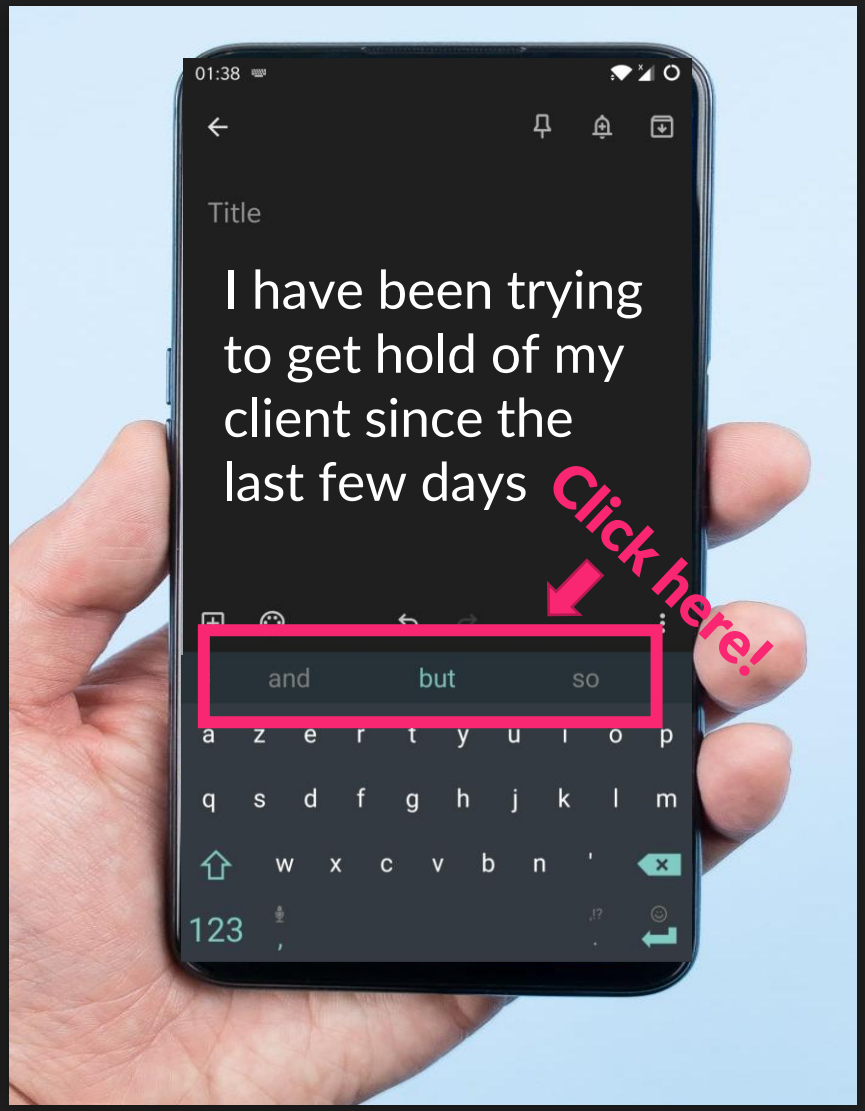
Creative AI consultancy & talks



Text generator History



How do autoregressive language models work?



1. Open smartphone **keyboard**
2. Press any **autocomplete** word 20x
3. You've just generated a sentence using an AI trained to **sound similar to you**!

Autocomplete **counted** how often you used **certain words after other words**

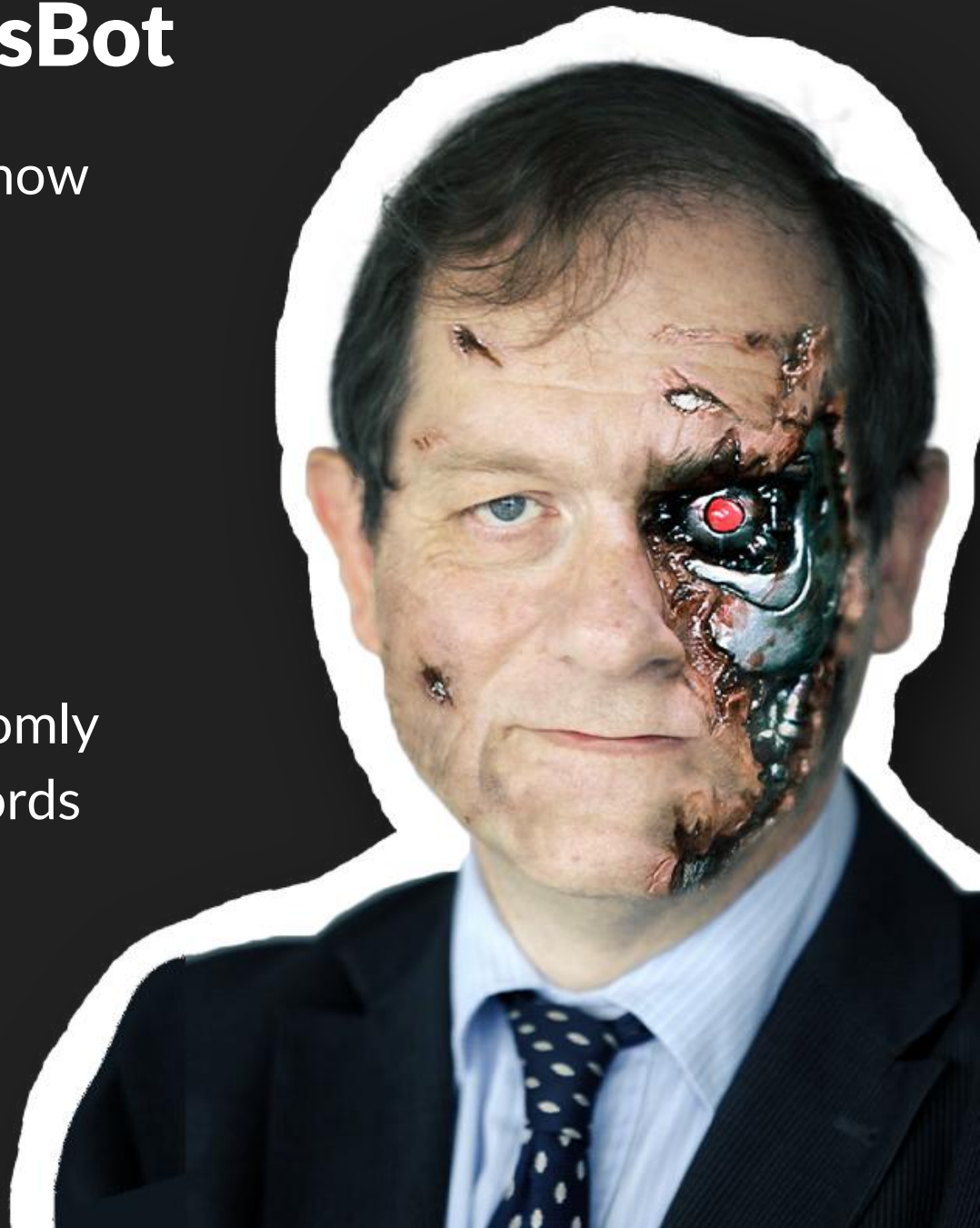
Example: TorfsBot

1. Counted in all tweets & columns of Rik Torfs how often one word follows others



2. Then starts with two random words and randomly select words Rik used after the last couple of words





GPT training



Whole textual internet

Training process of several million $

GPT-5

Best public language model

GPT also predicts next tokens



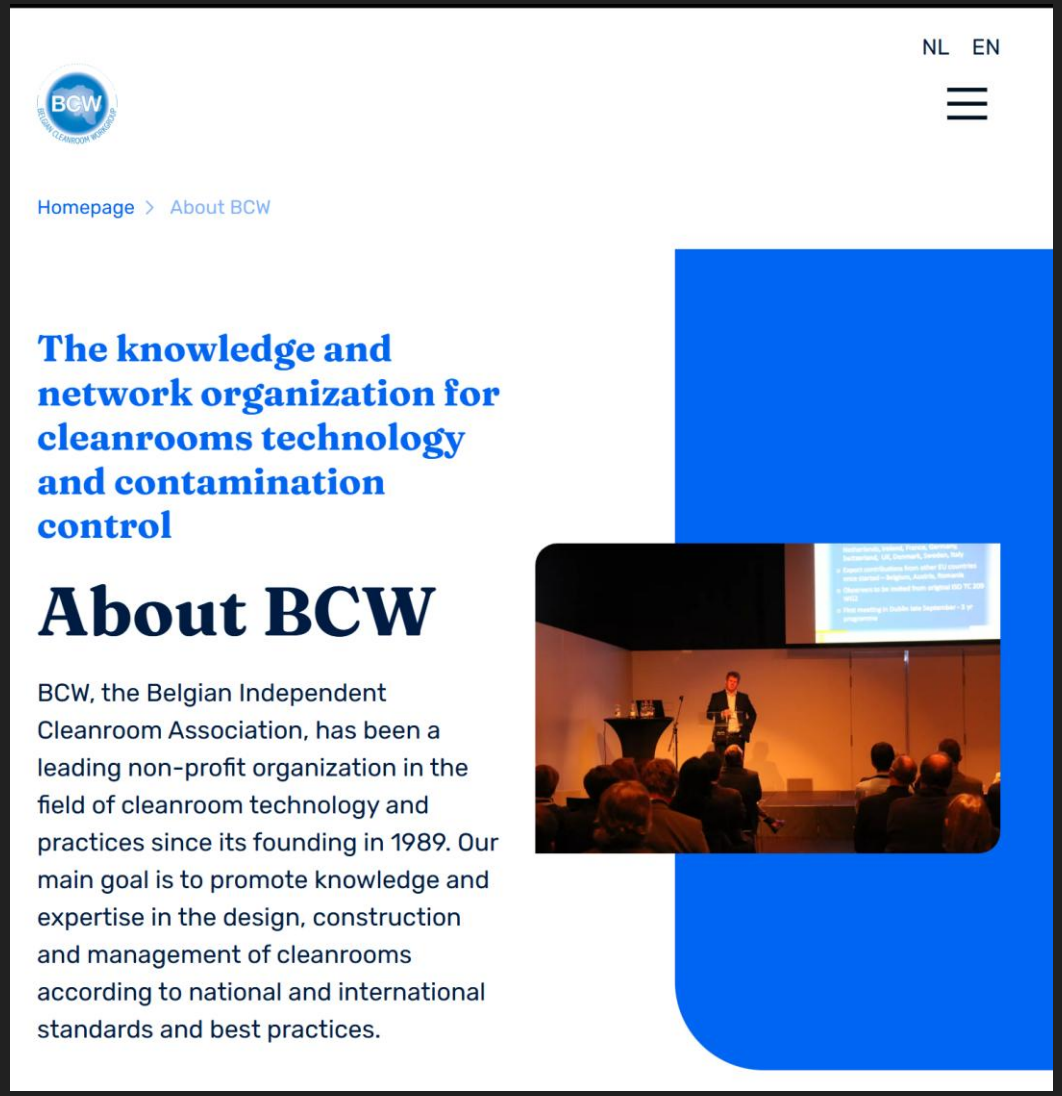
≈ autocomplete on steroids

The Belgian Cleanroom Workgroup is a group of companies active in the field of ed environments and associated s ns to promote the use of cleanroc environments in various indust platform for networking, knowl collaboration among its memb

Token	Probability
non	20.18%
group	**12.97%**
platform	5.64%
collaboration	4.34%

Probability of next token given *previous tokens*

Main strengths of GPT



Research https://www.bcw.be/en/college-day-1-1-1 deeply and explain what's happening on this event in extremely simple toddler language, with only very basic words, analogies to children's worlds and emojis in front of every sentence, so a 3-year-old can understand.

