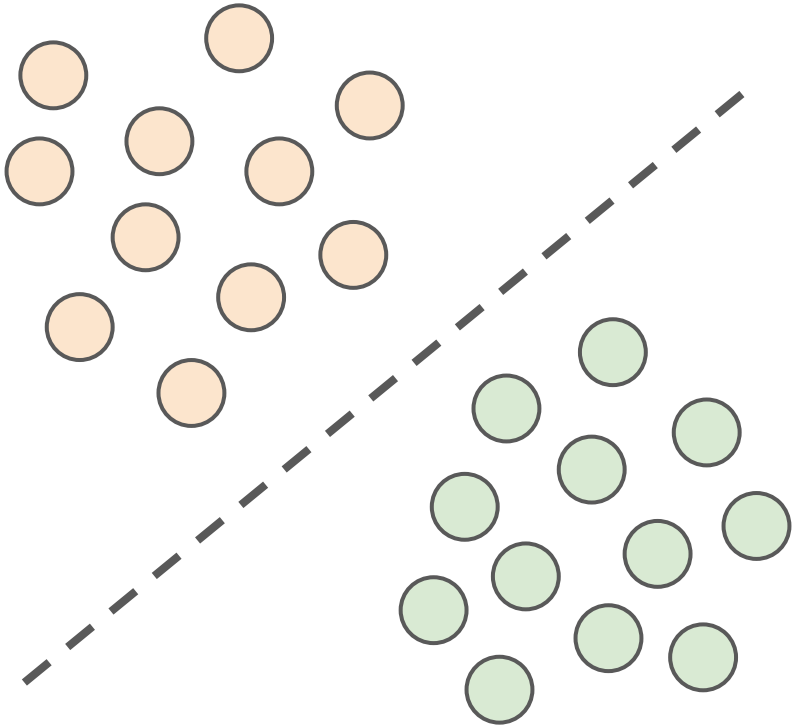
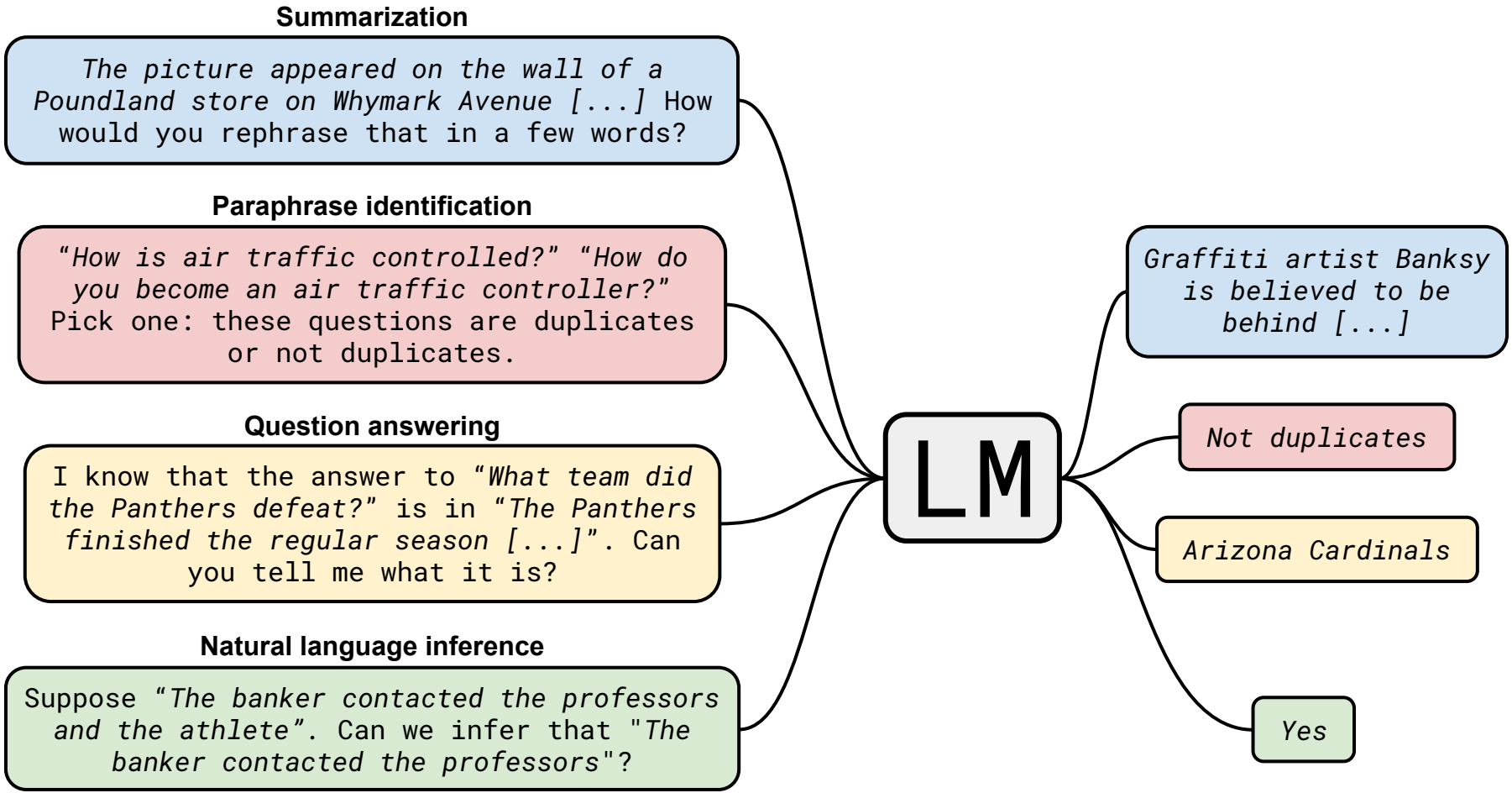
# Building Better Language Models

