

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

Bernal Jiménez Gutiérrez¹, Yiheng Shu¹, Yu Gu¹, Michihiro Yasunaga², Yu Su¹

¹The Ohio State University, Department of Computer Science & Engineering,

²Stanford University, Computer Science Department

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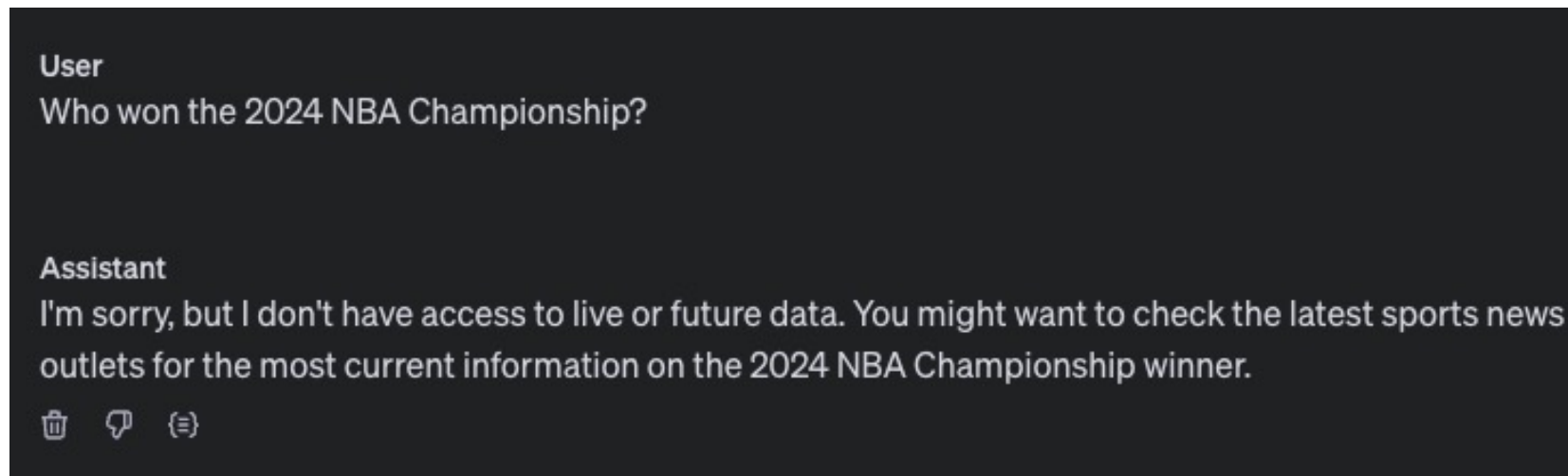


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LLM Long-Term Memory

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



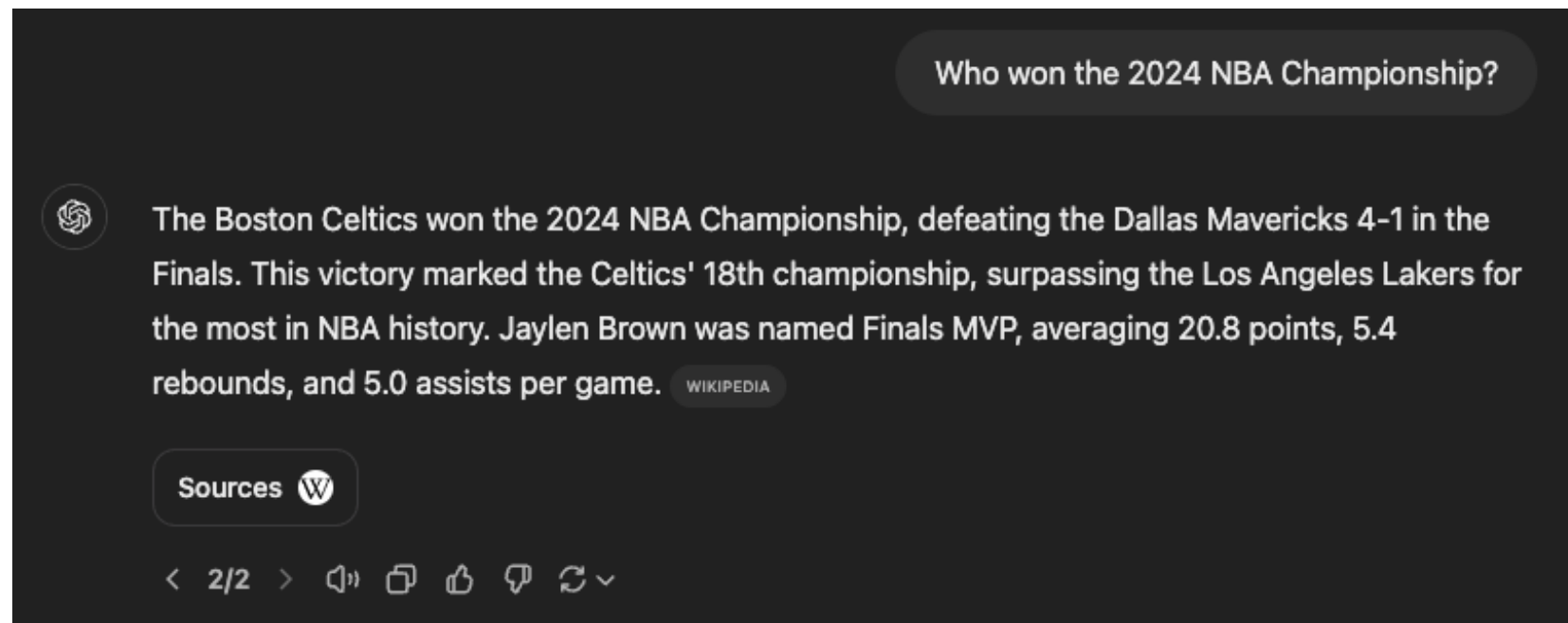
GPT-4o API



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LLM Long-Term Memory

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



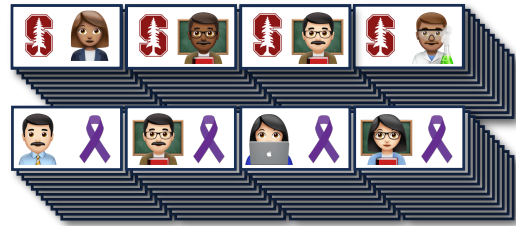
ChatGPT-4o




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However, RAG sometimes struggles...