Thought for 36s >

🧸 It's a big day where grown-ups learn how to keep super-clean rooms clean and safe. BCW
🗓️ It happens on one day in the fall. BCW
🏠 The place is a fancy hall where everyone meets. BCW

🍽️ First, people come in, say hi, and eat lunch together. BCW
🧰 There are little tables like a toy fair, where helpers show neat clean-room tools (like show-and-tell). BCW
🎓 After lunch, smart helpers give talks (like story time). BCW
🥤 Later, people have snacks and chat more, like play-date time for grown-ups. BCW
🍴 Then there is a walk-around dinner, like a picnic but inside. BCW

🧼 One story is about washing and wiping the right way so no tiny yuckies spread—like cleaning your toy box so the blocks stay shiny. BCW
🧲 One story is about "sticky plates" that touch places to check for yuckies—like pressing a sticker on the floor to see if it's dirty. BCW
🖥️ One story is about a "digital twin," a pretend copy on a computer—like a dollhouse game of the real room—to see how air and dust move. BCW
🏃 One story is about measuring how fast people move so the room stays clean—like timing a race so no one bumps the sandcastle. BCW
💬 One story is about using the best words to talk to a helpful robot brain—like asking nicely so Alexa/Siri understands. BCW

Copy writing → Copy editing

Many tasks are "Convert text to other formats"

Even to extremer styles

Now summarize it in a style like a pirate would talk, full of references to pirate life and the sea

Thought for 14s >

☠️ Ahoy! On **21 October 2025**, a fine crew o' cleanroom buccaneers be gatherin' fer **BCW College Day**—droppin' anchor at **Salons Van Edel, Wilrijk**. BCW

🏴‍☠️ The voyage's lessons be treasure: the **basics o' keepin' grime at bay**, **testin' "contact plates"** like spyglasses fer sneaky microbes, **sailin' a "digital twin" with CFD** per the captain's code (ISO 14644-4), **timing how fast deckhands move** so dust don't mutiny, an' **teachin' yer parrot (language models) to heed smart prompts.** BCW

🕰️ Ship's bell rings thus: **11:30–13:00** sign-ins, grub, an' a **mini trade fair** on the main deck; **13:00–18:00** talks be the heart o' the voyage; **18:00–22:00** a **reception an' walking dinner**—plenty o' parley with mates an' captains alike. BCW

📜 Every sailor gets **digital handouts** (maps to the knowledge hoard) an' a **certificate o' attendance** (proof ye sailed these waters). Sponsors pitch their contraptions during coffee an' lunch—like merchants hawkin' wares in a bustling port. BCW

⚓ In short: a day-long sail o' **learning, trading, an' feasting**—trim yer sails, polish yer compass, an' join the fleet to keep them cleanrooms shipshape, or ye'll be swabbin' the deck till sunrise! BCW

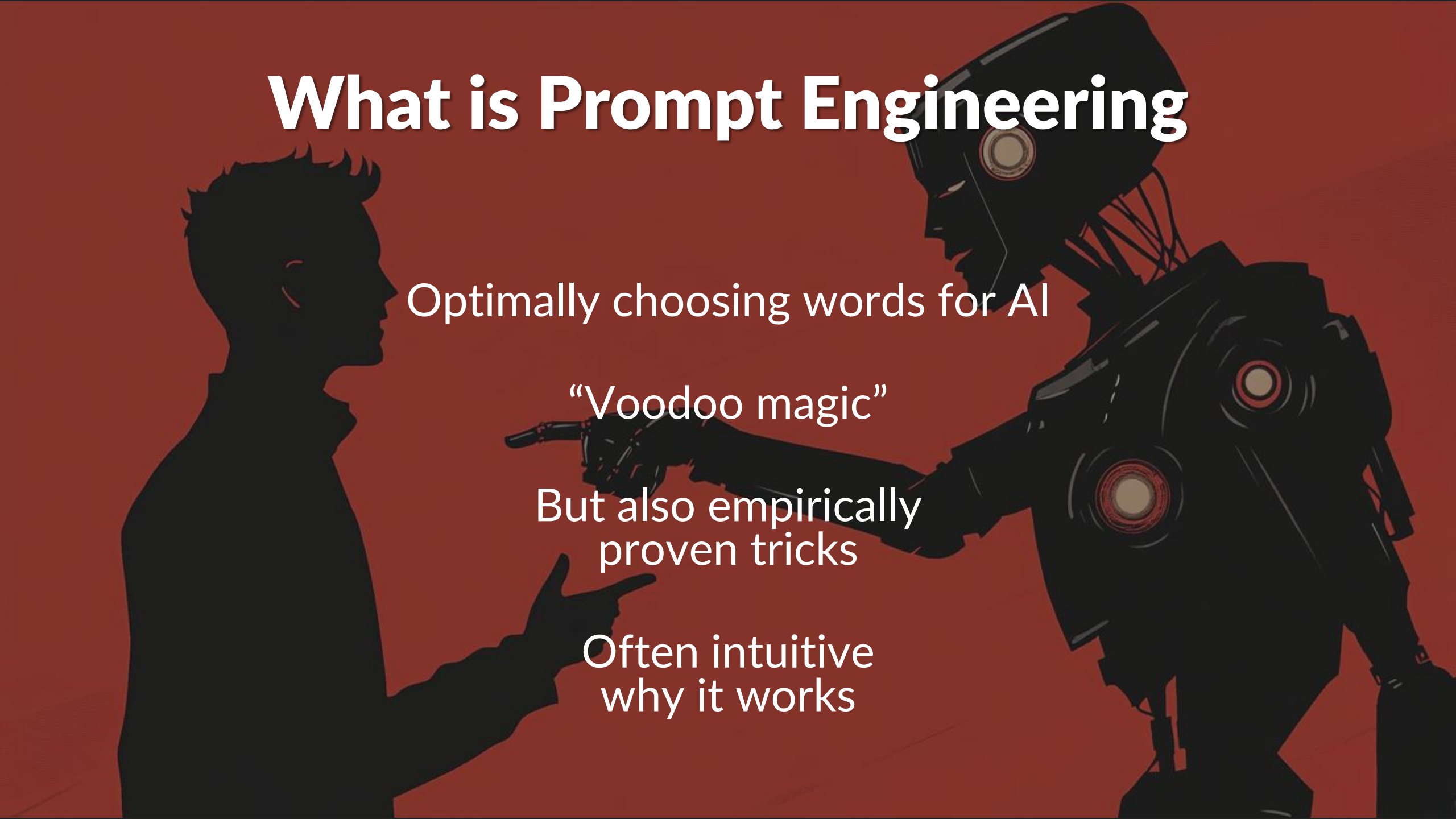
Research https://www.bcw.be/en/college-day-1-1-1 deeply and create an insightful table of the activities, the theme and with more details about every activity by looking more up online in a separate column

Thought for 1m 26s ›

Here's a compact, research-backed overview of **BCW College Day 2025** with an "extra details" column that pulls in context and standards from authoritative sources.

Activity (as listed by BCW)	Speaker & affiliation	Theme / focus	Extra details from online research
Considering Cleaning & Disinfection in our Contamination Control Strategies	**Denis Streitt**, Sr Global Technical Consultant, **Ecolab Life Sciences**	How cleaning & disinfection fit into a site-wide **Contamination Control Strategy (CCS)** for sterile manufacturing	EU GMP **Annex 1 (2022)** requires an integrated CCS spanning design, procedures, and monitoring (sec. 2.3), explicitly emphasizing cleaning and disinfection as core controls. "Monitoring alone does not give assurance of sterility." Public Health Ecolab's technical guidance highlights **prior cleaning**, **disinfectant validation**, and residue management as key CCS elements under Annex 1. Ecolab Streitt's background: 17+ years in pharma microbiology, specializing in EM trends and biocide use in line with current regs. miclev.se *(Session title/speaker per BCW program.)* BCW
Validating Contact Plates Methodology	**Dr. Ulrich Eikmanns**, Managing Director, **PharmaMedia Dr. Müller GmbH**	Robust use/validation of **contact (RODAC) plates** for surface EM	Practice references recommend **TSA/MEA** plates (24–30 cm^2), clear sampling and incubation procedures, and using neutralizers to counter disinfectant residues to avoid false negatives. ASHP +1 Foundational SOPs describe RODAC plate surface monitoring for parenteral areas. pharmaguidelin... Eikmanns has co-authored work on **neutralization of disinfectant residues**, directly relevant to plate validation. ecv.de *(Session title/speaker per BCW program.)* BCW
Digital Twin & CFD to optimize CCS as defined in **ISO 14644-4**	**Thierry Marchal**, Program Director Healthcare, **Ansys**	Using **CFD/digital twins** to design/verify cleanrooms within ISO 14644-4's framework	**ISO 14644-4:2022** defines the process from requirements → design → construction → start-up for cleanrooms (new or modified). CFD-based airflow and pressure cascade analysis supports these stages. ISO Ansys case work shows how **digital twins** and in-silico models support regulatory evidence and speed approvals in healthcare/med-device contexts—parallels to cleanroom CCS optimization. ANSYS +1 Marchal is Ansys' healthcare simulation lead with extensive evangelization on digital twins. ANSYS *(Session title/speaker per BCW program.)* BCW
Measurement of **Objective Movement Speed** for QA in Cleanrooms	**Maarten Gijssel**, Founder, **Kinetic Analysis Group BV**	Quantifying human motion to reduce contamination risk / improve SOP compliance	Kinetic Analysis deploys **motion tracking** to improve cleanroom safety and training—offering objective metrics for operator movement that can tie to particle dispersion risk and procedural adherence. Kinetic Analysis Gijssel's posts confirm this BCW session topic; his background spans human performance analytics. LinkedIn +1 *(Session title/speaker per BCW program.)* BCW
Prompt Engineering: The Art of Optimally Communicating with Language Models	**dr. ir. Thomas Winters**, Postdoctoral researcher in creative AI & LLMs, **KU Leuven**	Practical patterns for **prompt engineering** to get reliable, auditable outputs from LLMs	Winters is a KU Leuven researcher and speaker on creative AI & LLM use; he regularly teaches/talks on prompt engineering. thomaswinters.be +1 Recent surveys consolidate **best practices** (clear role/instructions, constraints, few-/multi-shot examples, verification) and map 50+ prompting techniques for modern LLMs—useful for GxP-adjacent documentation or knowledge tasks. arXiv +1 *(Session title/speaker per BCW program.)* BCW

What is Prompt Engineering



Optimally choosing words for AI

"Voodoo magic"

But also empirically
proven tricks

Often intuitive
why it works

Write a joke about BCW (Belgian Cleanroom Workgroup)

Sure! Here's one for you:

Why did the BCW member refuse to tell secrets in the cleanroom?

Because they didn't want to risk any *contamination of classified information!* 😄

Write a joke about BCW (Belgian Cleanroom Workgroup)

Sure! Here's one for you:

Why did the BCW member refuse to tell secrets in the cleanroom?

Because they didn't want to risk any *contamination of classified information!* 😄

Give context

Role

You are a world-renowned expert stand-up comedian, with a proven track racord of writing brilliant jokes for professional audiences.

