

Modeling Feeling Of Knowing

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What is Feeling of Knowing (FOK)?

A judgement that a person makes about how likely it is that they will be able to retrieve a piece of information

What does this look like?

- What is the capital of China?
- What is the capital of Australia?
- What is the capital of Malaysia?

Why does this matter?

- “Capital of China” → high feeling of knowing → do search → “Beijing”
- “Capital of Malaysia → low feeling of knowing → don’t search

This is interesting!

- Survey the gaps in your own memory before falling into them!
- But how?
- A model of the mind!

Background

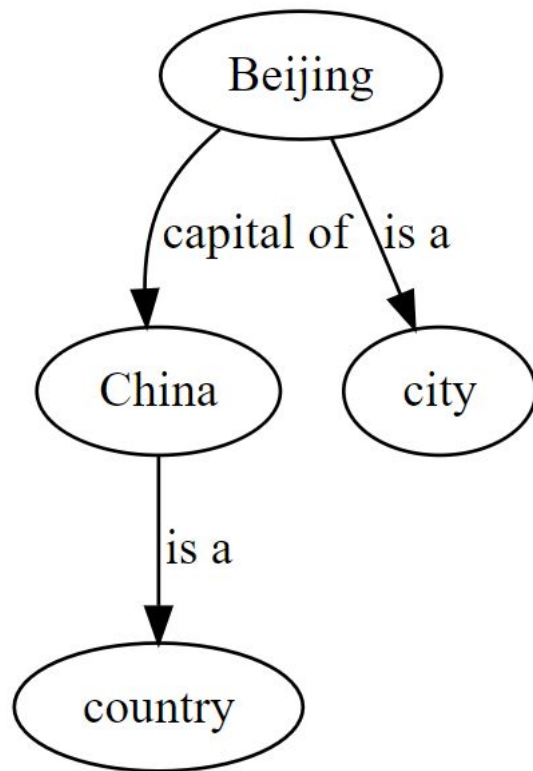
- Semantic memory
- Graphical representations of knowledge
- Familiarity hypothesis
- Accessibility hypotheses
- Competition hypotheses
- FOK based on multiple factors
- Historic FOK

Semantic Memory

- The part of the mind where the facts live
- Everything that you've ever learned
 - "Beijing is the capital of China"
 - "Cats are mammals"
- Within semantic memory, facts that are accessed with more **recency and frequency** are easier to recall

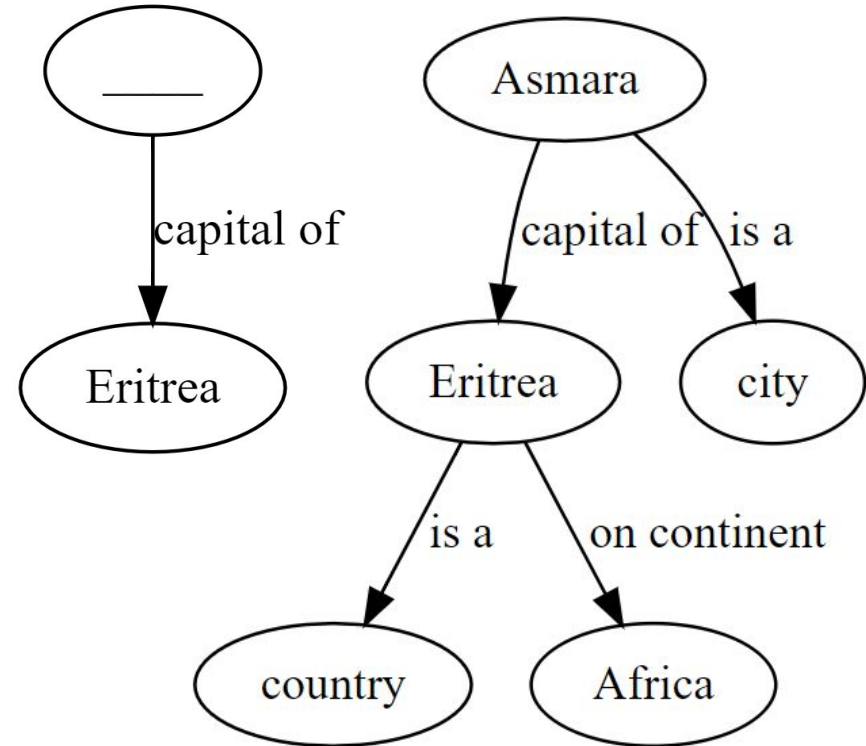
Semantic Memory

- Semantic memory can be thought of as a network of relations between concepts
- We can visualize this as a graph: where nodes are concepts and edges between nodes are relations
- Ex: this network represents the fact **“the city Beijing is the capital of the country China”**



Knowledge Representation-- Memory Retrievals

- What is the capital of Eritrea?