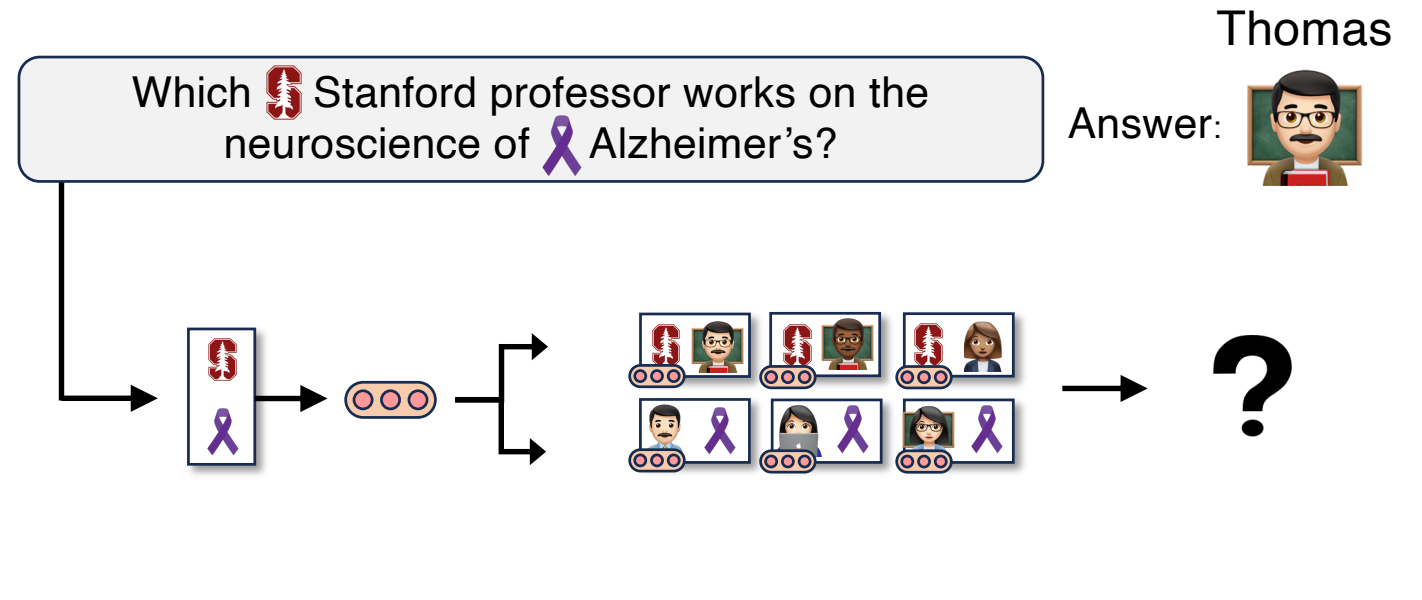
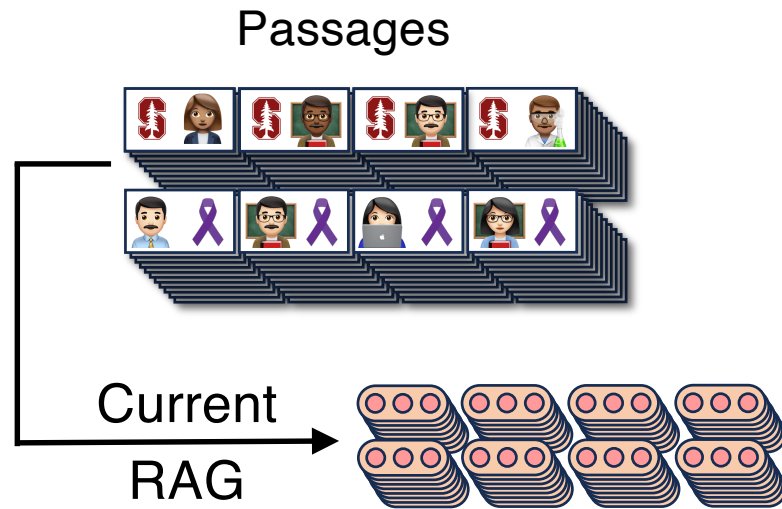
Passages



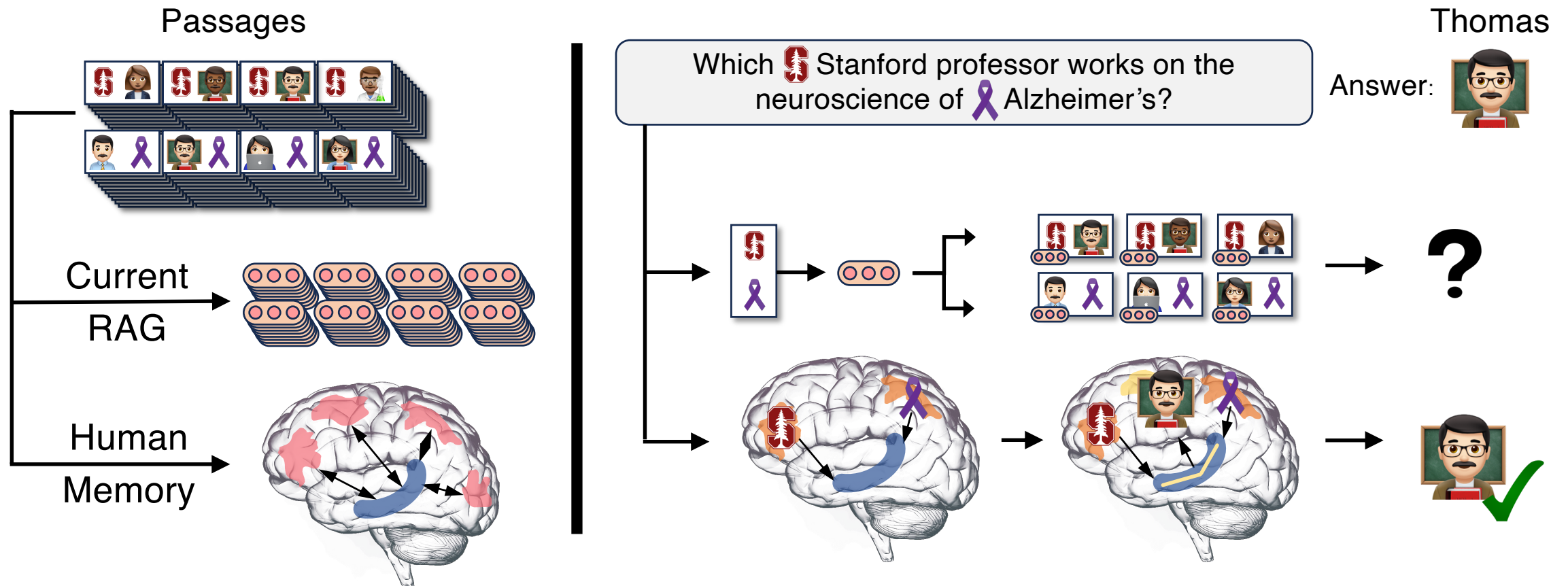
Which  Stanford professor works on the neuroscience of  Alzheimer's?

Thomas
Answer: 

However, RAG sometimes struggles...

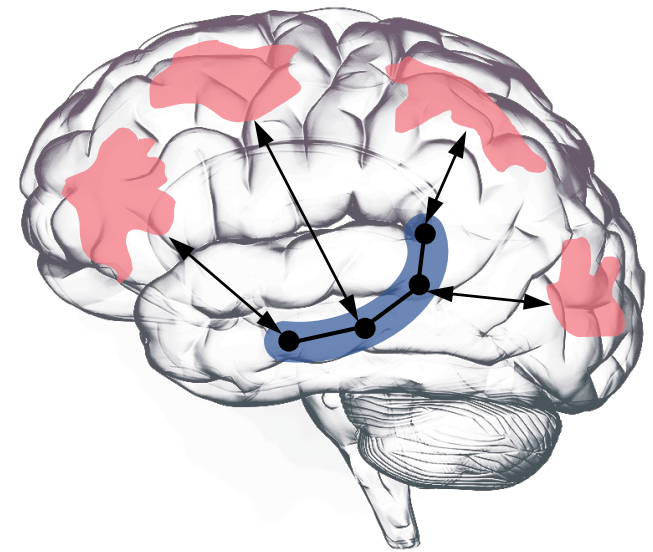


... where human memory thrives



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



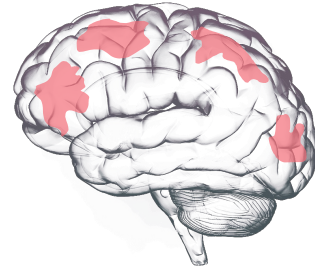
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HippoRAG