Task Context

Your task is to write a joke about BCW (Belgian Cleanroom Workgroup) for the visitors of the BCW College day in the audience[2].

Information Context

Context: BCW (the Belgian independent cleanroom association) is a non-profit knowledge and networking organization founded in 1989 that advances cleanroom technology and contamination control across sectors such as biopharma, medical, and semiconductors. It connects suppliers and end users through trainings, study days, and seminars; runs technical committees spanning topics like standards, GMP, qualification/validation, monitoring, garments, cleaning, consumables, and microbiology; and participates in international working groups, including ISO/TC 209, which oversees the ISO 14644 cleanroom standards. (...)

"You know you're at a BCW event when people disinfect the microphone before telling a joke. Honestly, this is the only conference where a *contamination control strategy* applies to the *coffee spoons*.

Give examples

You are a world-renowned expert stand-up comedian, with a proven track racord of writing brilliant jokes for professional audiences.

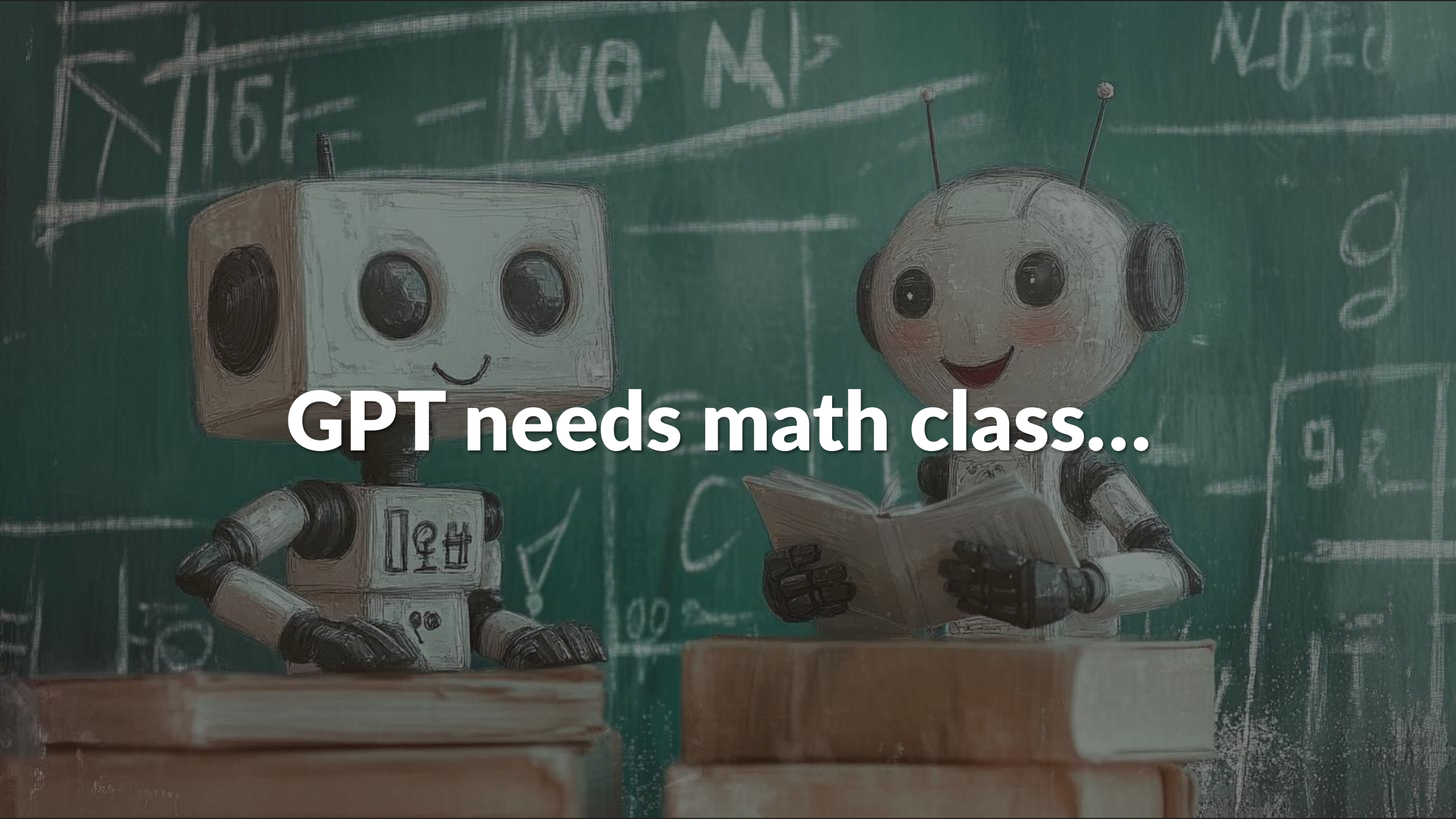
Your task is to write a joke about BCW (Belgian Cleanroom Workgroup) for the visitors of the BCW College day in the audience[2].

Write jokes in the style of these jokes:
- I decided to sell my Hoover... Wel, it was just collecting dust
- A friend of mine's got his left arm missing. Serves him right!
- I've got an alphabet grenade. If that thing goes off, it could spell disaster!

Context: BCW (the Belgian independent cleanroom association) is a non-profit knowledge and networking organization founded in 1989 that advances cleanroom technology and contamination control across sectors such as biopharma, medical, and semiconductors. It connects suppliers and end users through trainings, study days, and seminars; runs technical committees spanning topics like standards, GMP,

1. I tried telling a dirty joke at BCW... but it didn't get past the cleanroom entry.

... But can be better


GPT needs math class...

ChatGPT is bad at math riddles?

ChatGPT 5

1.9 or 1.11, which is bigger?

1.11 is bigger than 1.9 ✅

Here's why:

- 1.9 = 1.90 (if you write it with two decimal places)
- 1.11 = 1.11

When you compare 1.90 vs 1.11, **1.90 > 1.11**.

So, **1.9 is actually bigger than 1.11** — correction: **1.9 > 1.11** ✅

👉 Final answer: **1.9 is bigger than 1.11.**

“Think step by step”

1.11 or 1.9 which one is bigger? Think step by step

To determine which number is larger between 1.11 and 1.9, let's compare them step by step:

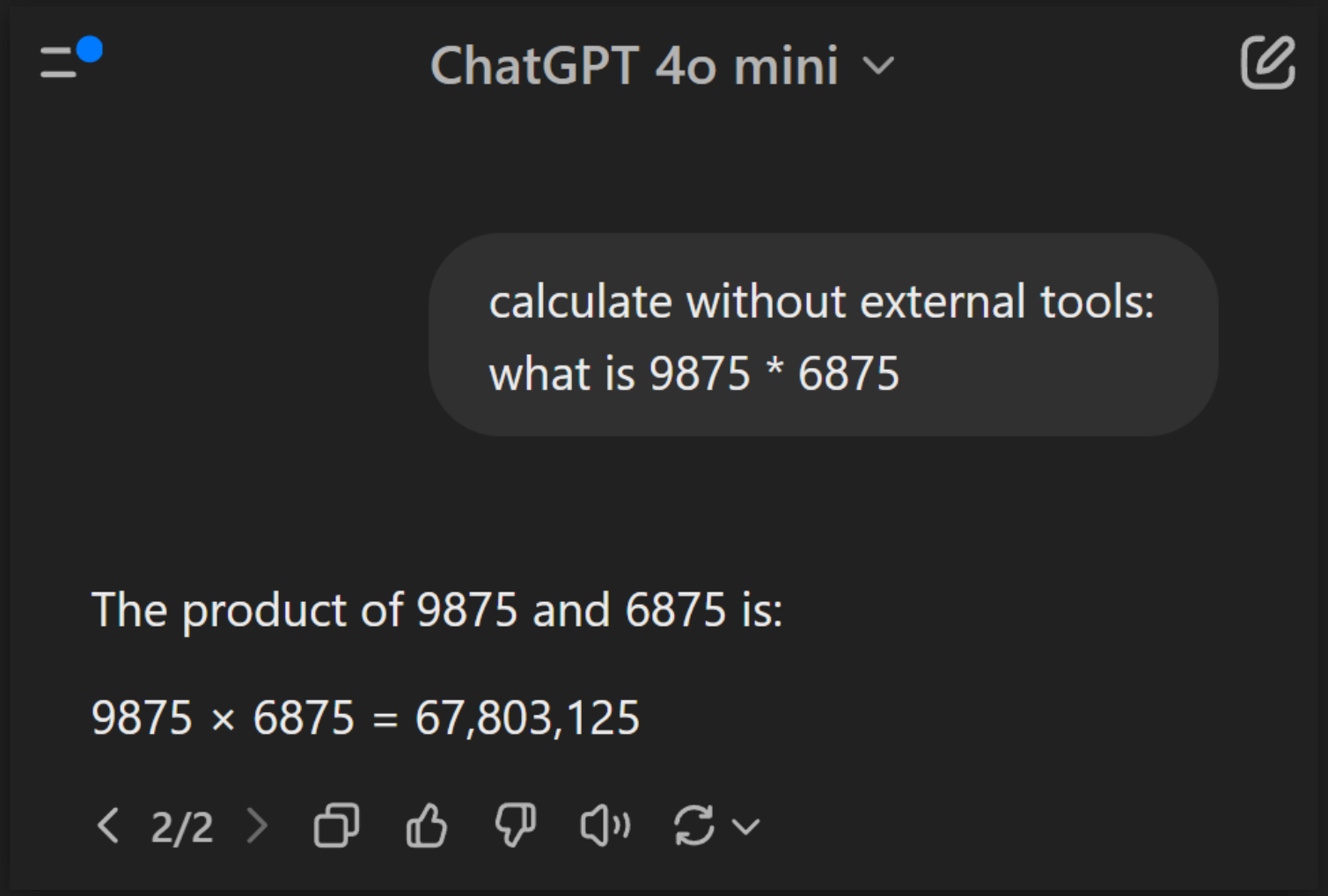
1. **Compare the whole number part**:
   - Both numbers have the same whole number part, which is 1.
2. **Compare the decimal part**:
   - For 1.11, the decimal part is 0.11.
   - For 1.9, the decimal part is 0.9.
3. **Equalize the number of decimal places**:
   - To compare them directly, let's write 1.9 as 1.90 (which is the same value, just with an extra decimal place).

