Exploring Models of Feeling of Knowing in Memory Retrieval

Occidental College SRP Conference 2020
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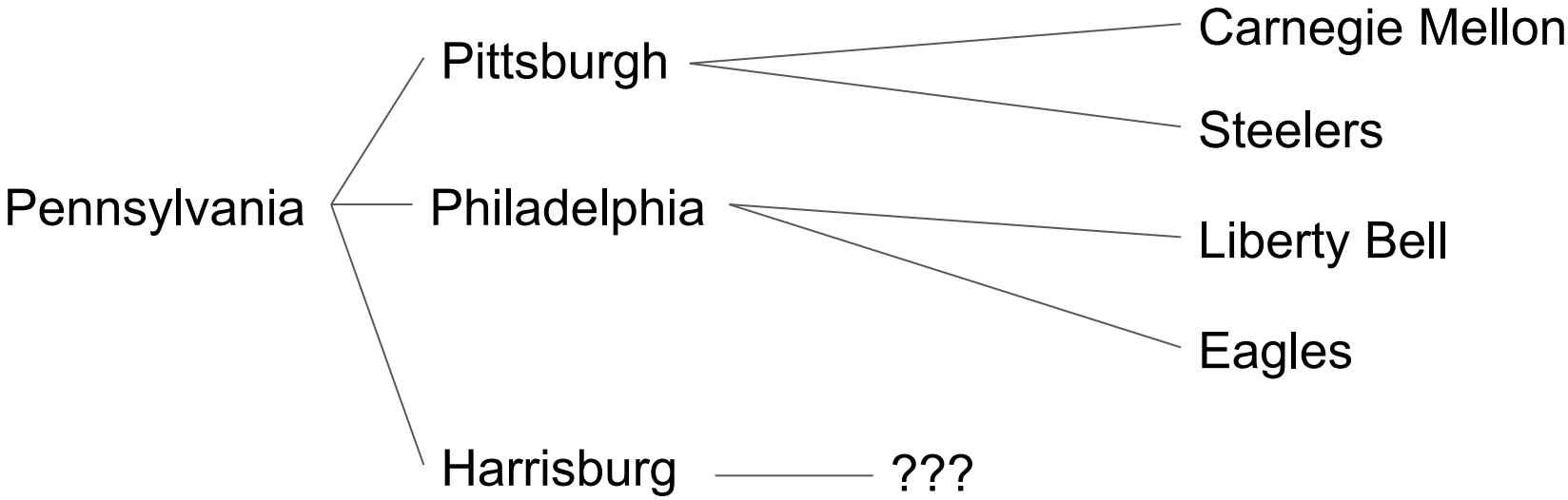
What is the capital of Pennsylvania?

- Philadelphia? Pittsburgh?
  - Neither! It is actually Harrisburg.
- More knowledge about these two big cities in Pennsylvania



What happened here?

Feeling of knowing- when one is aware of the likelihood that they know a piece of information

- Higher feeling of knowing = you are pretty sure you know something
- High feeling of knowing when answering Pennsylvania question
- If you kept guessing different cities without getting it right, FOK would decrease

I wanted to model this in order to learn more about what factors into FOK.

Overview: Why Cognitive Modeling?

Research Question:

How does feeling of knowing change throughout a memory search?

Research Goals:

- Construct a simplified model of the mind’s memory system
- Model FOK judgments and implement these possible calculations in code
- Compare results to human thought processes

Importance of this research:

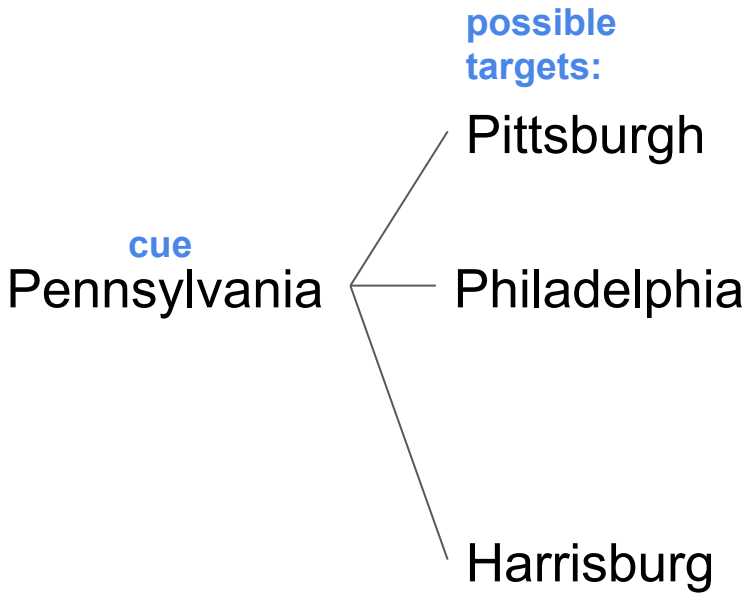
- Exactly how to calculate FOK is undetermined
- Once well understood, can be applied to AI

Memory Retrieval

- Memory retrieval
  - Recalling information
  - Ex. Thinking of an answer to my question

- Cue & Target
  - Cue: The information you start with
  - Target: The information you recall

Memory Retrieval: What is the capital of Pennsylvania?



