



HippoRAG: Neurobiologically Inspired Long-Term Memory for Large Language Models

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NeurIPS 2024



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LLM Long-Term Memory

- LLMs still cannot update their long-term memory natively.

User
Who won the 2024 NBA Championship?

Assistant
I'm sorry, but I don't have access to live or future data. You might want to check the latest sports news outlets for the most current information on the 2024 NBA Championship winner.

🔗 🗑️ 🎯

GPT-4o API



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LLM Long-Term Memory

- RAG is the de-facto solution for this problem.

The screenshot shows a dark-themed interface of a large language model (LLM) application. At the top right, a rounded rectangular input field contains the question "Who won the 2024 NBA Championship?". Below the input field, the LLM's response is displayed. To the left of the response is a circular icon containing a stylized AI or neural network logo. The response text reads: "The Boston Celtics won the 2024 NBA Championship, defeating the Dallas Mavericks 4-1 in the Finals. This victory marked the Celtics' 18th championship, surpassing the Los Angeles Lakers for the most in NBA history. Jaylen Brown was named Finals MVP, averaging 20.8 points, 5.4 rebounds, and 5.0 assists per game." To the right of the response text is a small, semi-transparent "WIKIPEDIA" watermark. At the bottom left of the screen, there is a button labeled "Sources" with a small "W" icon. At the very bottom, there is a row of small, light-colored icons representing various functions or controls.

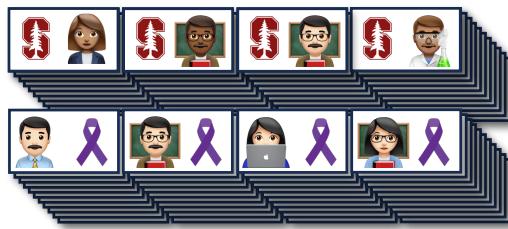
ChatGPT-4o



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However, RAG sometimes struggles...

Passages



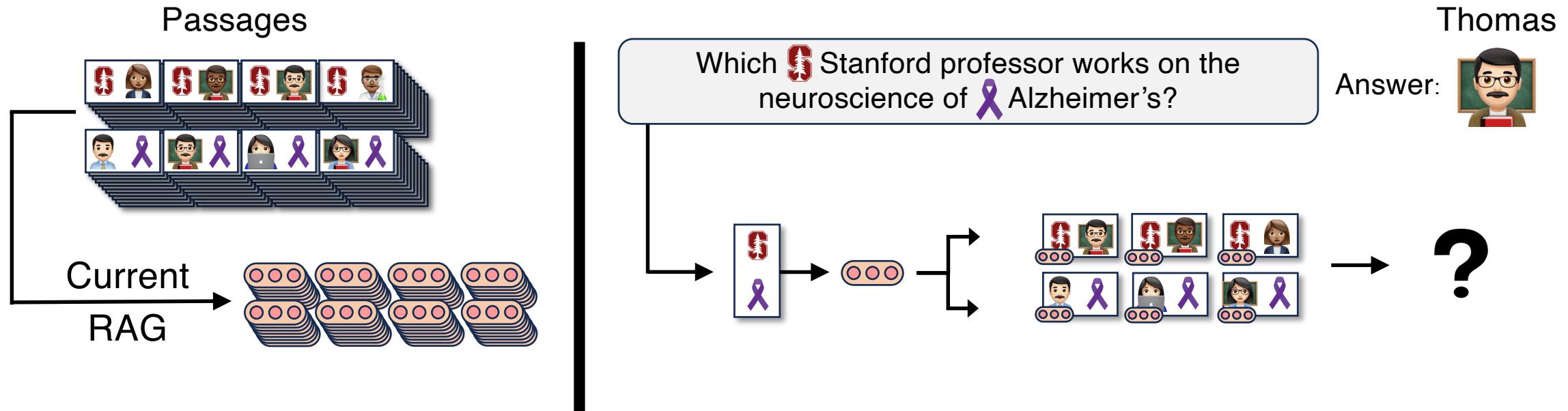
Which  Stanford professor works on the neuroscience of  Alzheimer's?

Thomas

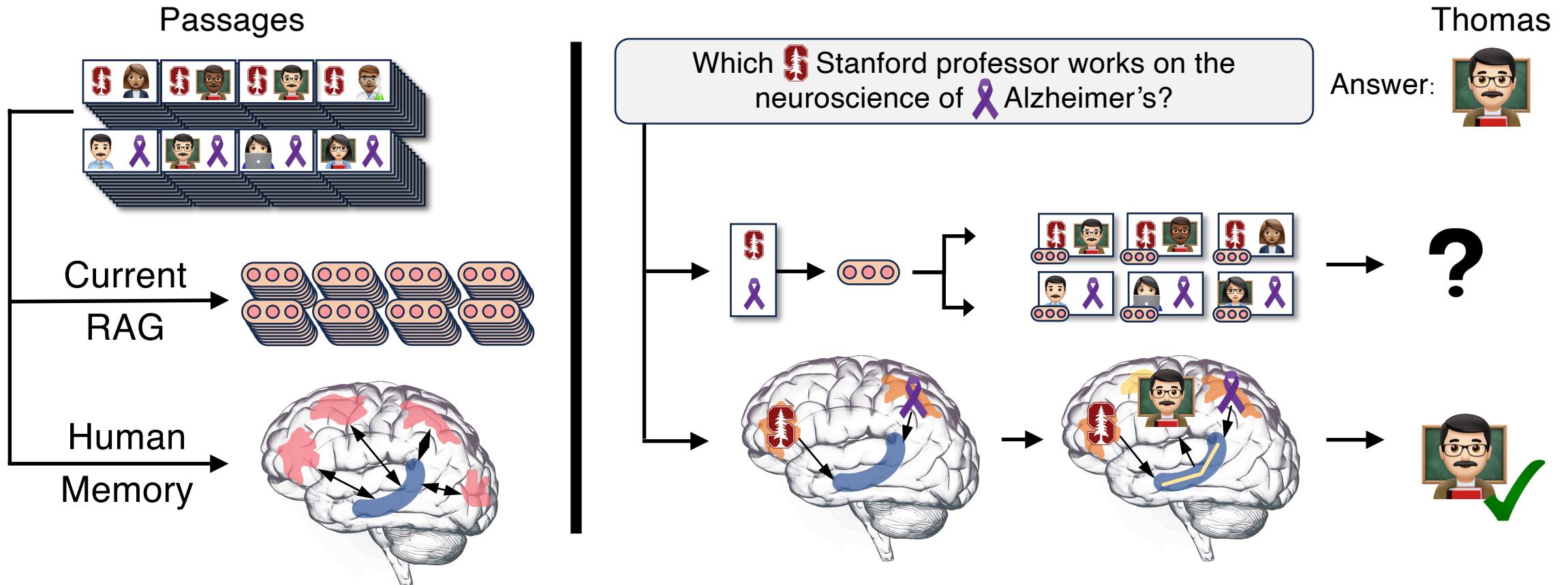
Answer:



However, RAG sometimes struggles...

