
Chain-of-Thought Prompting Elicits Reasoning in Large Language Models



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Introduction

❖ Chain-of-Thought Prompting Elicits Reasoning in Large Language Models

- NeurIPS 2022, Google Research

Chain-of-Thought Prompting Elicits Reasoning in Large Language Models

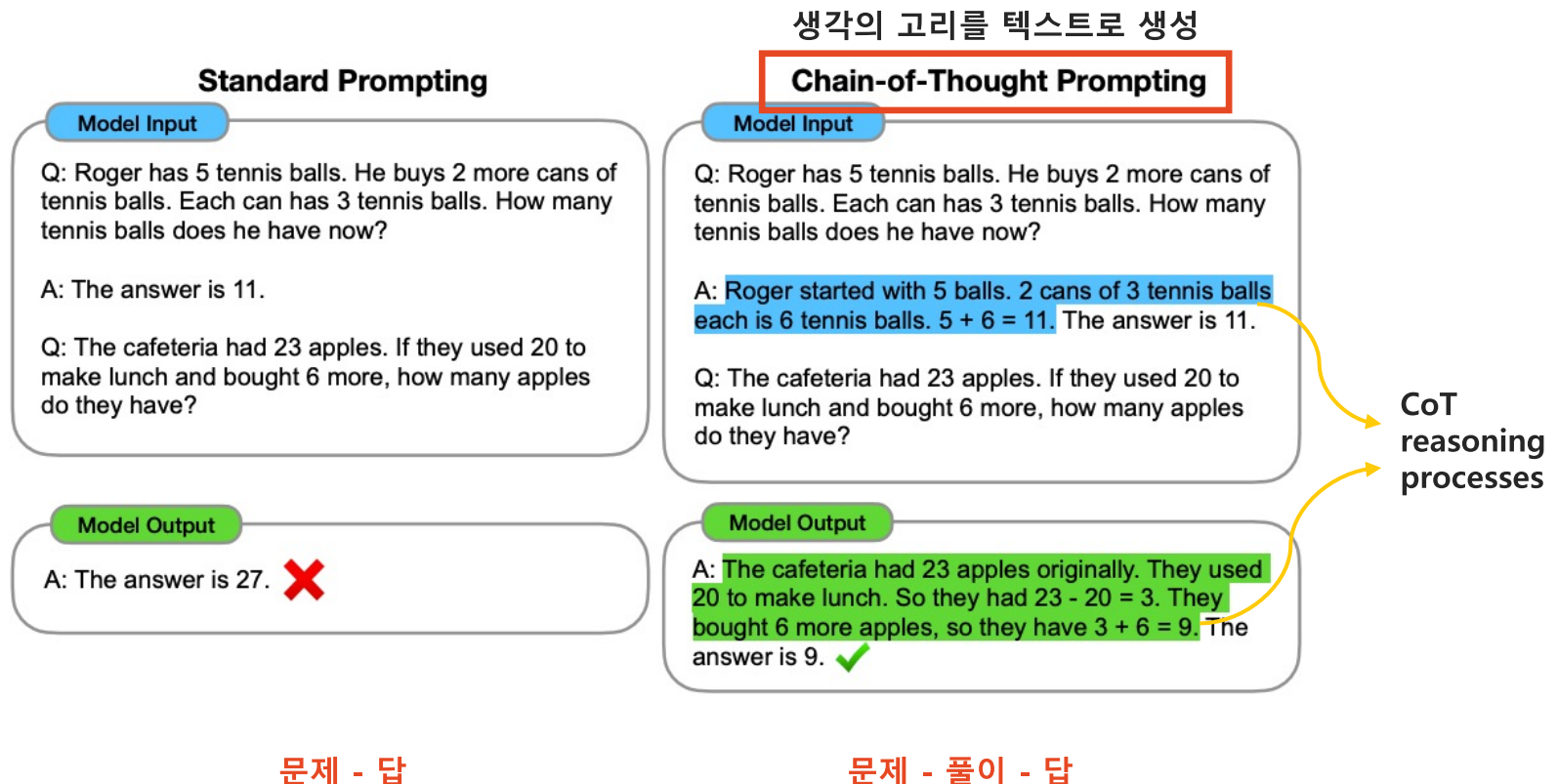
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Introduction

