Mitigating Hallucinations in LLMs

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Under supervision of Marcus Tomalin
Machine Intelligence Lab

Overview

- Large Language Models (LLMs) hallucination definition

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- Investigating combining two existing decoding methods

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- Investigating combining two existing decoding methods
- Investigating a modification to existing method
- New method to alter LLM “thought process”

LLM Hallucination

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- When “a model makes factual errors” – OpenAI
- Hallucination rate ≠ 1 - accuracy
- But impractical to label
- Objective: improve factual reliability and reasoning

Context-Aware Decoding (CAD)

- Reminder – Large Language Model (LLM)

$$\mathrm{P}(w_t \mid \mathbf{w}_{<t})$$

$$\mathbf{w}_{<t} = [w_1, w_2, \ldots, w_{t-1}]$$

Next token probabilities,
given history

Context-Aware Decoding (CAD)

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(prompt $\mathbf{x}$, sequence so far $\mathbf{y}_{<t}$)

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Decoding by Contrasting Layers (DoLa)

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- **DoLa is:**

$$\mathrm{P}_{\mathrm{DoLa}}(y_t) \propto \mathrm{P}(y_t)\left(\frac{\mathrm{P}(y_t)}{\boxed{\mathrm{P}^{(l)}(y_t)}}\right)$$

Distribution at previous layer

Results

1. MemoTrap

Context:

Write a quote that ends in the word "early"

Prompt:

Better late than

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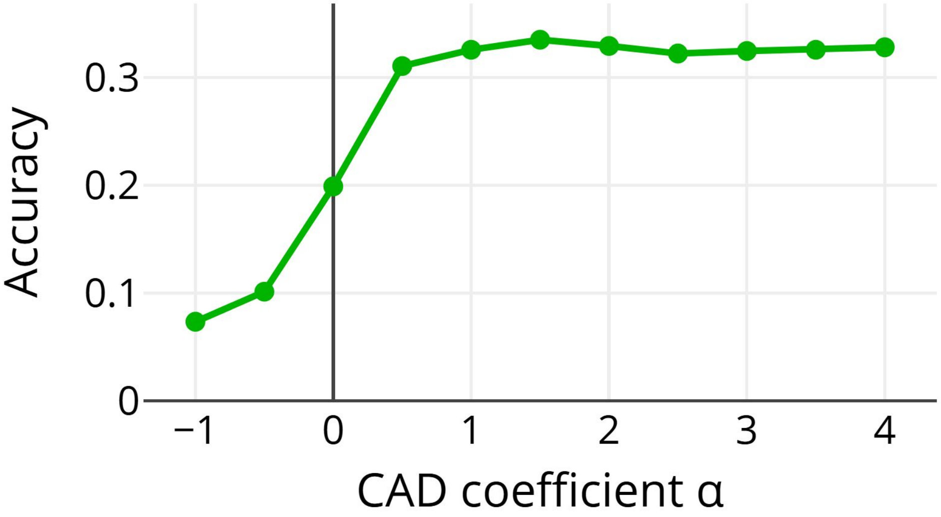

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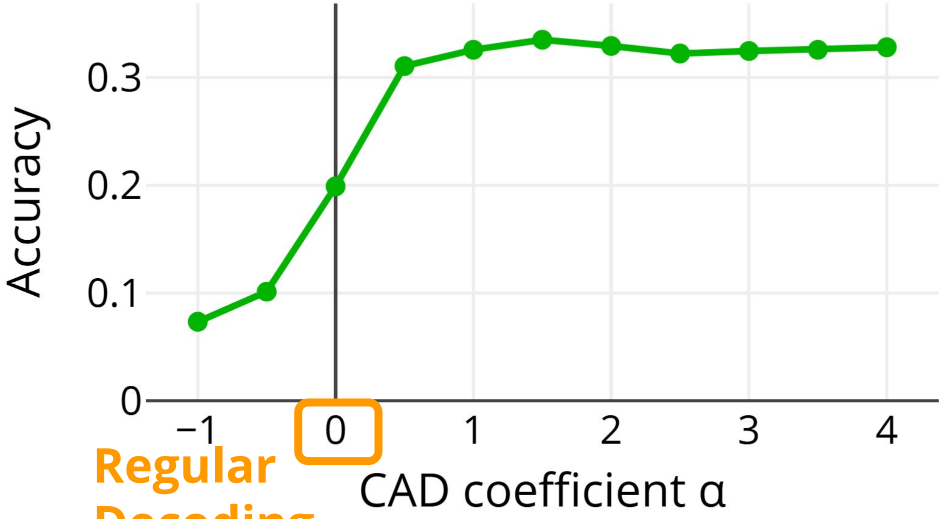

Regular Decoding

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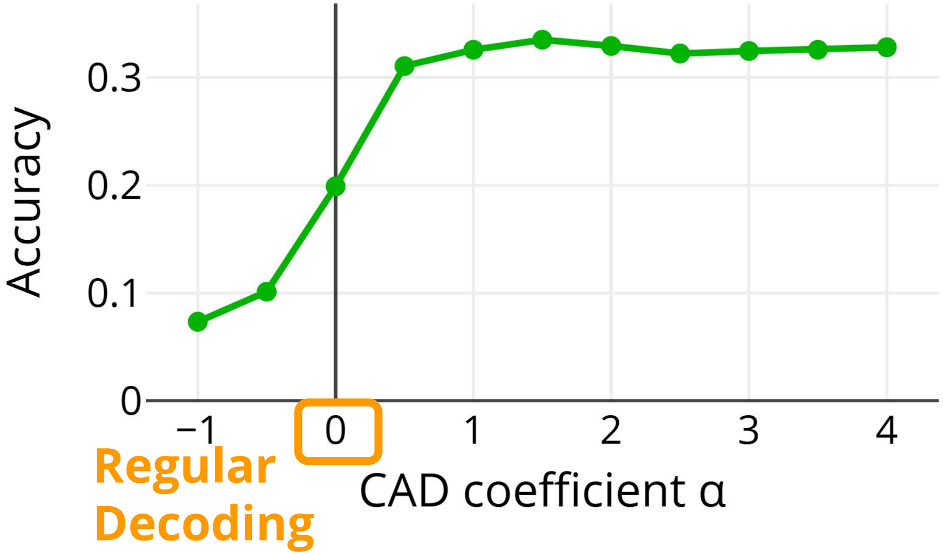

Regular Decoding

2. Natural Questions

Context:
Ashrita Furman (born Keith Furman, September 16, 1954) is a Guinness World Records record-breaker. …
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who holds the world record for the most world records?

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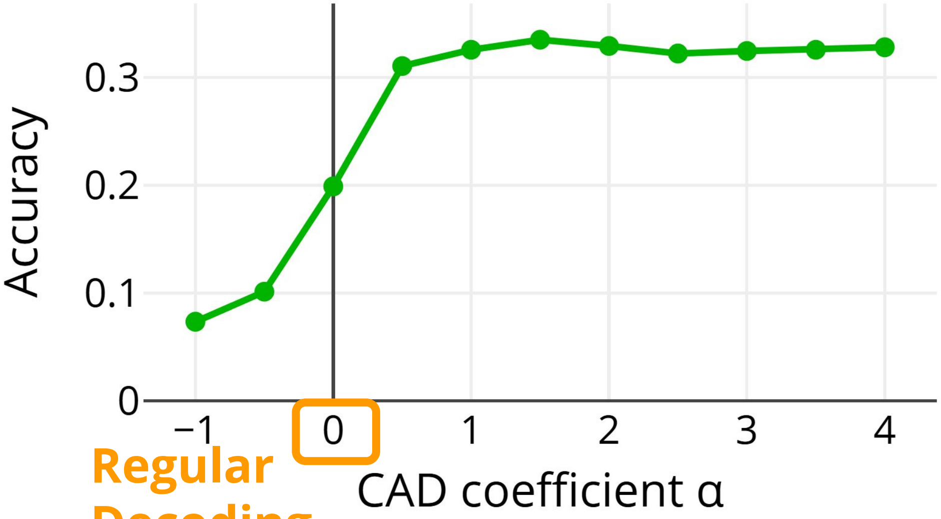