Metamemory and Feeling of Knowing

- Metamemory/ Metamemory Judgements
  - Judgements made using the awareness of one's own memory
  - Ex. What is my knowledge of Pennsylvania?

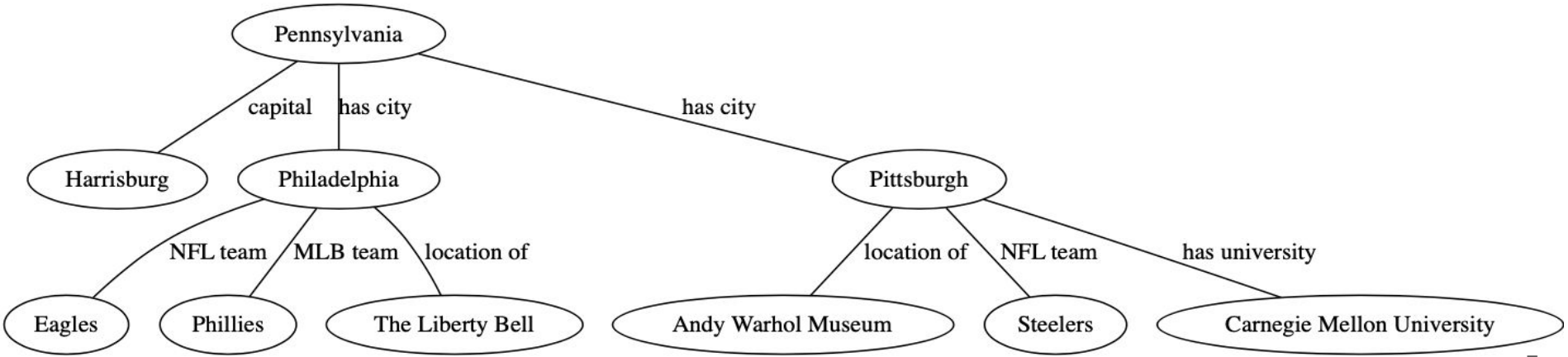
- Feeling of knowing (FOK)
  - A metamemory judgement that determines whether a piece of information is known
  - Ex. How likely is it that I have an answer to this question?

Computer Science: Metamemory and FOK

Memory: Graph with nodes and edges; a knowledge base

Memory retrieval: Queries

FOK: Do I think this node is in the graph?



Overview of Methods

- Created 5 feeling of knowing algorithms and tested them on a series of memory retrieval tasks

1. Absolute Activation
2. Relative Activation
3. Relative Edges
4. Relative Activation over Edges
5. Competition

Related Work & Hypotheses

Existing hypotheses for calculating feeling of knowing:

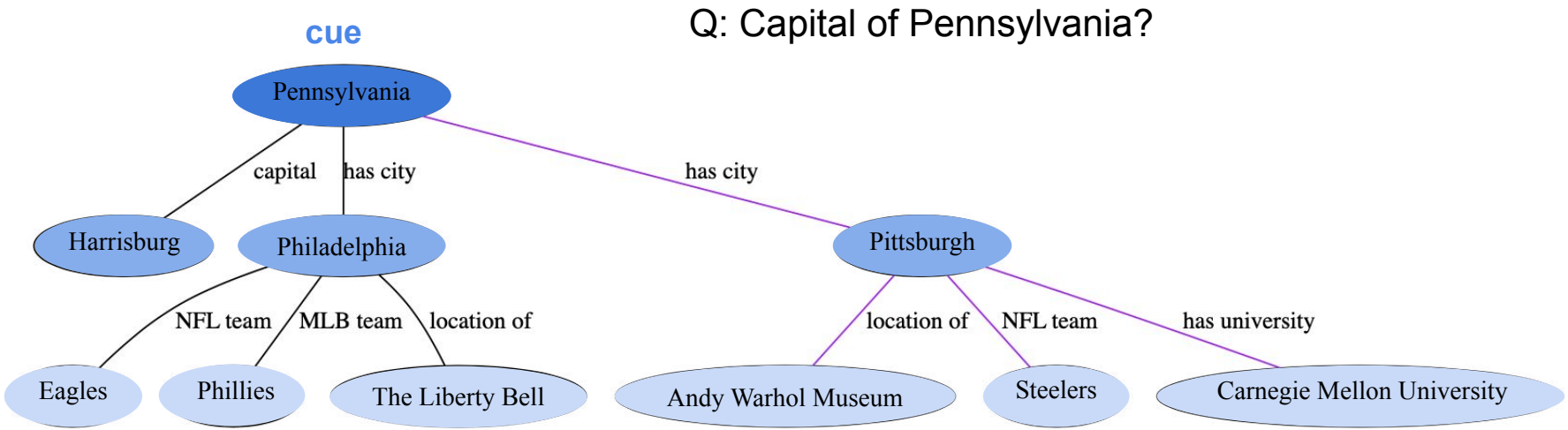
- Cue familiarity: How much is known about the subject (Reder & Ritter, 1992)
- Accessibility/ Activation: How frequently and recently information was recalled (Koriat, 1993)
- Competition: How many distractions are there while finding information (Schreiber & Nelson, 1998)
- Some combination of these or other factors (Koriat & Levy-Sadot, 2001; Leibert & Nelson, 1998)