❖ Chain-of-Thought Prompting Elicits Reasoning in Large Language Models

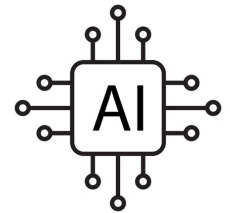
- CoT 프롬프트를 적용하면 산술 연산, 상식 추론, 기호 논리와 같은 다양한 작업에서 성능 향상



Chain-of-Thought Prompting

❖ Decompose the problem into intermediate steps

After Jane gives 2 flowers to her mom she has 10 ...
then after she gives 3 to her dad she will have 7 ...
so the answer is 7



Language models

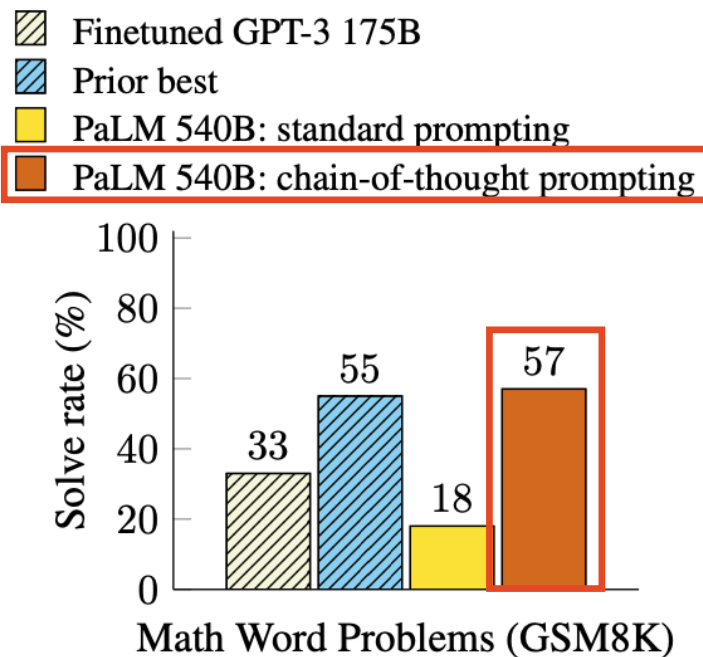
a step-by-step thought process for arriving at the answer

모델이 단순한 답변을 내놓는 것이 아니라, 논리적 사고 과정을 따라가며 추론하도록 유도

Chain-of-Thought Prompting

❖ Chain-of-Thought Prompting 성능 향상

- 산술 추론, 상식 추론, 기호 추론 벤치마크 실험적 평가



기준 프롬프팅보다 훨씬 높은 성능 기록

Arithmetic Reasoning

❖ Chain-of-Thought Prompting의 효과

- 540B 규모 대형 언어 모델에서 CoT prompting을 적용하면, 특정 task에 맞게 finetuning된 모델과 비슷한 성능을 보임

Standard 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: 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 answer is 27. ❌

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. ✅

Arithmetic Reasoning

❖ Chain-of-Thought Prompting Elicits Reasoning in Large Language Models

- 대형 언어 모델의 추론 능력을 향상시키는 방법

Math Word Problems (free response)

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.