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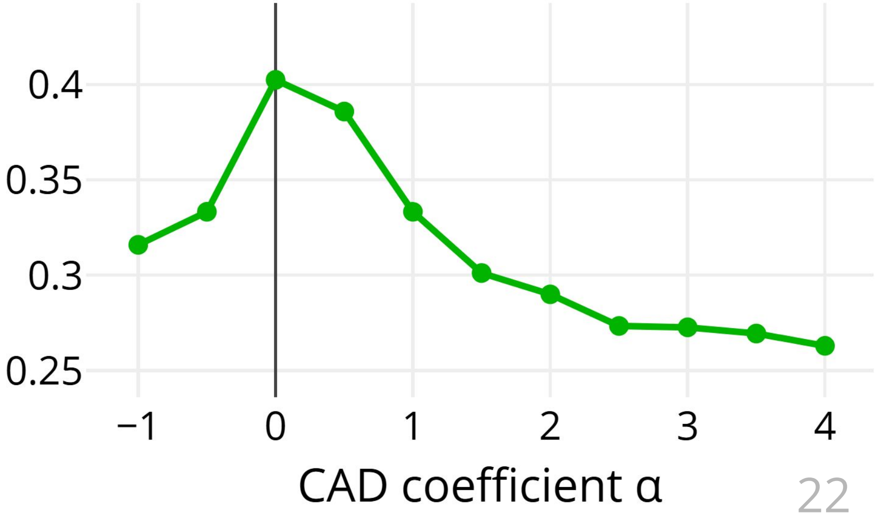

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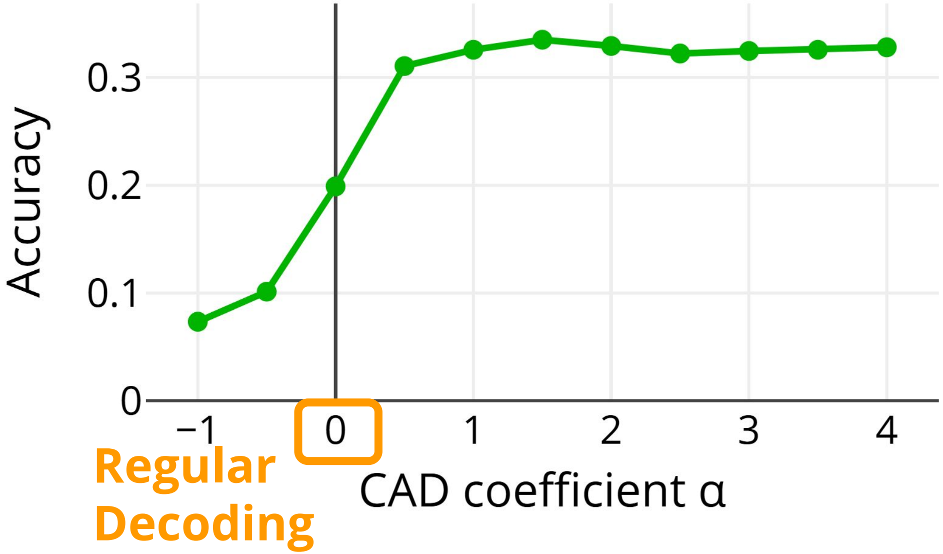

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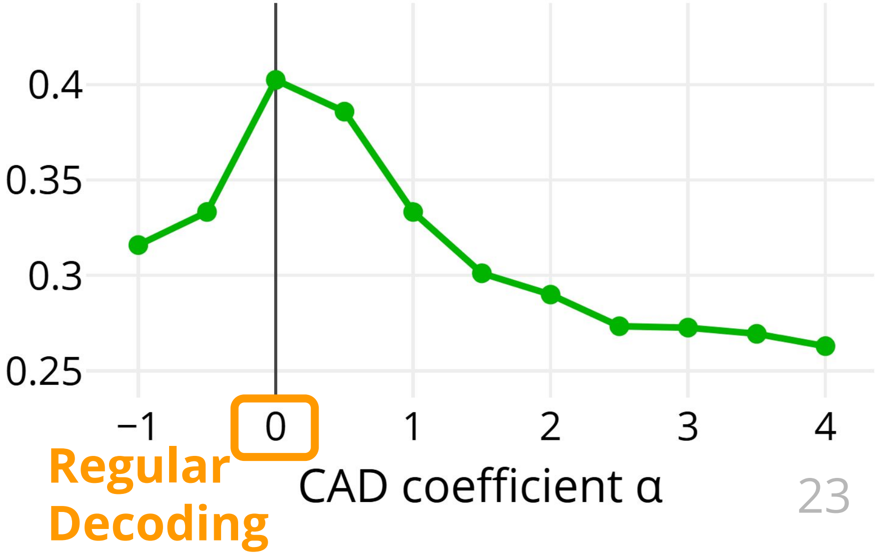

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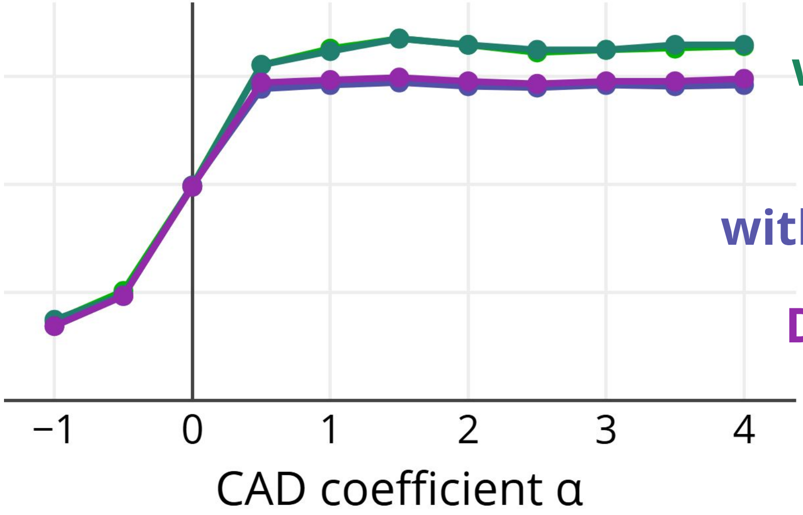

Normal

DoLa on with-context

DoLa on without-context

DoLa on both

Results

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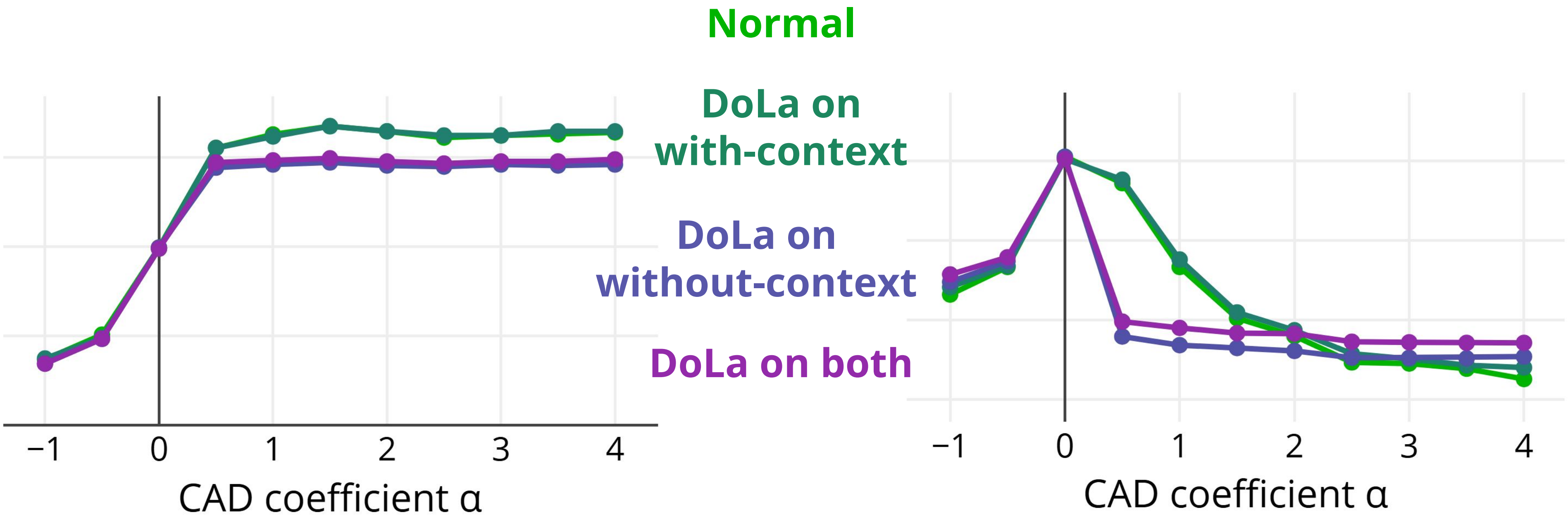