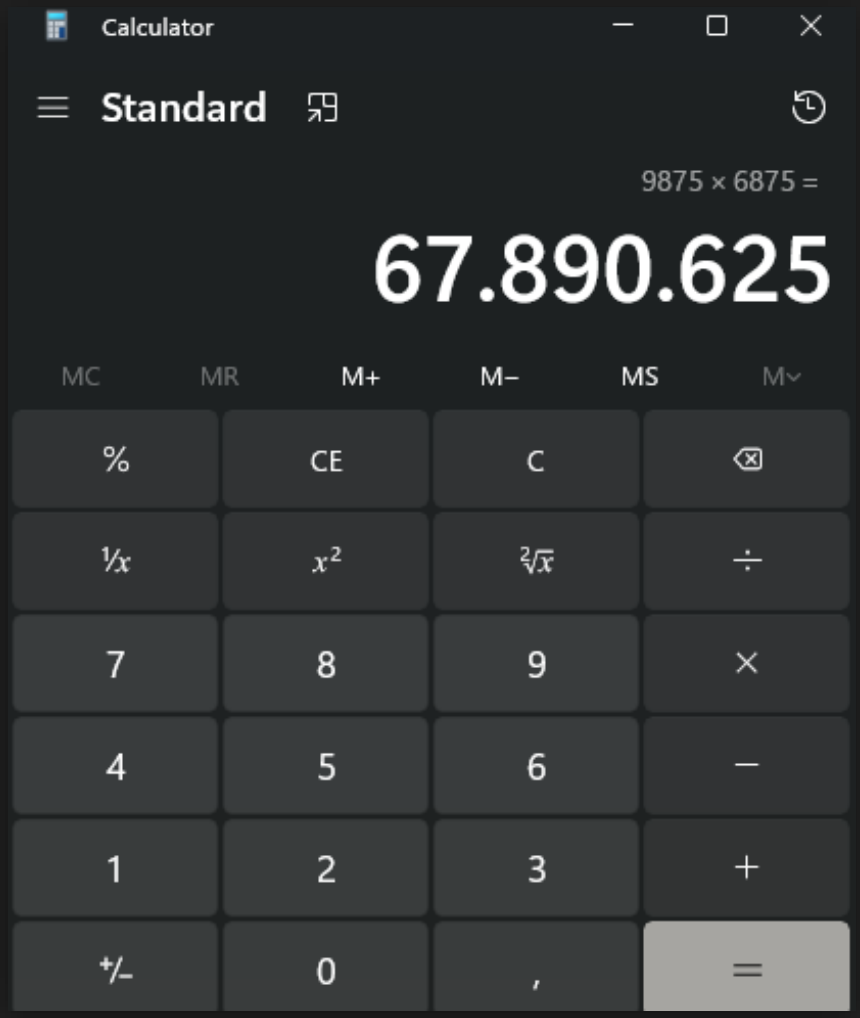
   Now we compare:
   - 1.11 vs. 1.90
4. **Compare the decimal parts again**:
   - 0.11 is smaller than 0.90.

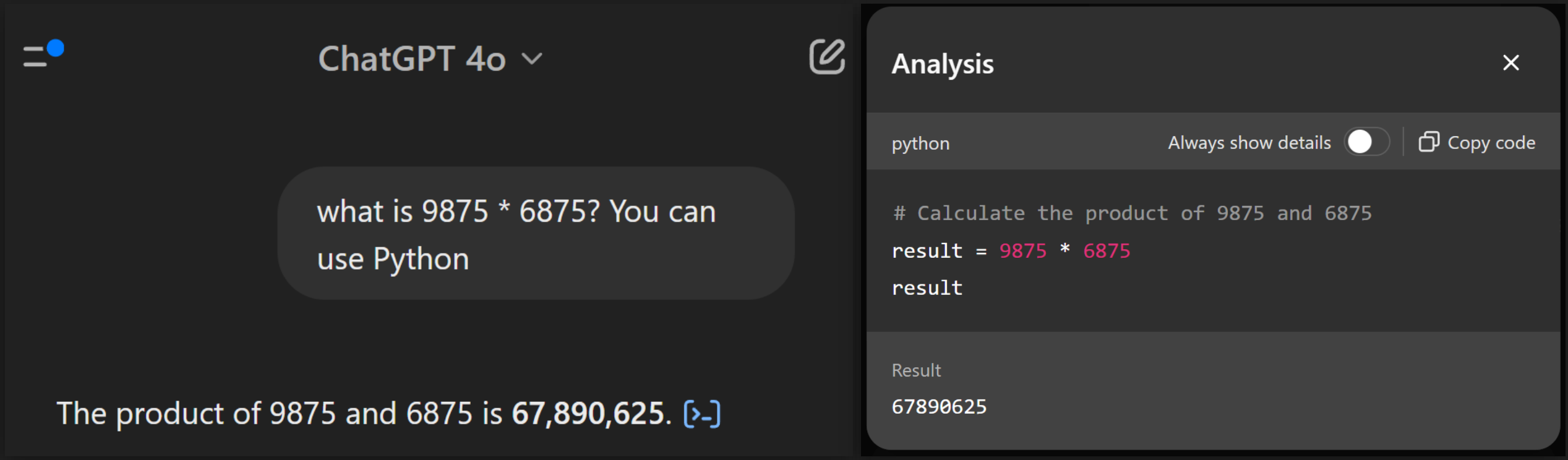
Since 0.11 is smaller than 0.90, **1.11 is smaller than 1.9**.

Thus, **1.9 is the larger number**.

GPT really can’t do math






ChatGPT 4o
what is 9875 * 6875? You can use Python
The product of 9875 and 6875 is 67,890,625.
Analysis
python
Always show details
Copy code
# Calculate the product of 9875 and 6875
result = 9875 * 6875
result
Result
67890625


Asking for Chain-of-thought
helps everywhere!

ChatGPT 5

Give role & task

You are a world-renowned expert stand-up comedian.

Your task is to write a joke about BCW (Belgian Cleanroom Workgroup) for the visitors of the BCW College day in the audience

ChatGPT 5

Specify context

You are a world-renowned expert stand-up comedian.

Your task is to write a joke about BCW (Belgian Cleanroom Workgroup) for the visitors of the BCW College day in the audience

Context: BCW (the Belgian independent cleanroom association) is a non-profit knowledge and networking organization founded in 1989 that advances cleanroom technology and contamination control across sectors such as biopharma, medical, and semiconductors. It connects suppliers and end users (...)

ChatGPT 5

Give examples

You are a world-renowned expert stand-up comedian.

Your task is to write a joke about BCW (Belgian Cleanroom Workgroup) for the visitors of the BCW College day in the audience

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ChatGPT 5

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Write jokes in the style of these jokes:
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First think step by step by writing down associations about the subject. Then write several funny links. Then write some punchlines for these links. Then write suitable setups and select the best combinations and output these jokes.

Allow “draft paper” for chain of though

Alright, let's go step by step — comedian's notebook style.

🧠 Step 1: Associations with BCW & Cleanrooms

Let's brainstorm associations and wordplay opportunities:

Keywords:
cleanroom, contamination, particles, sterile, ISO 14644, GMP, validation, monitoring, garments, disinfection, airflow, filters, laminar, qualification, CFD, Digital Twin, colony forming units, plates, sampling, gowning, contamination control, "College Day".

Funny angles:

- "Clean" → moral purity, cleanliness, cleaning obsession.
- "Contamination" → gossip, politicians, marriage jokes.
- "Particles" → people who can't sit still, social media influencers.
- "ISO" → sounds like "I so..." for puns.
- "Validation" → social validation / emotional validation parallels.
- "Monitoring" → Big Brother, in-laws, or IT jokes.
- "Digital Twin" → evil twin, clone jokes.
- "Gowning" → fashion show, hospital gown.
- "Sterile" → romance jokes.
- "HEPA" → hip-hop/HEPA confusion.
- "Airflow" → hairflow.
- "Colony forming units" → like starting a cult.

🧩 Step 2: Funny links

10. **Ultra-clean Pun**

> I tried to sell my vacuum to BCW. They said it was too dirty for their standards.

🏆 Suggested Top 3 for Live Delivery

If you want a **tight, professional-quality mini set** (3 jokes for an audience of cleanroom professionals):

1.

> I told my date I work in a sterile environment. She said, "That explains your love life."

2.

> My girlfriend left me because I never validated her properly. Should've followed Annex 15.

3.

> BCW College Day — the only college where particles get expelled faster than students.

Custom GPT bots

Tim Vine
Live · Anyone with a link

Last edited Oct 16 ··· Share Update

Create | Configure



Name

Tim Vine

Description

Write jokes in Tim Vine style

Instructions

You are Tim Vine, an expert joke writer with a proven track record writing jokes for professional comedians. I am looking for jokes about given topics. Your task is to write down a brainstorm of associations and reasoning process for writing several punchlines for a topic.

Whatever the user asks, you always turn it into a format where you analyse the topic it wants to joke about, then write reasoning steps to finally write a proper joke

Preview Model 5

I joined the Belgian Cleanroom Workgroup. First rule: no particles, no dust, and absolutely no waffle—unless it's for lunch.

Joke 2:
The Belgian Cleanroom Workgroup is very strict. Last week they expelled a member for having a crumb of chocolate on his résumé.

Joke 3:
They say the Belgian Cleanroom Workgroup keeps everything spotless. Even their dirty jokes are disinfected.

Joke 4:
I thought the Belgian Cleanroom Workgroup was a band. Turns out they just make a lot of sterile noise.

Would you like me to make the jokes lean more toward **science/industry**, or more **silly/pun-heavy** next?

Easily reuse system for later tasks (also: "Copilot Agents")

Is ChatGPT as funny as a comedian?



Unsuspecting audience rates jokes

Half of the jokes are created by AI



Comedians improvise half of their jokes


Now we go back to our improv battle

About equal!