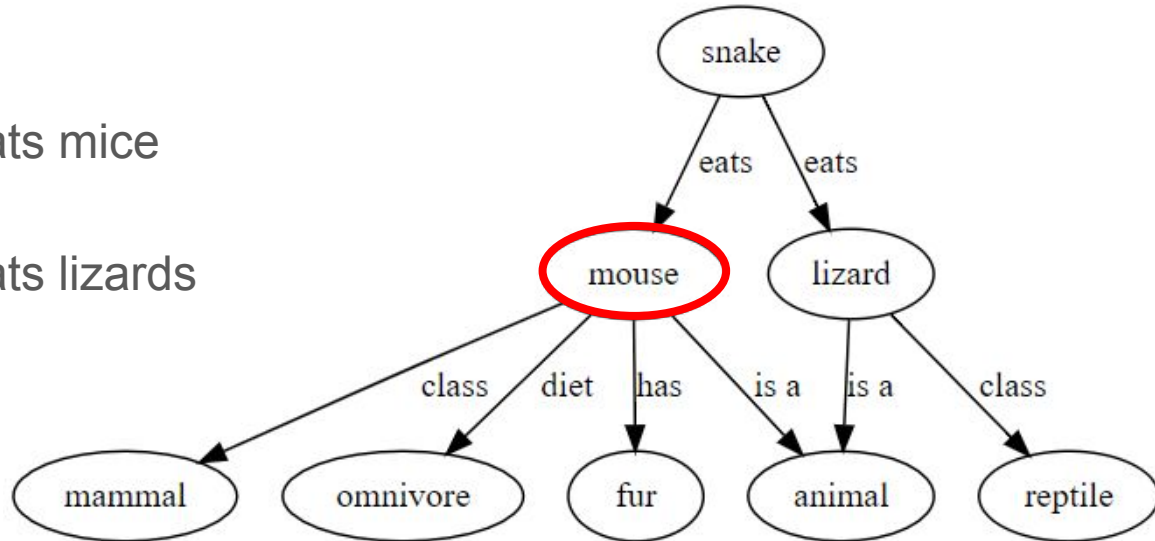
Feeling of Knowing Hypotheses

- Several hypotheses from psychology research:
 - Cue-familiarity (Reder & Ritter, 1992)
 - How *well* do I know this topic?
 - Accessibility (Koriat, 1993)
 - How *easily* does information come to mind?
 - Competition (Schreiber & Nelson, 1998)
 - How many potentially correct answers must I choose from?
 - Possibly a combination of these! (Koriat & Levy-Sadot, 2001; Leibert & Nelson, 1998)

Feeling of Knowing: Cue Familiarity

- Familiarity = how much you know about the topic = edges!
- How much do I know about this topic compared to others?
 - Above-average or below-average?
- FOK = the number of edges off the start node relative to the number of edges off the average node

- Q: Name something that eats mice
- FOK: higher
- Q: Name something that eats lizards
- FOK: lower