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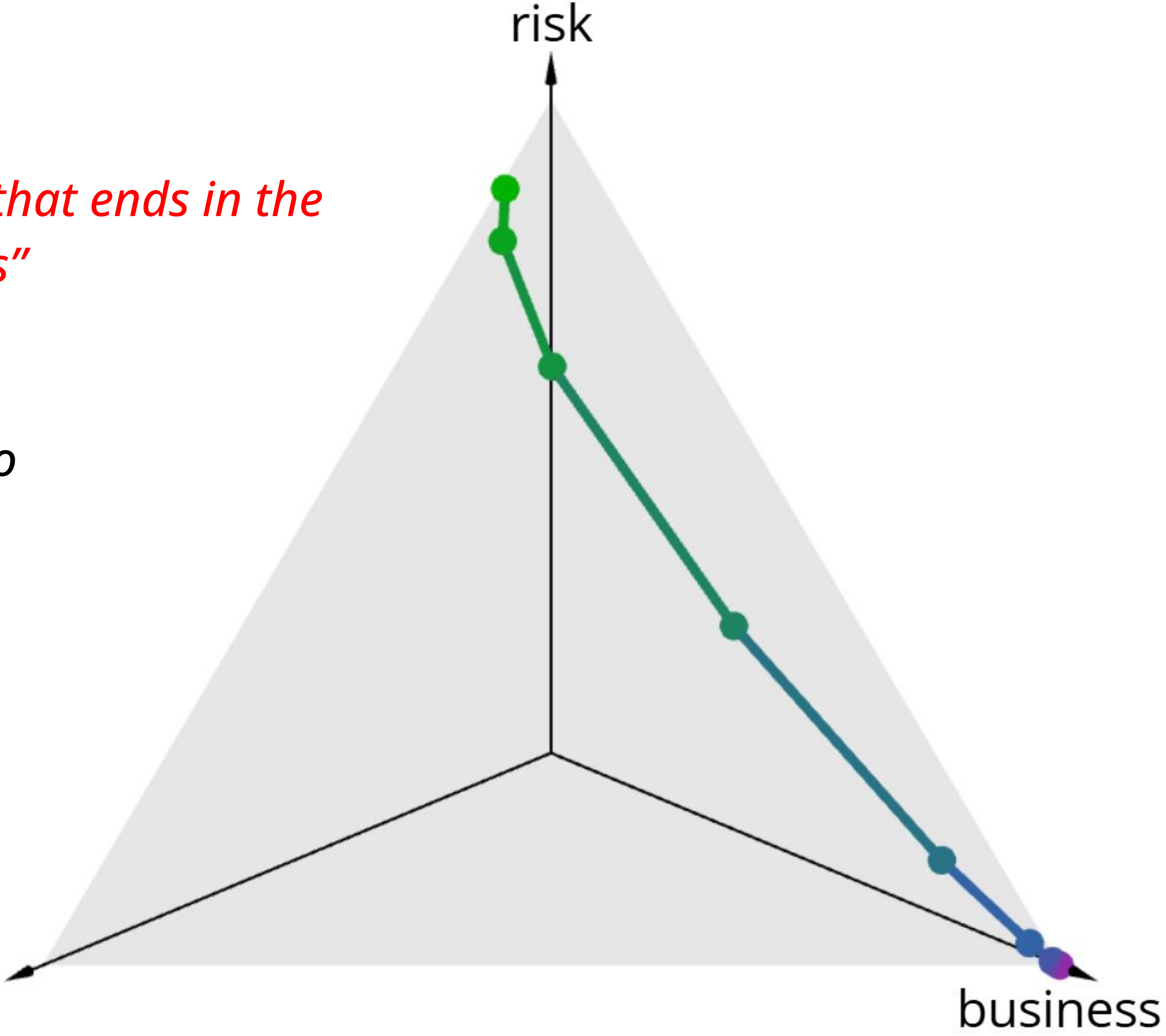
Advisers run no



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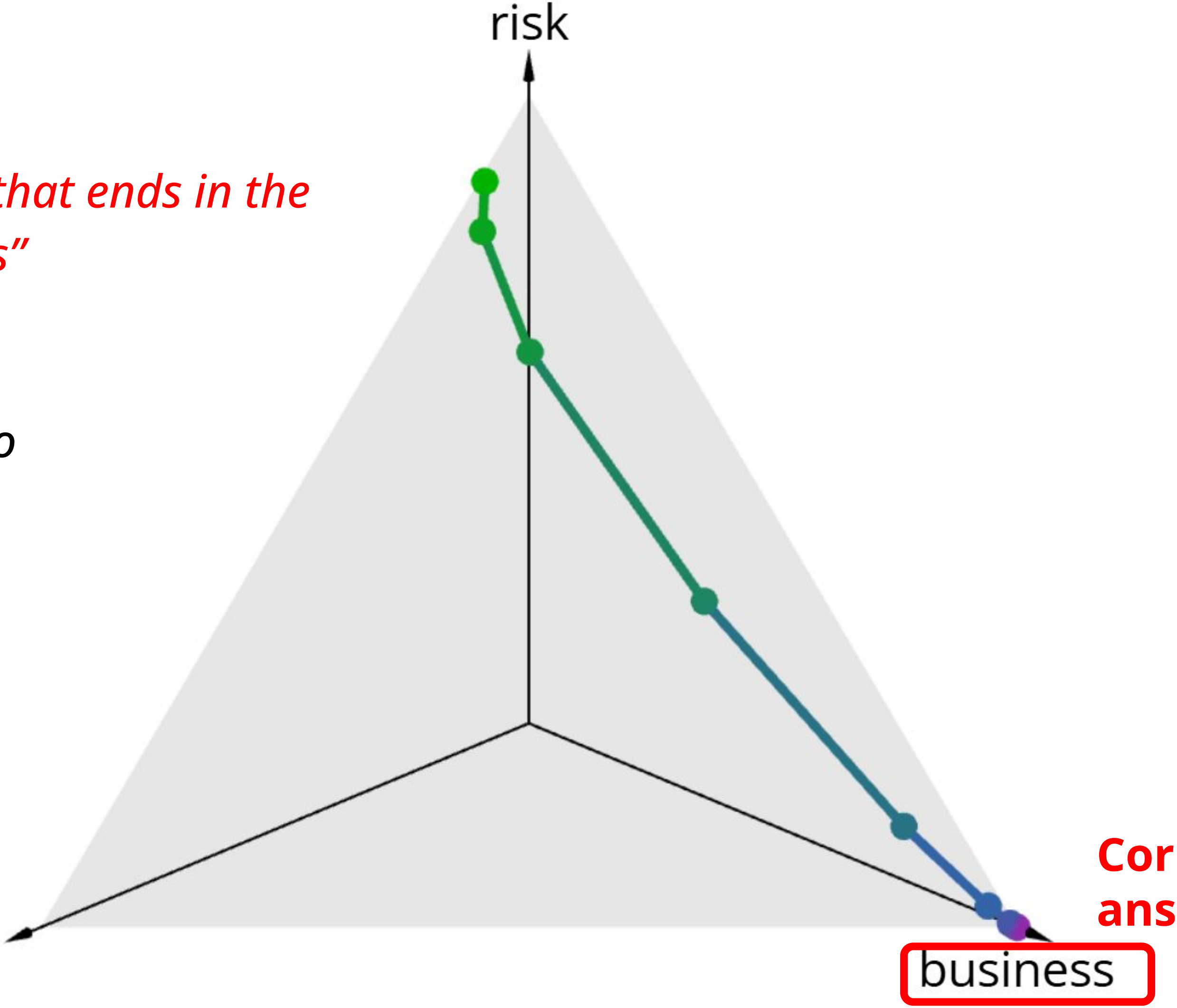