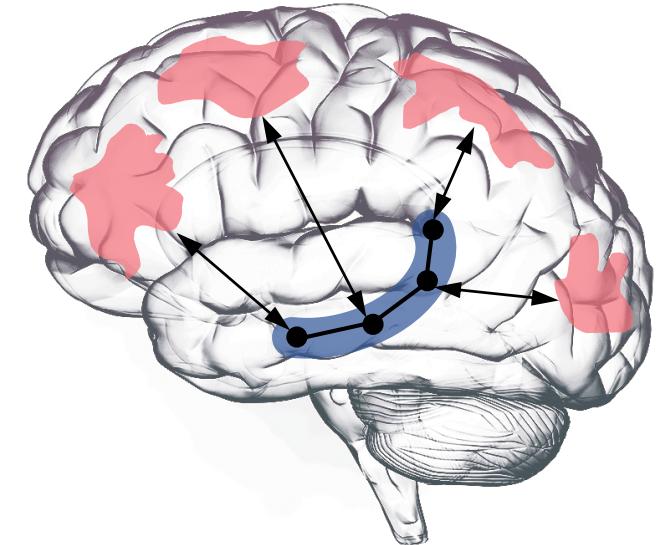


... where human memory thrives

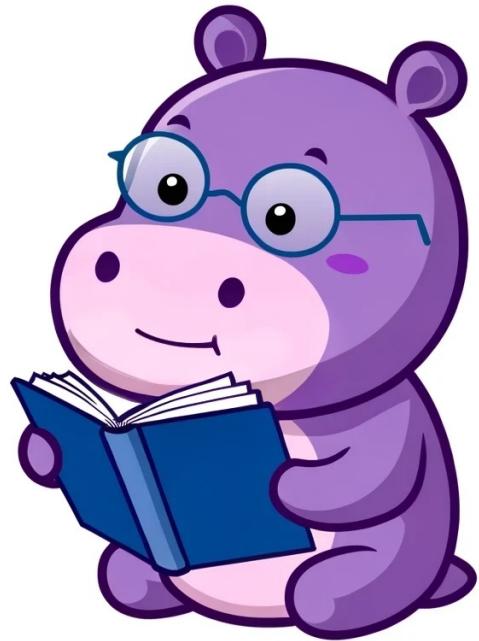


Human Long-Term Memory

- One well-established theory of human long-term memory is the **hippocampal memory indexing theory** (Teyler et al. 1986).
 - The **hippocampus (blue)** is a store for **indices** (which point to memories stored in **neocortex**) and **associations** between them.

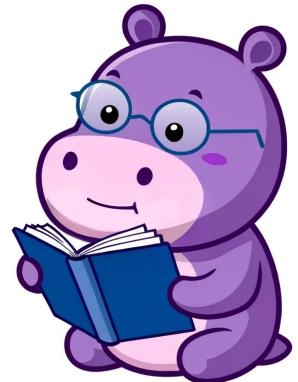


HippoRAG



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HippoRAG



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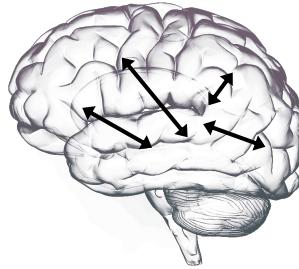