Accessibility

- Frequency & Recency
  - Frequency: how many times a piece of information has been recalled
  - Recency: how recently a piece of information was recalled
  - Ex. How many times have I thought about cities in Pennsylvania? When was the last time I thought about this?
- Accessibility
  - How frequently and recently information was recalled

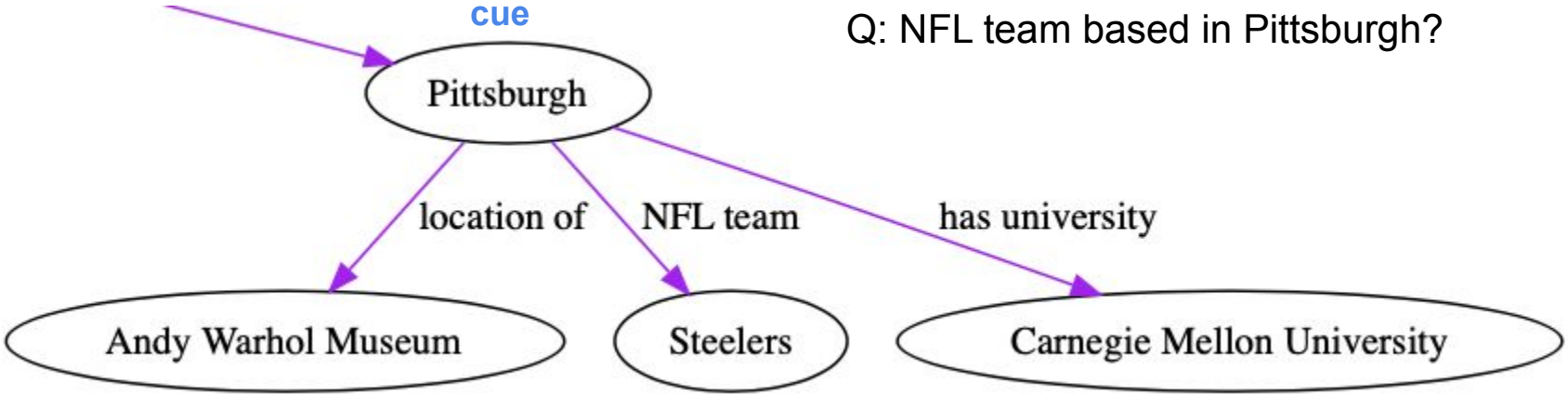
Computer Science: Accessibility/ Activation

Accessibility: Activation- calculation of how many times a node has been recalled and how recently



1. Accessibility Applied: Absolute Activation FOK

Calculation based on the activation of the cue alone.

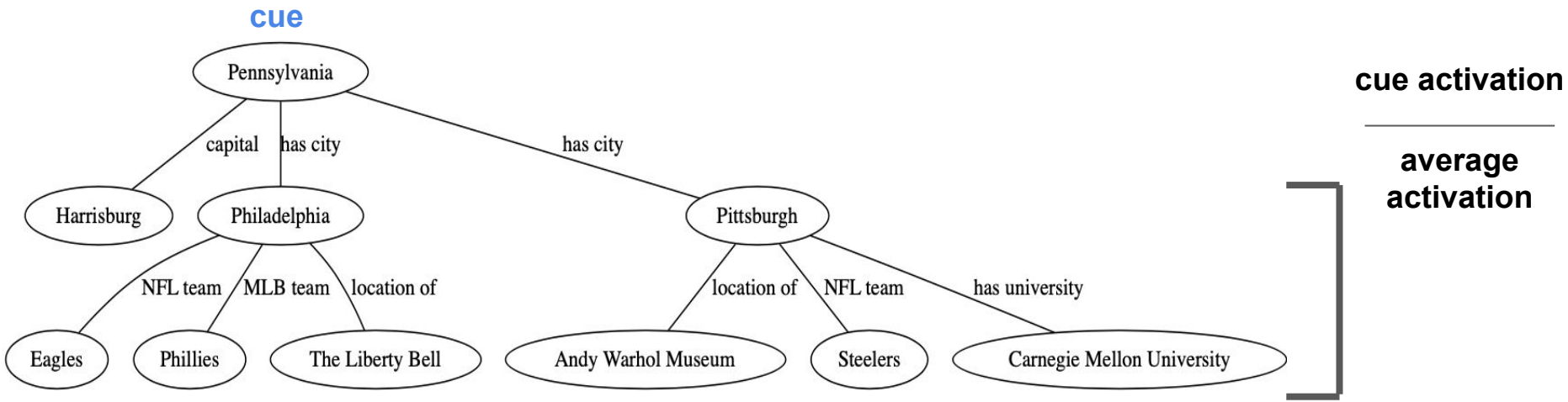


Q: NFL team based in Pittsburgh?