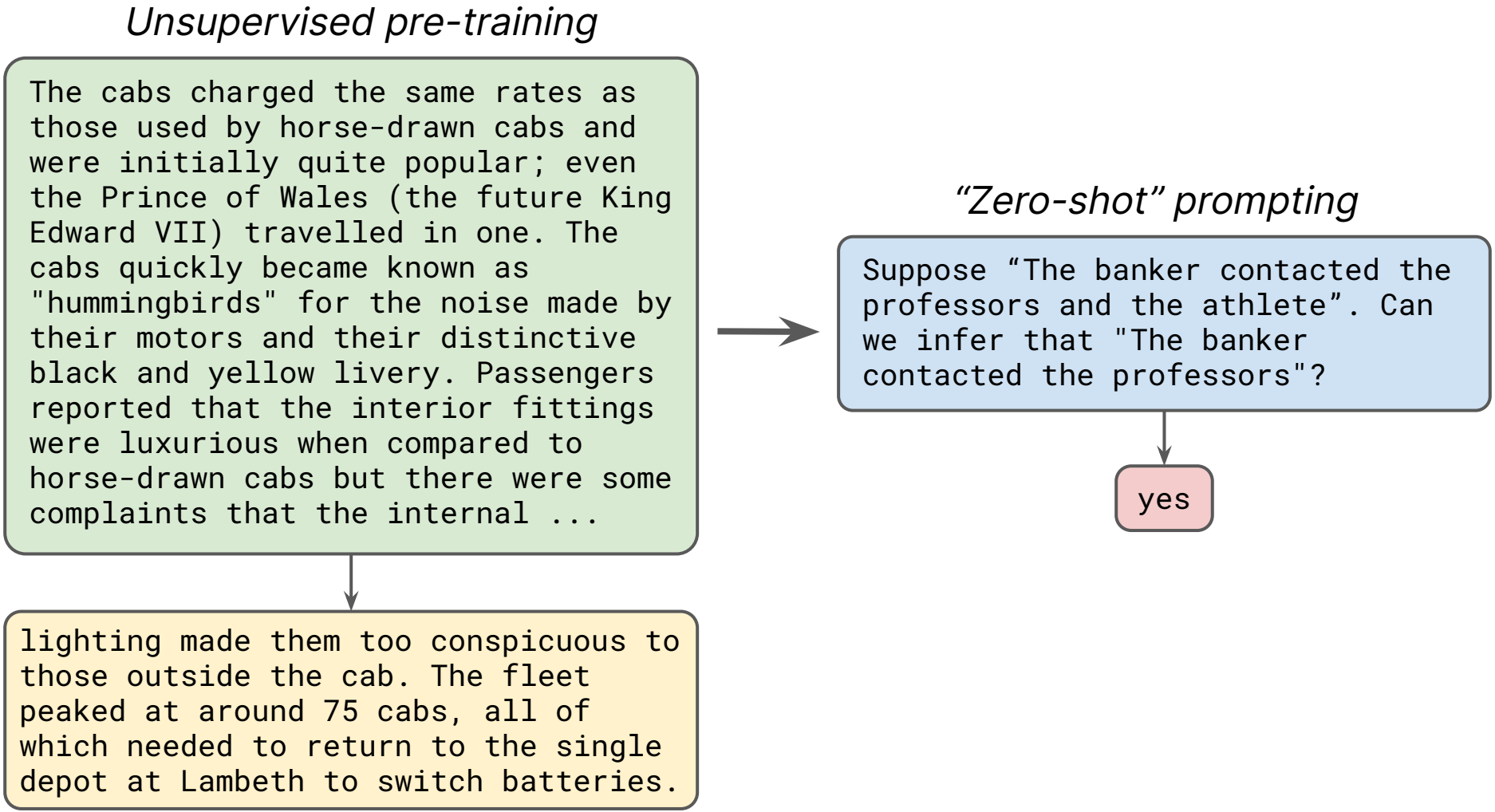
Colin Raffel

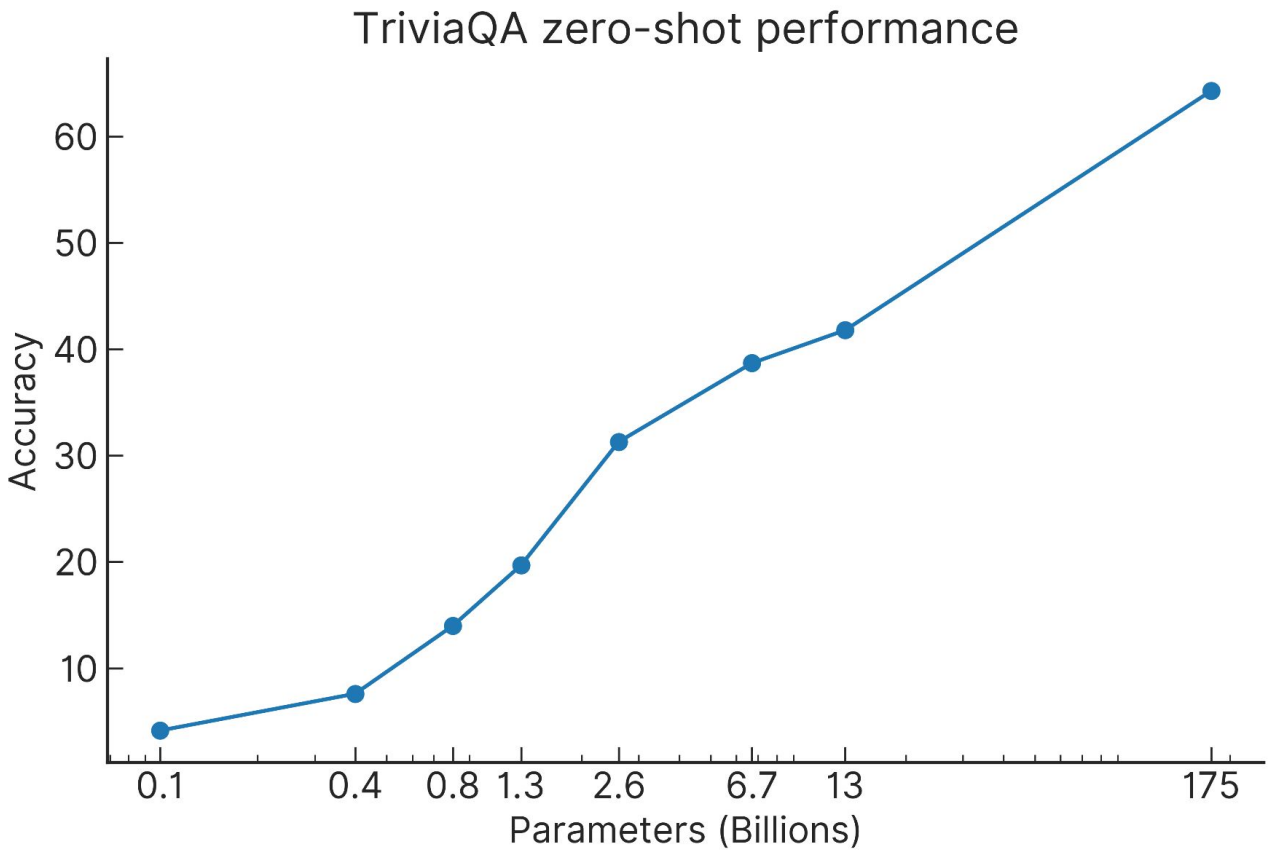
```
<word
    form="appalling"
    cornetto_synset_id="n_a-513370"
    wordnet_id="a-00193367"
    pos="JJ"
    sense="causing consternation"
    polarity="-0.6"
    subjectivity="1.0"
    intensity="1.0"
    confidence="0.8"
/>
```

```
a = []
for w, pos in words:
    if w in self and pos in self[w]:
        # Known word not preceded by a modifier ("good").
        if m is None:
            a.append(dict(w=[w], p=p, s=s, i=i, n=1)
        # Known word preceded by a modifier ("really good").
        if m is not None:
            a[-1]["w"].append(w)
            a[-1]["p"] = max(-1.0, min(p * a[-1]["i"], +1.0))
            a[-1]["s"] = max(-1.0, min(s * a[-1]["i"], +1.0))
            a[-1]["i"] = i
        # Known word preceded by a negation ("not really good").
        if n is not None:
            a[-1]["w"].insert(0, n)
            a[-1]["i"] = 1.0 / a[-1]["i"]
            a[-1]["n"] = -1
polarity = avg([(w, p) for w, p, s, x in a])
```




Summarization
The picture appeared on the wall of a Poundland store on Whymark Avenue [...] How would you rephrase that in a few words?
Paraphrase identification
"How is air traffic controlled?" "How do you become an air traffic controller?" Pick one: these questions are duplicates or not duplicates.
Question answering
I know that the answer to "What team did the Panthers defeat?" is in "The Panthers finished the regular season [...]". Can you tell me what it is?
Natural language inference
Suppose "The banker contacted the professors and the athlete". Can we infer that "The banker contacted the professors"?
LM
Graffiti artist Banksy is believed to be behind [...]
Not duplicates
Arizona Cardinals
Yes


Unsupervised pre-training
The cabs charged the same rates as those used by horse-drawn cabs and were initially quite popular; even the Prince of Wales (the future King Edward VII) travelled in one. The cabs quickly became known as "hummingbirds" for the noise made by their motors and their distinctive black and yellow livery. Passengers reported that the interior fittings were luxurious when compared to horse-drawn cabs but there were some complaints that the internal ...
lighting made them too conspicuous to those outside the cab. The fleet peaked at around 75 cabs, all of which needed to return to the single depot at Lambeth to switch batteries.
"Zero-shot" prompting
Suppose "The banker contacted the professors and the athlete". Can we infer that "The banker contacted the professors"?
yes




*From "Language Models are Few-Shot Learners" by Brown et al.*

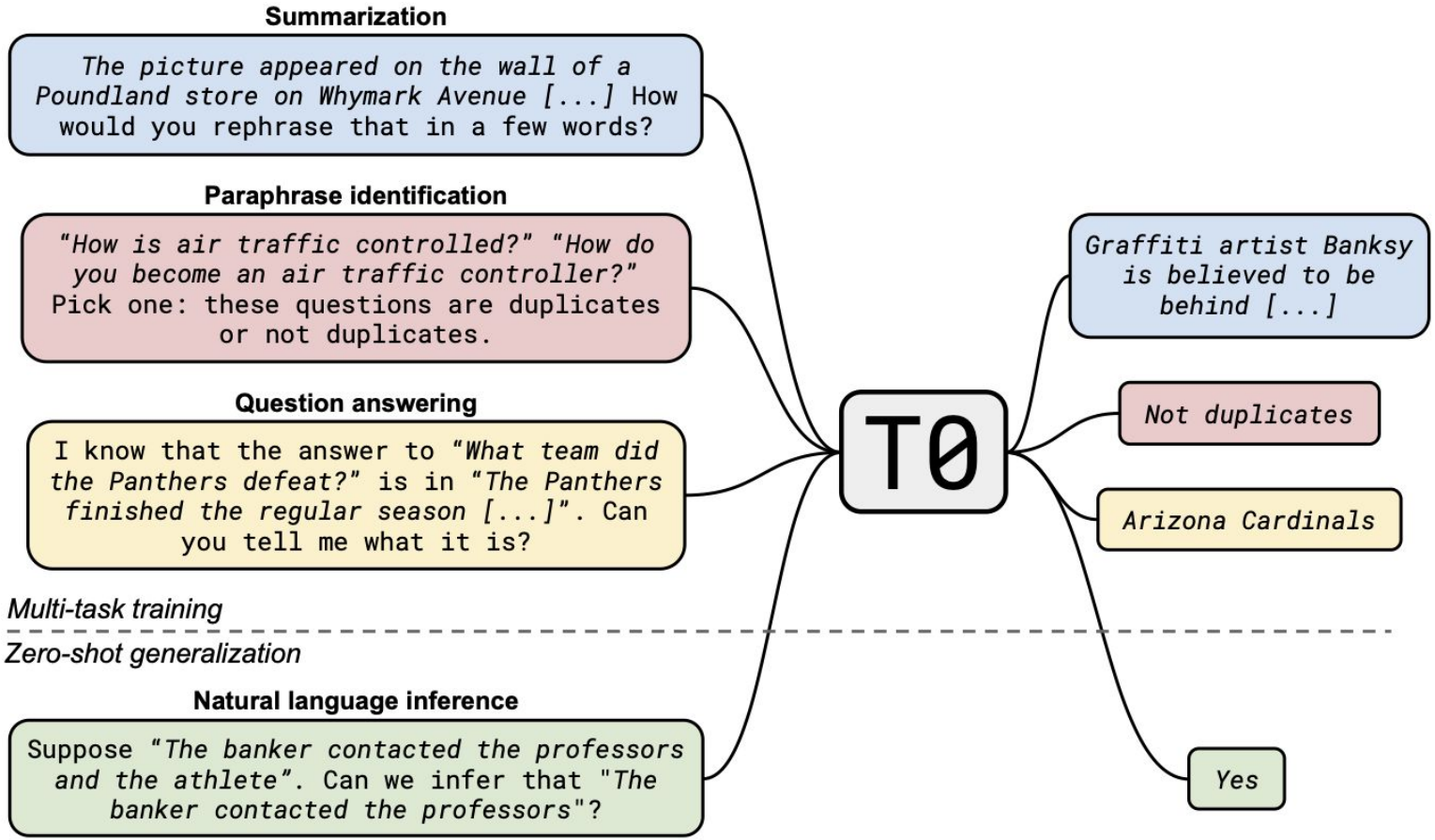
**Closed-book question answering**
http://www.autosweblog.com/cat/trivia-questions-from-the-50s
who was frank sinatra? a: an american singer, actor, and producer.

**Paraphrase identification**
https://www.usingenglish.com/forum/threads/60200-Do-these-sentences-mean-the-same
Do these sentences mean the same? No other boy in this class is as smart as the boy. No other boy is as smart as the boy in this class.

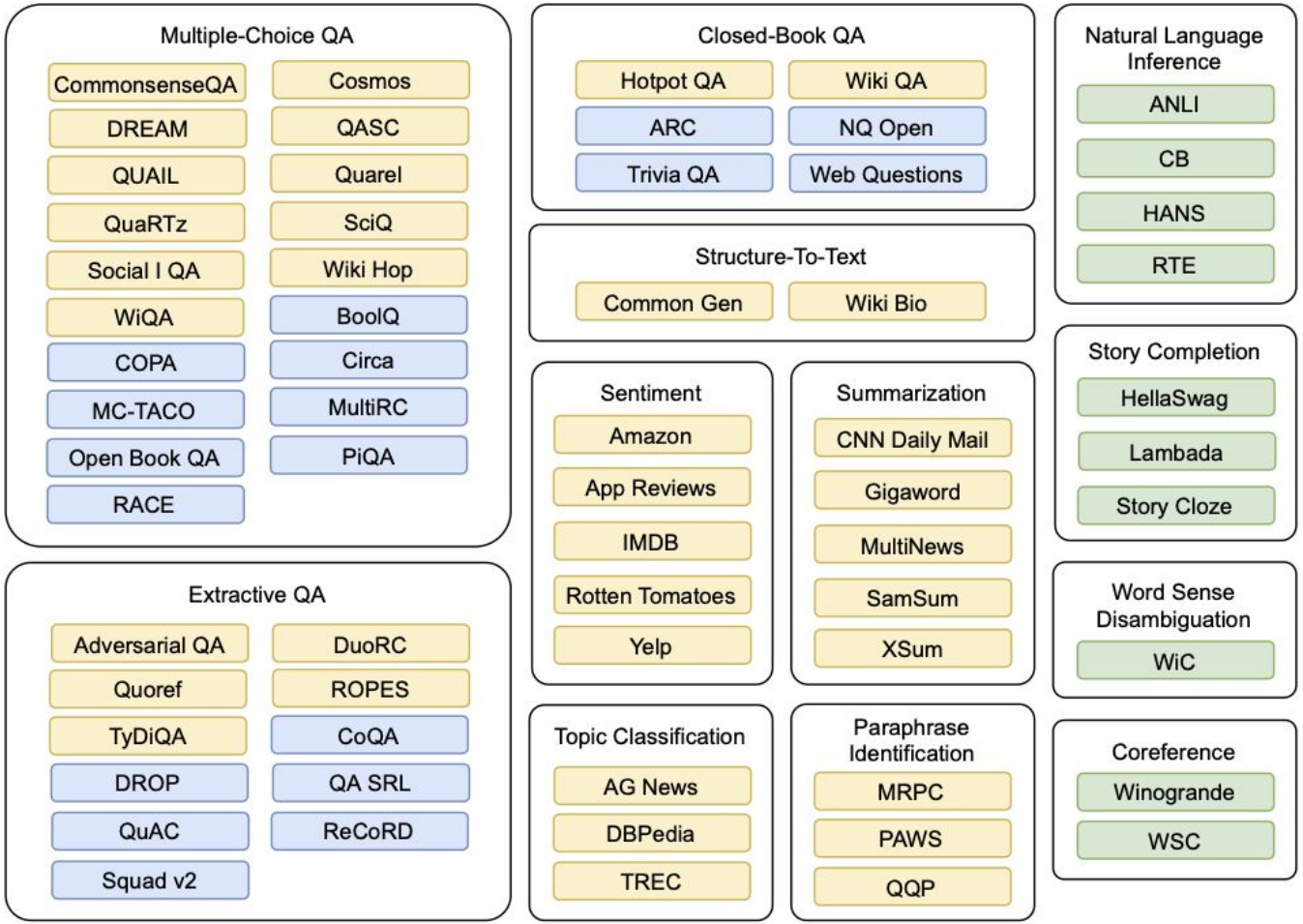
**Natural Language Inference**
https://ell.stackexchange.com/questions/121446/what-does-this-sentence-imply
If I say: He has worked there for 3 years. does this imply that he is still working at the moment of speaking?