Math Word Problems (multiple choice)

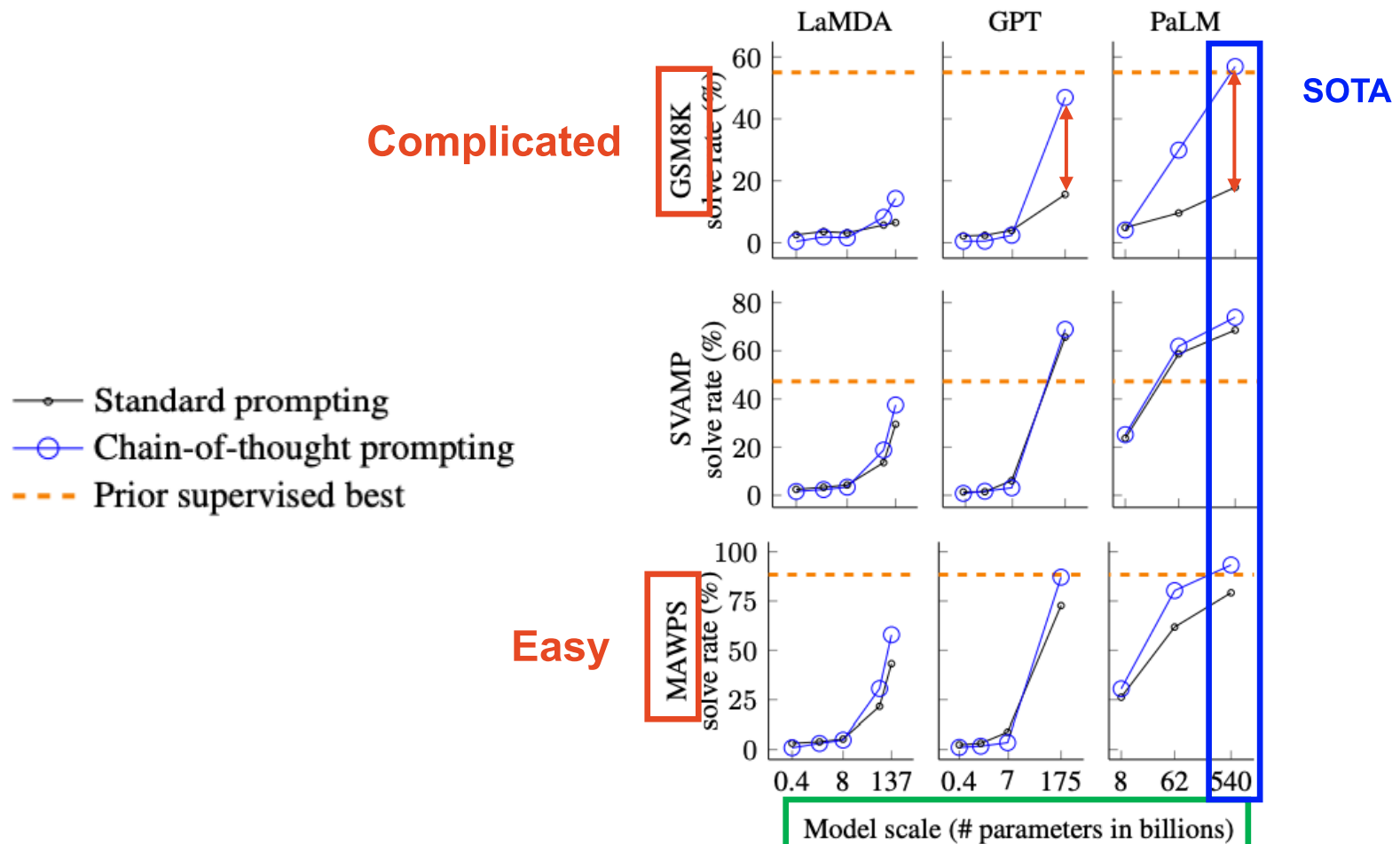
Q: How many keystrokes are needed to type the numbers from 1 to 500?

Answer Choices: (a) 1156 (b) 1392 (c) 1480 (d) 1562 (e) 1788

A: There are 9 one-digit numbers from 1 to 9. There are 90 two-digit numbers from 10 to 99. There are 401 three-digit numbers from 100 to 500. $9 + 90(2) + 401(3) = 1392$. The answer is (b).