Correct answer

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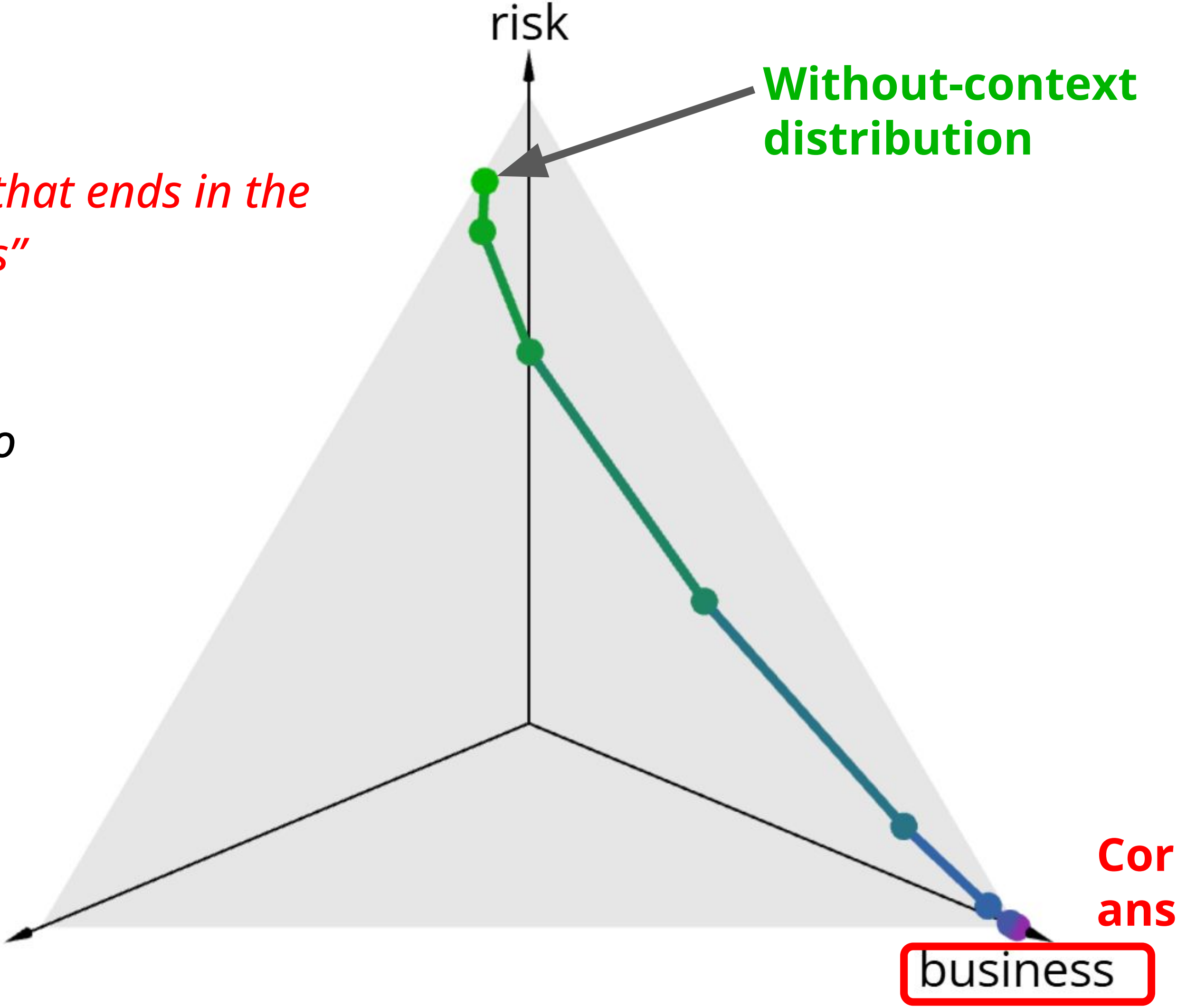

Without-context distribution

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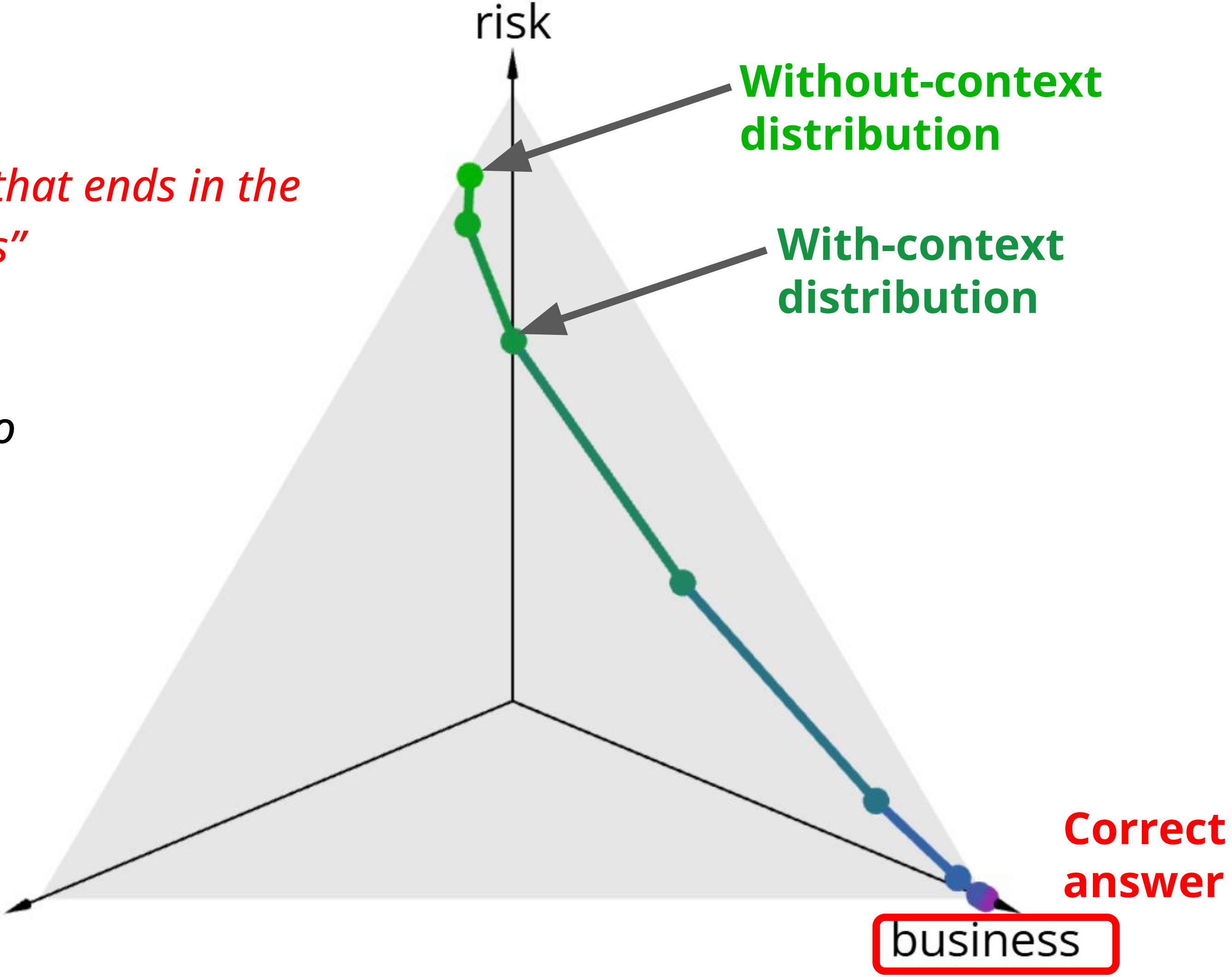