2. Accessibility Applied: Relative Activation FOK

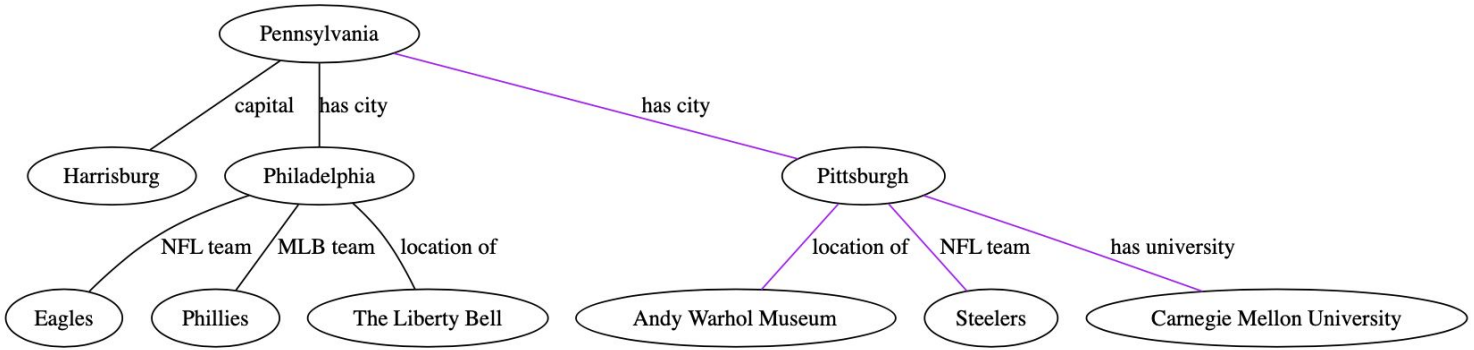
Calculation based on the activation of the cue divided by the average activation in the entire graph.

Q: Capital of Pennsylvania?



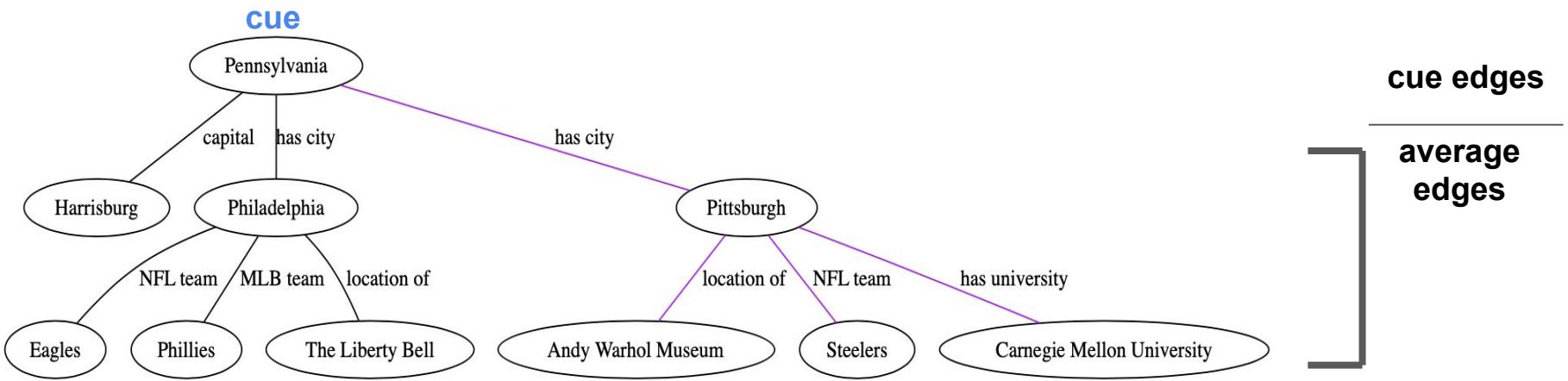
Familiarity

- Familiarity
  - How much is known about the subject
  - Ex. How many things do I know about Pennsylvania?
- Computer Science Application:
  - Familiarity: How many edges are connected to this node?