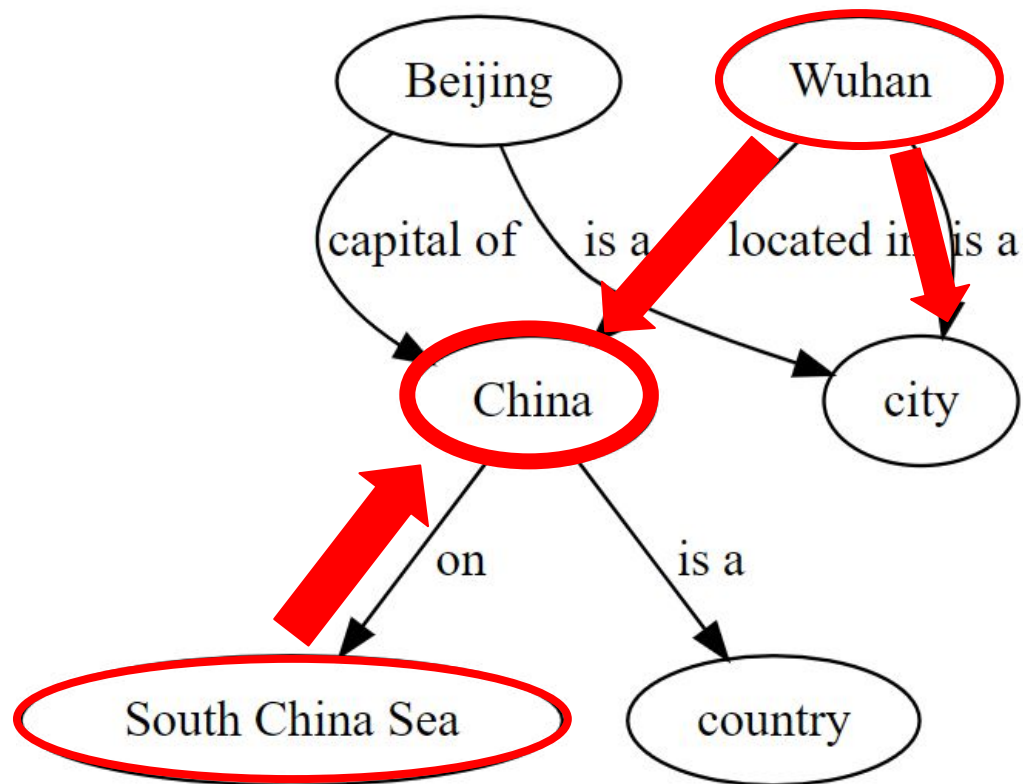


Feeling of Knowing: Accessibility

- Accessibility = how easily something comes to mind = activation!
- A number attached to each node in semantic memory
- Increases when the node is accessed
- Decreases as time goes by without accessing the node
- Accessing one node causes its neighbors to be activated as well
 - This is called spreading activation.

Feeling of Knowing: Accessibility

- What is the capital of China?
- Accessing Wuhan and the South China Sea activates these nodes
- Activation spreads to neighbors
- China receives an activation boost, making it easier to recall



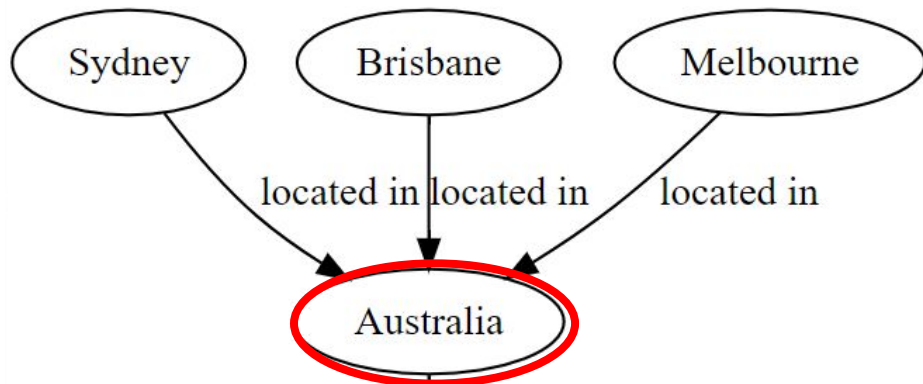
Feeling of Knowing: Accessibility

Two models:

1. Activation-- how easily does this information come to mind?
2. Relative Activation-- how much easier does this information come to mind compared to everything else I know?