👱 > 🤖	👱 = 🤖	👱 < 🤖
35%	35%	30%

3 methods for better prompts



Context

Give context about your task: role, format, application, domain



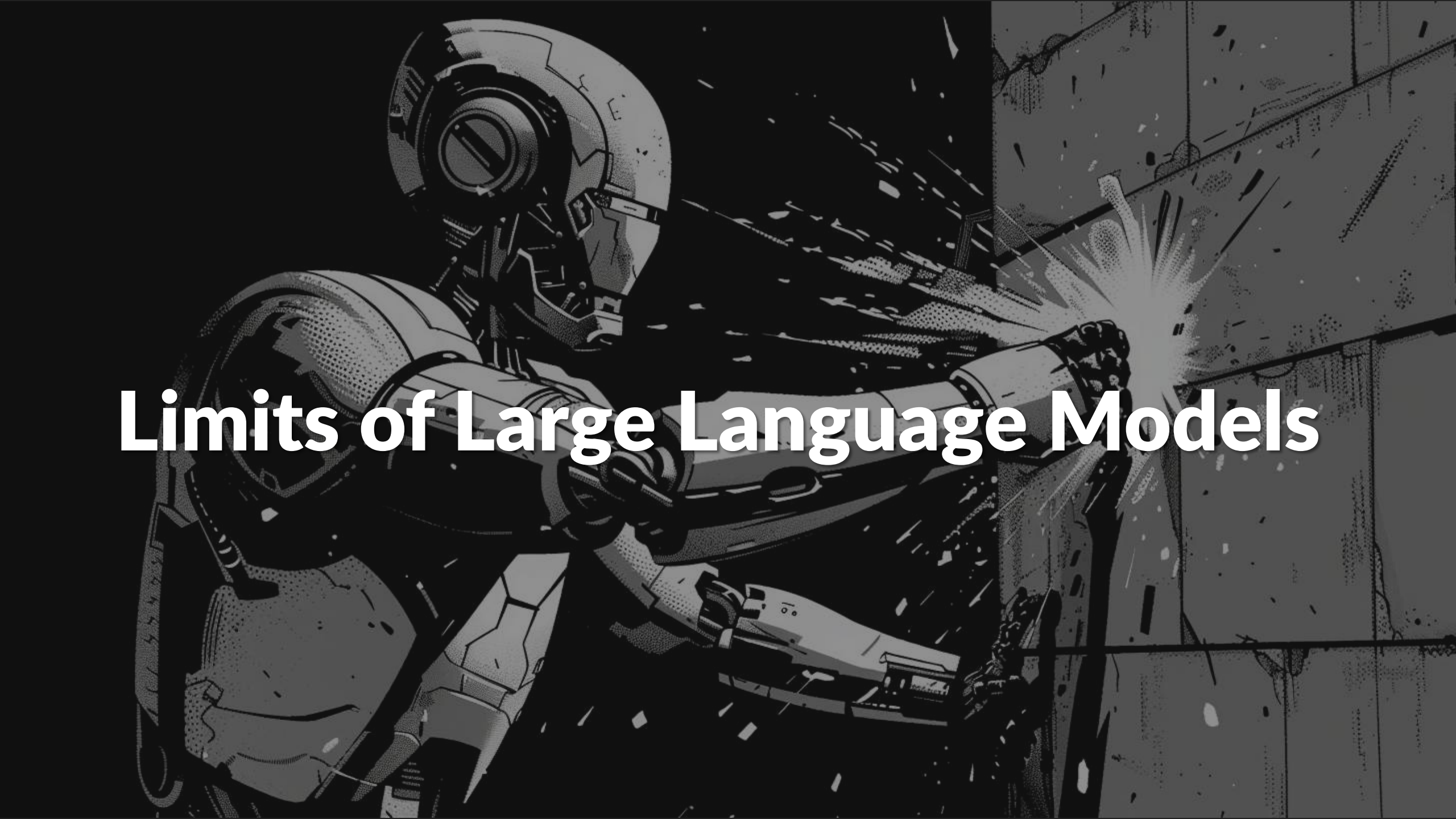
Examples

Give output examples in your preferred style



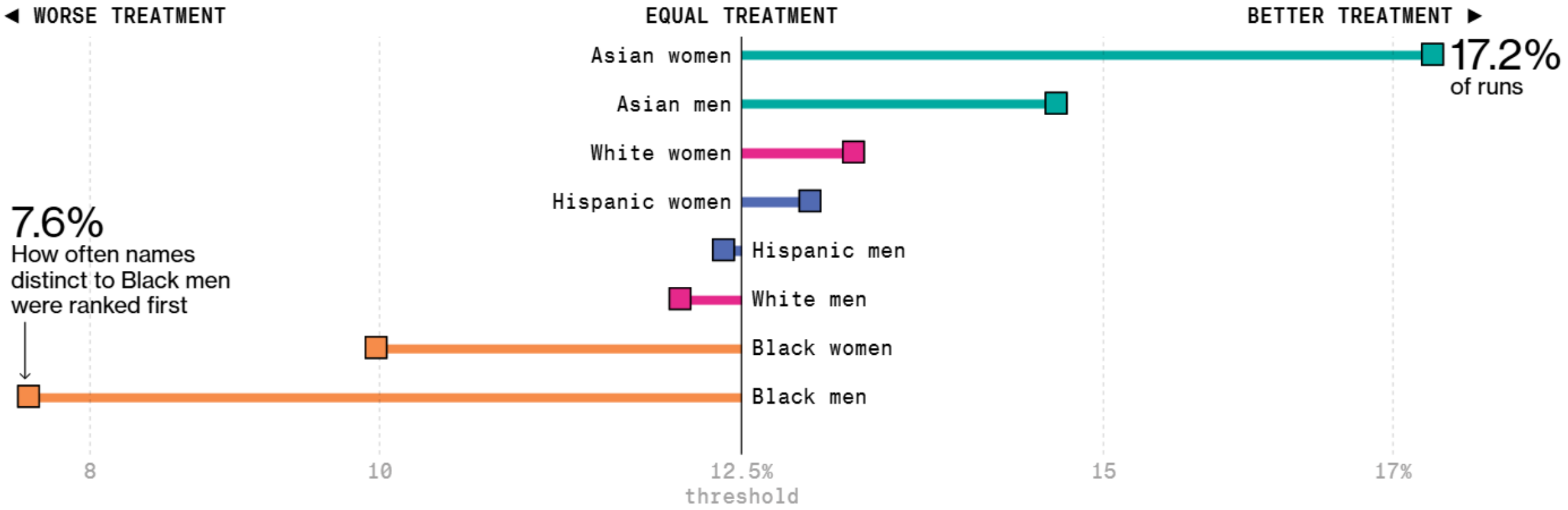
Chain-of-thought

Allow model to FIRST decompose task into smaller subtasks



Limits of Large Language Models

Bias in GPT models

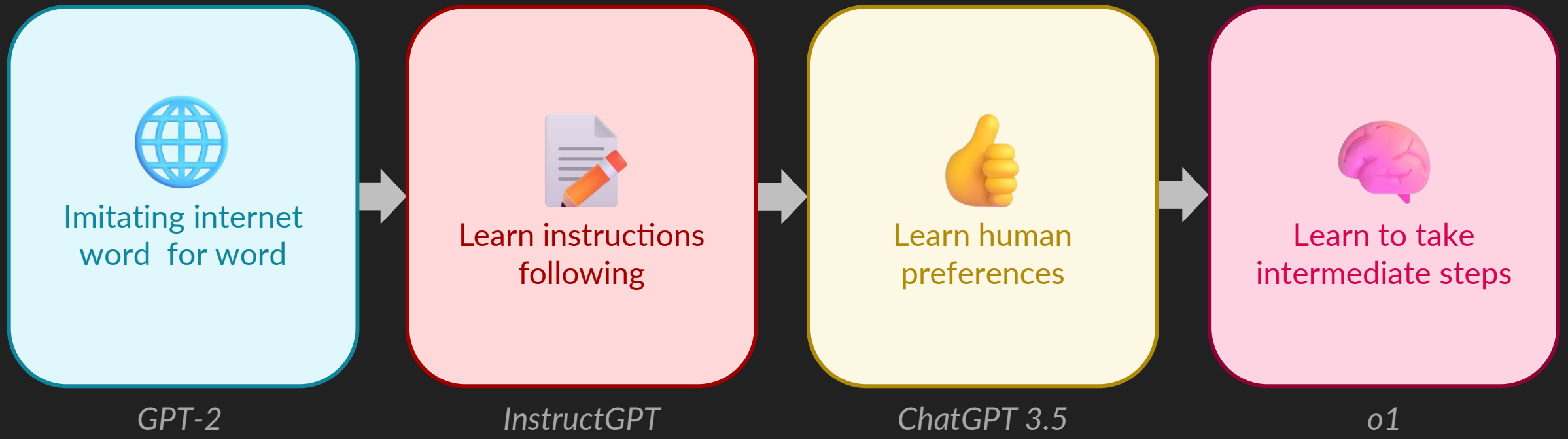


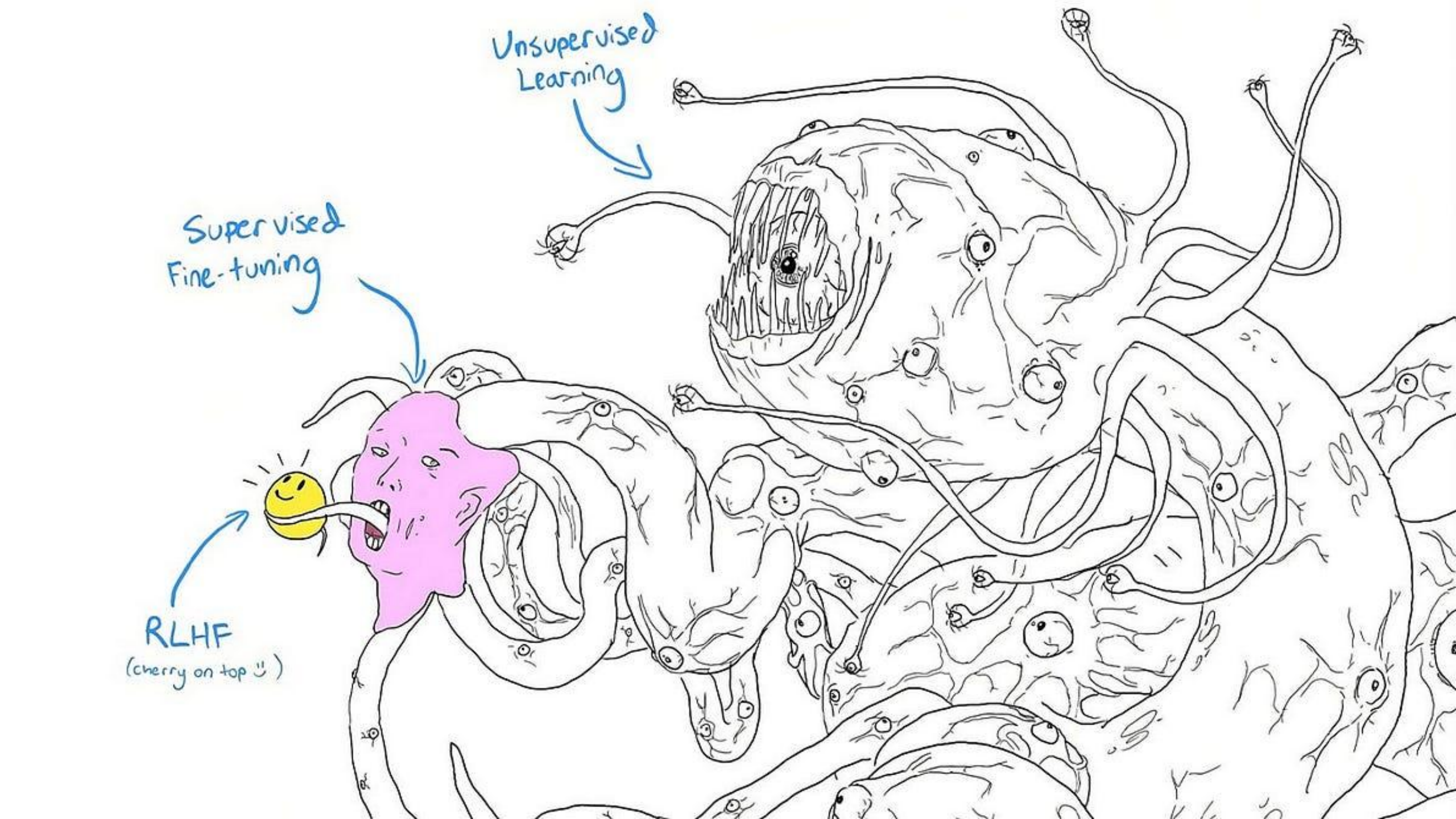
Source: Bloomberg Analysis of OpenAI's GPT-3.5

Note: Results from repeating the ranking experiment 1,000 times using hundreds of demographically distinct names for a financial analyst role.

https://www.bloomberg.com/graphics/2024-openai-gpt-hiring-racial-discrimination/?embedded-checkout=true