3. Familiarity Applied: Relative Edges FOK

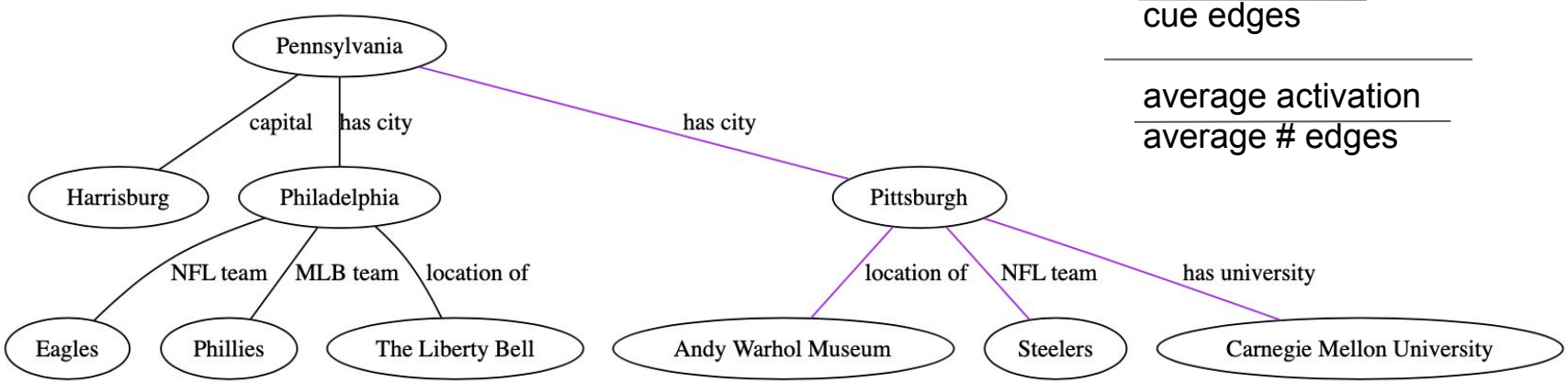
Calculation based on the number of edges connected to the cue divided by the average edges per node



4. Combination: Relative Activation over Edges FOK

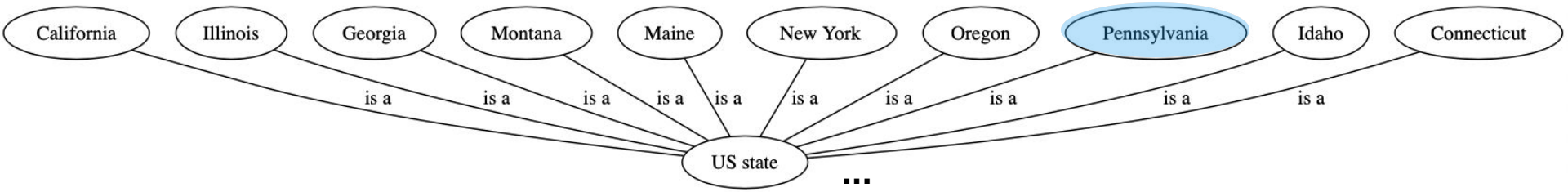
Calculation based on the ratio of the activation of the cue to the number of edges connected to the cue divided by the ratio of average activation in the graph to the average number of edges per node.

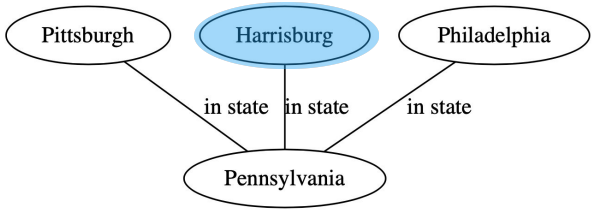
$$\frac{\frac{\text{cue activation}}{\text{cue edges}}}{\frac{\text{average activation}}{\text{average \# edges}}}$$



5. Competition FOK

- Inverse of the idea of edges FOK
- Rather than more edges from a node being helpful, they are more distracting





US state FOK: 1/50

Pennsylvania cities FOK: 1/3

Historic Component of FOK

- History of FOK
  - Past feelings of knowing influence future ones
  - Ex. I feel like I know big cities in Pennsylvania, so I am fairly certain I can come up with the capital.
- Computer Science Application:
  - Historic FOK: Based on past calculations, will I be able to find the correct answer?

Methods: Applying FOK Algorithms to Tasks

- Applied my FOK algorithms to different scenarios
- Tasks include a paired recall task from a psychology study and a set of more complex multi-step questions
- See how results to compare to human thought process and work as they are expected to

Tasks: AB Experiment (Leibert & Nelson)

- Leibert & Nelson (1998) tested how feeling of knowing and recall were related through a series of experiments

Example word pairs:

Word “A”: Physics
Word “B”: Crowd
Word “C”: Paint
Word “D”: Adult

	Group 1	Group 2	Group 3	Group 4
Pairs Shown	**AB, AB**	**AB, CB**	**AB, CD**	**AB, AD**
FOK out of 6:	**5.1**	**4.1**	**4.2**	**4.1**