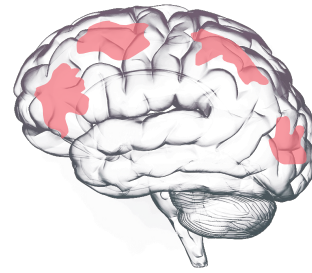
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HippoRAG

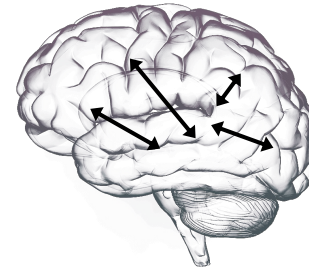


Neocortex

HippoRAG

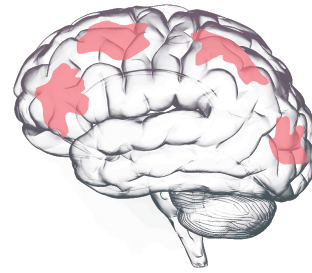


Neocortex

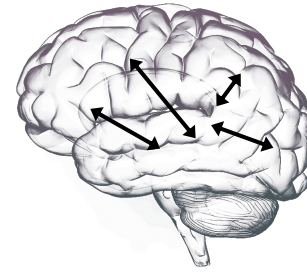


Parahippocampal Regions

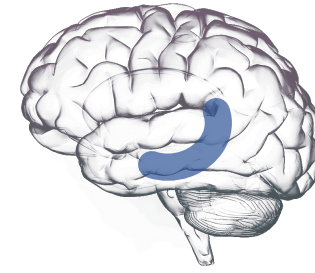
HippoRAG



Neocortex

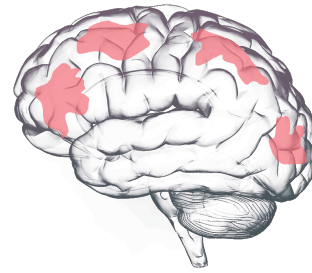


Parahippocampal Regions

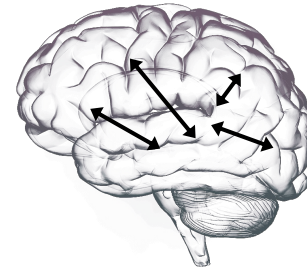


Hippocampus

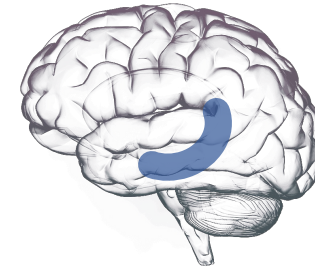
HippoRAG



Neocortex
Perception, language
& executive functions



Parahippocampal Regions

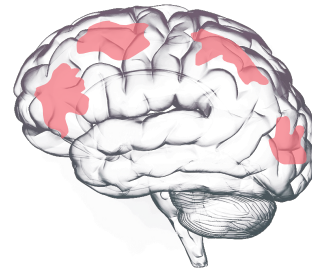


Hippocampus

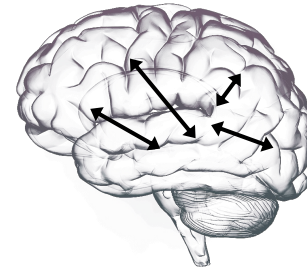
LLM



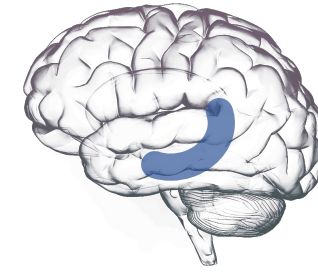
HippoRAG



Neocortex
Perception, language
& executive functions



Parahippocampal Regions
Bridge between areas;
working memory

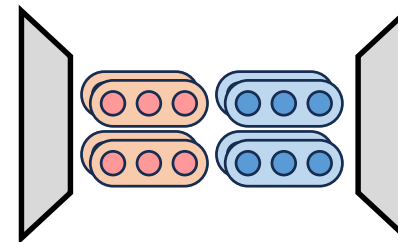


Hippocampus

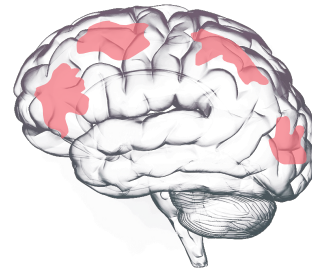
LLM



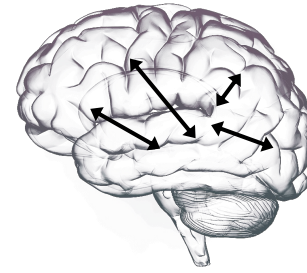
Retrieval Encoders



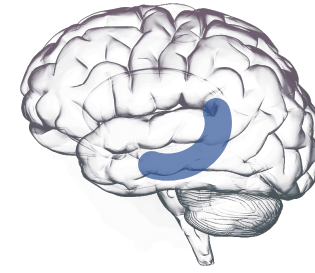
HippoRAG



Neocortex
Perception, language
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Parahippocampal Regions
Bridge between areas;
working memory

