

# Chain of Thought Reasoning without Prompting

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# Chain of thought reasoning

- Chain of thought has been proven super useful in many reasoning tasks
- How to elicit chain of thought reasoning from LLMs?
  - Chain of thought prompting: few-shot, zero-shot, and many many follow-up works
  - Fine-tuning with a lot of CoT data

## Chain-of-Thought Prompting

### Model Input

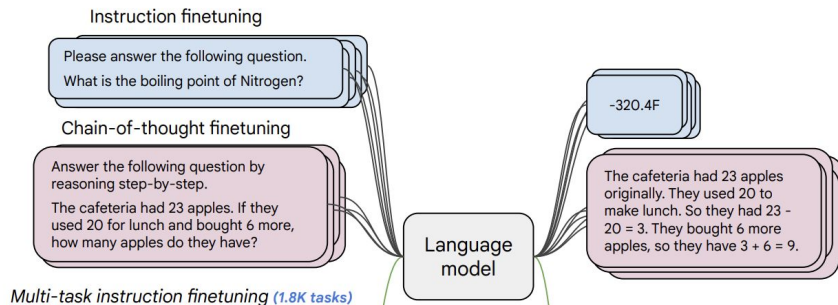
Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls.  $5 + 6 = 11$ . The answer is 11.

Q: The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?

### Model Output

A: The cafeteria had 23 apples originally. They used 20 to make lunch. So they had  $23 - 20 = 3$ . They bought 6 more apples, so they have  $3 + 6 = 9$ . The answer is 9. ✓



# Chain of thought reasoning

- Chain of thought has been proven super useful in many reasoning tasks
- How to elicit chain of thought reasoning from LLMs?
  - Chain of thought prompting: few-shot, zero-shot, and many many follow-up works
    - How to disentangle the effect of “human teaching” in the prompt vs. the model’s own ability to reason?
  - Fine-tuning with a lot of CoT data
    - Requires collecting a large amount of CoT data



## Chain of thought reasoning from a different angle

We want to answer: can LLMs reason by themselves? If yes, to what extent?

- Prompting or fine-tuning both involve a lot of **human intervention**
- We can skip both if we want to understand model's **intrinsic** reasoning abilities
- But...
  - So far existing literature shows LLMs can't reason without CoT-prompting or CoT-finetuning
  - Is it true?



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We want to answer: can LLMs reason by themselves? If yes, to what extent?

- Prompting or fine-tuning both involve a lot of **human intervention**
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- But...
  - So far existing literature shows LLMs can't reason without CoT-prompting or CoT-finetuning
  - Is it true?
    - The answer is No!
    - We show that this is an **artifact** of the predominant practice of only looking at the **greedy decoding** path in LLMs



# CoT-decoding: Beyond Greedy Decoding Paths

## Standard QA format

Q: *I have 3 apples, my dad has 2 more apples than me, how many apples do we have in total?*

A:

Language model

## Decoding step 0

top-1: 5

## Continue greedy decoding

5 apples



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A:

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## Decoding step 0

top-1: 5

top-2: I

top-3: We

top-4: You

top-5: The

## Continue greedy decoding

5 apples ❌

I have 3 apples, my dad has 2 more apples than me, so he has 5 apples.  $3+5=8$ . We have 8 apples in total. ✅

We have 5 apples in total. ❌

You have 3 apples, your dad has 2 more apples than you, so he has 5 apples.  $3+5=8$ . You have 8 apples in total. ✅

The answer is 5. ❌



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I have 3 apples, my dad has 2 more apples than me, so he has 5 apples.  $3+5=8$ . We have 8 apples in total.



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The answer is 5.