Arithmetic Reasoning

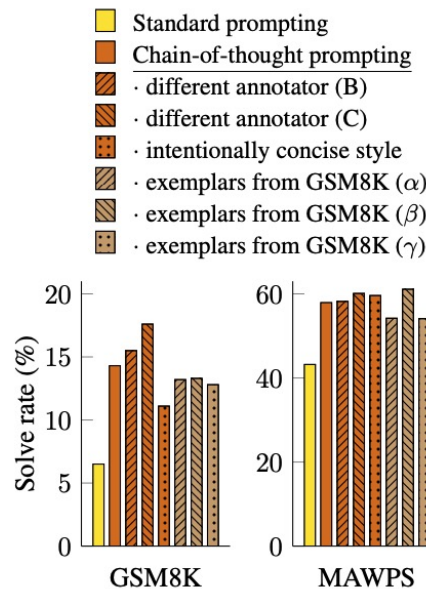
❖ Model collection, model size, benchmark



Chain-of-Thought Prompting

❖ Robustness of Chain of Thought

- Dataset별 8개의 manual CoT prompt를 구축하고 실험 진행
- Manual하게 작성, CoT prompt annotator에게 specific instruction이 주어지지 않음
 - Final answer를 도출할 수 있도록 step-by-step reasoning process를 서술하도록 단순 요청
 - 각 annotator의 고유한 CoT writing 스타일 반영



Chain-of-Thought Prompting

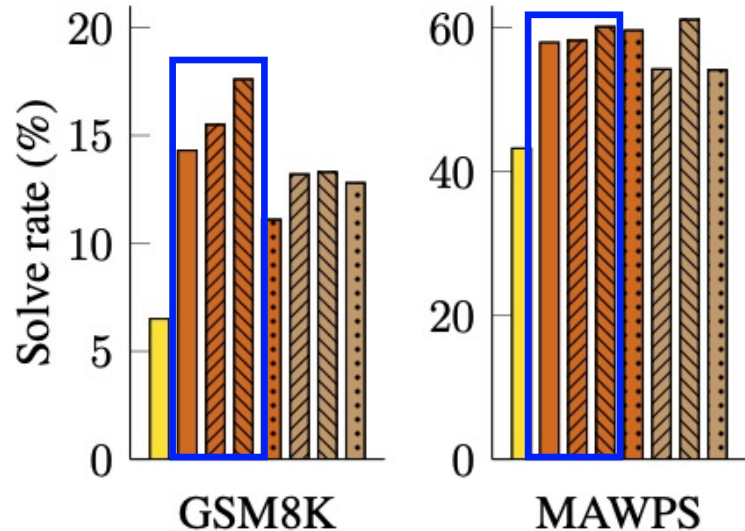
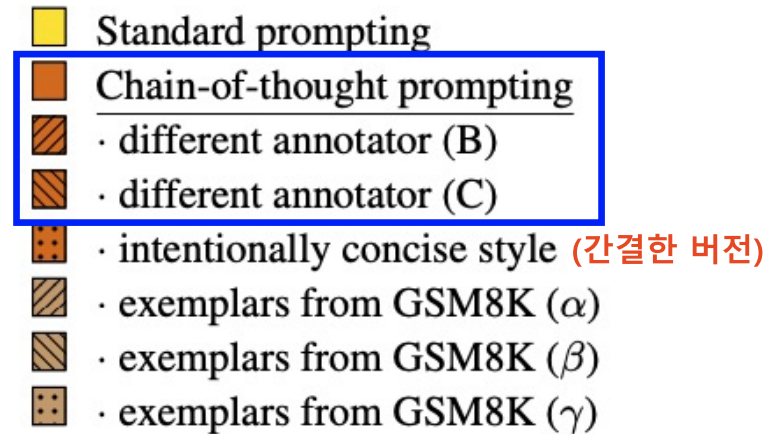
❖ Robustness of Chain of Thought