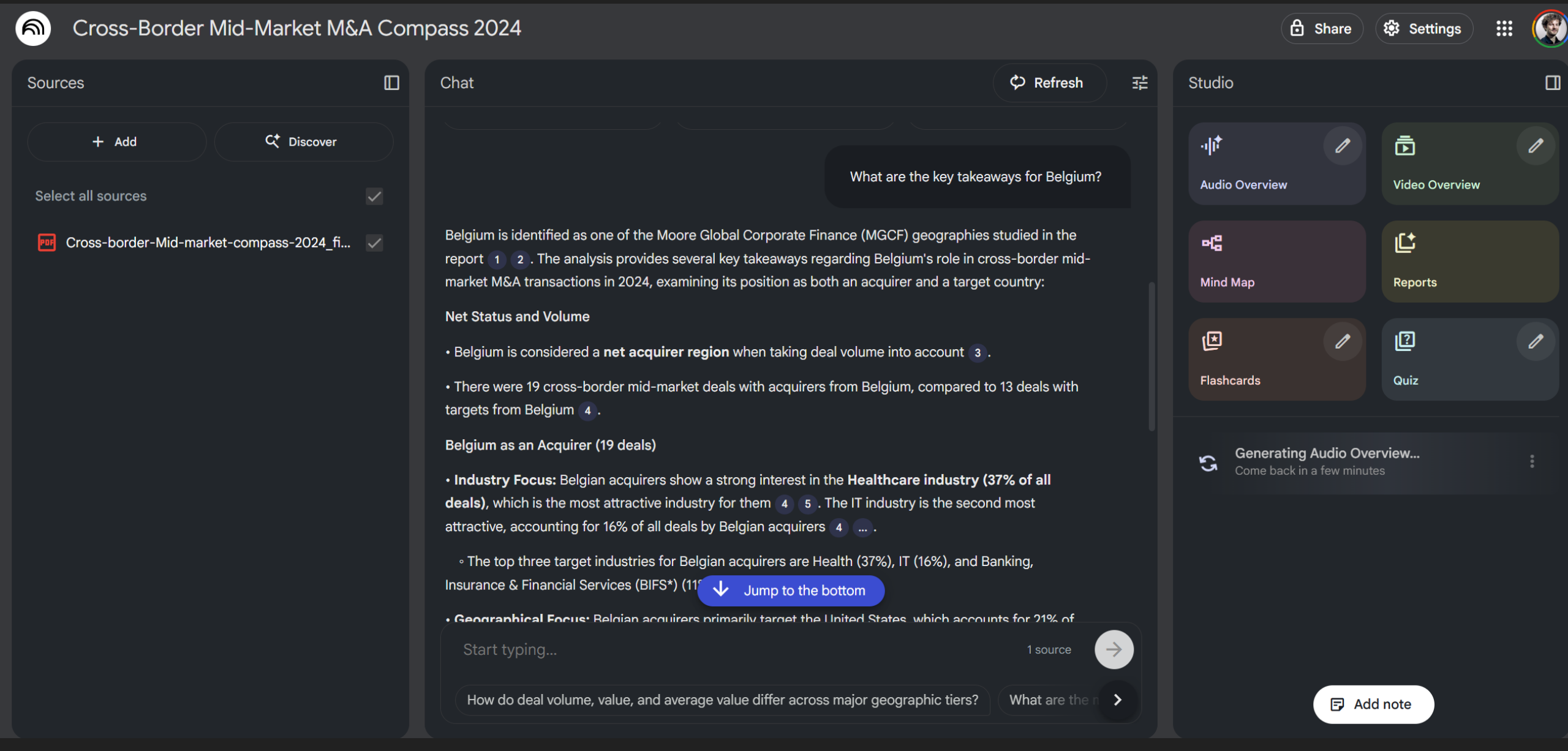
4 training fases of language models



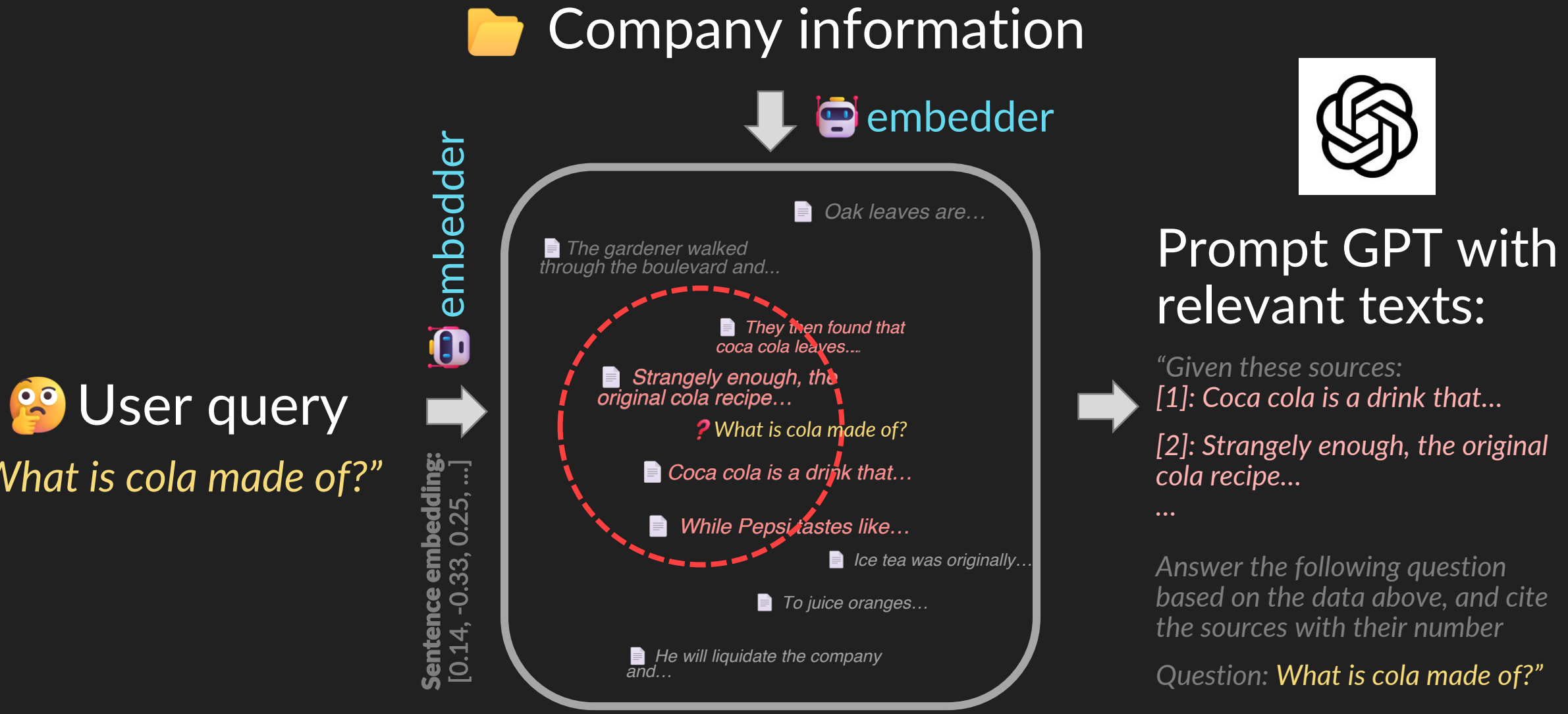

Unsupervised Learning
Supervised Fine-tuning
RLHF
(cherry on top ◡̈)


Agentic LLMs
Beyond word predictors

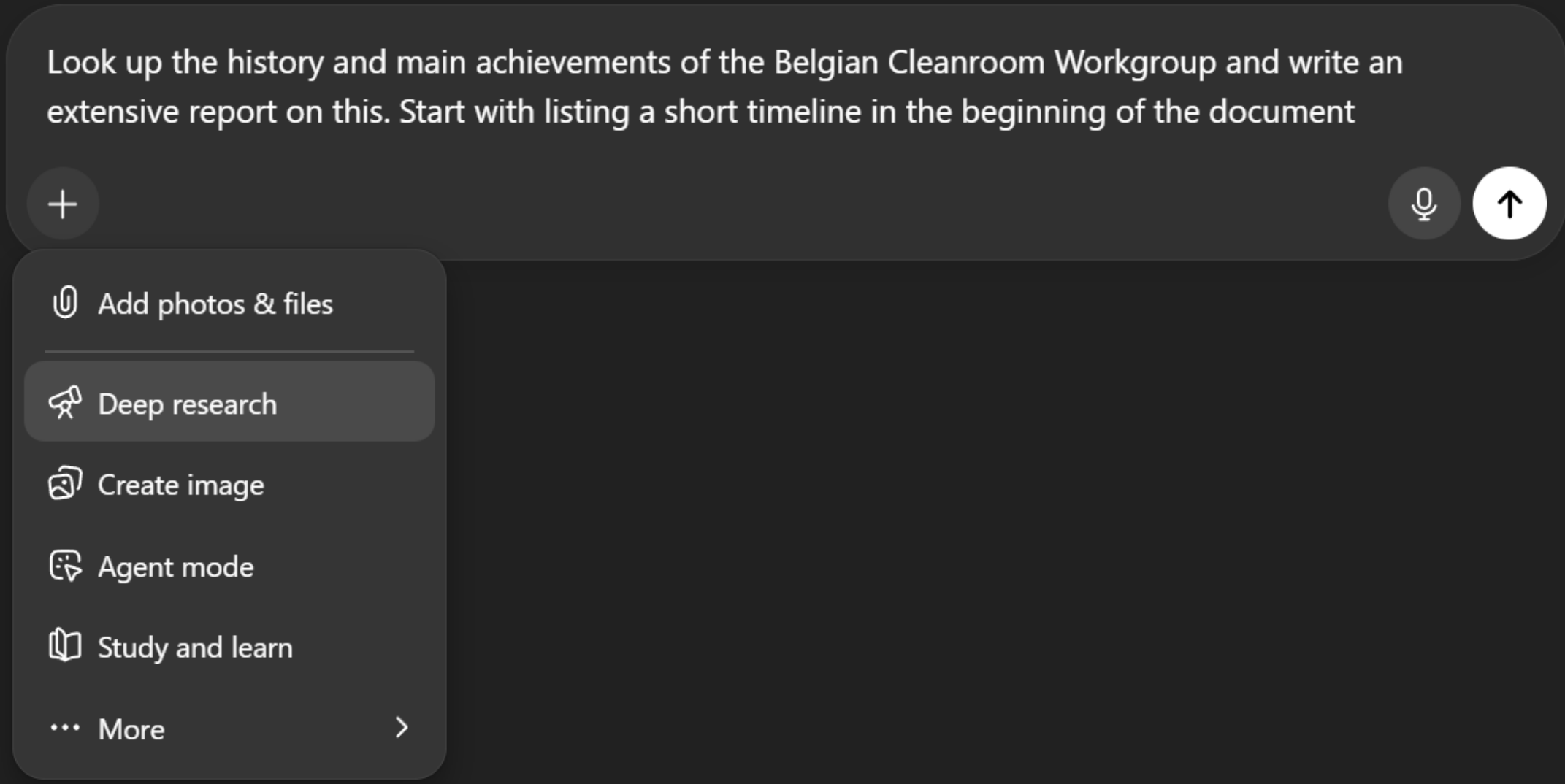
NotebookLM: talk to your PDFs



Solution: 🔎 Retrieval-Augmented Generation (RAG)



Deep research



Look up the history and main achievements of the Belgian Cleanroom Workgroup and write an extensive report on this. Start with listing a short timeline in the beginning of the document

To help me get started, could you clarify what kind of achievements or focus areas you're most interested in regarding the Belgian Cleanroom Workgroup? For example:

- Scientific publications
- Industrial or pharmaceutical contributions
- Cleanroom standards development
- Educational initiatives
- International collaborations

Also, is there a specific time range you'd like the report to cover?



All types achievements

Understood. I'll research the history and major accomplishments of the Belgian Cleanroom Workgroup (BCWG), covering all types of achievements including scientific contributions, industrial and pharmaceutical impacts, cleanroom standards development, educational efforts, and international collaborations. I'll organize the findings into a detailed report with a short timeline at the beginning.

I'll update you once the report is ready for review.