**Summarization**
https://blog.nytsoi.net/tag/reddit
... Lately I've been seeing a pattern regarding videos stolen from other YouTube channels, reuploaded and monetized with ads. These videos are then mass posted on Reddit by bots masquerading as real users. tl;dr: Spambots are posting links to stolen videos on Reddit, copying comments from others to masquerade as legitimate users.

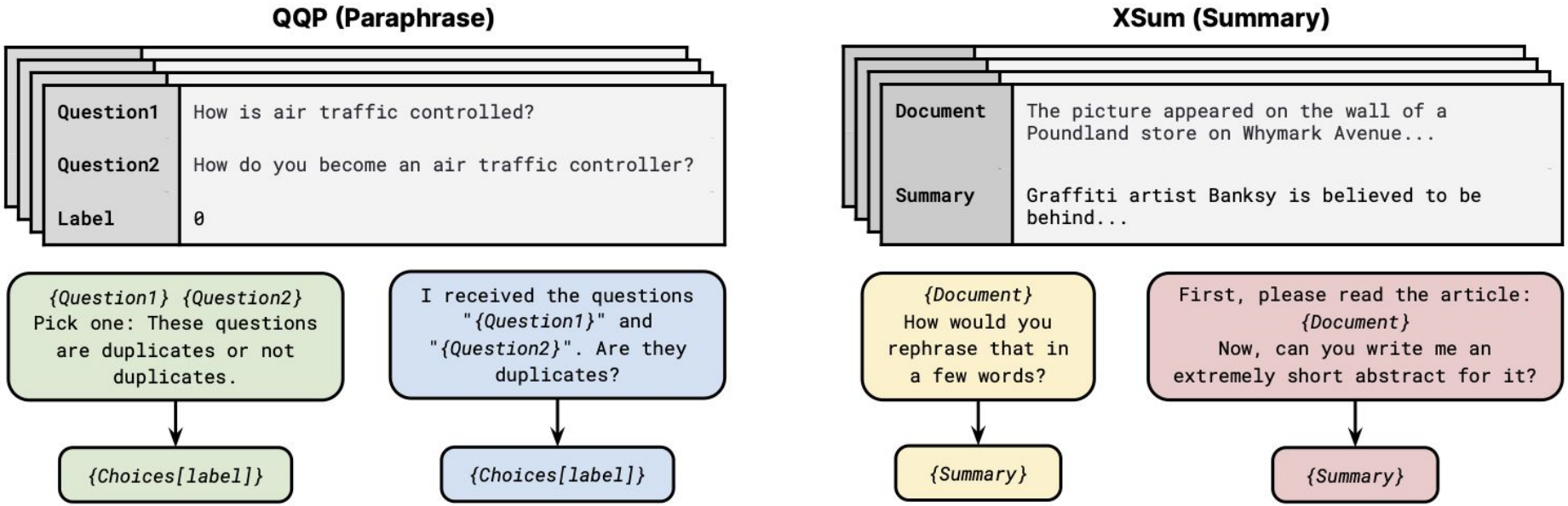
**Pronoun resolution**
https://nursecheung.com/ati-teas-guide-to-english-language-usage-understanding-pronouns/
Jennifer is a vegetarian, so she will order a nonmeat entrée. In this example, the pronoun she is used to refer to Jennifer.



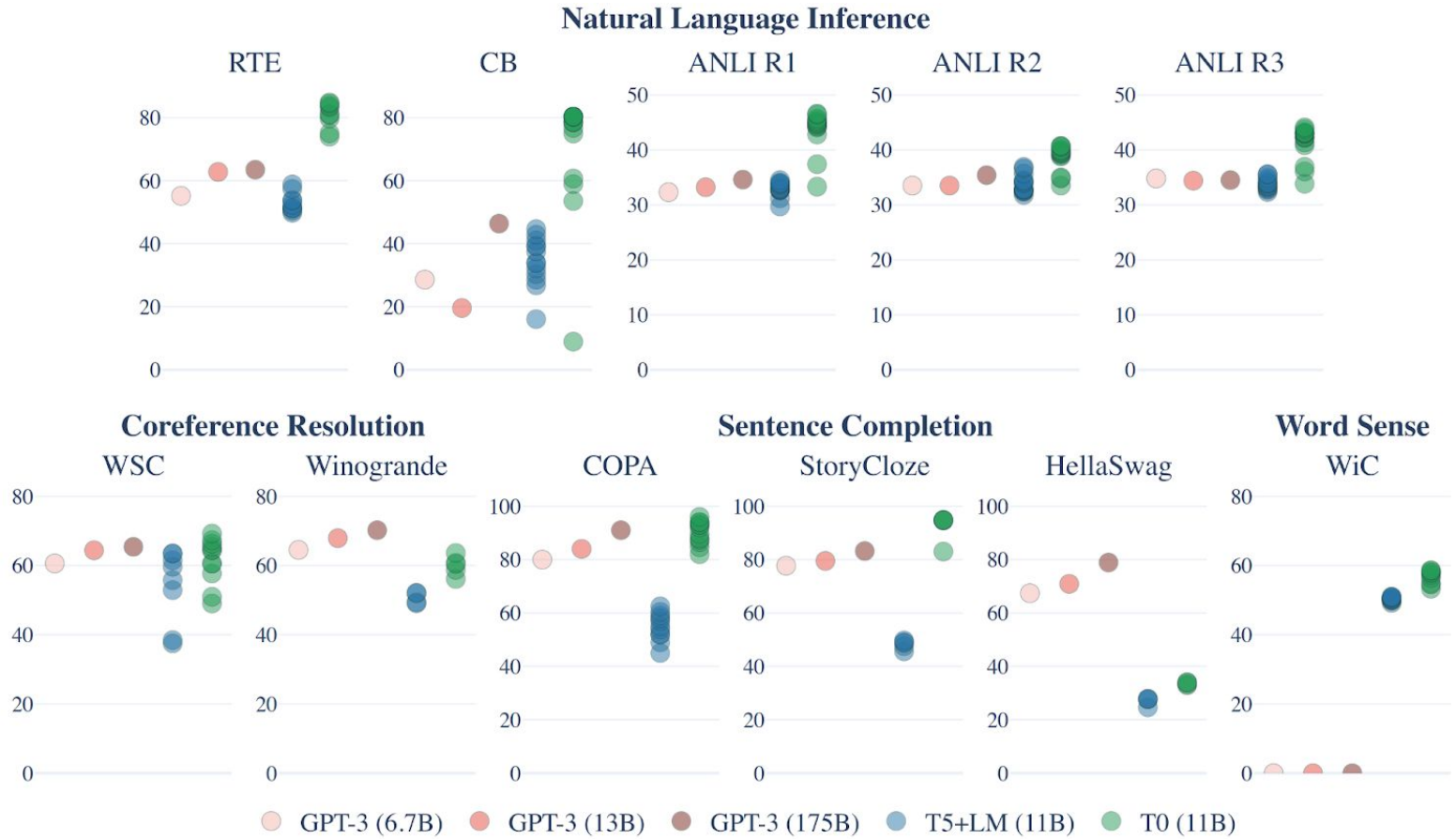

*From "Multitask Prompted Training Enables Zero-Shot Task Generalization" by Sanh et al.*



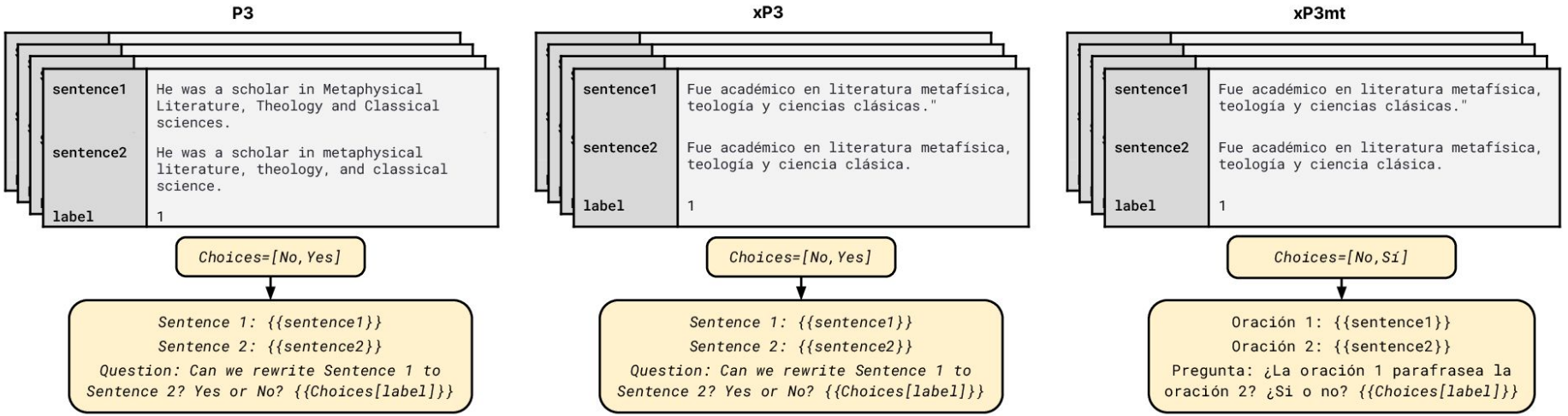

*From "Multitask Prompted Training Enables Zero-Shot Task Generalization" by Sanh et al.*