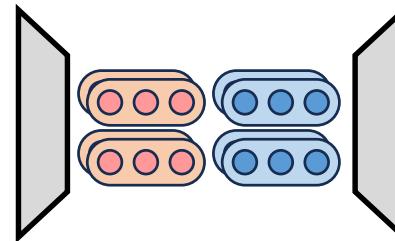


Hippocampus
Indexing & auto-
associative memory

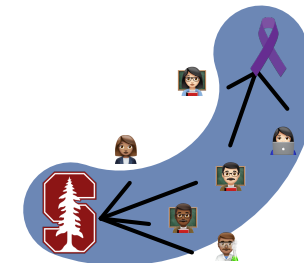
LLM



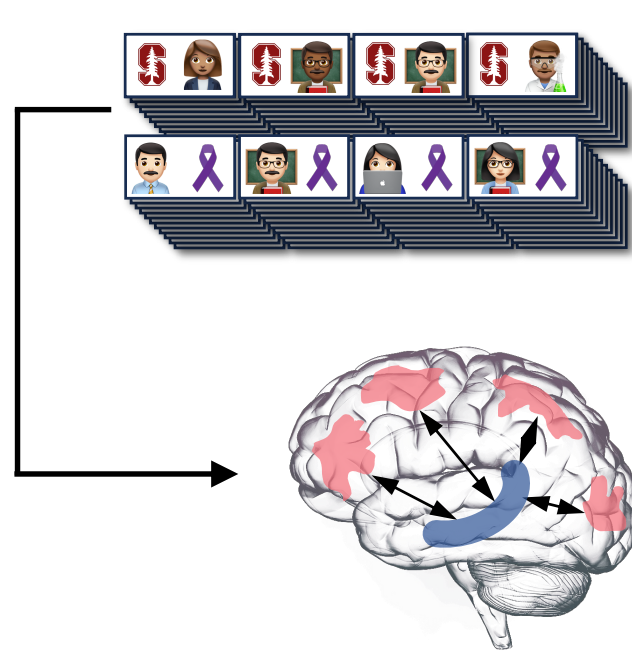
Retrieval Encoders



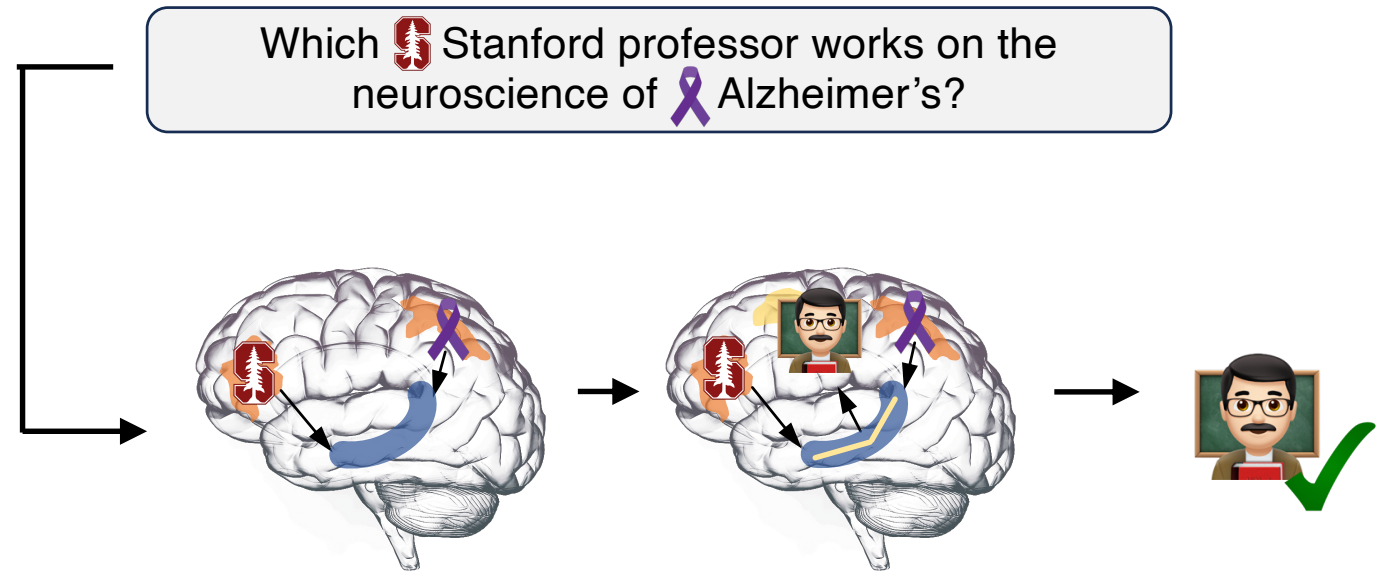
KG + Personalized PageRank



HippoRAG

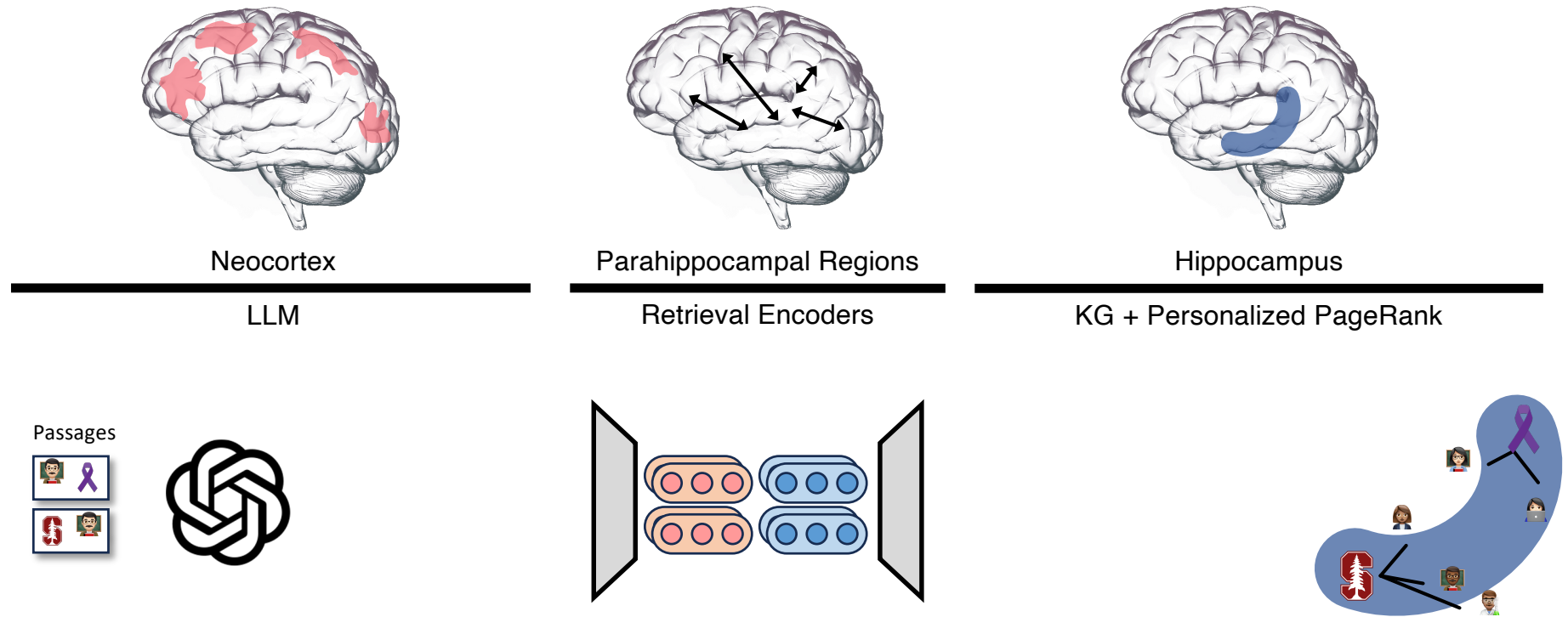


Offline Indexing

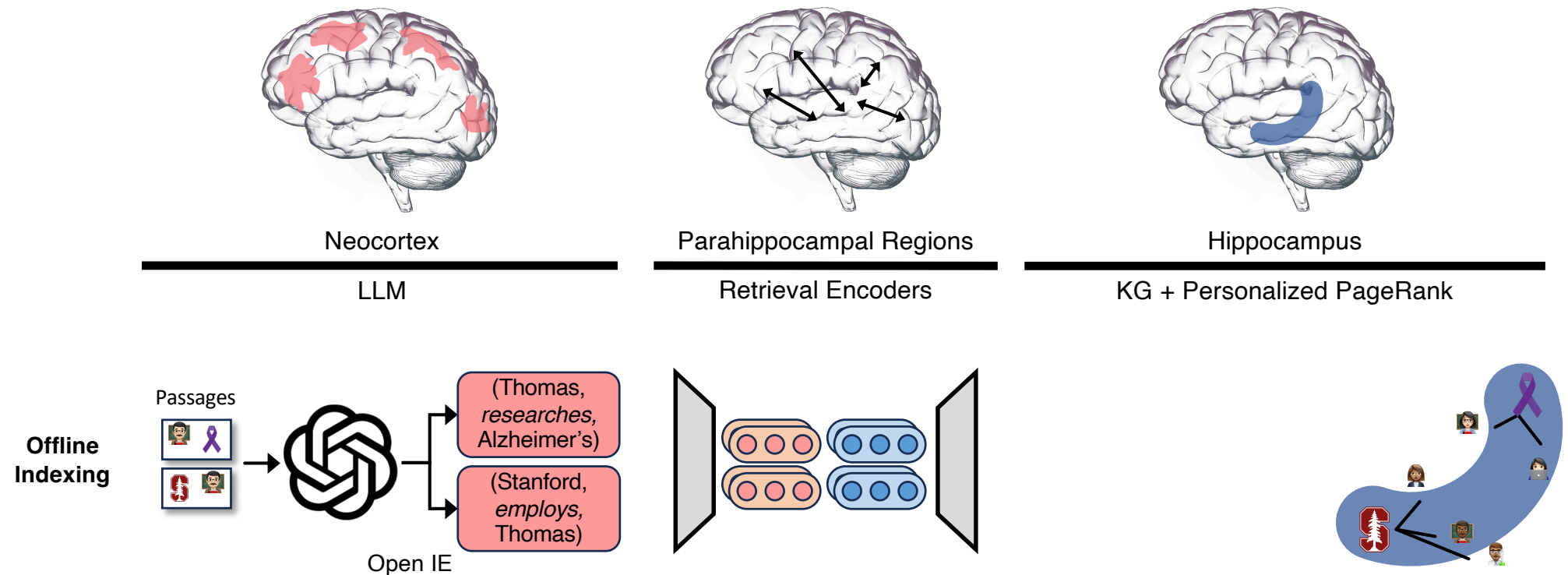


Online Retrieval

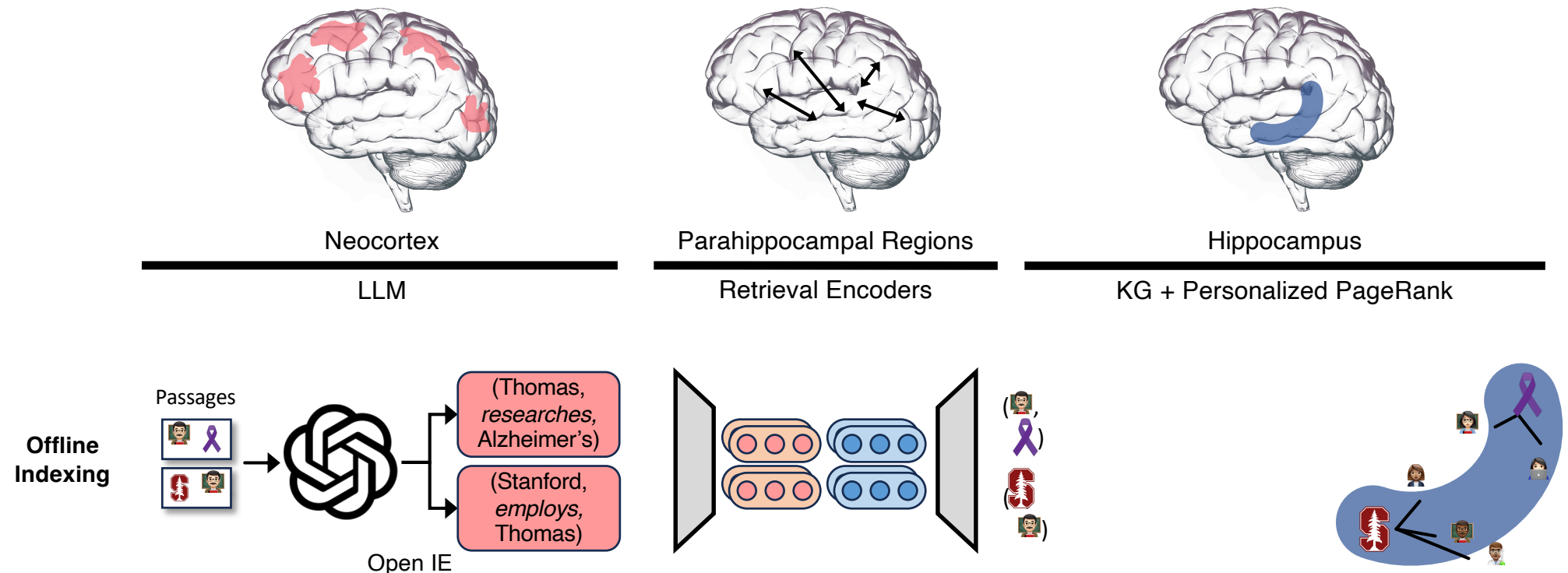
HippoRAG: Offline Indexing



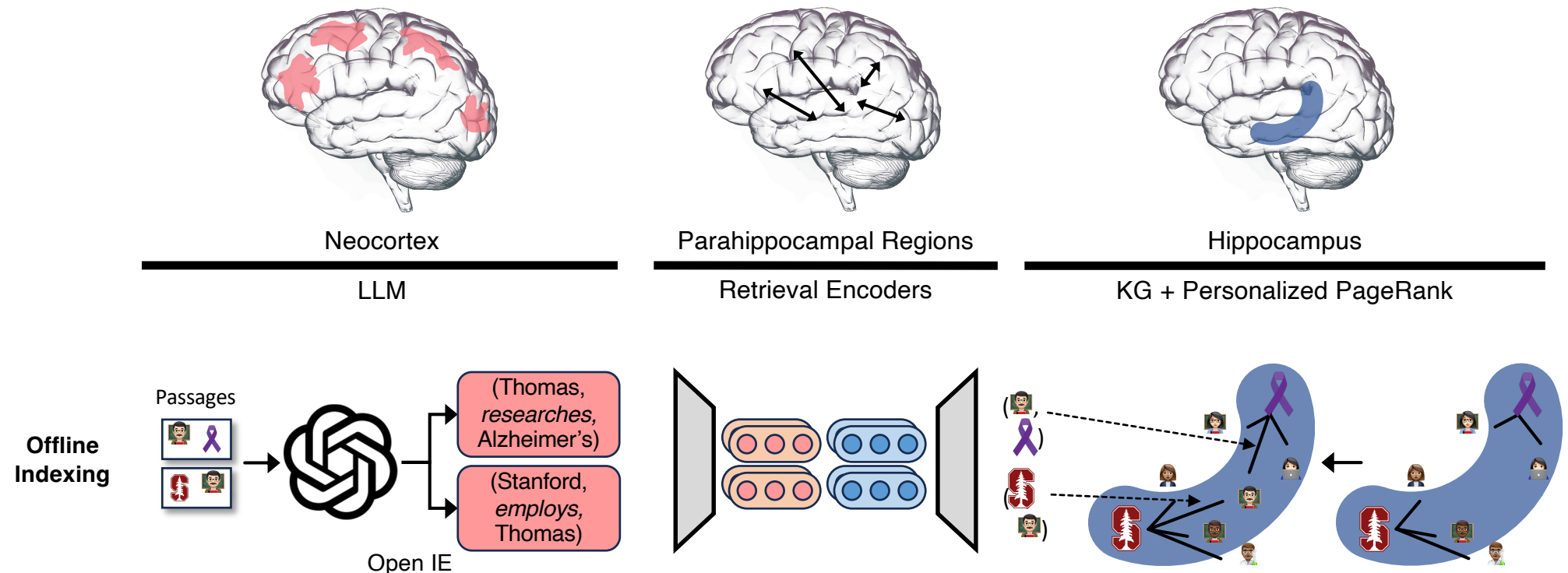
HippoRAG: Offline Indexing



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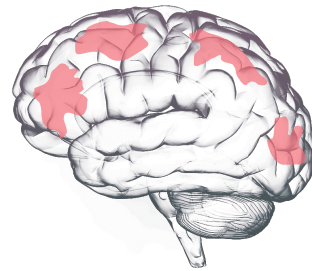