Neocortex

HippoRAG



Neocortex

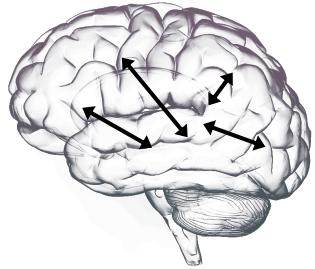


Parahippocampal Regions

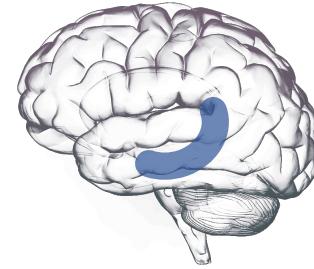
HippoRAG



Neocortex



Parahippocampal Regions

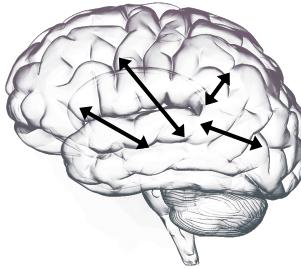


Hippocampus

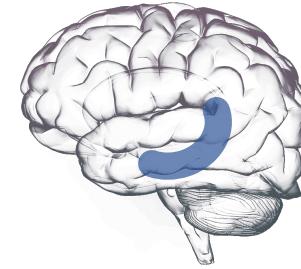
HippoRAG



Neocortex
Perception, language
& executive functions



Parahippocampal Regions



Hippocampus

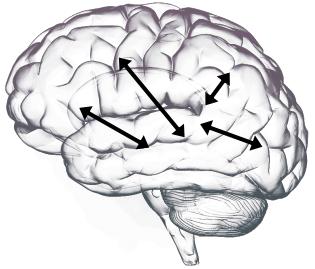