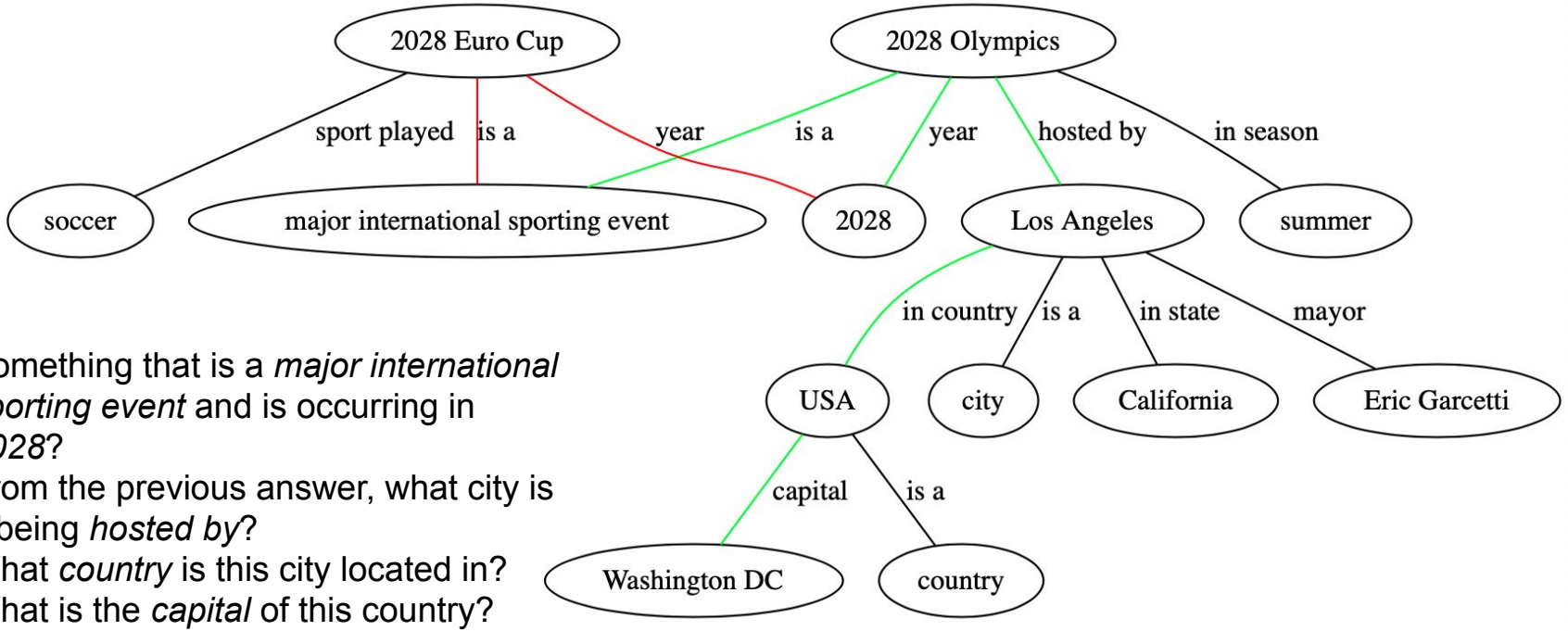
Results: AB Experiment Task

	FOK by paradigm			
FOK Method	**ABAB**	**ABCB**	**ABCD**	**ABAD**
Actual Results	5.1	4.1	4.2	4.1
activation_fok *	0.71	0.64	0.64	0.71
relative_activation_fok	1.6	1.6	1.6	1.7
outgoing_edges_fok	-0.96	-0.97	-0.96	-0.27
act_over_edges_fok *	2.4	2.4	2.3	1.8
competition_fok *	1	1	1	0.50

Tasks: Jeopardy & Multi-step Questions

- Jeopardy-style questions asking for specific facts, given some information
- Multi-step questions that are more complex than Jeopardy questions
    - Takes more steps to get to an answer from the information initially given
        - Ex. What is the capital city of Pennsylvania? **1 step**
        - Ex. What is the population of the capital city of Pennsylvania? **2 steps**

What is the capital of the nation that is hosting a major international sporting event in 2028?