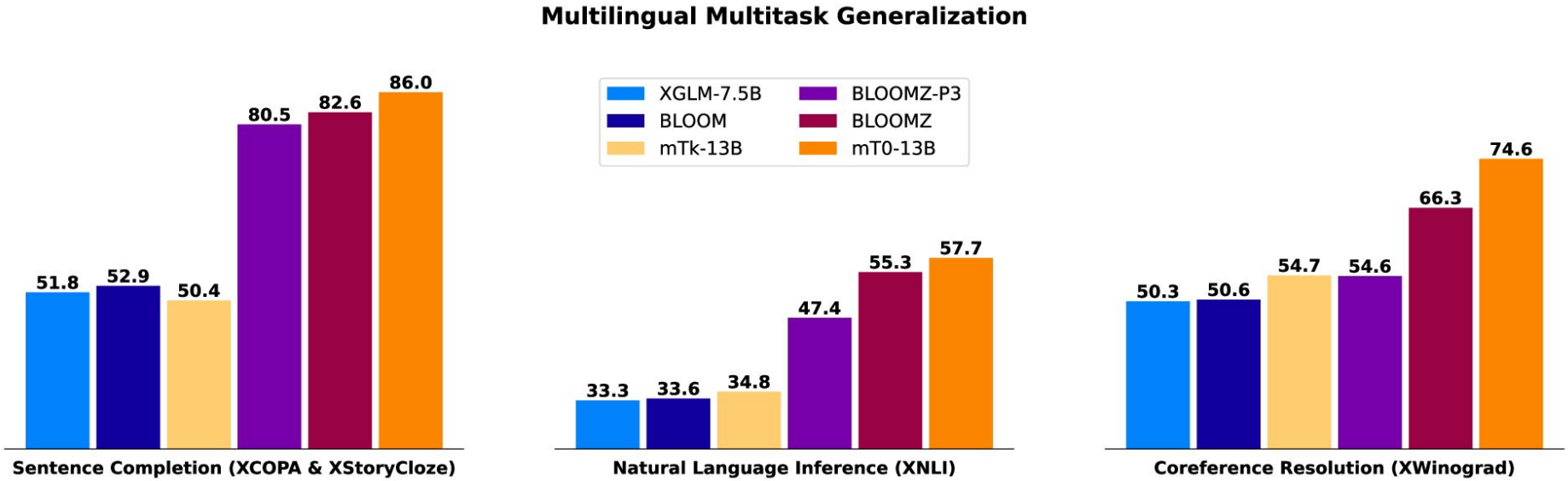

*From "Multitask Prompted Training Enables Zero-Shot Task Generalization" by Sanh et al.*



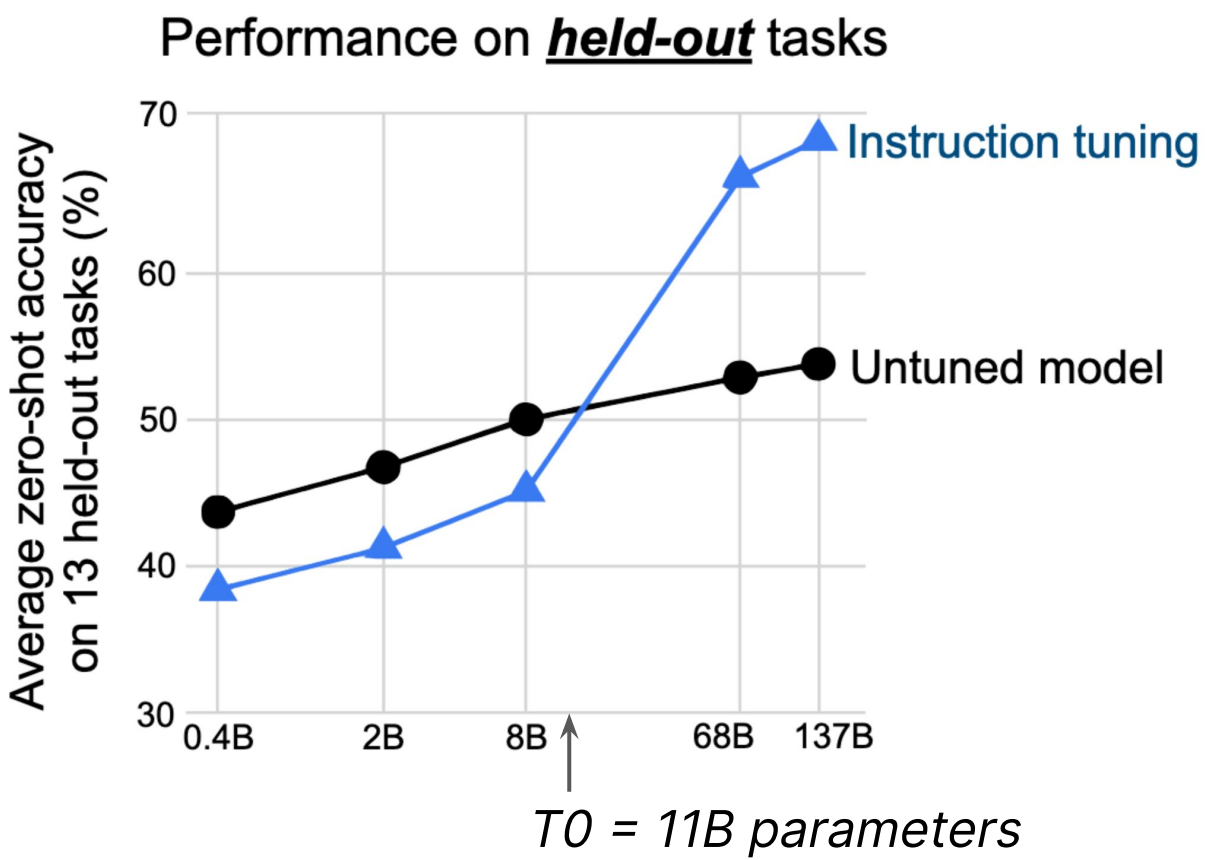

*From "Multitask Prompted Training Enables Zero-Shot Task Generalization" by Sanh et al.*



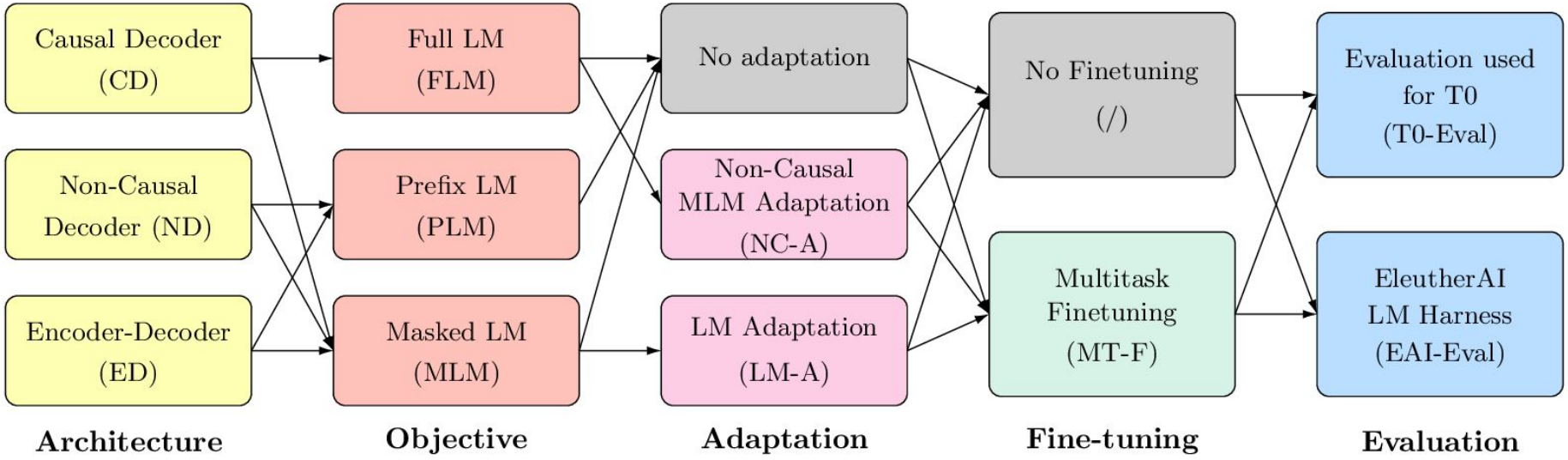

*From "Crosslingual Generalization through Multitask Finetuning" by Muennighoff et al.*



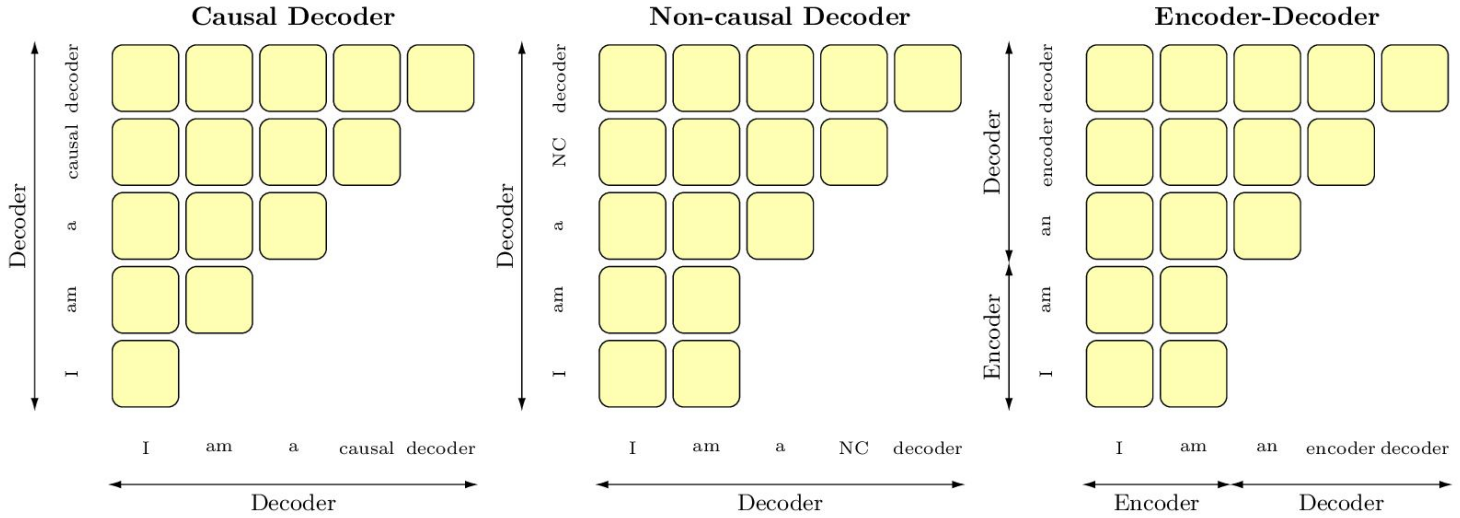

*From "Crosslingual Generalization through Multitask Finetuning" by Muennighoff et al.*