LLM



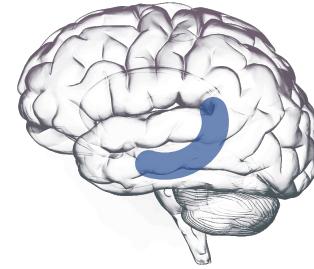
HippoRAG



Neocortex
Perception, language
& executive functions



Parahippocampal Regions
Bridge between areas;
working memory

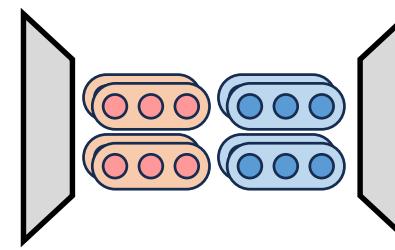


Hippocampus

LLM



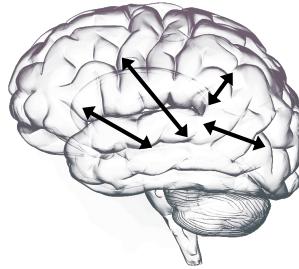
Retrieval Encoders



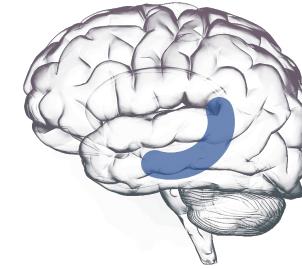
HippoRAG



Neocortex
Perception, language & executive functions