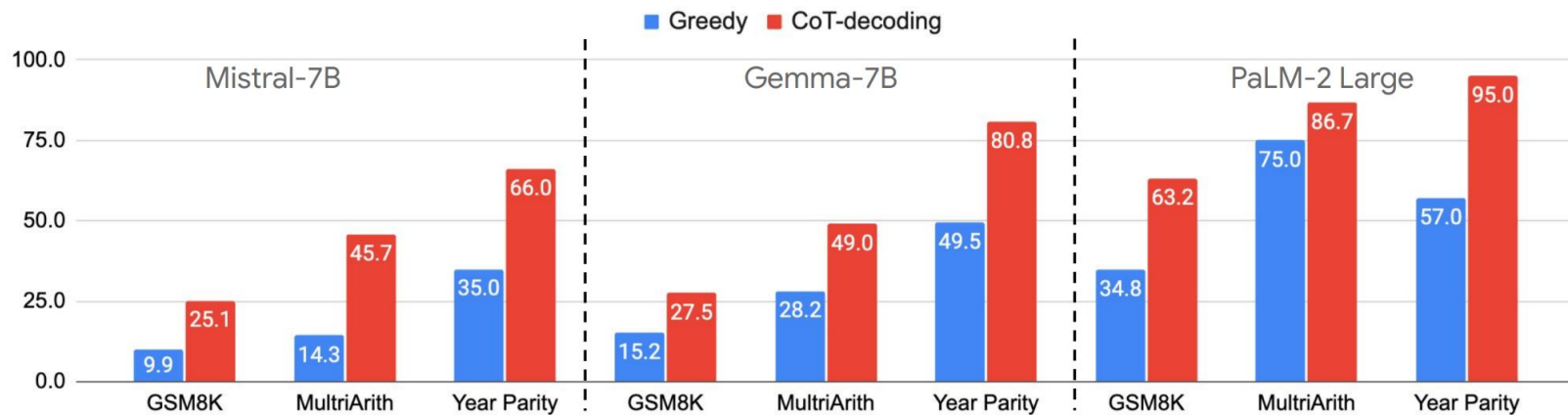
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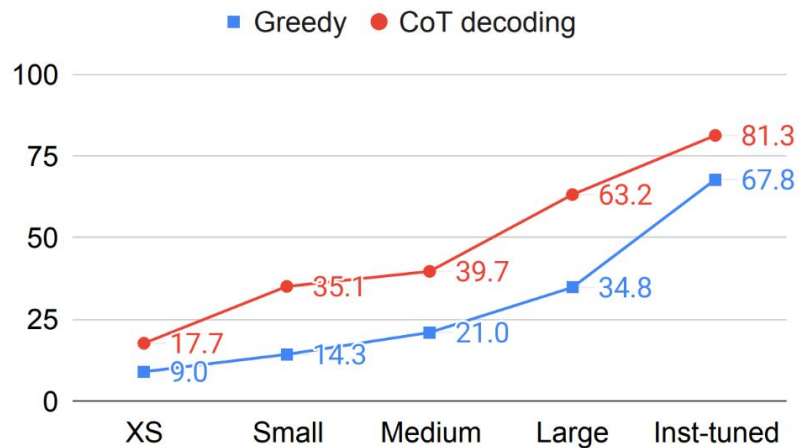


## CoT-decoding elicits reasoning on different LM families

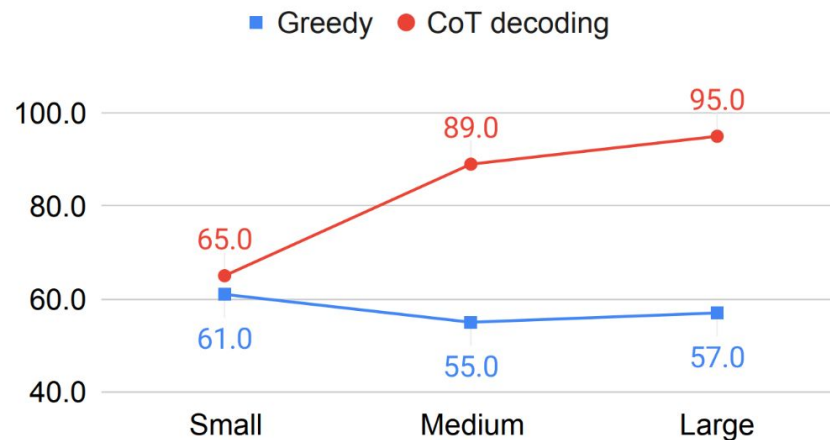


# CoT-decoding works reliably across model scales

GSM8K accuracy



Year Parity accuracy



## Summary

- LLMs can reason by simple decoding change, no prompting/fine-tuning needed
- LLMs possess intrinsic reasoning abilities right after pre-training
- CoT-decoding can reliably extract CoT-paths by answer confidence

## Check out our paper and poster!

- <https://arxiv.org/abs/2402.10200>
- Poster at Fri 13 Dec 4:30 p.m. — 7:30 p.m.
- Questions: xuezhiw@google.com