- 각 주석자가 작성한 CoT가 서로

다름에도 불구하고, 모든 CoT

프롬프트가 standard prompting보다

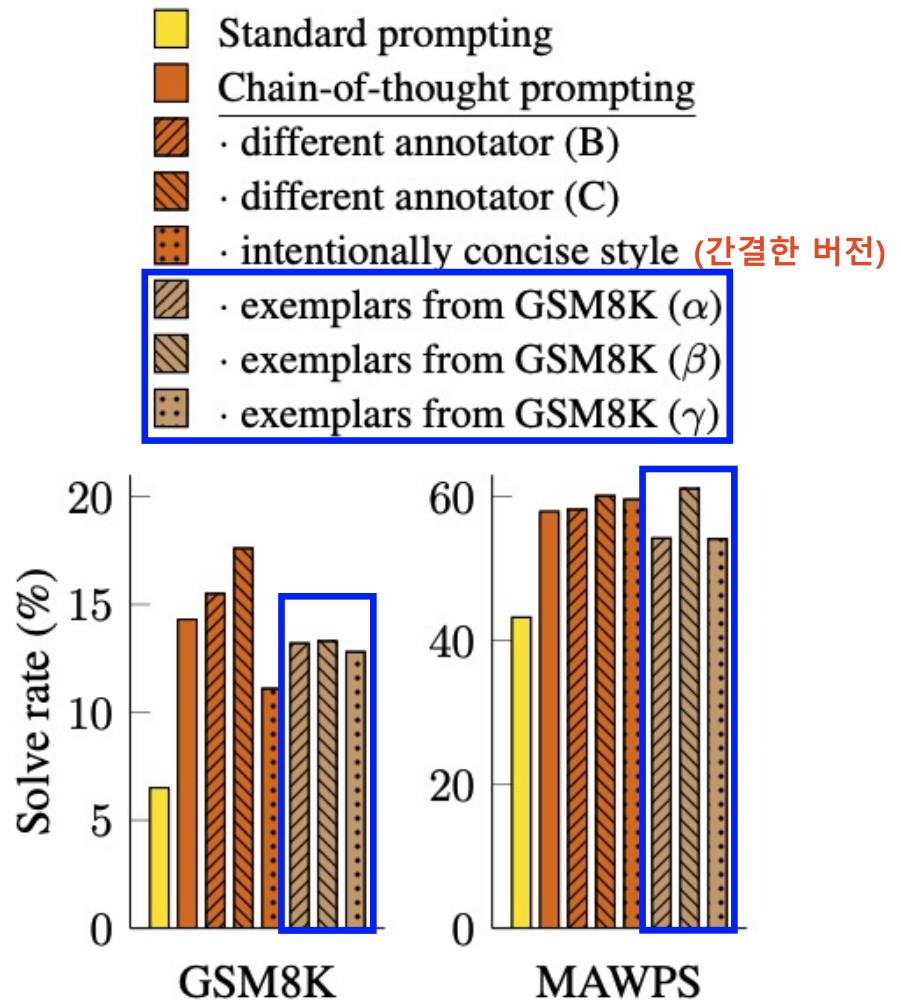
성능이 크게 향상됨



Chain-of-Thought Prompting

❖ Robustness of Chain of Thought

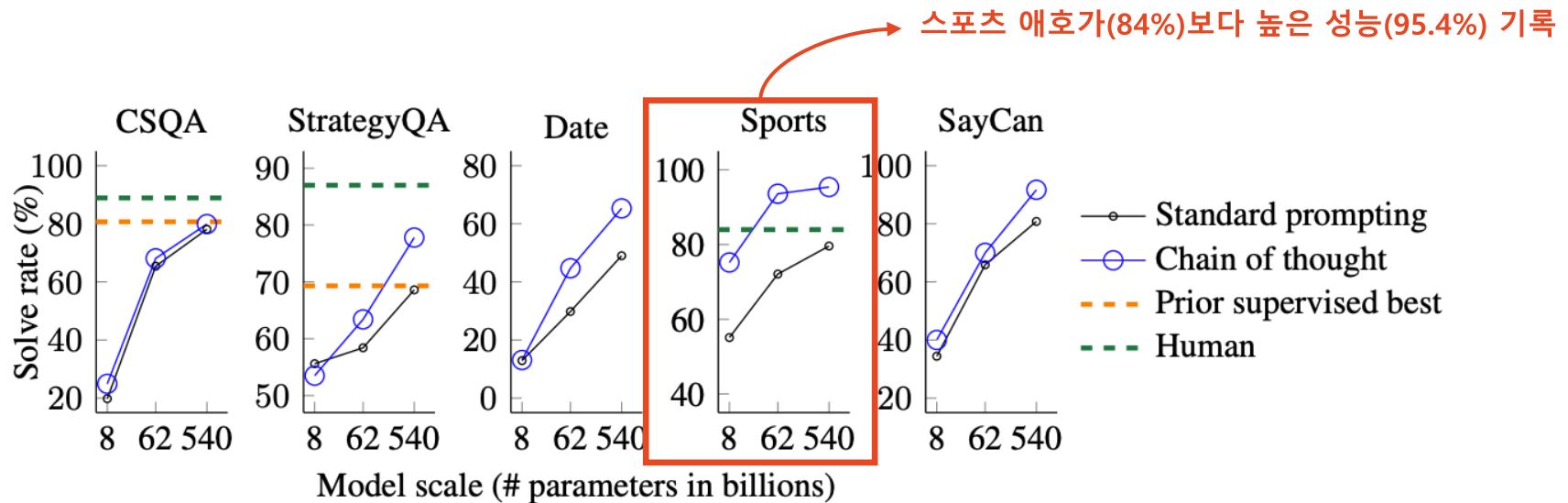
- 무작위로 선택한 예제(exemplar)를
사용해도 CoT 효과가 유지되는지 평가
- GSM8K에서 무작위로 8개의 문제를
선택하여 하나의 프롬프트로 사용



Commonsense Reasoning