Parahippocampal Regions
Bridge between areas; working memory

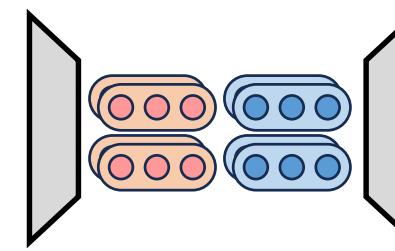


Hippocampus
Indexing & auto-associative memory

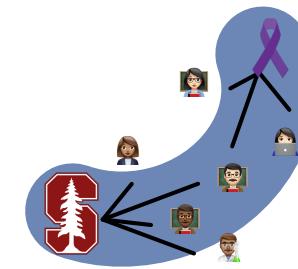
LLM



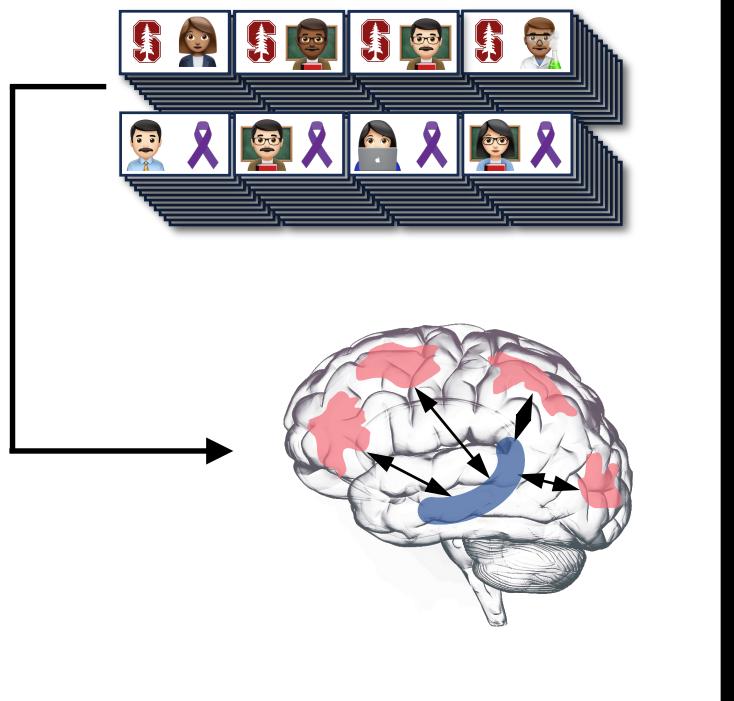
Retrieval Encoders



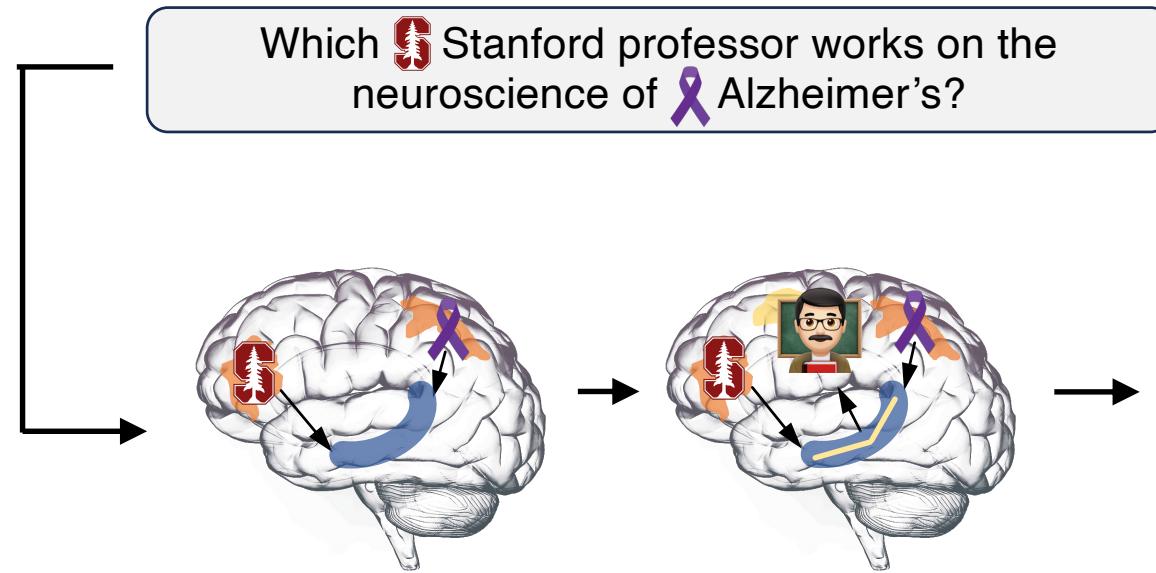
KG + Personalized PageRank



HippoRAG

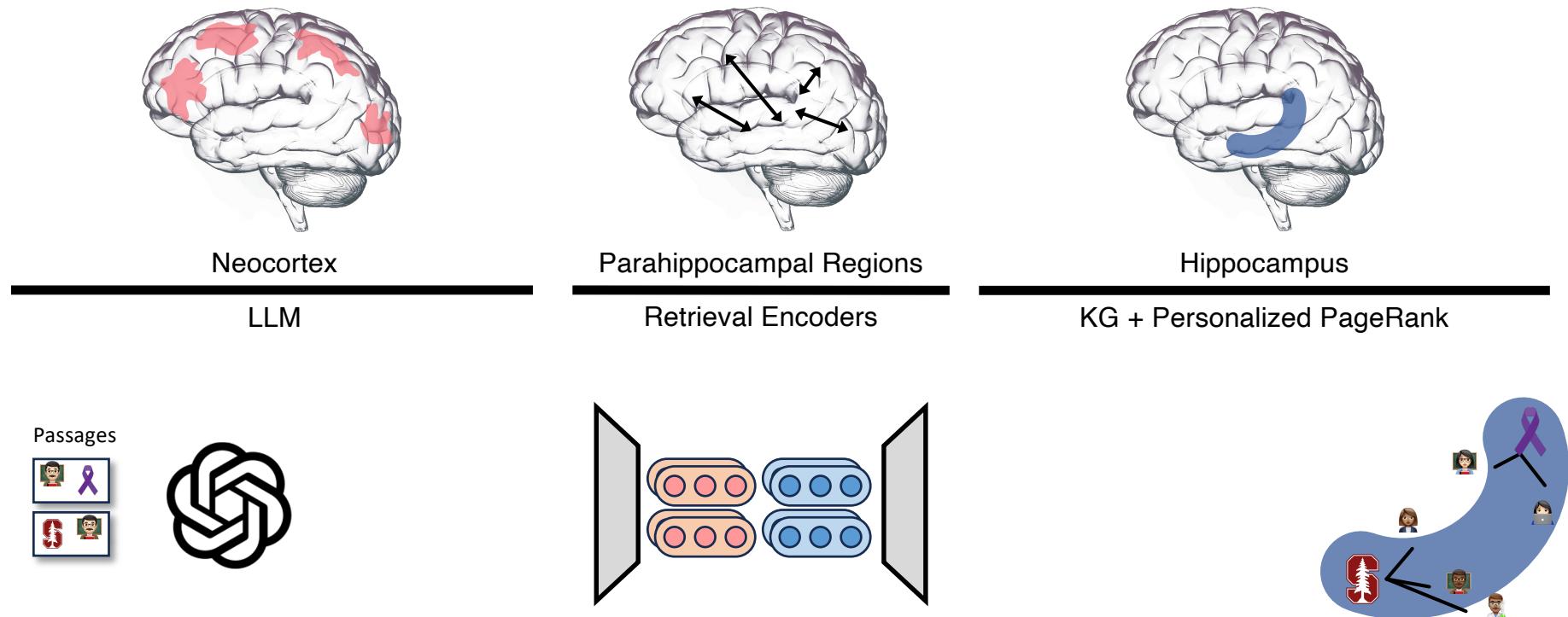


Offline Indexing