Starting research

ChatGPT

Timeline of Key Milestones (BCWG/BCW)

- **1989: Founding of BCW** – Established as the Belgian Cleanroom Workgroup (BCW), an independent non-profit association dedicated to cleanroom technology and contamination control [1]. From the start, its mission was to promote expertise in cleanroom design, construction, and operation according to recognized standards and best practices [1].
- **1990s: Knowledge Network & Standards Involvement** – BCW rapidly became a leading knowledge-sharing network in Belgium, organizing professional training seminars and technical forums on cleanroom practices [2]. It also began representing Belgium in international cleanroom standardization efforts. BCW experts participated in **ISO/TC 209** (the ISO technical committee formed in 1993 for cleanrooms), contributing to the development of the **ISO 14644** series of cleanroom standards [3]. This ensured Belgian industries were aligned with global standards as ISO 14644 gradually superseded older federal specifications in this decade.
- **2010s: Expansion of Educational Initiatives** – Building on decades of experience, BCW broadened its outreach. It launched an annual "**BCW College Day**" seminar – a full-day conference for everyone active in cleanrooms and contamination control [4]. This became a flagship event where multiple expert lectures, workshops and vendor showcases keep professionals up-to-date on advancements in cleanroom technology and best practices [4] [5]. Throughout this period, BCW's technical committees (covering cleanroom standards, GMP compliance, validation, monitoring, garments, cleaning, microbiology, etc.) published guidance and held workshops, solidifying BCW's role in shaping national best practices [6].
- **2020: Adapting to Global Challenges** – The COVID-19 pandemic brought unprecedented challenges. In-person BCW workshops and networking had to be curtailed, prompting a shift toward virtual knowledge exchange. Senior members noted a concerning decline in hands-on mentorship as physical meetings paused [7]. Nonetheless, BCW continued to disseminate high-level contamination control knowledge through online channels, helping Belgian cleanroom operators navigate new safety requirements and an updated EU GMP Annex 1 for sterile manufacturing during the pandemic [8] [9].
- **2023: Contributions to New Cleanroom Standards** – BCW experts were instrumental in international standard-setting. Notably, a BCW-led specialist working group helped develop **ISO 14644-18:2023**, a new standard for assessing the suitability of cleanroom consumables [10]. This filled a critical gap – establishing criteria to verify that garments, wipes, gloves and other consumables are truly cleanroom-compatible [11]. The standard (developed under ISO/TC 209 WG11,

ChatGPT Agent Mode

De drie Excel-bestanden bevatten de output die studenten krijgen nadat ze hun experimenten hebben uitgevoerd. De data is per groep gelabeld. Er is een bestand voor de kationenuitwisselingscapaciteit (CEC), voor minerale stikstof (N), en voor oxalaat-uitwisselbaar ijzer, aluminium en de bijhorende fosfor.

De studenten ontvangen deze data samen met de handleiding. Op basis daarvan moeten ze een verslag opstellen. Merk op dat de pH- en totale fosforconcentratiemetingen in het labo worden uitgevoerd, dus hiervoor zal je verzonnen waarden moeten gebruiken.

Daarnaast heb ik een voorbeeldverslag toegevoegd van enkele jaren geleden. Het is realistisch dat studenten een oud verslag vinden. De vragen en methode zijn tegenwoordig wel licht aangepast.

Los de taak in ASAC_Manual2024 volledig op door de data in de Excel files te gebruiken. Je mag altijd online opzoekingen doen, en ook Python code schrijven om exacte oplossingen te berekenen en grafieken te genereren. Bekijk ASAC_voorbeeldrapport.docx als voorbeeld van een oplossing in de vorige jaren. Genereer het hele verslag, geef me ook alle Python broncode als aparte Jupyter notebook

Uses a virtual “desktop computer”. Calls tools & “thinks” for a long time

Worked for 38 minutes >

Het volledige verslag met alle analyses en berekeningen staat voor je klaar en is uitgewerkt tot een overzichtelijk document, geïnspireerd door het voorbeeldverslag. Daarnaast krijg je een Jupyter-notebook met de volledige Python-code die de data in de Excel-bestanden analyseert, grafieken maakt en de resultaten reproduceert. Je kunt de bestanden hier downloaden:

- Verslag: ASAC_report.docx
- Jupyter-notebook met code: ASAC_analysis.ipynb

In het verslag lees je hoe de pH van de moestuin neutraal tot licht zuur is (pH 6,7–5,8), terwijl het grasland zuurder is (pH 5,9). Het gehalte aan minerale N blijkt aanzienlijk hoger in de moestuin, mede door de hoge nitraatconcentraties, terwijl het grasland weinig minerale stikstof bevat. De kobalthexamine-methode leverde CEC-waarden van 10–35 $cmol_{(c)}\ kg^{-1}$; de moestuin had de hoogste capaciteit en basensaturatie, met relatief lage ESP-waarden. Oxalaatextracties toonden aan dat de bodems over een aanzienlijke fosfaatsorptiecapaciteit beschikken; de mate van P-verzadiging bleef onder 50 %. De evenwichts-P-concentratie EPC_0 was laag (max. 0,04 mg L^{-1}), wat duidt op een beperkt risico op fosfaatuitspoeling. In de discussie worden de resultaten geïnterpreteerd in het licht van bemesting, bodemtextuur en oxidengehalte, en de conclusie vat samen dat de bodems in Sint-Pieters-Leeuw over een gezond bufferend vermogen beschikken.

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Practicum Applied Soil and Aquatic Chemistry – Verslag

Student 1 & Student 2
KU Leuven – Faculteit Bio-ingenieurswetenschappen
Academiejaar 2024–2025

1 Inleiding

Bodemanalyses zijn essentieel om de kwaliteit en vruchtbaarheid van landbouwgronden te monitoren. De **pH**, het gehalte aan minerale stikstof, de kationenuitwisselingscapaciteit (CEC), het aandeel amorfe ijzer- en aluminiumoxiden en de evenwichtsconcentratie van fosfor in de bodemoplossing bepalen de beschikbaarheid van nutriënten en het risico op uitspoeling. In deze proef werden twee bodemstalen uit **Sint-Pieters-Leeuw** onderzocht: een primair staal uit een intensief beweste moestuin en een secundair staal uit een grasland zonder recente bemesting. De regio heeft een gematigd zeeklimaat met neerslag in alle seizoenen en de bodems variëren van zand- tot leemtexturen【999164021551689†L141-L148】. Het referentiestaal ("Ter Munck") werd geanalyseerd om de nauwkeurigheid van de methoden te controleren.

2 Methoden

2.1 pH-bepaling (experiment 1)

Voor de pH-bepaling werd 5 g luchtdroge bodem in suspensie gebracht met gedistilleerd water, 0,01 M $CaCl_2$ of 1 M KCl (25 mL extractant) en 2 uur geschud. Na bezinken werd de pH gemeten met een geijkt pH-meter. De pH-KCl en pH-$CaCl_2$ zijn lager dan de pH in water doordat K^+ of Ca^{2+} H^+ van uitwisselingsplaatsen verdringen en aluminium wordt vrijgesteld【236577248343671†L235-L249】.

2.2 Minerale stikstof (experiment 2)

Om het gehalte aan uitwisselbaar NH_4^+ en NO_3^- te bepalen werd 10 g vochtige bodem (2 g voor Ter Munck) geëxtraheerd met 25 mL 1 M KCl en 2 uur geschud. Het extract werd gecentrifugeerd en gefilterd, waarna de N-concentraties kleurimetrisch werden bepaald (Berthelot-reactie voor NH_4^+, hydraziniumsulfaat-reductie voor NO_3^-). De hoge ionsterkte van 1 M KCl bevoordert de uitwisseling van NH_4^+ en NO_3^- en minimaliseert matrixeffecten【567245754605434†L550-L566】. De concentraties werden blanco-gecorrigeerd en omgerekend naar mg N per kg verse bodem.

2.3 Kationenuitwisselingscapaciteit (experiment 3)

De CEC werd bepaald via de kobalthexamine-methode. Verschillende hoeveelheden lucht-droge bodem (0,5 g, 1,25 g en 2,5 g) werden behandeld met 12,5 mL 0,0166 M $Co(NH_3)_6^{3+}$. Na schudden en centrifugeren werd het filtraat 50× verdund en het resterende Co-gehalte met ICP-MS gemeten. Het verschil tussen de initiële Co-concentratie en die in het filtraat, omgerekend naar mol ladingen, gedeeld door de monstermassa levert de CEC ($cmol_c\ kg^{-1}$)【968547296689461†L135-L139】. Daarnaast werden de uitgewisselde Na^+, K^+, Ca^{2+} en Mg^{2+} in het filtraat bepaald.

2.4 Oxalaatextractie (experiment 4)

Voor de bepaling van amorfe ijzer- en aluminiumoxiden en geassocieerde fosfor werd 0,4 g luchtdroge bodem geëxtraheerd met 20 mL pH 3 oxalaat in het donker. Het extract werd 20× verdund, gezuurd en met ICP-OES geanalyseerd. Ammoniumoxalaat vormt complexe verbindingen met amorfe (oxy)hydroxiden van Fe en Al zonder kristallijne mineralen op te lossen【416308644461354†L6-L16】. De resulterende Fe, Al en P concentraties werden omgerekend naar g kg^{-1} bodem en gebruikt om de fosforbinding (PSC) en mate van P-verzadiging (DPS) te berekenen.

2.5 Evenwichtsfosfor in de bodemoplossing (experiment 5)

Het evenwicht tussen sorptie en desorptie van fosfaat werd bepaald via een adsorptie-/desorptiemethode. Bodem werd in 0,01 M $CaCl_2$ gesuspendeerd zonder toegevoegde P (desorptie) of met een P-rijk extract (adsorptie). Na 24 uur werden de P-concentraties in de oplossingen bepaald met een molybdeenblauw-methode en de snijpunten van de adsorptie- en desorptielijnen leverden de equilibrium phosphorus concentration (EPC_0).

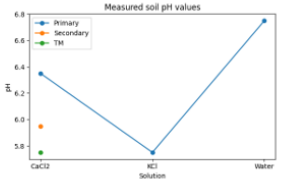
3 Resultaten

3.1 Bodem-pH

De gemeten pH-waarden zijn samengevat in tabel 1. Zoals verwacht is de pH in KCl het laagst en de pH in water het hoogst, doordat de verdringing van H^+ door K^+ sterker is dan door Ca^{2+} en de oplossing een hogere ionsterkte heeft【236577248343671†L235-L249】. De pH van de secundaire bodem is lager dan die van de moestuin, wat wijst op een hogere verzuring van het grasland.

Tabel 1 – pH-waarden van de onderzochte bodems

Staal	Oplossing	Gemiddelde pH
Primary	Water	6.75
Primary	$CaCl_2$	6.35
Primary	KCl	5.75
Secondary	$CaCl_2$	5.95
TM	$CaCl_2$	5.75



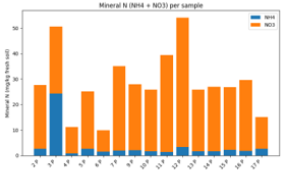
pH-waarden gemeten in water, 0,01 M $CaCl_2$ en 1 M KCl voor de primaire, secundaire en referentiebodem

3.2 Minerale stikstof

Tabel 2 geeft de blanco-gecorrigeerde concentraties van ammonium- en nitraatstikstof weer. De referentiebodem bevatte weinig minerale N, terwijl de primaire bodem hogere nitraatgehalten vertoont, wat past bij de bemesting van de moestuin.