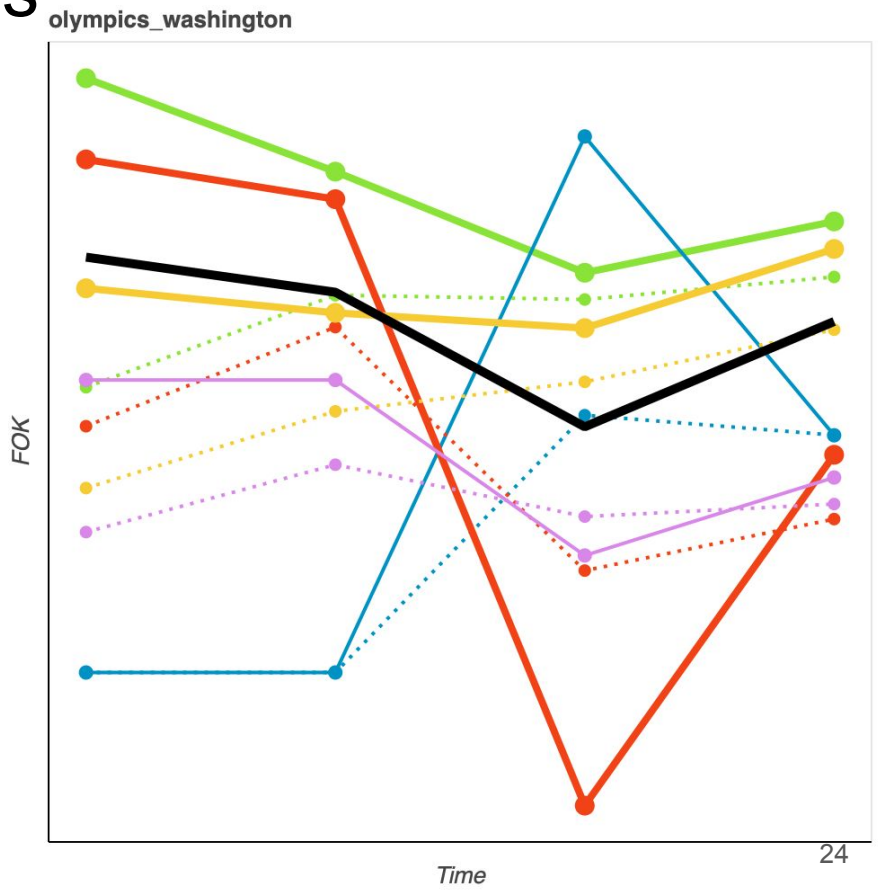


1. Something that is a *major international sporting event* and is occurring in *2028*?
2. From the previous answer, what city is it being *hosted by*?
3. What *country* is this city located in?
4. What is the *capital* of this country?

What is the capital of the nation that is hosting a major international sporting event in 2028?

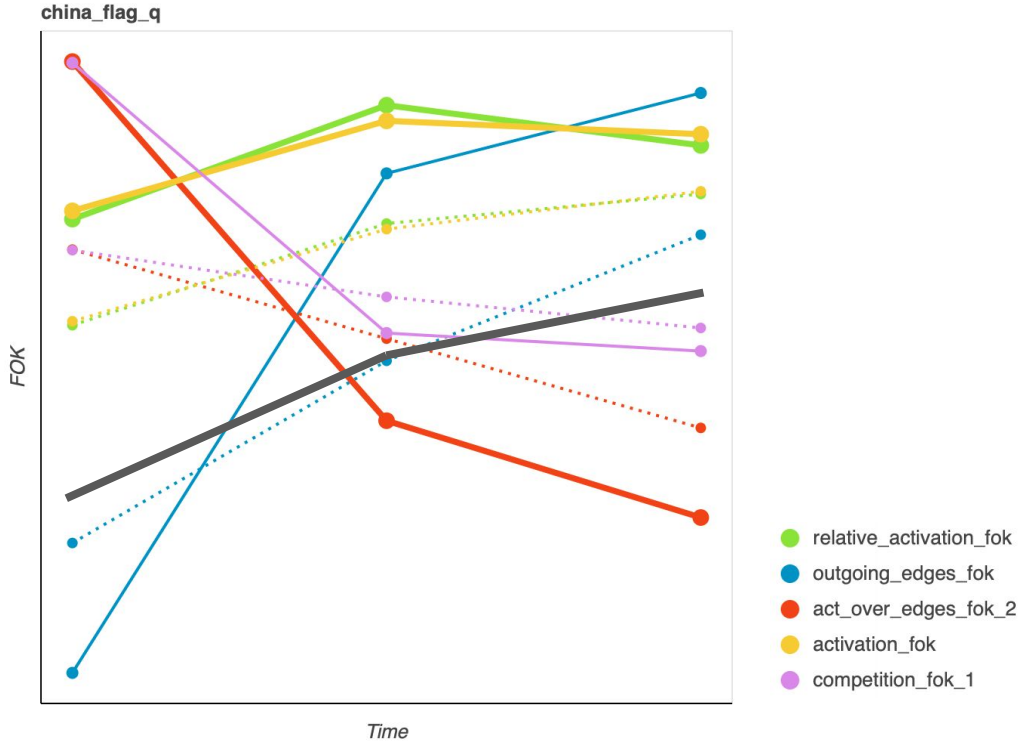
Results: Multi-Step Questions

- Three methods followed the thought process I wanted to model
  - Relative Activation FOK
  - Relative Activation/edges FOK
  - Absolute Activation FOK

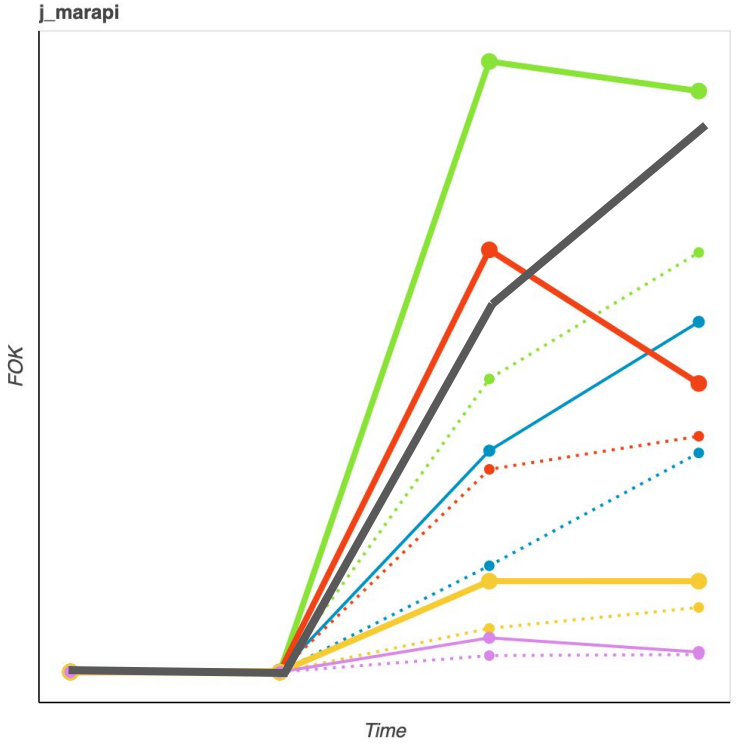


Other Multi-Step Questions

Q: What is the predominant color of the flag of the country that built the largest man-made structure in the world?
A: Red