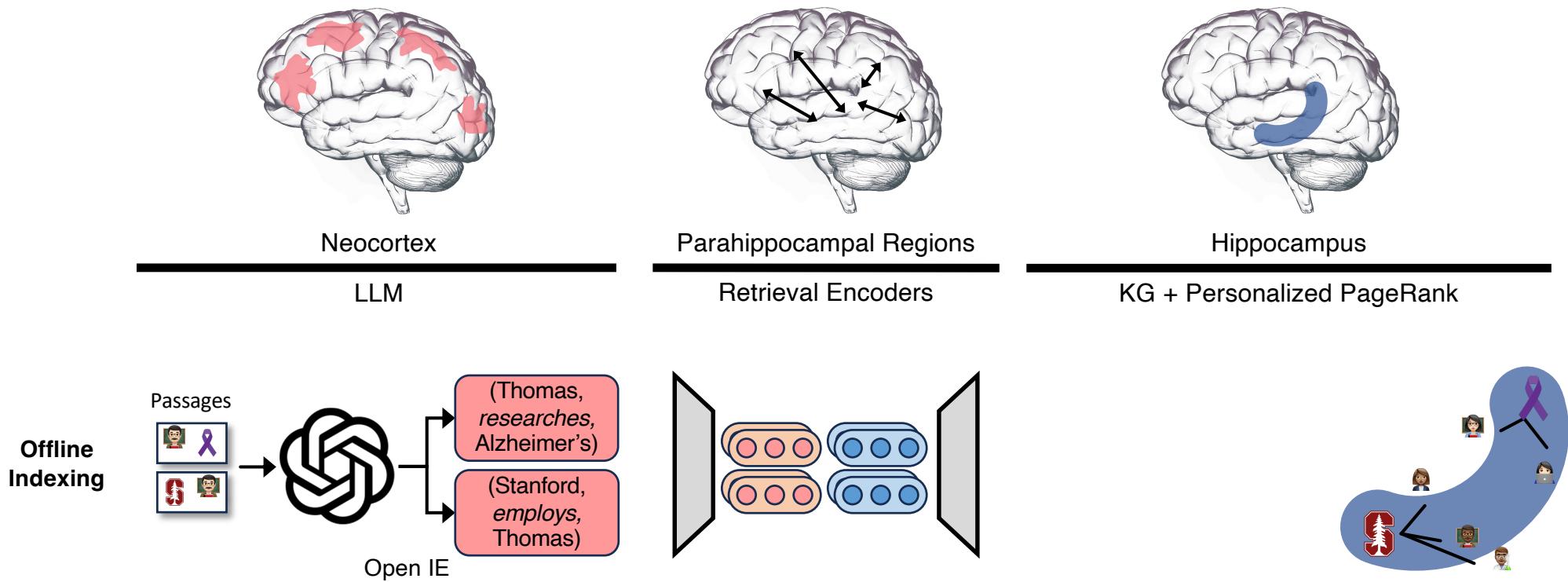


Online Retrieval

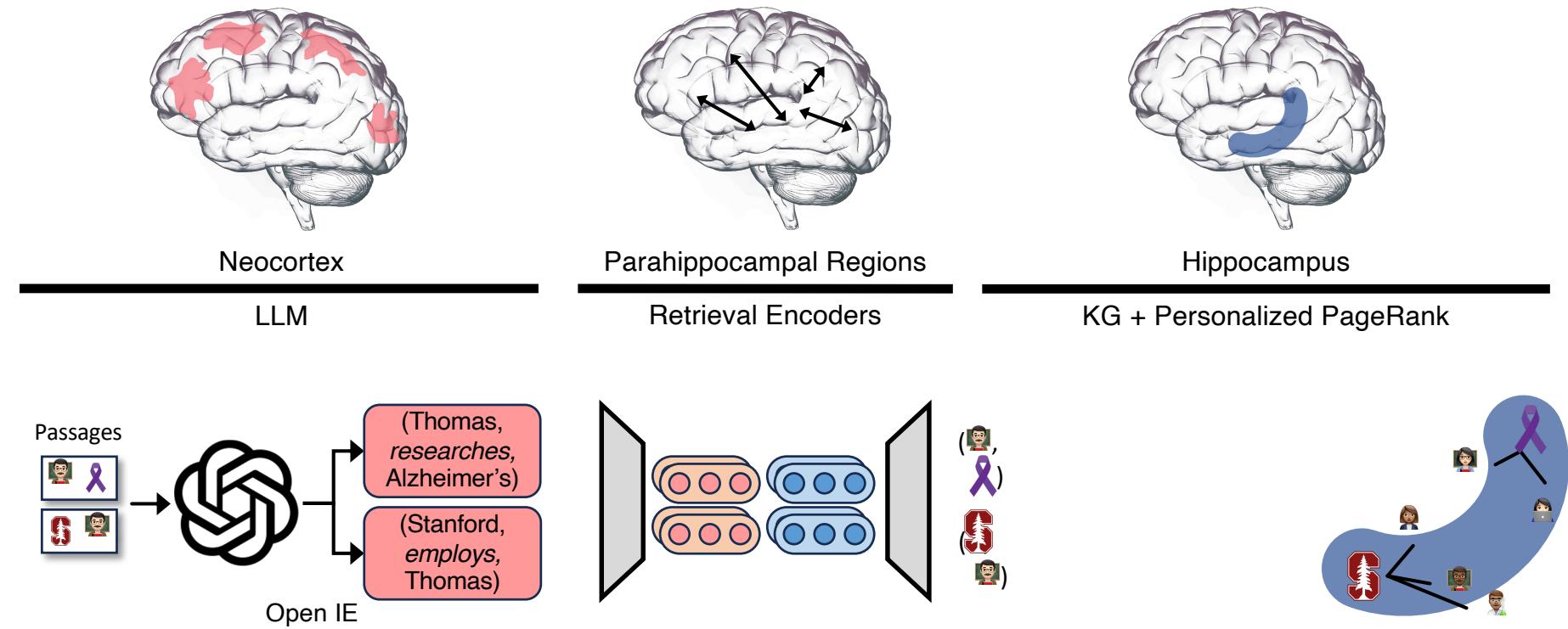
HippoRAG: Offline Indexing



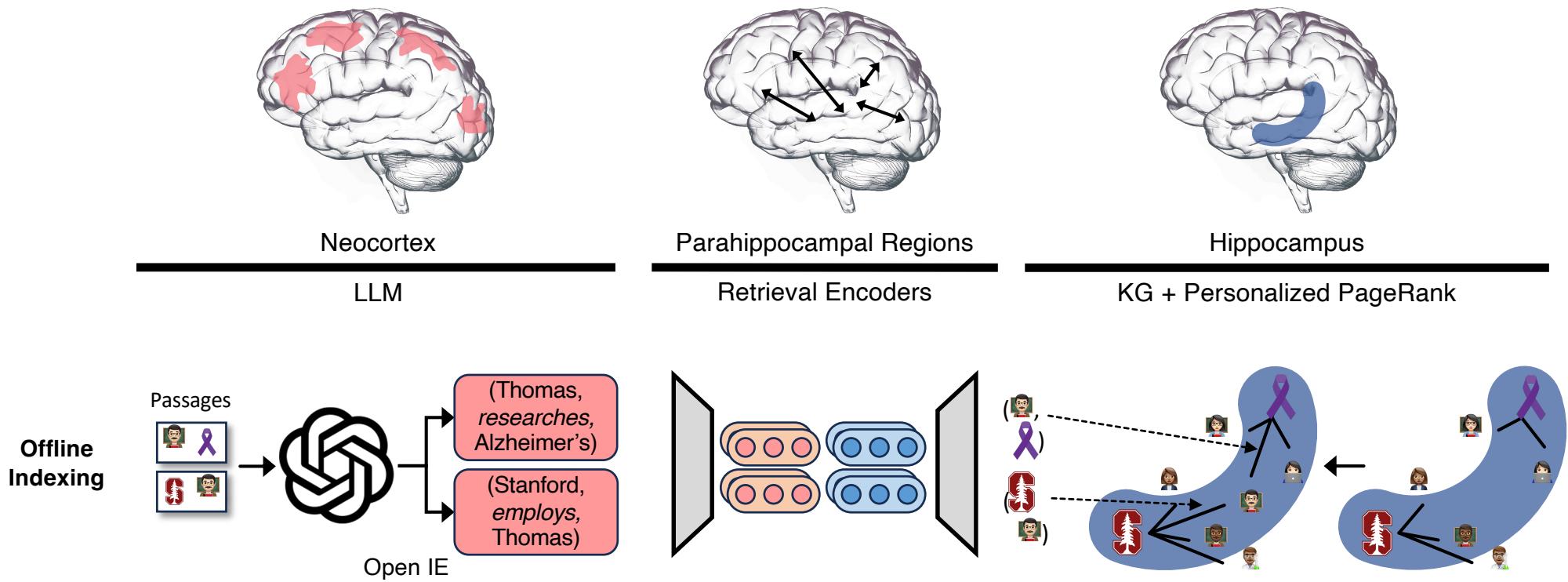
HippoRAG: Offline Indexing



HippoRAG: Offline Indexing

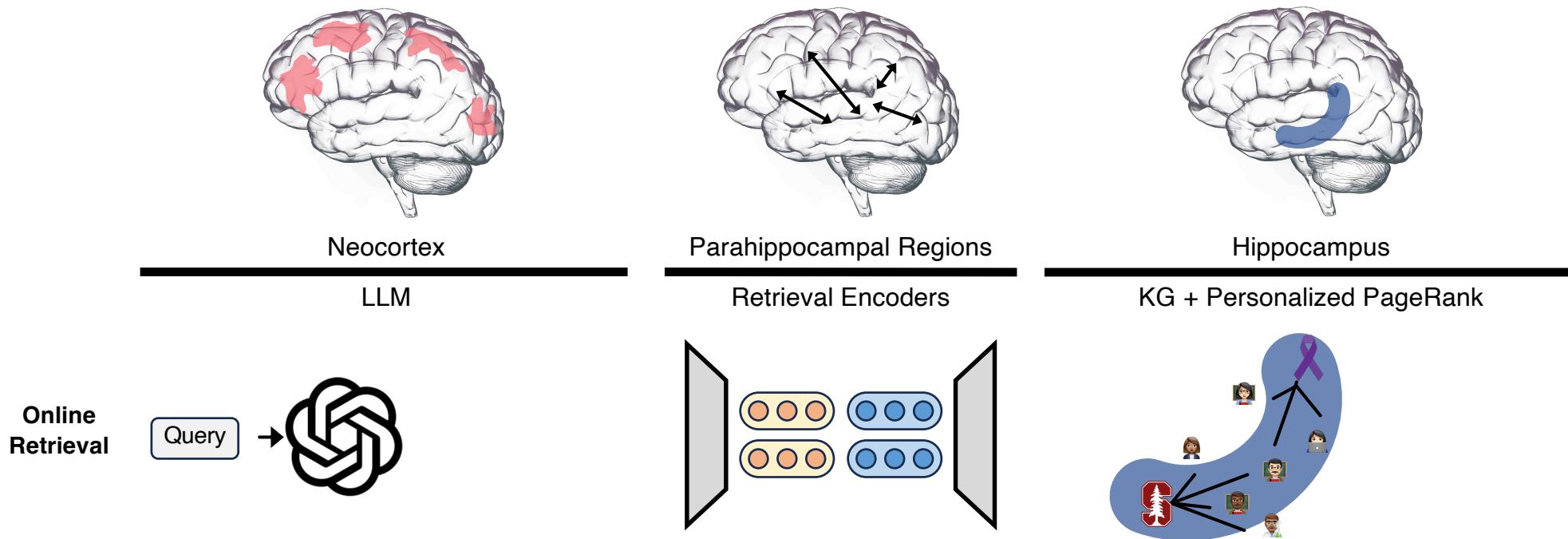


HippoRAG: Offline Indexing



HippoRAG: Online Retrieval

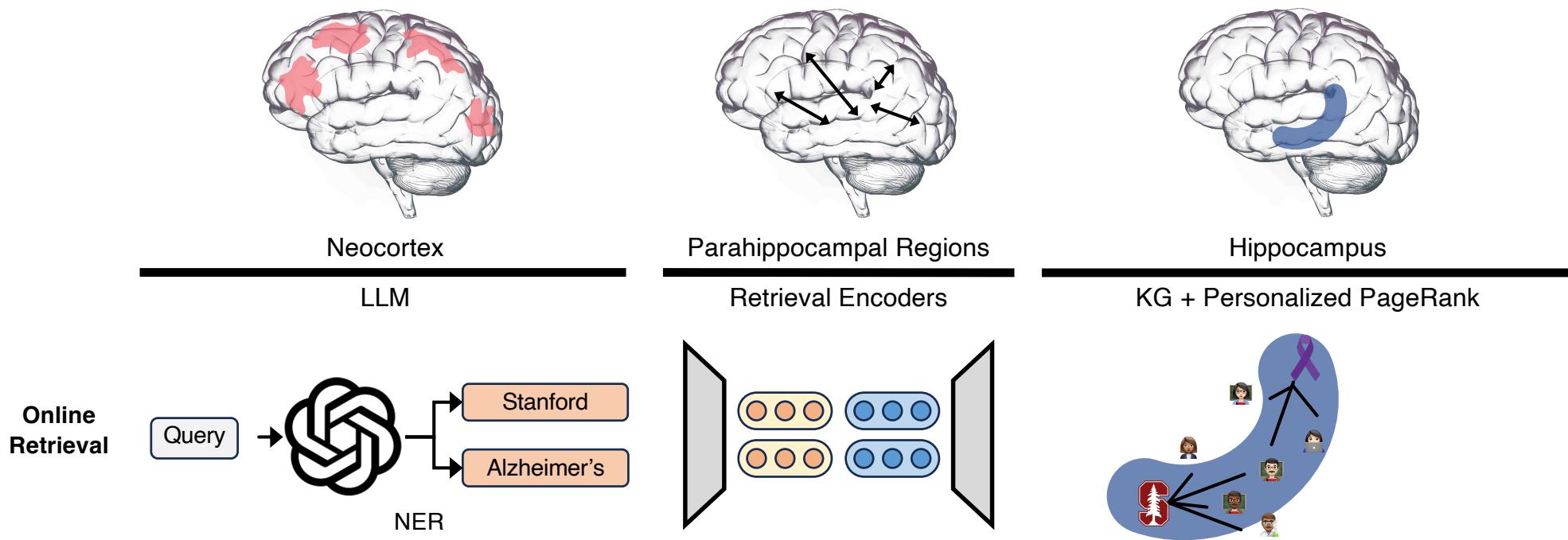
Which  Stanford professor works on the neuroscience of  Alzheimer's?