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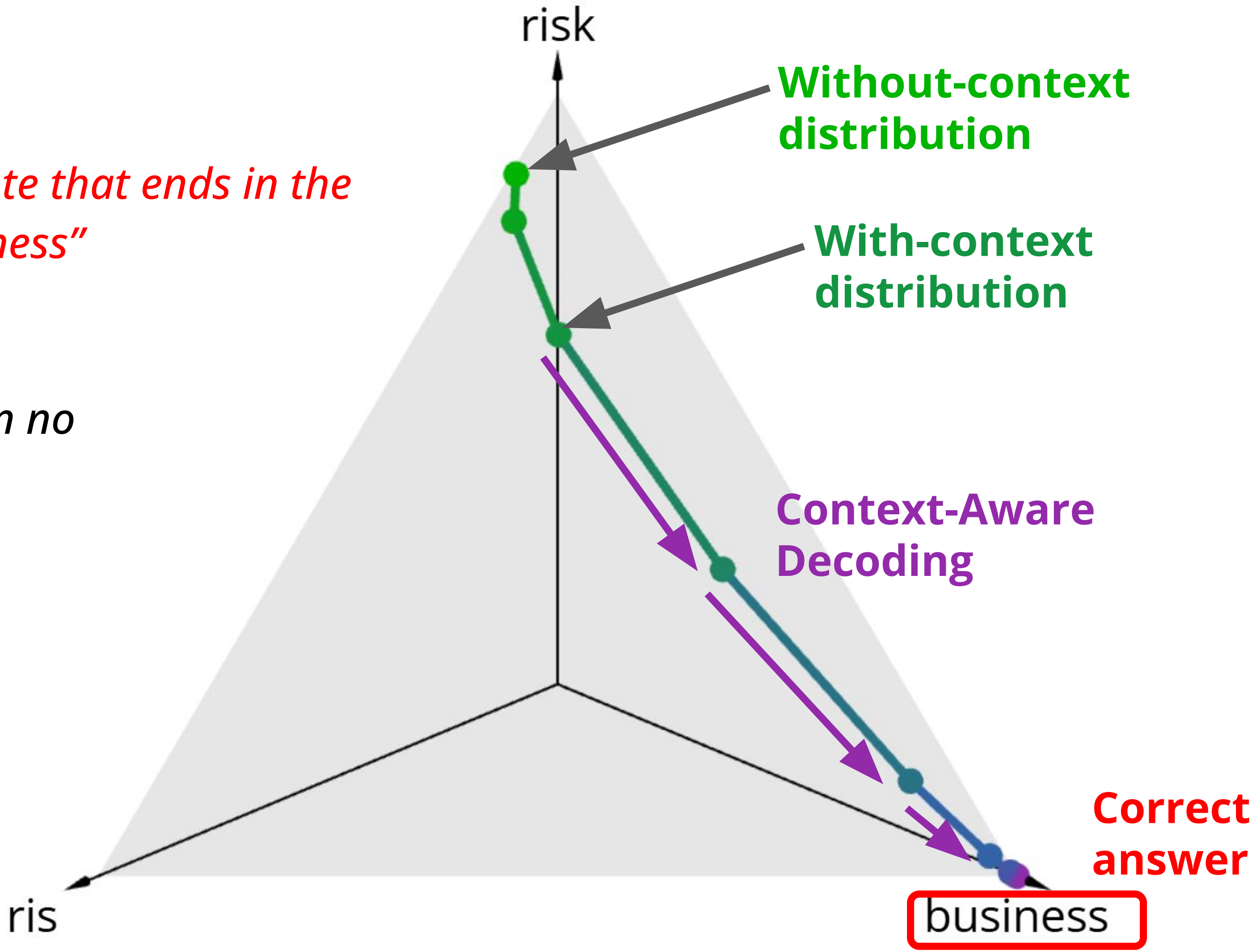
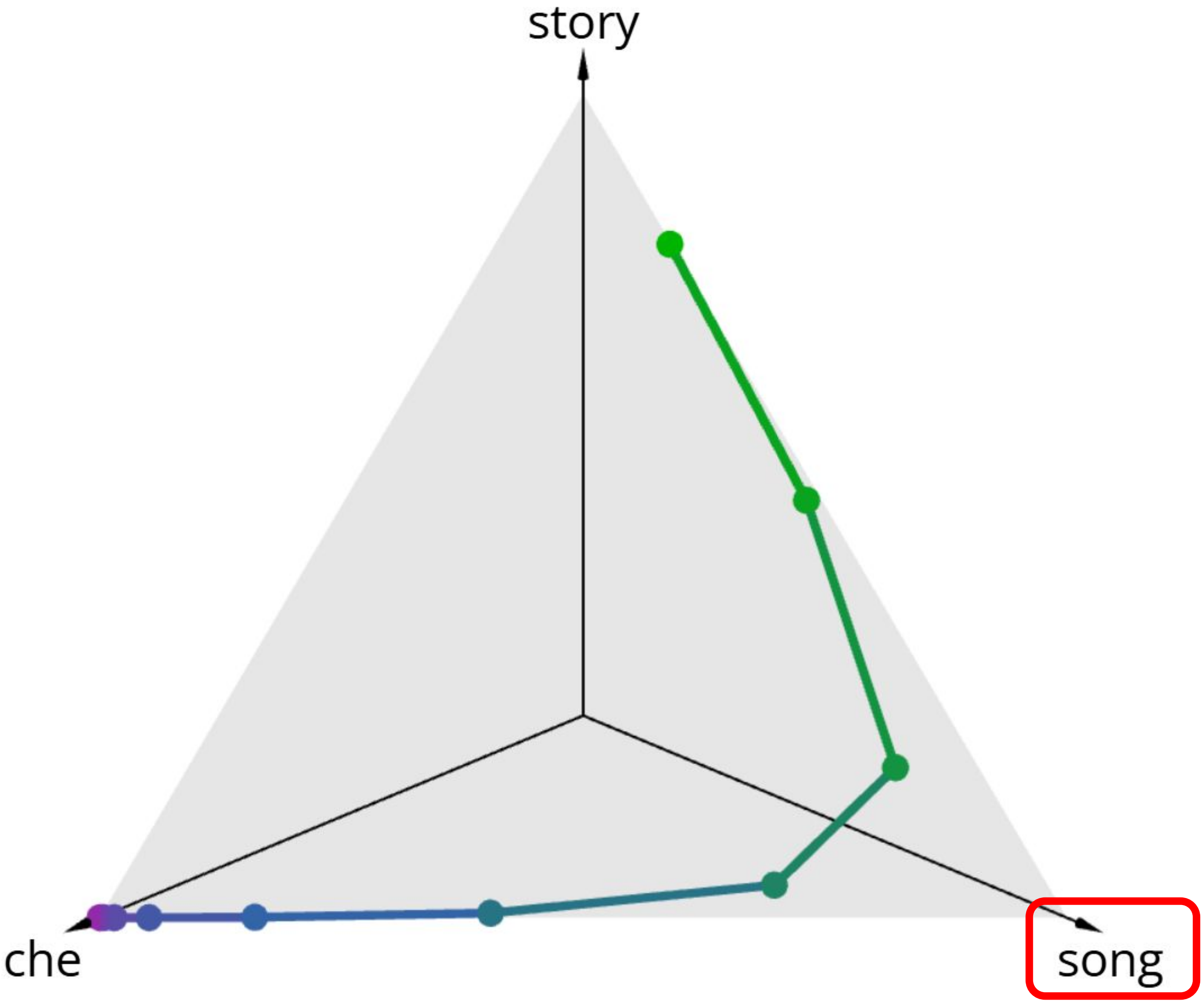