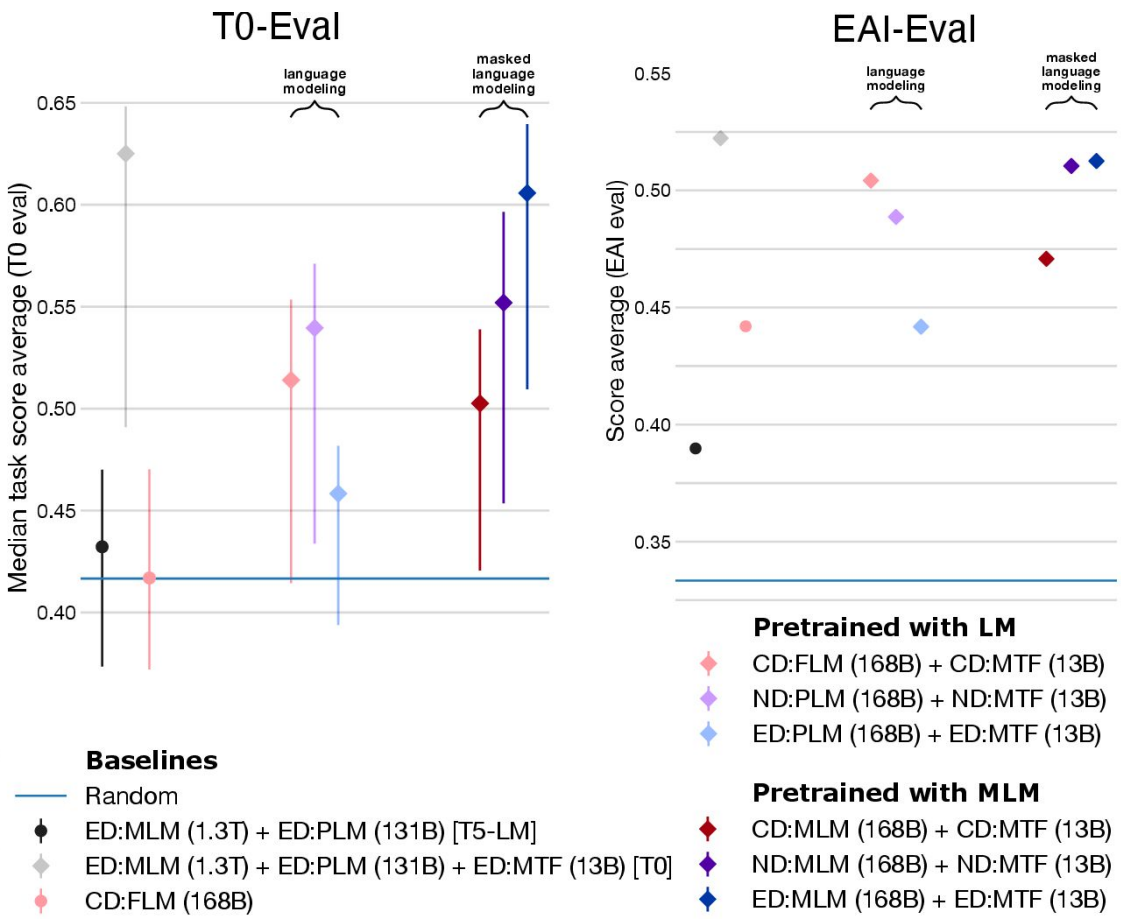

*From "Fine-Tuned Language Models are Zero-Shot Learners" by Wei et al.*



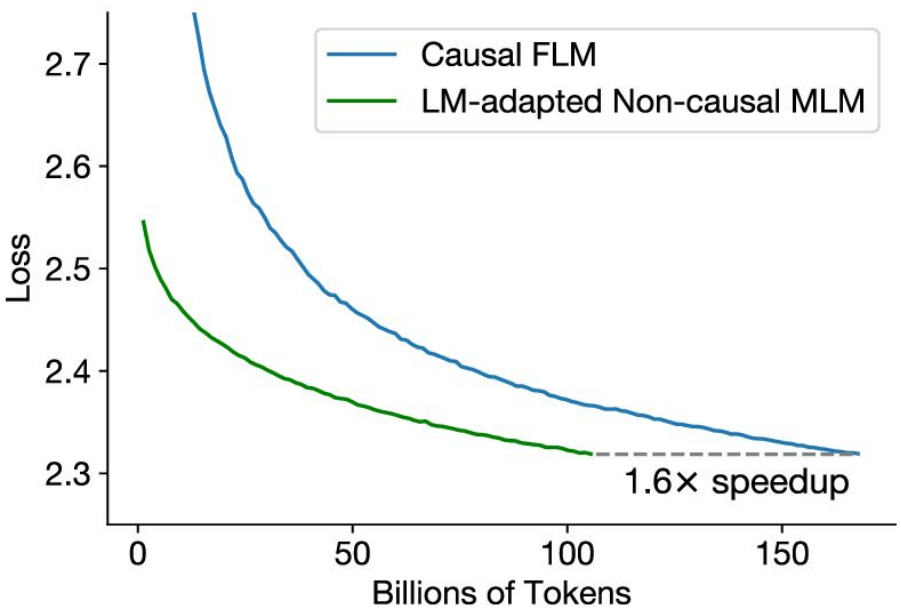

*From "What Language Model Architecture and Pretraining Objective Work Best for Zero-Shot Generalization?" by Wang et al.*

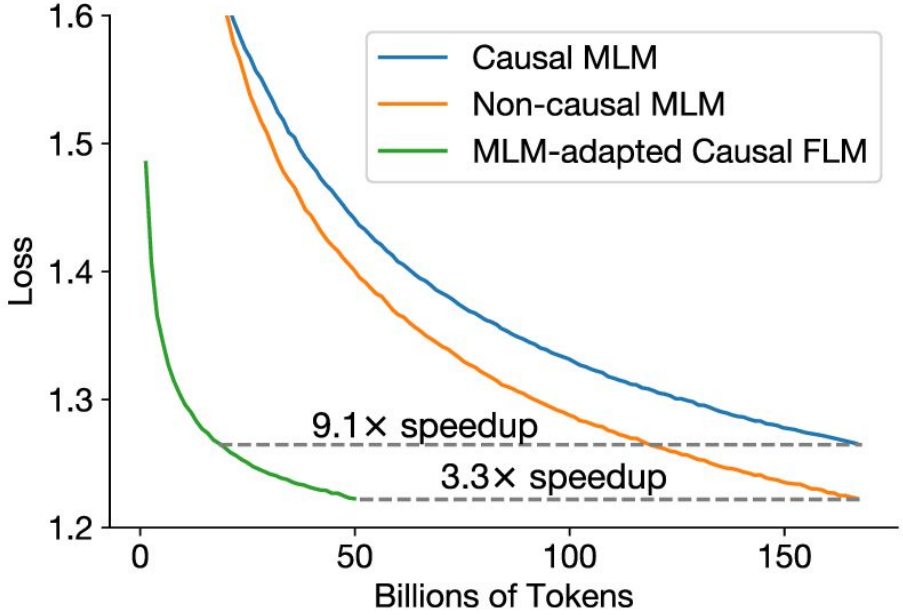



*From "What Language Model Architecture and Pretraining Objective Work Best for Zero-Shot Generalization?" by Wang et al.*




*From "What Language Model Architecture and Pretraining Objective Work Best for Zero-Shot Generalization?" by Wang et al.*




*From "What Language Model Architecture and Pretraining Objective Work Best for Zero-Shot Generalization?" by Wang et al.*

**Zero-shot**

The model predicts the answer given only a natural language description of the task. No gradient updates are performed.

```
1  Translate English to French:        ← task description
2  cheese =>                           ← prompt
```

---

**Few-shot**

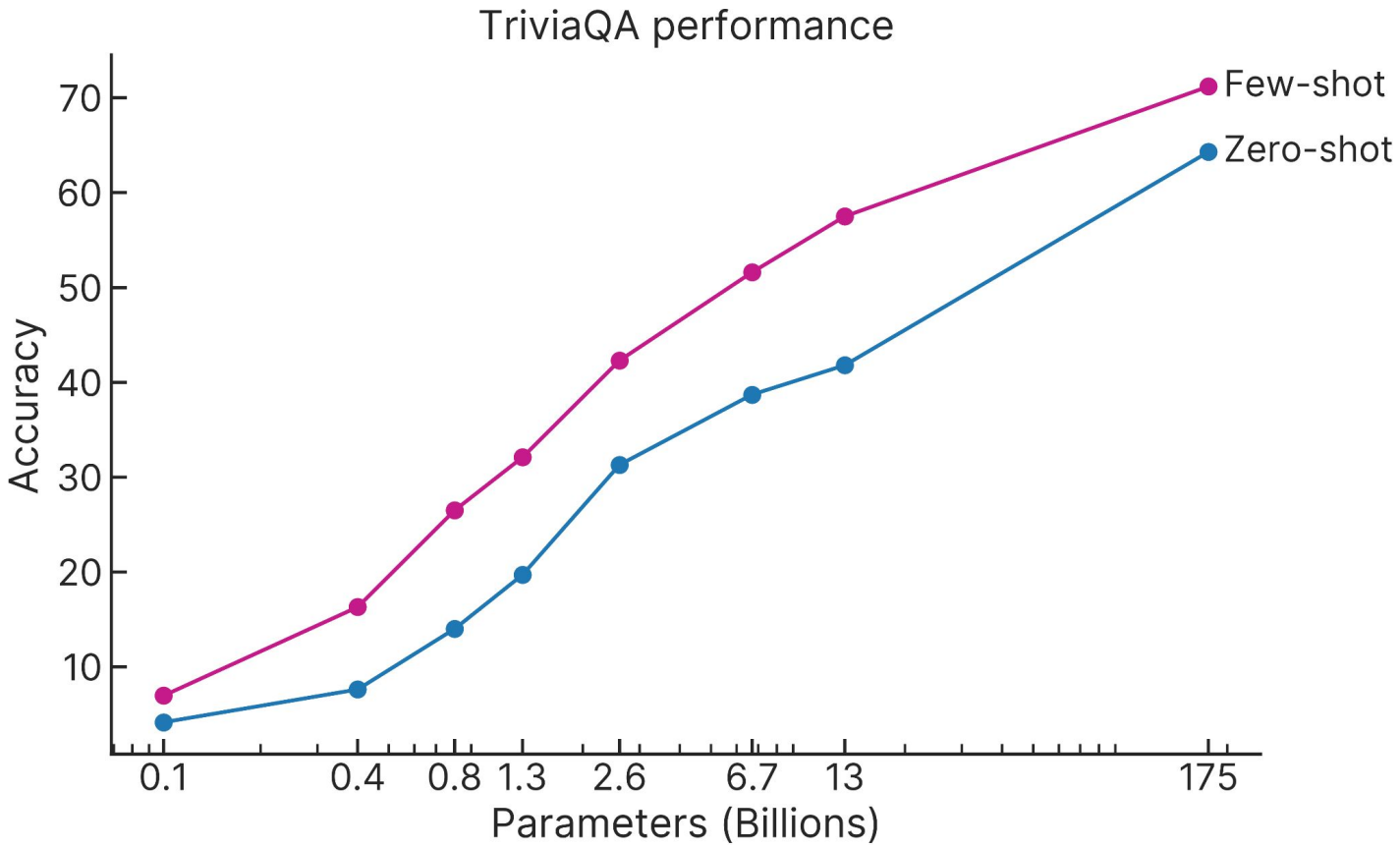
In addition to the task description, the model sees a few examples of the task. No gradient updates are performed.

```
1  Translate English to French:        ← task description
2  sea otter => loutre de mer          ← examples
3  peppermint => menthe poivrée        ←
4  plush girafe => girafe peluche      ←
5  cheese =>                           ← prompt
```