❖ 상식 추론

- 자연어 기반 추론 방식이기 때문에 보다 광범위한 상식 추론 문제에도 적용 가능
- 상식 추론: 물리적, 인간 상호작용에 대한 일반적인 배경 지식을 전제로 하여 논리적 사고를 수행하는 과정



Symbolic Reasoning

❖ 기호적 추론

Tasks

- **Last letter concatenation**

✓ ex) "Amy Brown" → "yn"

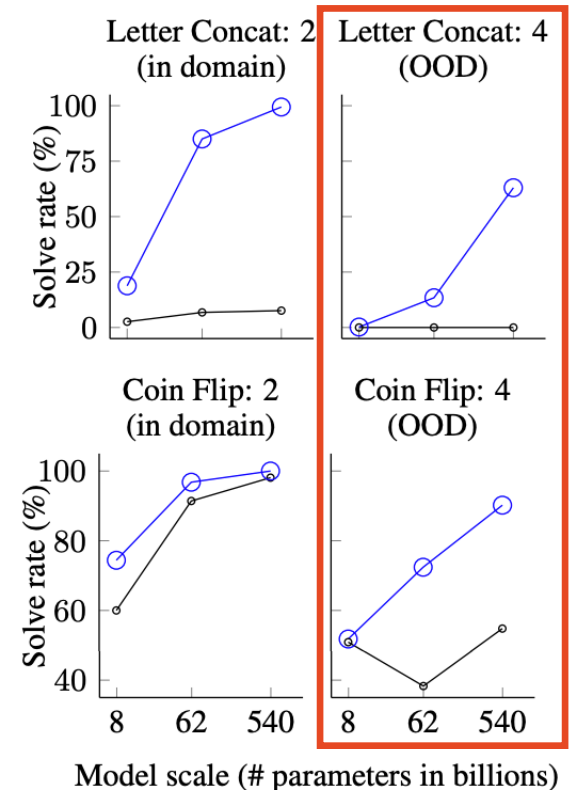
- **Coin Flip**

✓ e.g., "A coin is heads up. Phoebe flips the coin.