HippoRAG: Offline Indexing



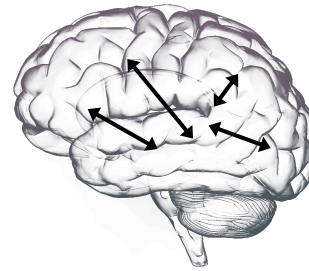
HippoRAG: Online Retrieval

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



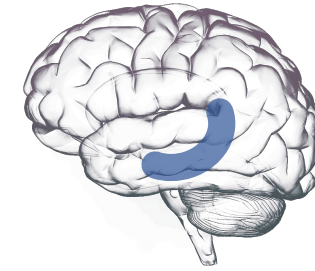
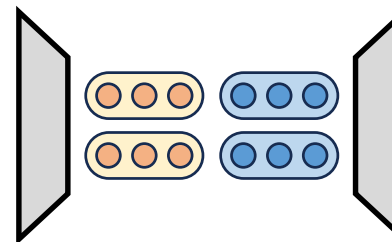
Neocortex

LLM



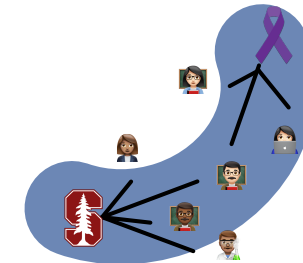
Parahippocampal Regions

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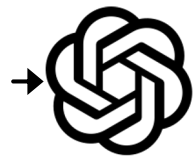
Hippocampus