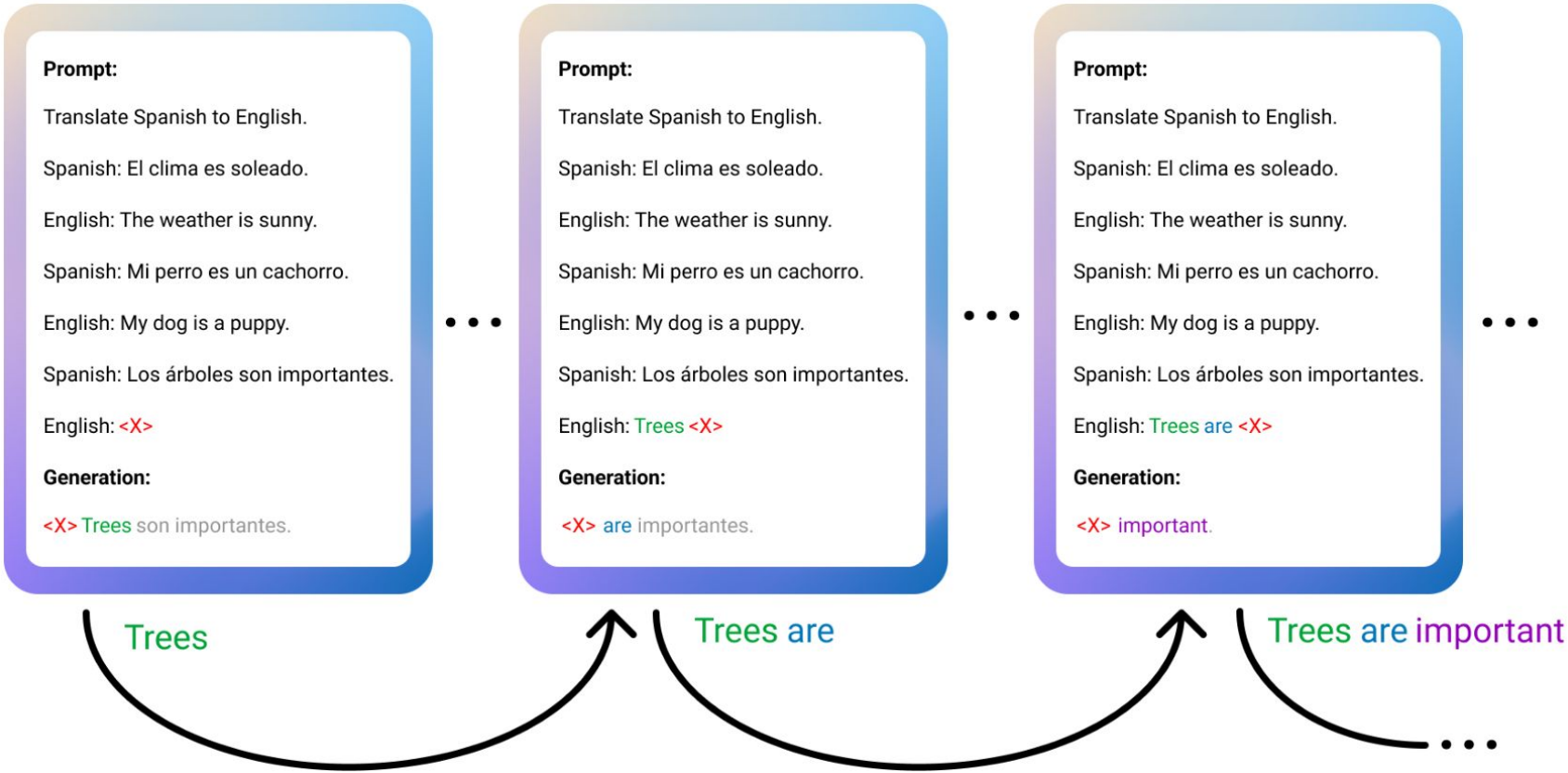
**Fine-tuning**

The model is trained via repeated gradient updates using a large corpus of example tasks.

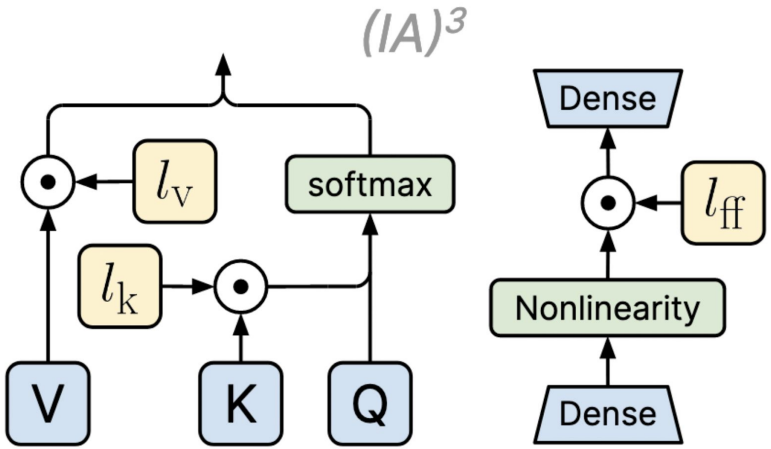

*From "Language Models are Few-Shot Learners" by Brown et al.*

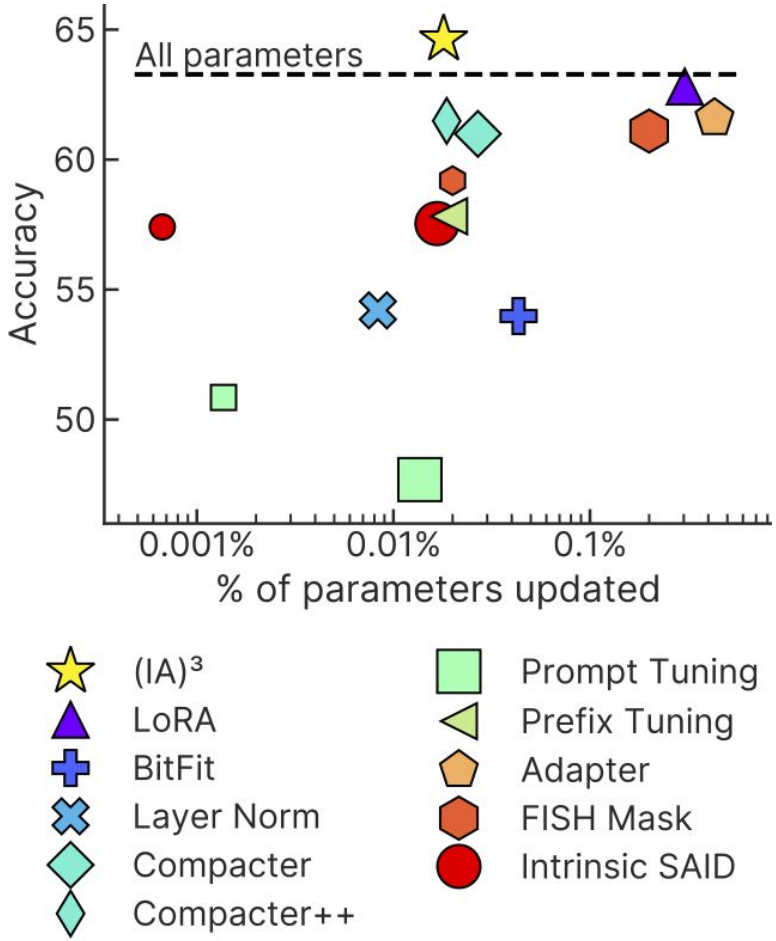



*From "Language Models are Few-Shot Learners" by Brown et al.*




*From "Bidirectional Language Models Are Also Few-shot Learners" by Patel et al.*

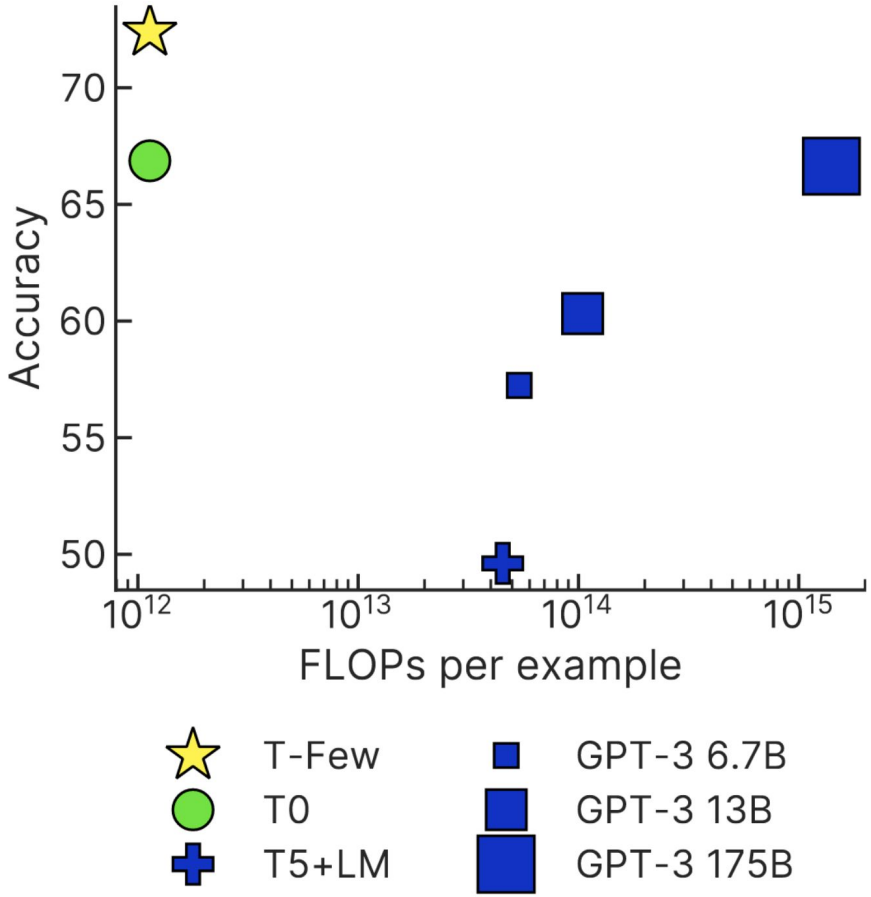



*From "Few-Shot Parameter-Efficient Fine-Tuning is Better and Cheaper than In-Context Learning", Liu et al. 2022*

| Method | Inference FLOPs | Training FLOPs | Disk space |
|---|---|---|---|
| `T-Few` | 1.1e12 | 2.7e16 | 4.2 MB |
| T0 [1] | 1.1e12 | 0 | 0 B |
| T5+LM [14] | 4.5e13 | 0 | 16 kB |
| GPT-3 6.7B [4] | 5.4e13 | 0 | 16 kB |
| GPT-3 13B [4] | 1.0e14 | 0 | 16 kB |
| GPT-3 175B [4] | 1.4e15 | 0 | 16 kB |