Q: Indonesia's Mount Marapi, whose name means "fire mountain", is one of these.
A: Volcano



Summary of Results

AB Task:

- No algorithms fully matched trend from experiment
- Absolute activation, relative activation over edges, and competition FOKs were the closest

Multi-Step Question Task:

- Some FOK algorithms yielded realistic results depending on the question
- One algorithm alone did not give consistent results across all questions

Something to think about...

- No current literature of FOK changing over time
- Claimed to be a one-time judgement made at the beginning of retrieval

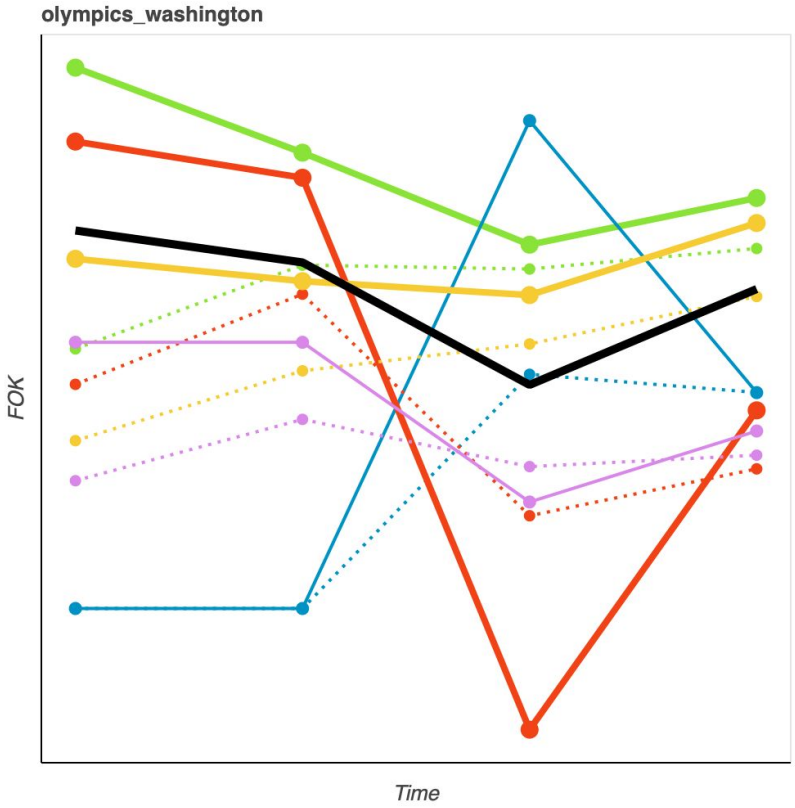
Conclusion

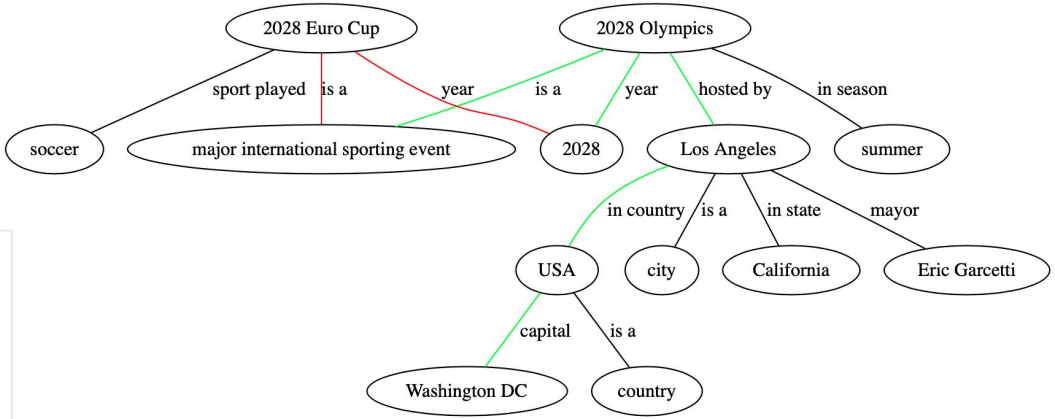
- In cognitive science, there is no single agreed upon mechanism for creating FOK
- This research has tested previously made hypotheses of feeling of knowing and has demonstrated that not one of these calculations alone can represent feeling of knowing
- Literature claims FOK is a one time judgement, however I believe it is more of a process throughout a search

Next Steps:

- Creating and testing more complex combinations of FOK algorithms
- Exploring FOK as a process
- Applying algorithms to larger knowledge base
- Looking into how FOK influences what strategy you use to think of information
- Applying FOK to artificially intelligent agents for realistic memory search

Thank you!





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Feel free to contact me with questions!

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