KG + Personalized PageRank





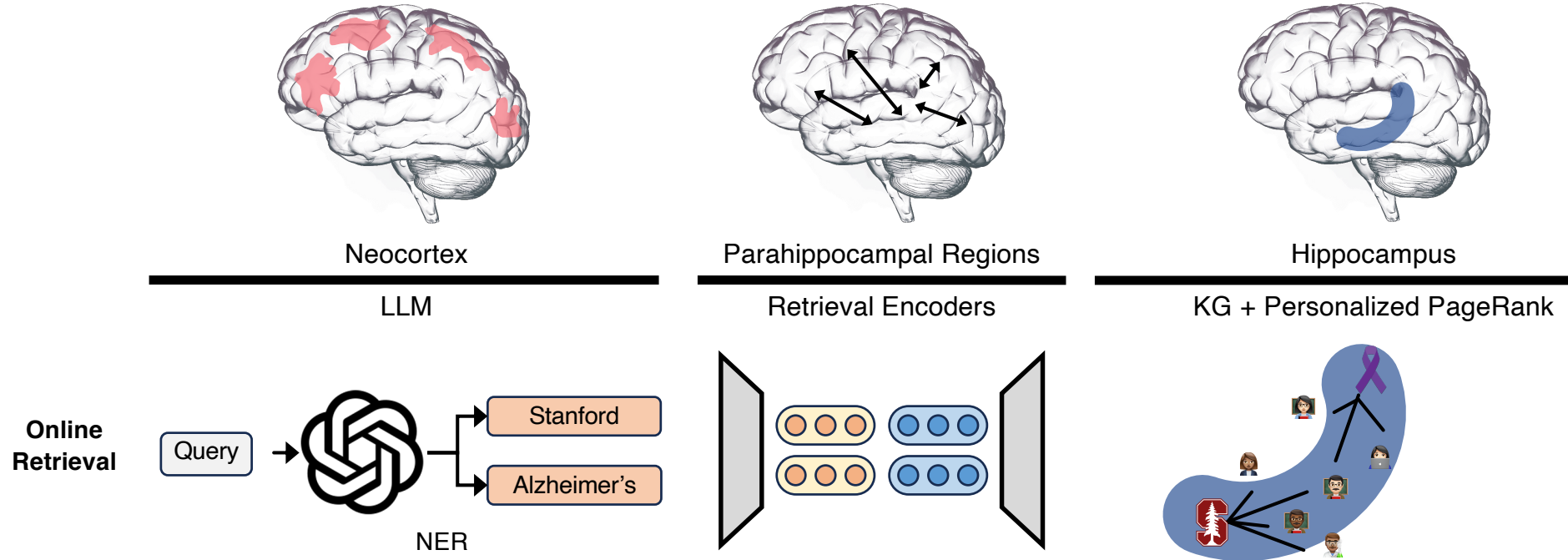
Online
Retrieval

Query



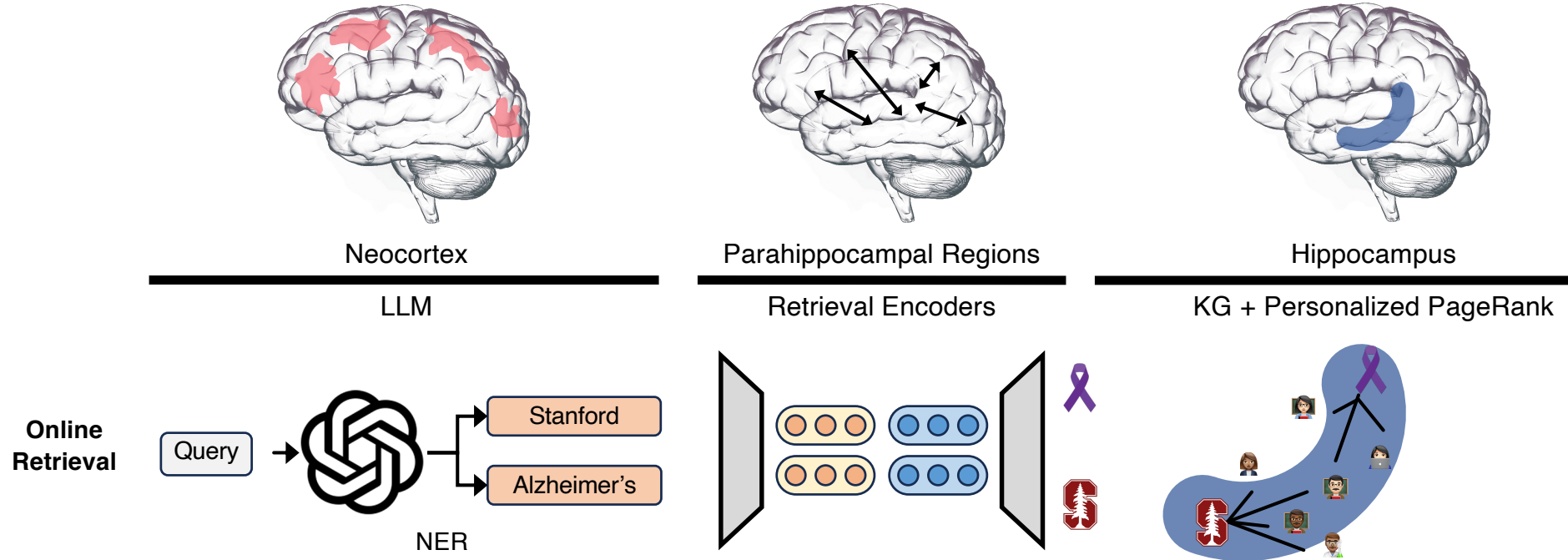
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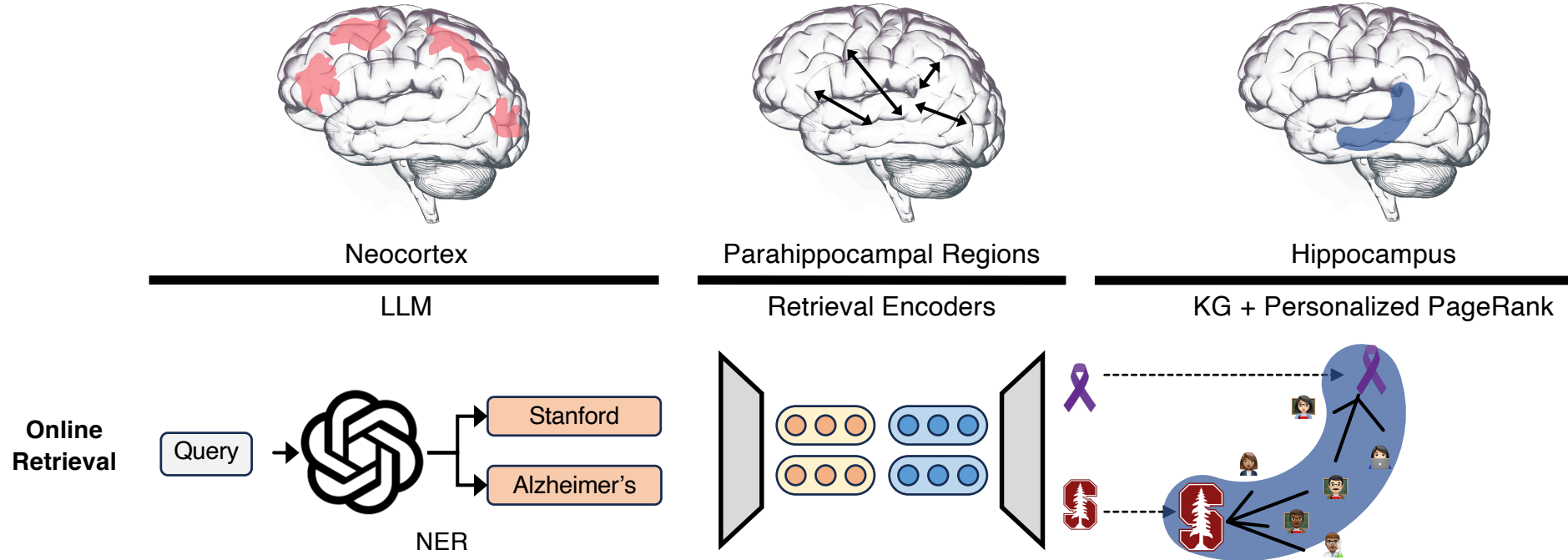