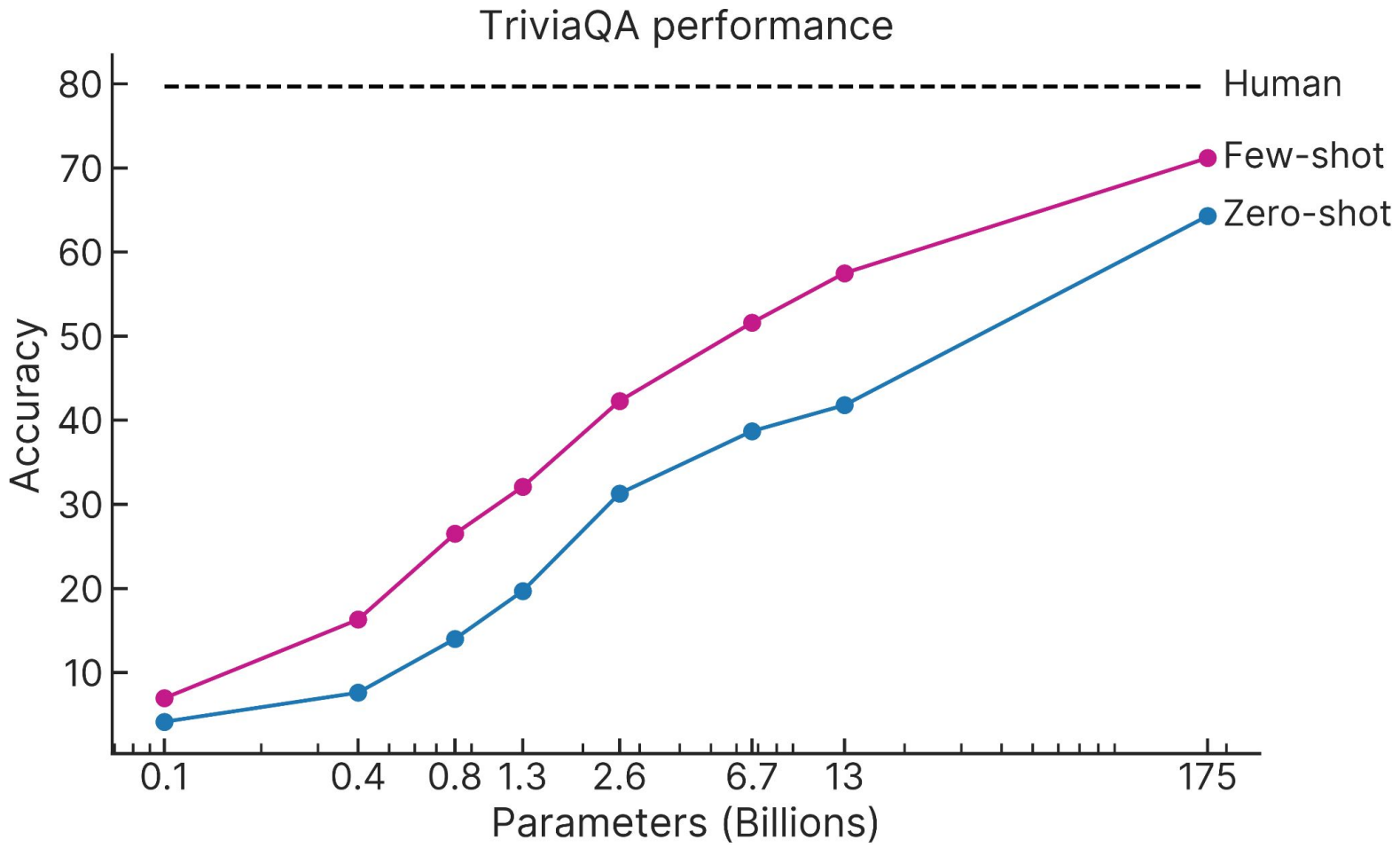
*From "Few-Shot Parameter-Efficient Fine-Tuning is Better and Cheaper than In-Context Learning", Liu et al. 2022*



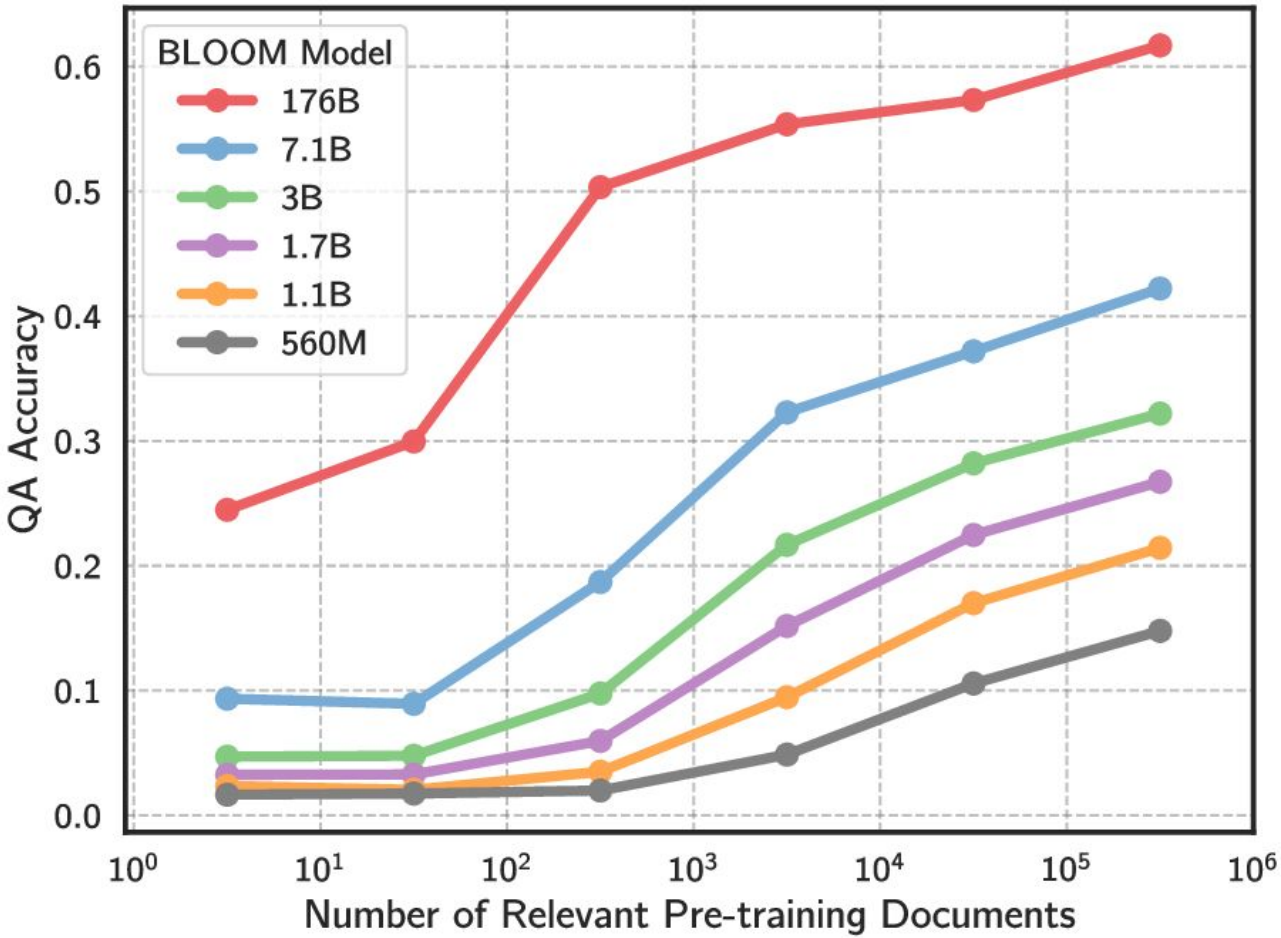

| Method | Acc. |
|---|---|
| `T-Few` | 75.8% |
| Human baseline [2] | 73.5% |
| PET [50] | 69.6% |
| SetFit [51] | 66.9% |
| GPT-3 [4] | 62.7% |

Table 2: Top-5 best methods on RAFT as of writing. `T-Few` is the first method to outperform the human baseline and achieves over 6% higher accuracy than the next-best method.

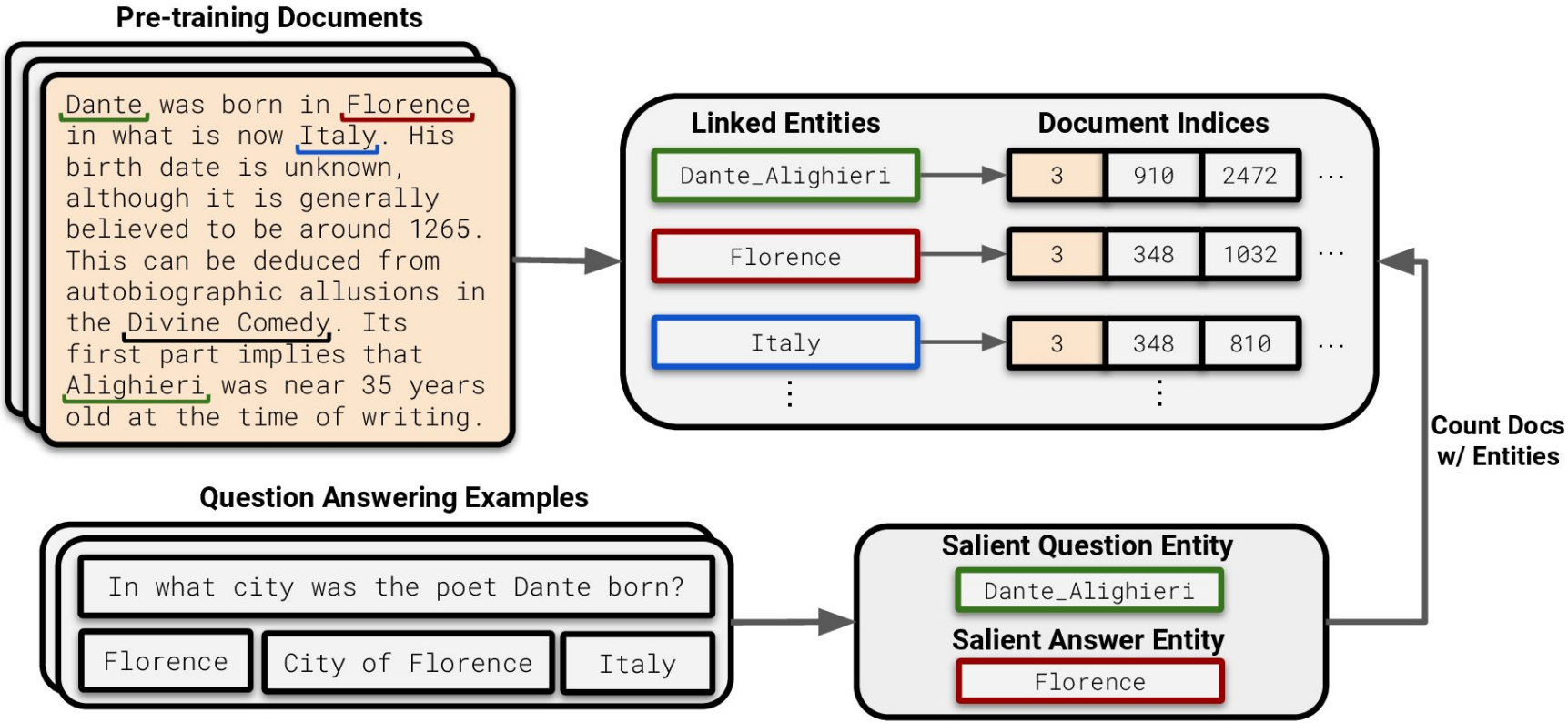
*From "Few-Shot Parameter-Efficient Fine-Tuning is Better and Cheaper than In-Context Learning", Liu et al. 2022*