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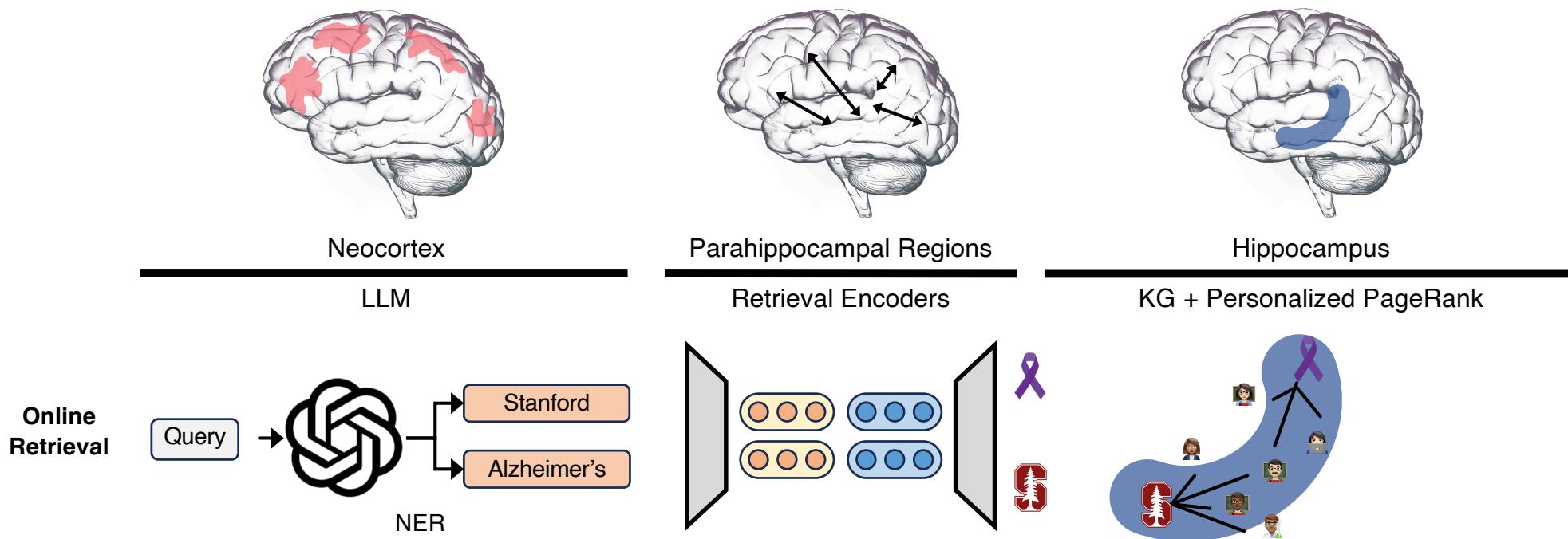
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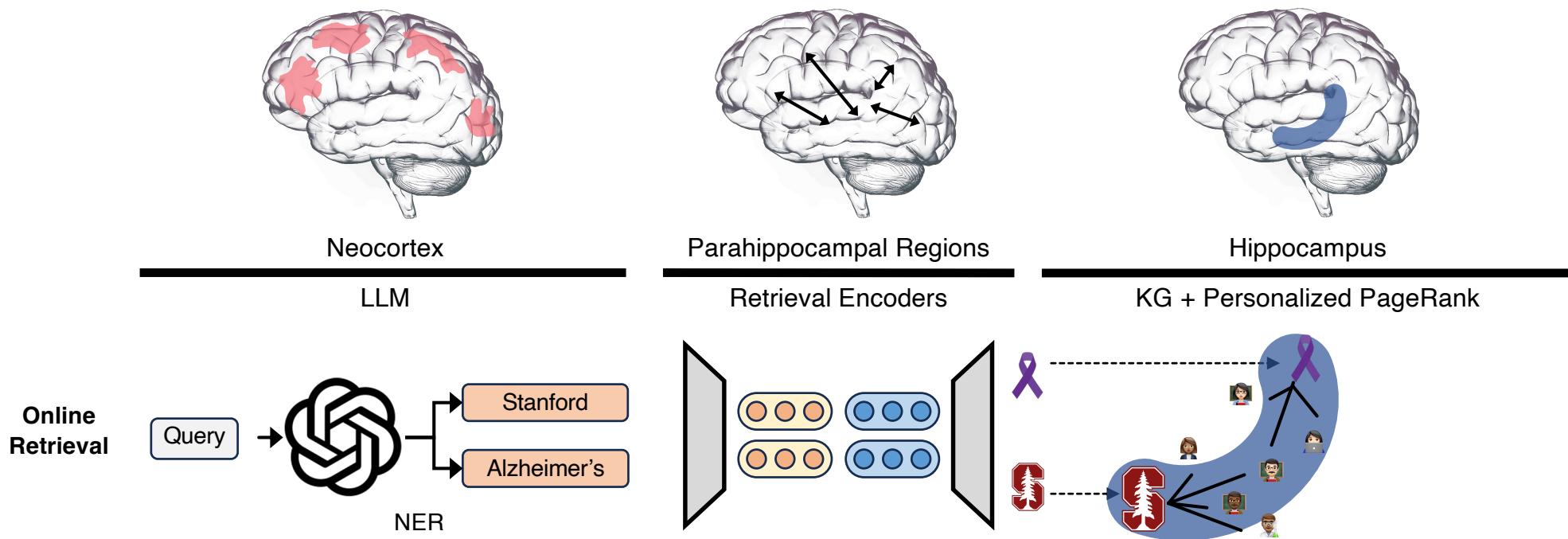
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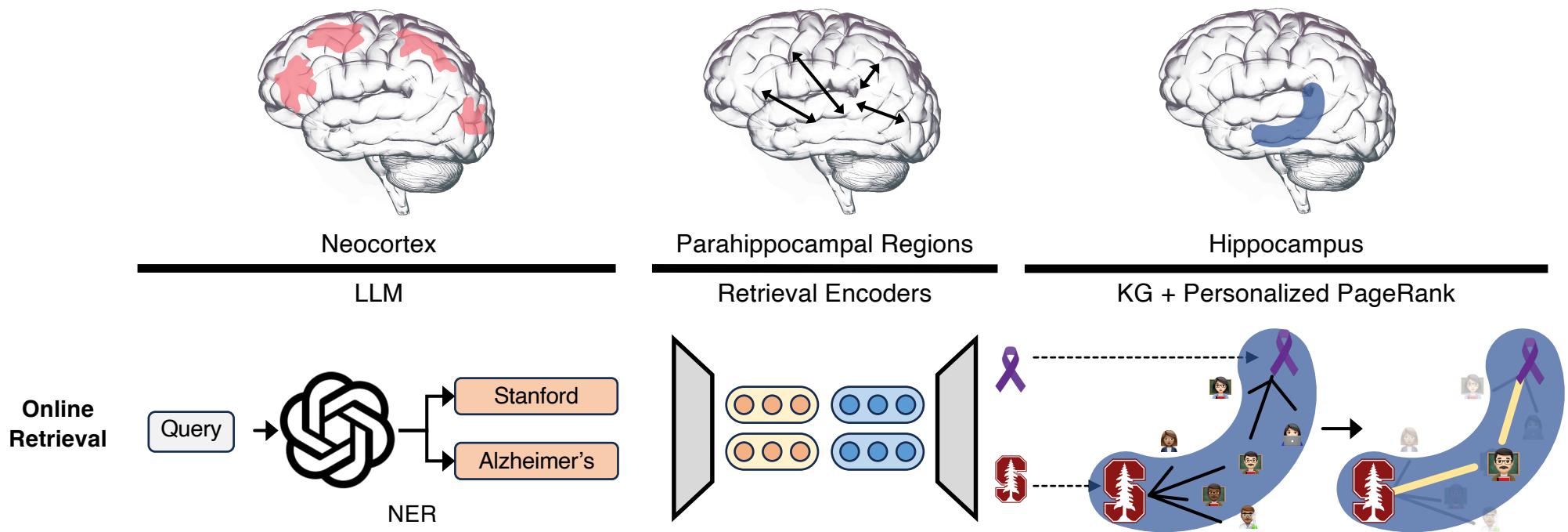
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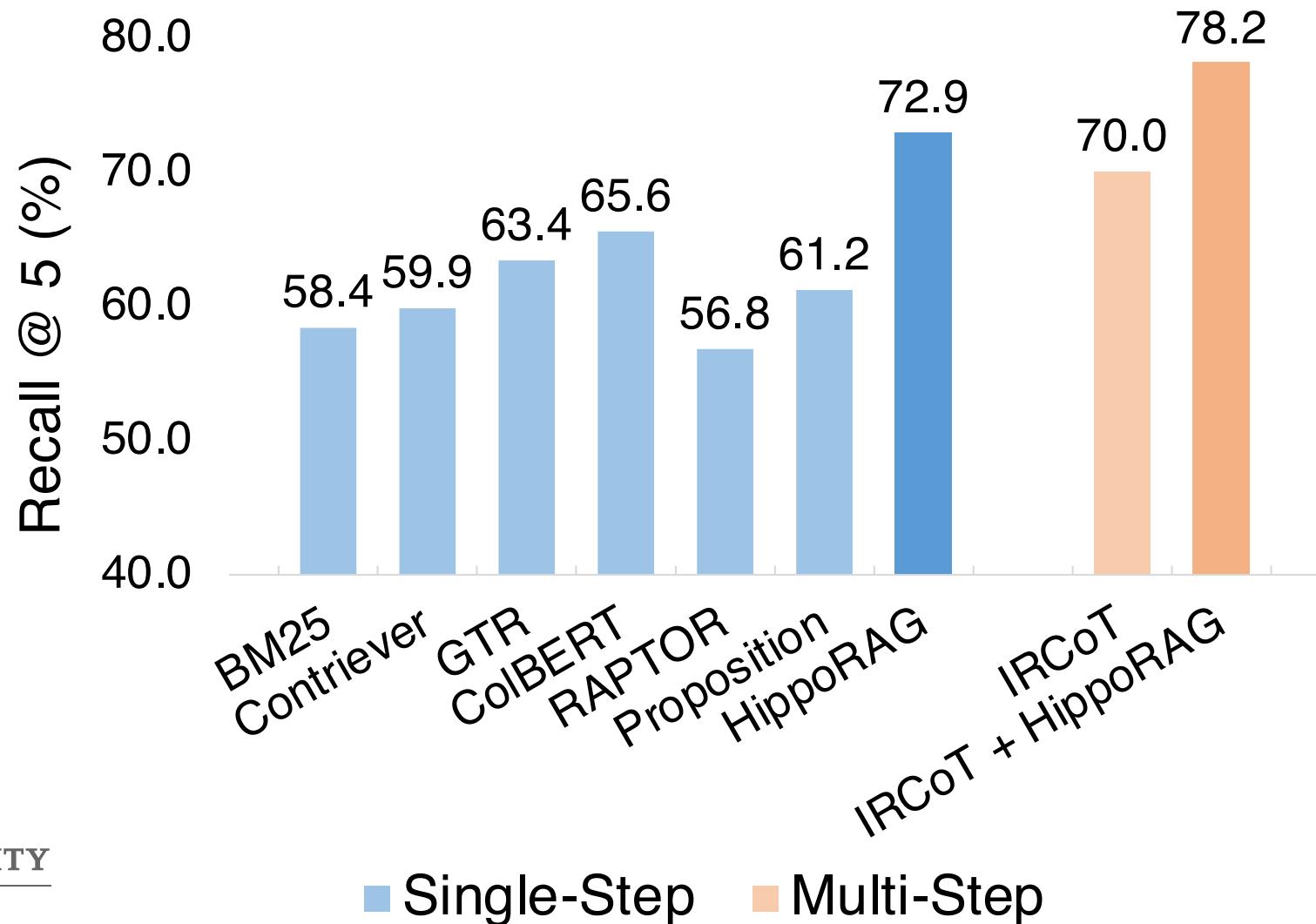