Osvaldo does not flip the coin. Is the coin still
heads up?" → "no"

더 어려운 문제로, CoT가 필요함.

—○— Standard prompting
—○— Chain-of-thought prompting



Conclusions

- ❖ CoT는 산술 추론, 기호적 추론, 상식 추론에서 일관된 성능 향상 제공
- ❖ Finetuning을 위한 CoT 데이터 구축 비용이 높음
 - 해결하기 위한 자동화 데이터 생성 연구 필요 (Zero-shot CoT)
- ❖ 대형 모델에서만 강력한 성능 향상이 나타나며, 작은 모델에서는 효과가 미미함

Appendix

Introduction

❖ Chain-of-Thought Prompting Elicits Reasoning in Large Language Models

- CoT 프롬프트를 적용하면 산술 연산, 상식 추론, 기호 논리와 같은 다양한 작업에서 성능 향상

<p>Math Word Problems (free response)</p> <p>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?</p> <p>A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls. $5 + 6 = 11$. The answer is 11.</p>	<p>Math Word Problems (multiple choice)</p> <p>Q: How many keystrokes are needed to type the numbers from 1 to 500?</p> <p>Answer Choices: (a) 1156 (b) 1392 (c) 1480 (d) 1562 (e) 1788</p> <p>A: There are 9 one-digit numbers from 1 to 9. There are 90 two-digit numbers from 10 to 99. There are 401 three-digit numbers from 100 to 500. $9 + 90(2) + 401(3) = 1392$. The answer is (b).</p>	<p>CSQA (commonsense)</p> <p>Q: Sammy wanted to go to where the people were. Where might he go?</p> <p>Options: (a) race track (b) populated areas (c) desert (d) apartment (e) roadblock</p> <p>A: The answer must be a place with a lot of people. Race tracks, desert, apartments, and roadblocks don't have a lot of people, but populated areas do. So the answer is (b).</p>
<p>StrategyQA</p> <p>Q: Yes or no: Would a pear sink in water?</p> <p>A: The density of a pear is about 0.6 g/cm^3, which is less than water. Thus, a pear would float. So the answer is no.</p>	<p>Date Understanding</p> <p>Q: The concert was scheduled to be on 06/01/1943, but was delayed by one day to today. What is the date 10 days ago in MM/DD/YYYY?</p> <p>A: One day after 06/01/1943 is 06/02/1943, so today is 06/02/1943. 10 days before today is 05/23/1943. So the answer is 05/23/1943.</p>	<p>Sports Understanding</p> <p>Q: Is the following sentence plausible? "Joao Moutinho caught the screen pass in the NFC championship."</p> <p>A: Joao Moutinho is a soccer player. The NFC championship is part of American football, not soccer. So the answer is no.</p>
<p>SayCan (Instructing a robot)</p> <p>Human: How would you bring me something that isn't a fruit?</p> <p>Explanation: the user wants something to eat that isn't a fruit. An energy bar is not a fruit, so I will bring the user an energy bar.</p> <p>Plan: 1. find(energy bar) 2. pick(energy bar) 3. find(user) 4. put(energy bar) 5. done().</p>	<p>Last Letter Concatenation</p> <p>Q: Take the last letters of the words in "Lady Gaga" and concatenate them.</p> <p>A: The last letter of "Lady" is "y". The last letter of "Gaga" is "a". Concatenating them is "ya". So the answer is ya.</p>	<p>Coin Flip (state tracking)</p> <p>Q: A coin is heads up. Maybelle flips the coin. Shalonda does not flip the coin. Is the coin still heads up?</p> <p>A: The coin was flipped by Maybelle. So the coin was flipped 1 time, which is an odd number. The coin started heads up, so after an odd number of flips, it will be tails up. So the answer is no.</p>