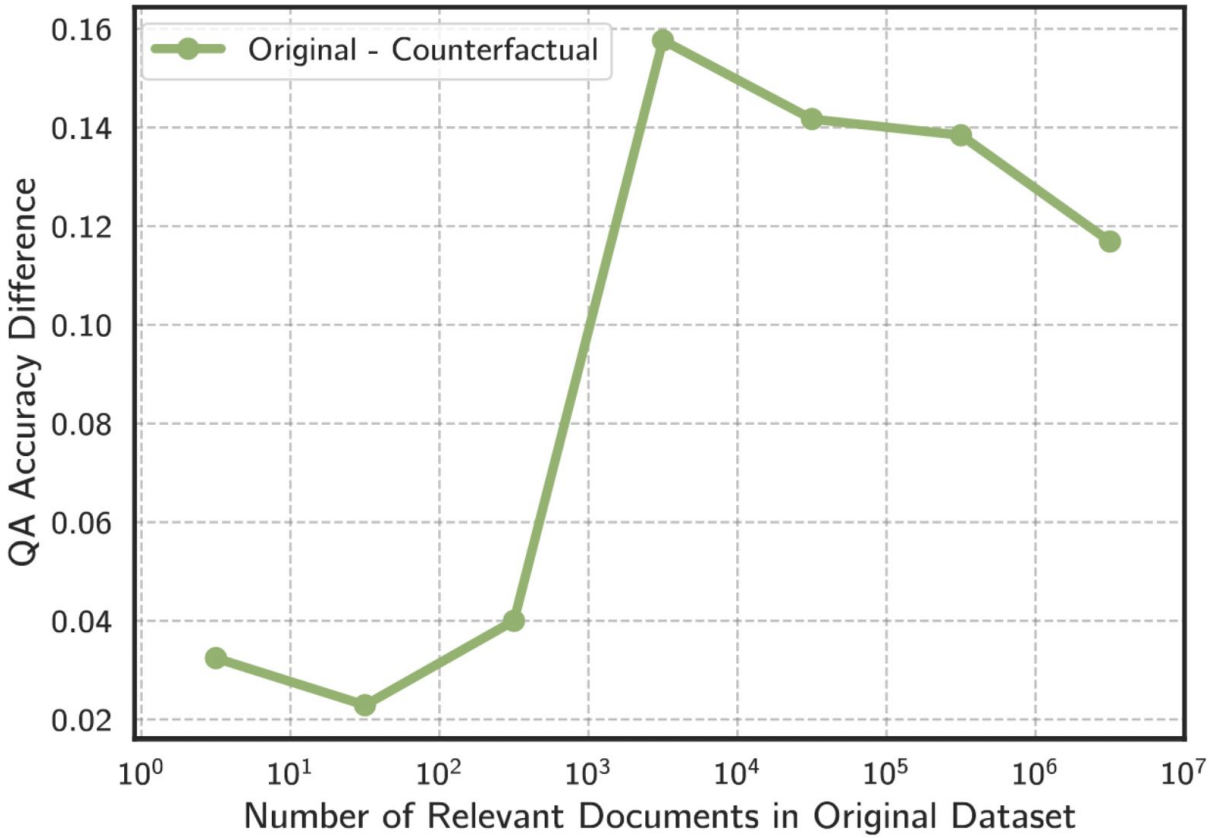

*From "Language Models are Few-Shot Learners" by Brown et al.*



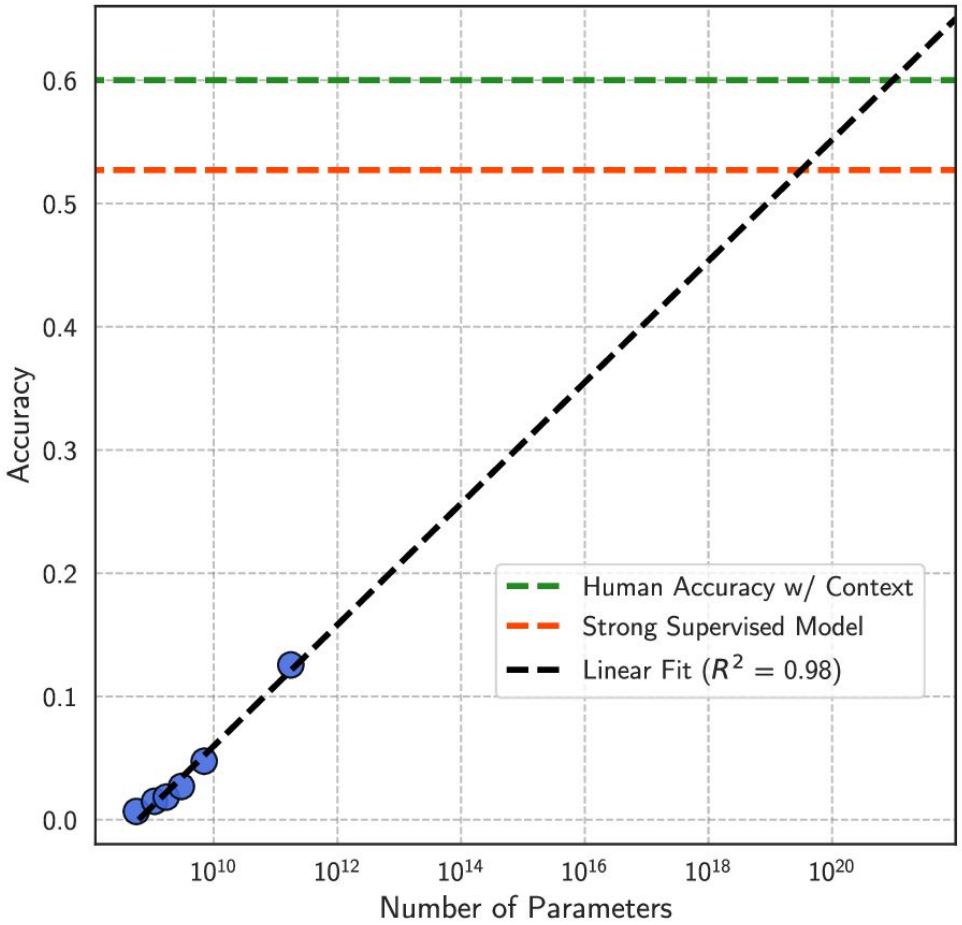

*From "Large Language Models Struggle to Learn Long-Tail Knowledge" by Kandpal et al.*



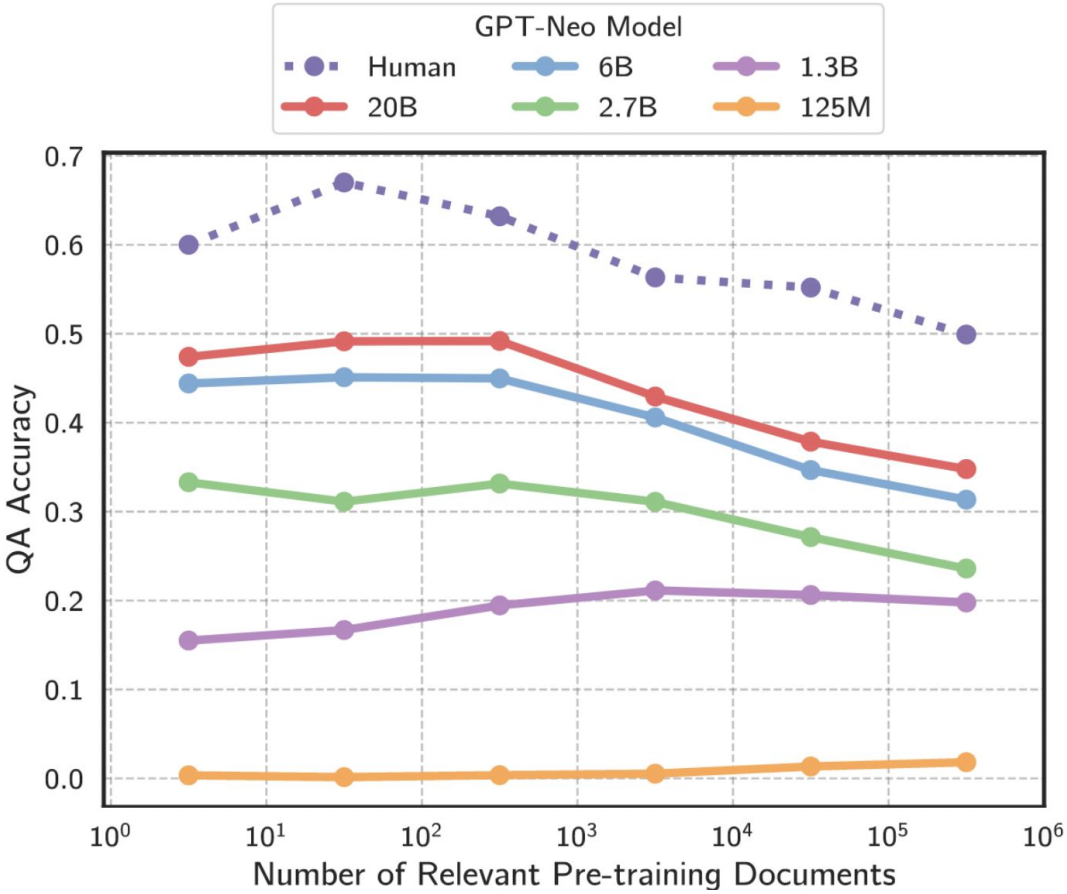

*From "Large Language Models Struggle to Learn Long-Tail Knowledge" by Kandpal et al.*




*From "Large Language Models Struggle to Learn Long-Tail Knowledge" by Kandpal et al.*




*From "Large Language Models Struggle to Learn Long-Tail Knowledge" by Kandpal et al.*




*From "Large Language Models Struggle to Learn Long-Tail Knowledge" by Kandpal et al.*

Thanks.

Please give me feedback:

http://bit.ly/colin-talk-feedback