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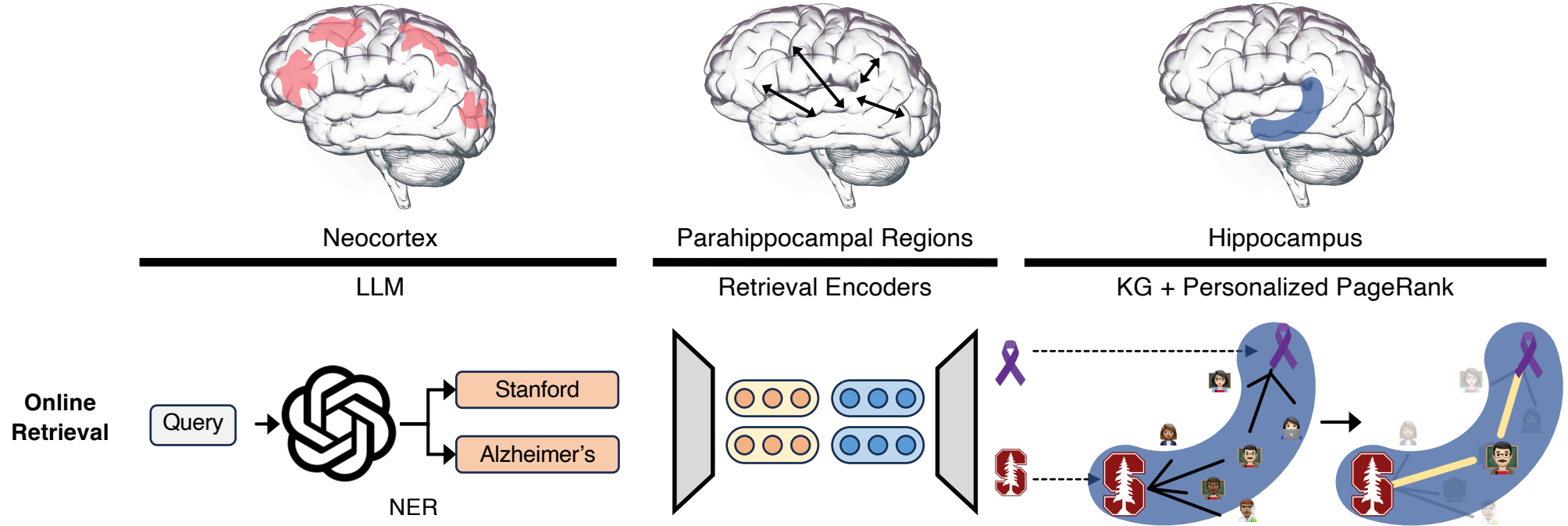
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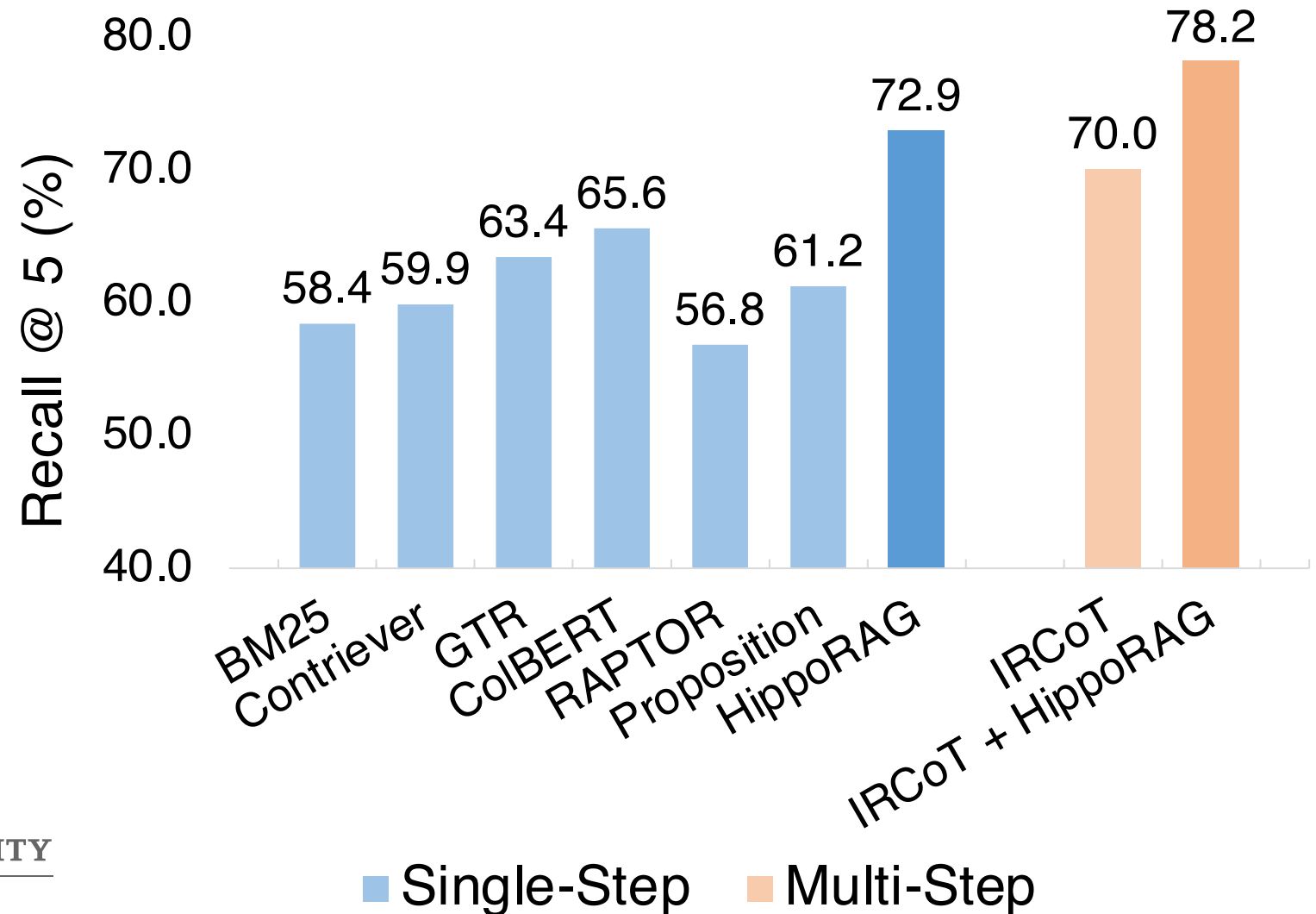
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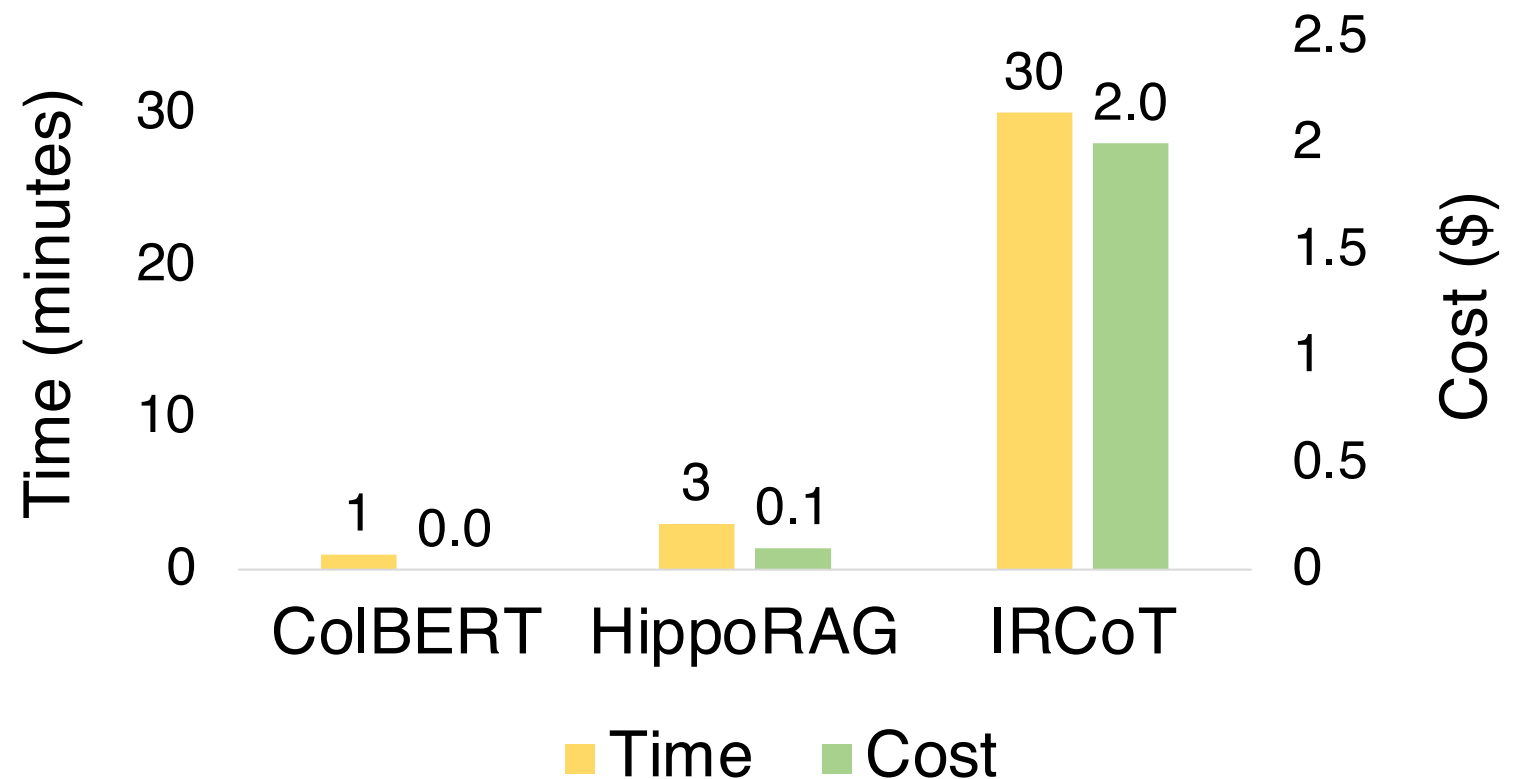
Experimental Results