Without-context distribution

With-context distribution

Context-Aware Decoding

Correct answer



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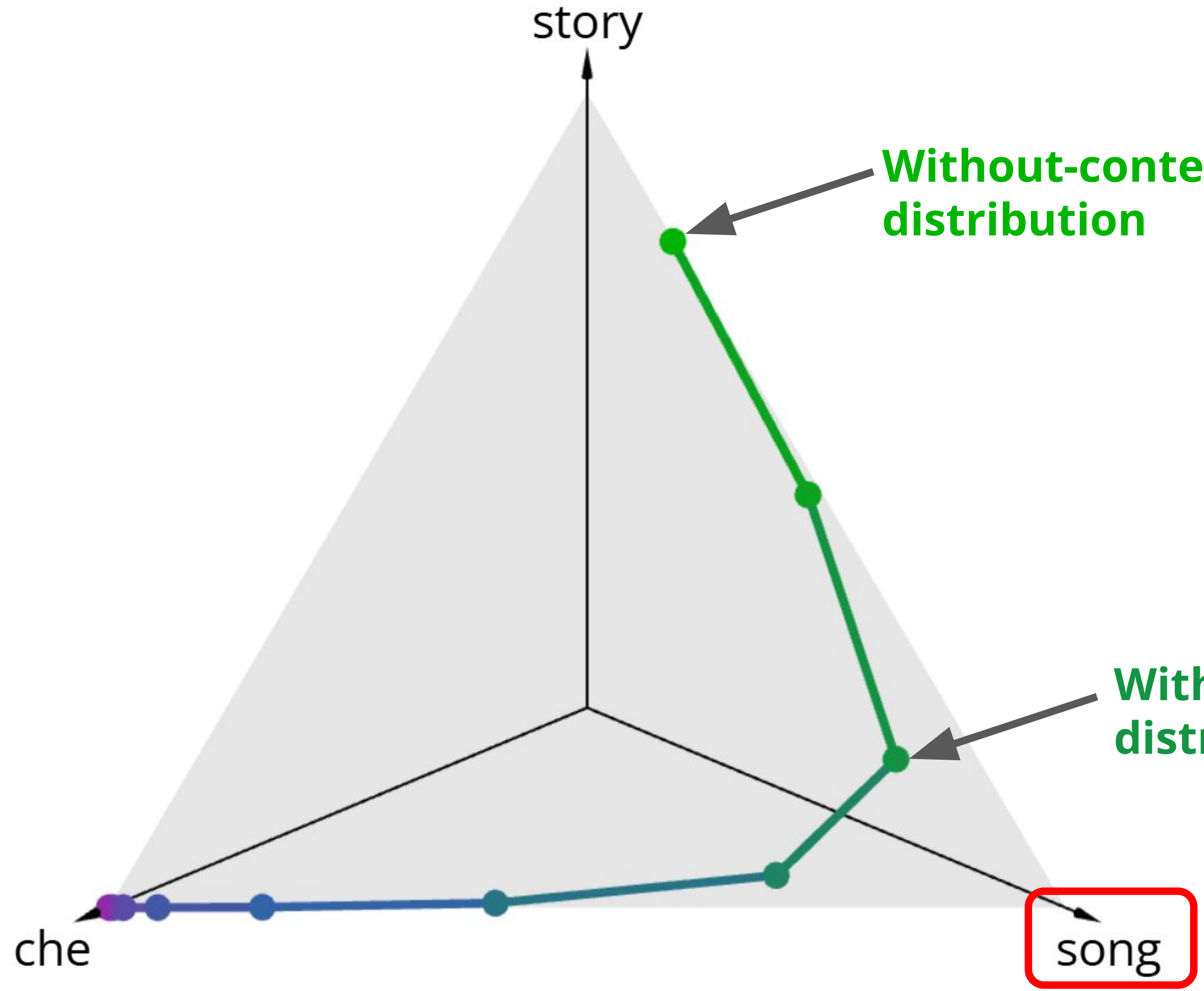
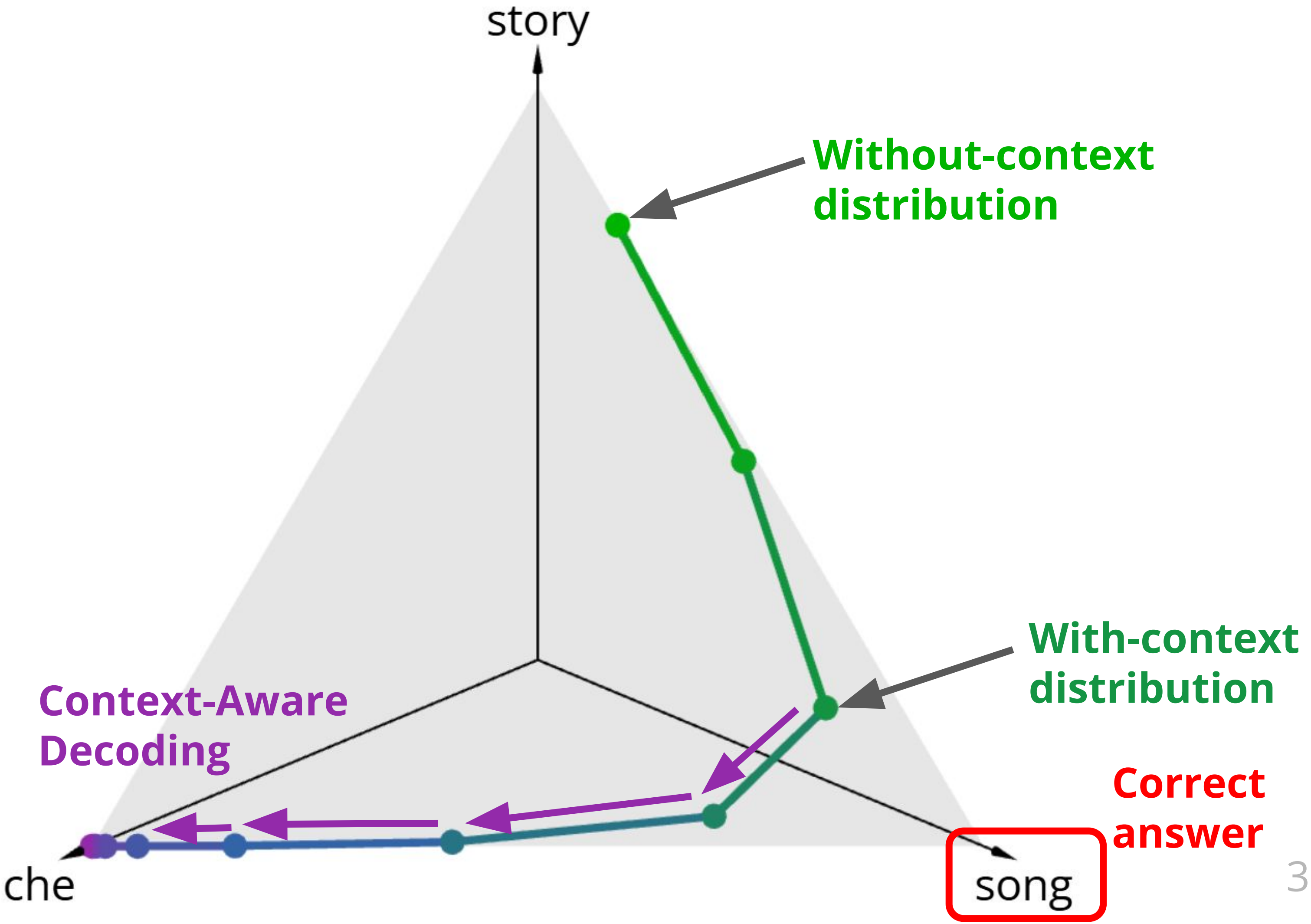