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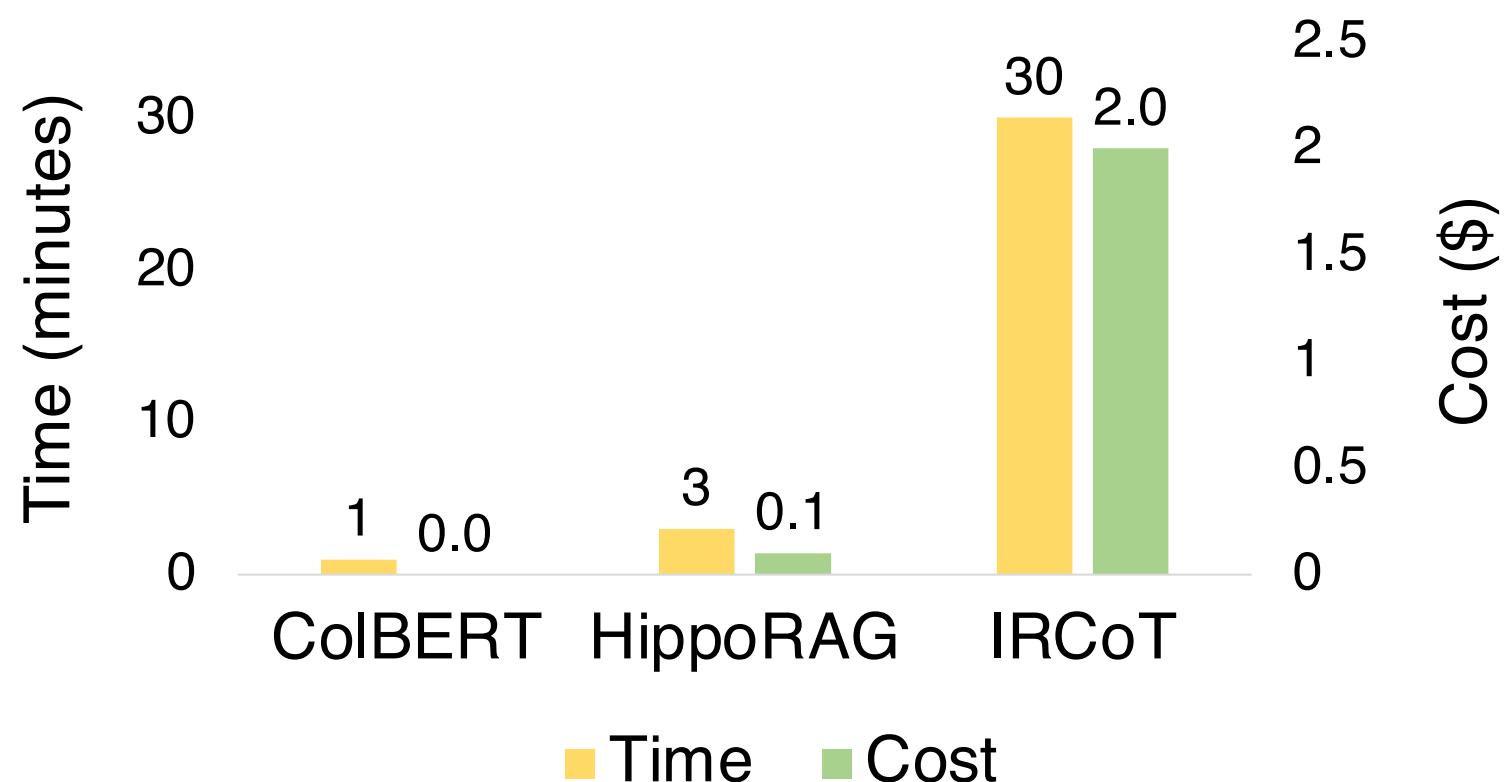
Experimental Results

- Averaged over 3 multi-hop QA datasets.
- **HippoRAG** outperforms standard RAG methods.
- Competes & is complementary with IRCoT.



Experimental Results

- On average it is 10 times cheaper and faster than IRCoT.





Thank you!



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