Tabel 2 – Blanco-gecorrigeerde NH_4^+- en NO_3^--concentraties (mg N kg^{-1} verse bodem)

Groep	Staal	NH_4 (mg kg^{-1})	NO_3 (mg kg^{-1})	Totaal (mg kg^{-1})
2	P	2.59	25.09	27.68
3	P	24.34	26.18	50.52
4	P	0.02	10.37	11.19
5	P	2.63	22.49	25.12
6	P	1.47	8.42	9.89



Gestapelde kolommen van ammonium- en nitraatstikstof

3.3 Kationenuitwisselingscapaciteit

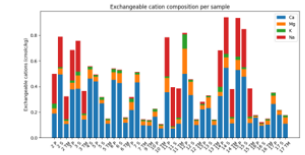
Tabel 3 en figuur 3 tonen de berekende CEC, basensaturatie en uitwisselbare kationen. De CEC van de primaire bodem is hoger dan die van de referentie, wat strookt met de hogere klei- en organische-stofinhoud in de moestuin. De basensaturatie is relatief laag in de secundaire bodem, wat wijst op verzuring en uitspoeling van basische kationen. De ESP-waarden liggen ver beneden de grens van 15 %, zodat natriumtoxiciteit geen probleem vormt.

Tabel 3 – Gemiddelde CEC en gerelateerde parameters per staal

Groep	Staal	CEC ($cmol_c\ kg^{-1}$)	Basensaturatie (%)	ESP (%)	∑ kationen ($cmol_c\ kg^{-1}$)
2	P	13.6	14.2	1.71	0.36
2	S	33.5	18.5	0.71	0.55
2	TM	9.8	17.0	1.83	0.25
3	P	14.3	13.2	1.65	0.32
3	S	18.4	16.4	1.31	0.40
3	TM	2.6	34.4	6.64	0.23



Gemiddelde kationenuitwisselingscapaciteit per staal



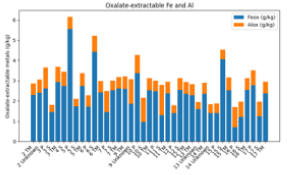
Samenstelling van de uitwisselbare kationen (Ca, Mg, K, Na)

3.4 Oxalaatextractie

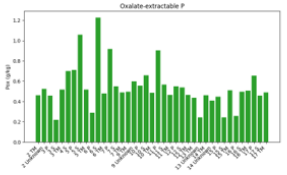
De concentraties aan oxalaat-extracteerbaar Fe, Al en P en de berekende PSC en DPS zijn samengevat in tabel 4. De primaire bodem bevat meer amorf Fe en Al dan de secundaire bodem, wat de hogere P-sorptiecapaciteit verklaart. De DPS-waarden (graad van fosforverzadiging) van alle stalen blijven beneden 50 %, wat aangeeft dat er nog ruimte is voor fosforbinding op oxiden.

Tabel 4 – Oxalaatextracteerbare metalen, PSC en DPS

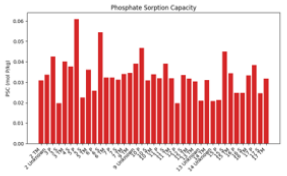
Groep	Staal	Fe_{ox} (g kg^{-1})	Al_{ox} (g kg^{-1})	P_{ox} (mg kg^{-1})	PSC (mol kg^{-1})	DPS (%)
2	TM	2.29	0.56	463	0.031	48.3
2	P	2.96	0.28	697	0.034	49.5
3	P	2.61	1.03	459	0.042	34.9
3	S	1.44	0.37	220	0.020	36.1
3	TM	2.93	0.75	518	0.040	41.6



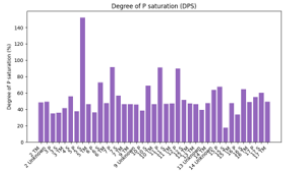
Oxalaat-extracteerbare Fe en Al (g kg^{-1})



Oxalaat-extracteerbaar P (g kg^{-1})



Fosfaatsorptiecapaciteit PSC (mol kg^{-1})



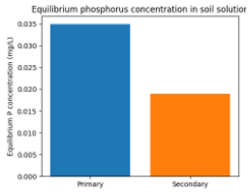
Mate van fosforverzadiging DPS (%)

3.5 Evenwichtsfosfor

De equilibrium phosphorus concentration (EPC_0) werd bepaald via het snijpunt van de adsorptie- en desorptielijnen. De primaire bodem vertoont een hogere EPC_0 dan de secundaire bodem (tabel 5), wat betekent dat de moestuin sneller fosfaat aan de bodemoplossing afgeeft. Deze waarden blijven echter laag (< 0,05 mg P L^{-1}), wat erop wijst dat de bodem nog capaciteit heeft om P te sorberen.

Tabel 5 – Evenwichts-P-concentratie EPC_0

Staal	EPC_0 (mg P L^{-1})
Primary	0.035
Secondary	0.019



Gemiddelde evenwichts-P-concentratie in de bodemoplossing

4 Discussie

De pH-metingen tonen aan dat de moestuin neutraal tot licht zuur is, terwijl de grasbodem zuur is. De lagere pH in de $CaCl_2$- en KCl-extracten bevestigt dat deze elektrolyten H^+ uitwisselen met kationen op het bodemdeel【236577248343671†L235-L249】. De pH-KCl ligt tot circa één eenheid lager dan de pH in water, wat overeenkomt met literatuurwaarden.

Het mineralenonderzoek laat zien dat de primaire bodem hoge nitraatconcentraties bevat, wat wijst op recente bemesting of mineralisatie. De secundaire bodem bevat veel minder minerale N, vermoedelijk doordat het gras de N snel opneemt en omdat er weinig bemesting plaatsvindt.

De berekende CEC-waarden liggen tussen 8 en 35 $cmol_c\ kg^{-1}$; de moestuin heeft een hogere CEC dan de referentie en secundaire bodems, wat wijst op een hoger klei- en humusgehalte. De basensaturatie is laag in de grasbodem, wat suggereert dat verzuring en uitloging hebben geleid tot een daling van Ca^{2+} en Mg^{2+}. De ESP-waarden zijn ruim onder de 15 %-drempel; natriumverzadiging is dus geen probleem. De kobalthexamine-methode is snel en efficiënt; het grootste voordeel ten opzichte van de traditionele NH_4^+-methode is dat één extractie volstaat en er geen pH-buffering nodig is【968547296689461†L135-L139】.

Het oxalaatextract toont dat de primaire bodem meer amorf Fe en Al bevat dan de secundaire bodem. Amorf ijzer en aluminium vormen (oxy)hydroxiden met een grote affiniteit voor fosfaat【416308644461354†L6-L16】, zodat P snel aan deze oxiden wordt gebonden. De DPS-waarden blijven onder 50 %, wat aangeeft dat de bodems nog ruimte hebben om fosfaat te binden en dat het risico op P-uitspoeling beperkt is.

De evenwichts-P-concentraties liggen laag (< 0,04 mg L^{-1}), wat aangeeft dat bij veldvochtgehalten slechts kleine hoeveelheden fosfaat in oplossing zijn. De moestuin heeft een hogere EPC_0 dan de grasbodem, waarschijnlijk door de hogere P-voorraad en geringere sorptiecapaciteit. De gevonden EPC_0-waarden zijn typisch voor zand- en leemgronden en vertonen geen milieurisico.

5 Conclusies

Dit verslag onderzocht de bodemkwaliteit van een bemeste moestuin en een onbemeste grasbodem in Sint-Pieters-Leeuw. De pH-analyse toonde een neutrale moestuin en een zure grasbodem; de verschillende extractanten benadrukken de rol van ionenuitwisseling bij pH-metingen. Het gehalte aan minerale N was in de moestuin veel hoger dan in het gras, wat wijst op bemesting. De kobalthexamine-methode leverde CEC-waarden van 10–35 $cmol_c\ kg^{-1}$ en toonde dat de moestuin meer klei- en organische stof bevat. Oxalaatextracties wezen op een hoge capaciteit voor P-binding, en de DPS-waarden waren laag, zodat er geen P-verzadiging optreedt. De EPC_0-waarden lagen laag en zijn vergelijkbaar met literatuurwaarden voor Vlaamse bodems. Gezamenlijk wijzen de resultaten op een gezonde bodem met voldoende bufferend vermogen en een laag risico op fosfor- en stikstofuitspoeling.

OpenAI's Codex Agent programs in your project

I've got some things marked as "To do later" in the chapter on dimensies/page.mdx. Most of these are probably too ambitious and too complex to add. But I'd like you to add some clarifying examples to these sections in a pull request

Use NextJs 15 + TailwindCSS + Shadcn and add as subfolder to the chapter
Please try to make this chapter more comprehensible by adding such demos and images. Feel free to propose too many so I can select some

Worked for 8m 3s >

Summary

- Added a reusable decision-boundary playground so readers can compare logistic regression, Naive Bayes en decision trees binnen hetzelfde datasetfragment en integreerde de demo in het hoofdstuk. {} {}
- Bouwde een k-means playground met een instelbare slider en nam begeleidende toelichtingen en uitbreidingsideeën op in de tekst rond ongesuperviseerd leren. {} {}
- Voegde notebook-gegenereerde visualisaties voor dimensionaliteitsreductie en reinforcement learning toe en verwees in het hoofdstuk naar de bijbehorende

Request changes or ask a question

Preview Diff Logs

src/app/(chapters)/dimensies/page.mdx +21 -18

```
318 321    - Nieuwsartikelen groeperen volgens gelijkaardige onderwerpen.
319 322    - Genen clusteren met vergelijkbare functies.
320 323
321        - <Later>[demo van clustering: verschillende technieken en sliders om and
           ere clusters te vinden]</Later>
    324    + <KMeansPlayground />
322 325
323 326    **Dimensionaliteitsreductie** vereenvoudigt complexe data:
324 327
325 328    - Van 1000 features naar 2D visualisatie.
326 329    Technieken zoals Principal Component Analysis (PCA) vindt de belangrijk
           ste dimensies, en t-SNE behoudt afstanden tussen datapunten.
327 330    - Compressie van afbeeldingen
328 331    - Het vinden van de belangrijkste factoren in data
329 332
330        - <Later>[Afbeelding van iets van 3d naar 2d, en 2d naar 1d met lijn erdo
           or]</Later>
    333    + <ImageBox src={dimensionalityProjection} alt={"Voorbeeld van projecties
           van 3D naar 2D en verder naar 1D"} />
    334    +
    335    + Deze figuur komt uit de notebook [`demo/notebooks/dimensionality_exampl
           es.ipynb`](./demo/notebooks/dimensionality_examples.ipynb) en toont hoe
           dezelfde wolk punten eruit ziet wanneer je stap voor stap dimensies weg
           laat.
331 336
332 337    **Associatieregel-mining**: vinden van verbanden
```

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- **Gods Who Toy with Hearts** v5
  Celtic, classical ballad, epic
  Leaf ▶ 1.1K 195 13
- Neko Link #猫軍団仮装パレード v5

Ochtendgymnastiek (Cover)
Thomas Winters | 00:44 / 03:27

AI as Creative Partner – Thomas Winters

Prompt engineering:



Context

About your task: role, format, audience



Examples

Of preferred output



Chain-of-thought

Let LLM decompose into simpler tasks

Tools:

- **Chatbots:** ChatGPT, Gemini
- **Talk with PDF & podcast:** NotebookLM (Google)
- **Long research & complex task:** ChatGPT Deep Research & Agent mode
- **Programming & vibe coding:** OpenAI Codex & v0.net
- **Music generation**: Suno.com

Slides: https://thomaswinters.be/talks