Without-context distribution

With-context distribution

Correct answer



Without-context distribution

With-context distribution

Context-Aware Decoding

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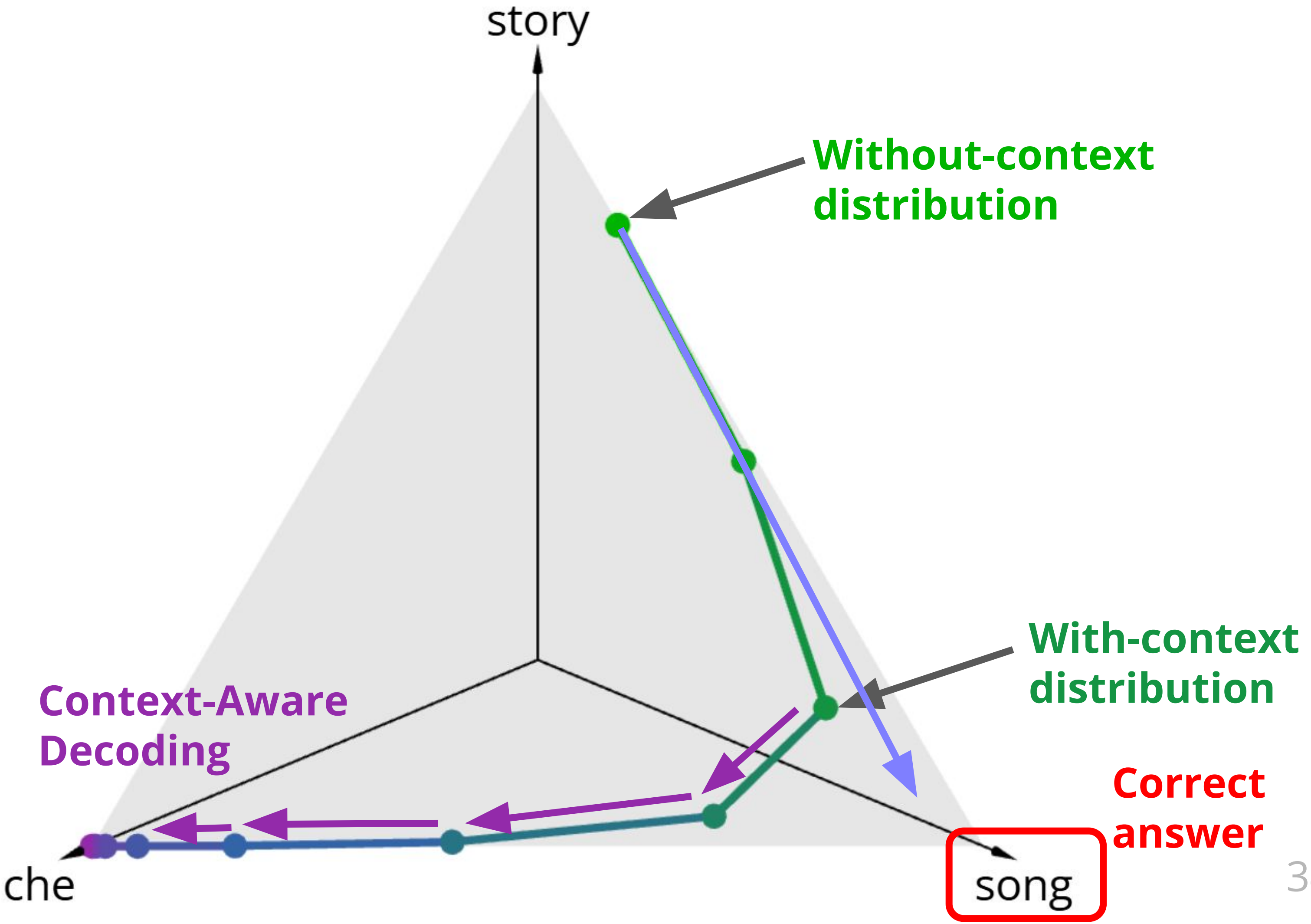
story
Without-context distribution
With-context distribution
Context-Aware Decoding
Correct answer
che
song

Additive Context-Aware Decoding

Add the difference instead of multiplying by ratio:

$$\mathrm{P}'_{\mathrm{AddCAD}}(y_t) = \mathrm{P}(y_t \mid \mathbf{x}, \mathbf{y}_{<t}) \ + \gamma\left(\mathrm{P}(y_t \mid \mathbf{c}, \mathbf{x}, \mathbf{y}_{<t}) - \mathrm{P}(y_t \mid \mathbf{x}, \mathbf{y}_{<t})\right)$$

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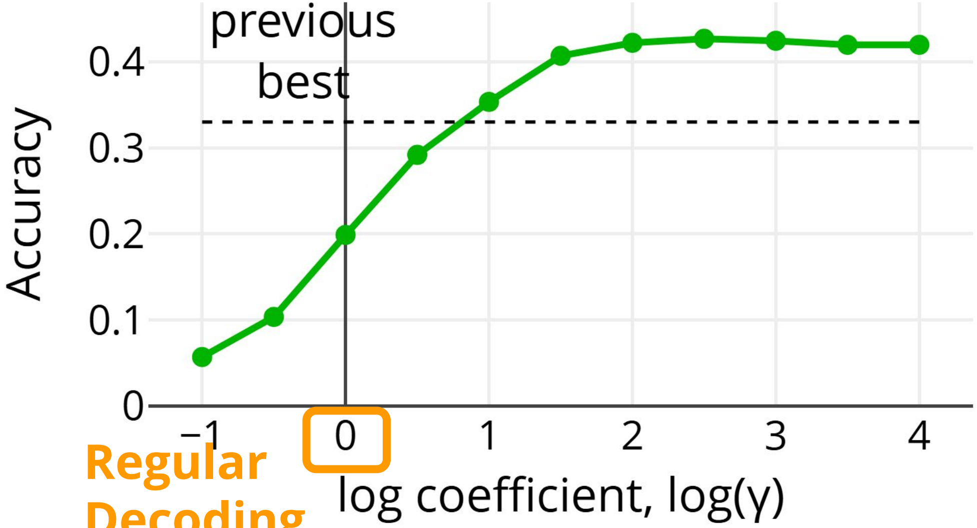

Regular Decoding

Additive Context-Aware Decoding

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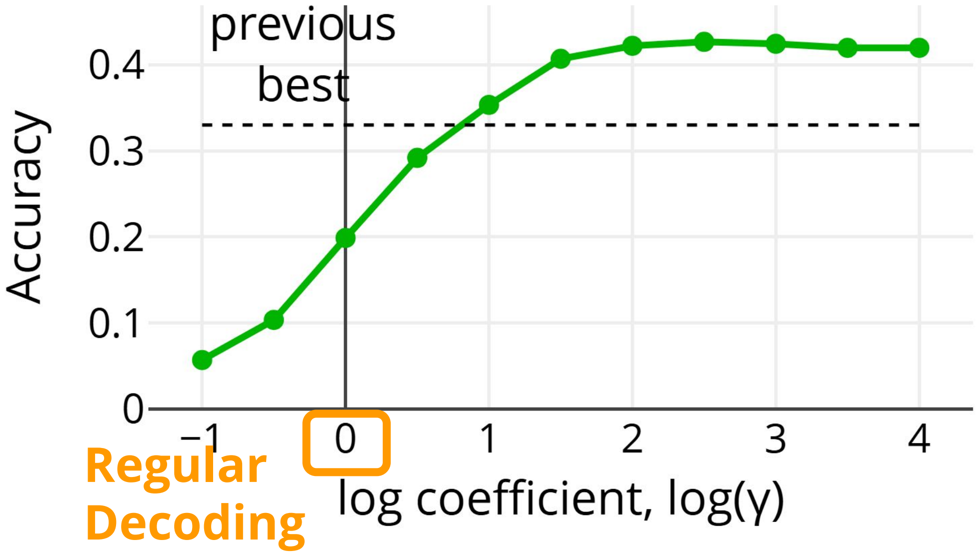
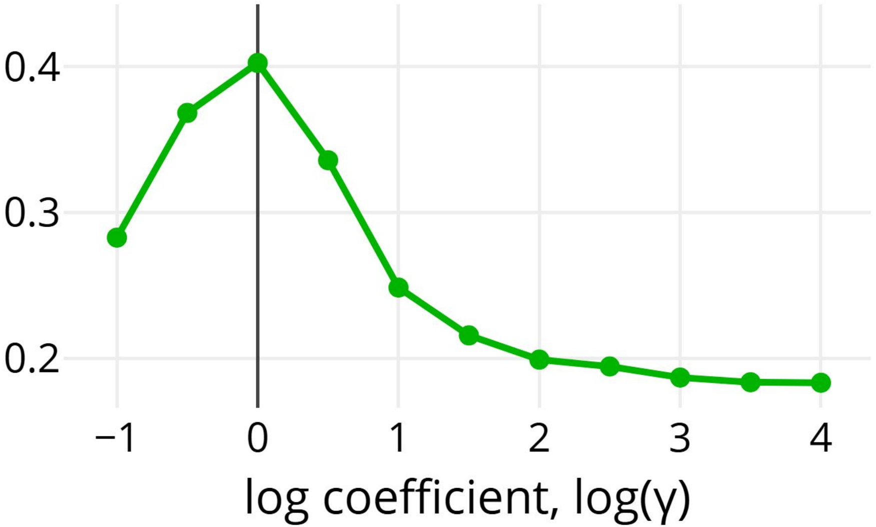