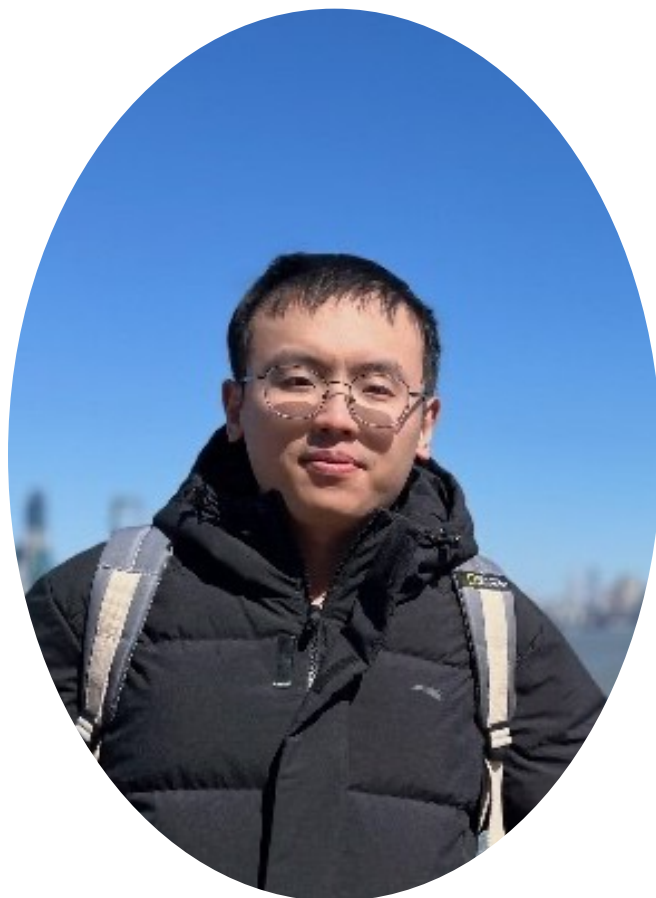
- Averaged over 3 multi-hop QA datasets.
- **HippoRAG** outperforms standard RAG methods.
- Competes & is complementary with IRCoT.



Experimental Results

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





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Thank you!