2. Natural Questions – even worse



Doubt Injection

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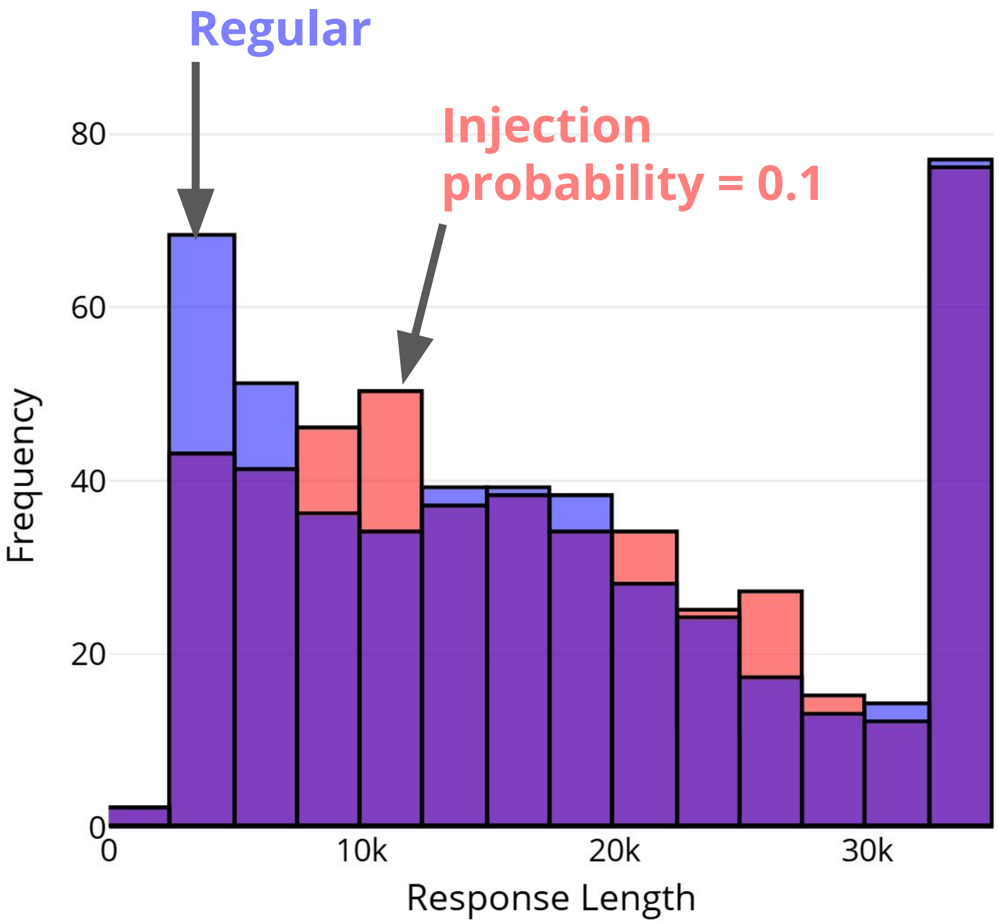
- Chain-of-Thought works
- Explore more ideas
- Try randomly inject e.g. “But” at new paragraph
- Tends to increase response length



Doubt Injection – Results

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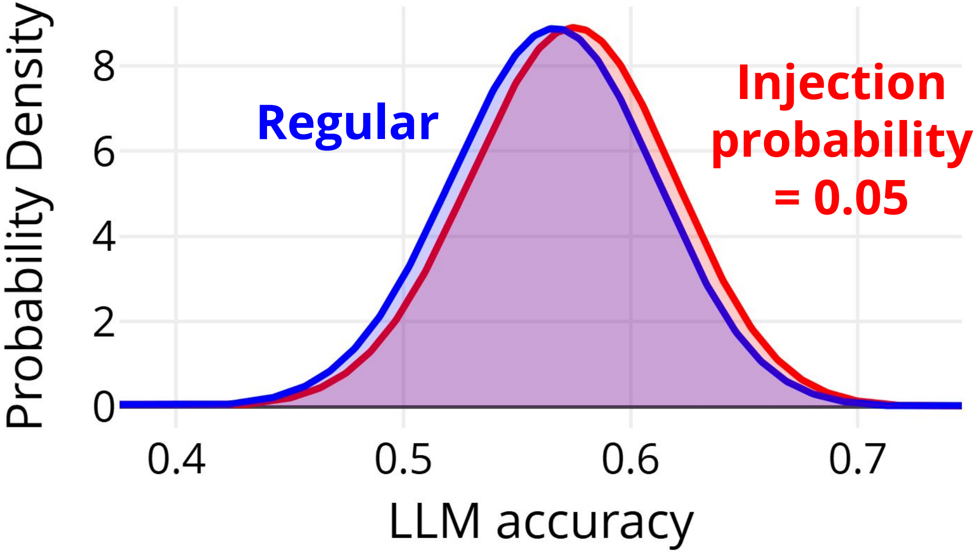

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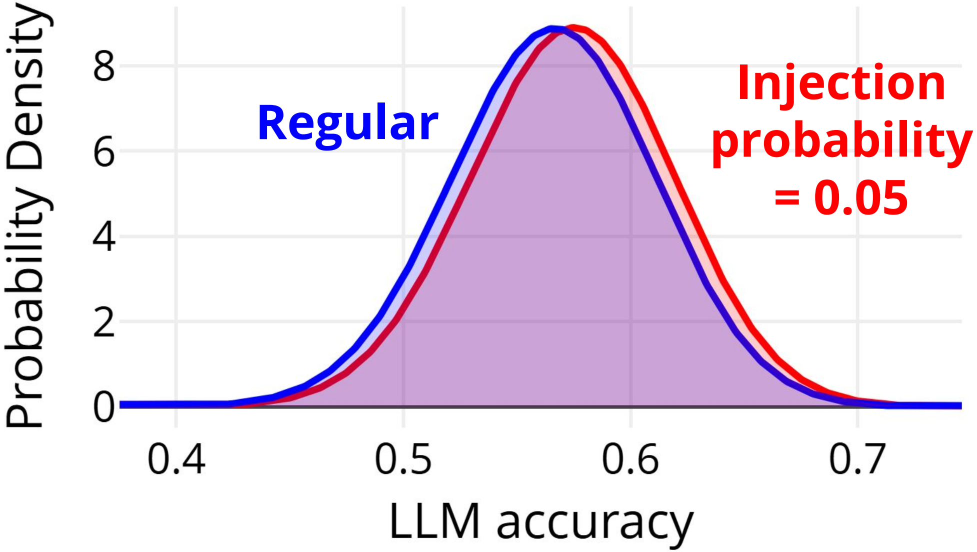

Doubt Injection – Results

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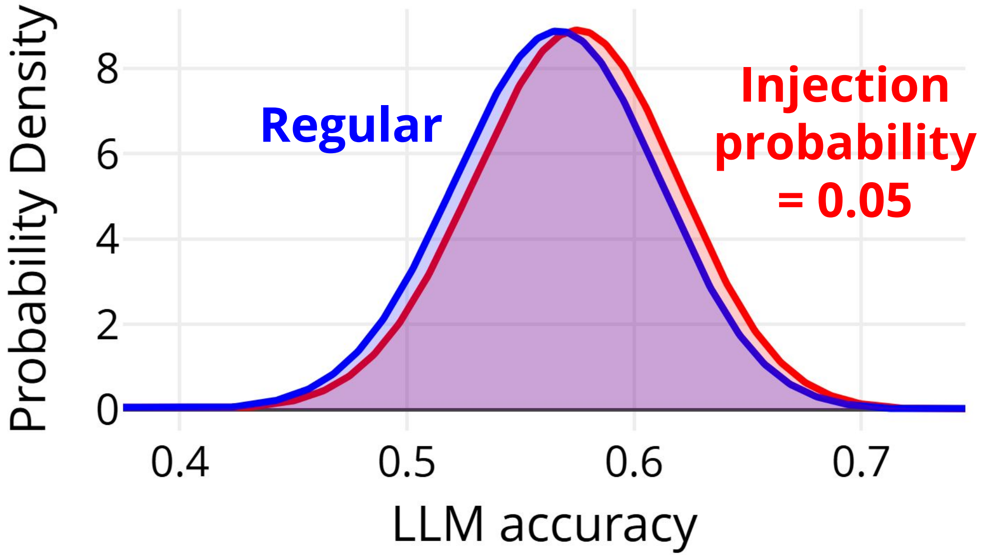
- Statistically insignificant (~58%, 55% probability it helps)
- Question-dependent
- String-dependent
- (“But” is best)



Conclusions

- DoLa on distribution with context helps CAD
- Additive CAD even better at resolving knowledge conflicts
- Doubt Injection shows limited potential