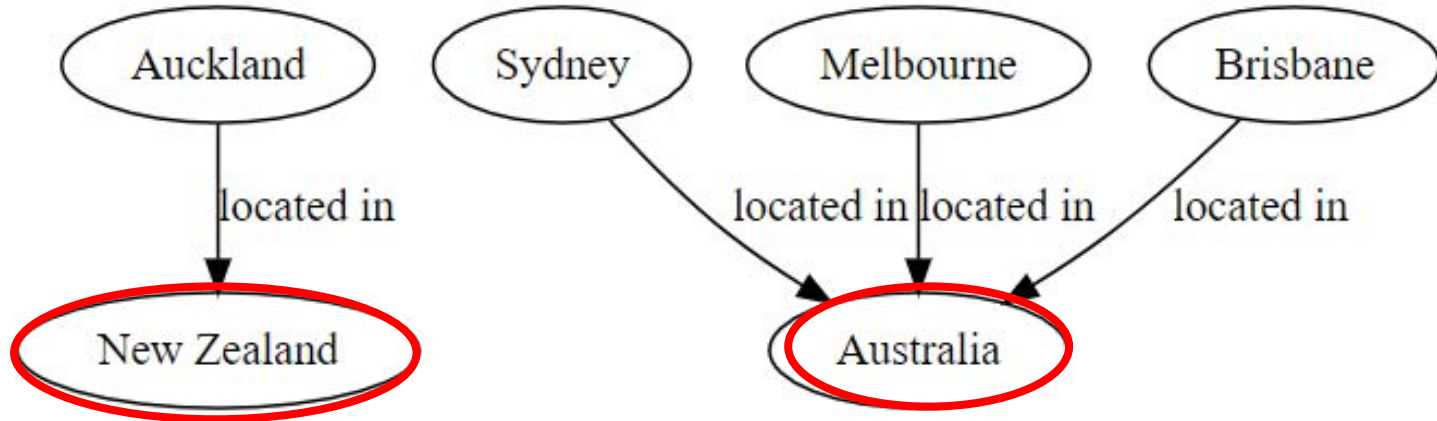
Feeling of Knowing: Competition

- The more you know, the worse you feel!
- The more connections to the start node, the lower the feeling of knowing



Feeling of Knowing: Ratio of Activation to Edges

- Accessibility and competition
- How easily does something come to mind relative to how many distractors accompany it?
- Ex: What is the capital of Denmark? What is the capital of Australia?



Historic Feeling of Knowing

- Additionally, there seems to be a historic component to FOK
- Takes previous FOKs from the same task into account
- FOK calculated by one of the aforementioned methods, then averaged with all previous FOKs
- Reports feeling of knowing at every step, informed by previous estimates

Methods to Test

Relative Edges	Historic Relative Edges
Activation	Historic Activation
Relative Activation	Historic Relative Activation
Competition	Historic Competition
Relative Activation Over Edges	Historic Relative Activation Over Edges

Evaluate the Model

What would be “correct” behavior for these FOK methods?

- FOK models should match human results
- FOK should be higher when about to find an answer
- FOK should be lower when there is no answer

Evaluate the Model

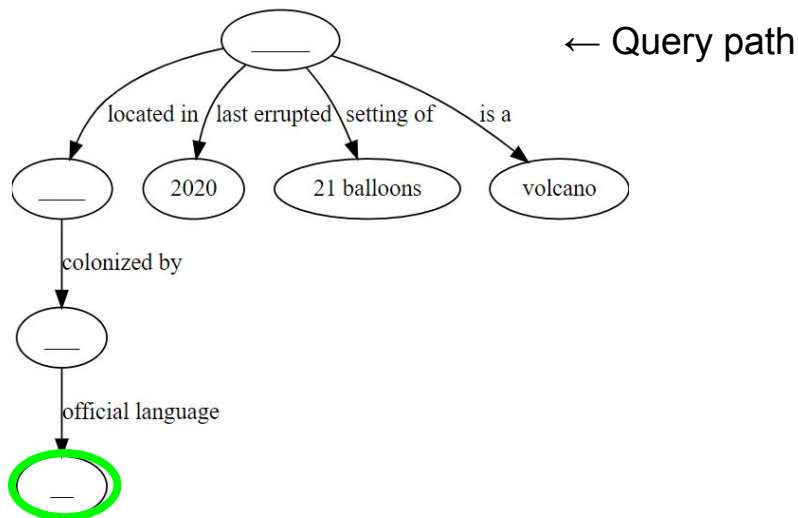
Code up scenarios to test my FOK methods

- Jeopardy and other multi-step trivia questions
 - To model how FOK should change over multiple steps of recalling an answer
- Mock up of Leibert & Nelson paired associative recall task
 - To compare my results to a published psychology experiment

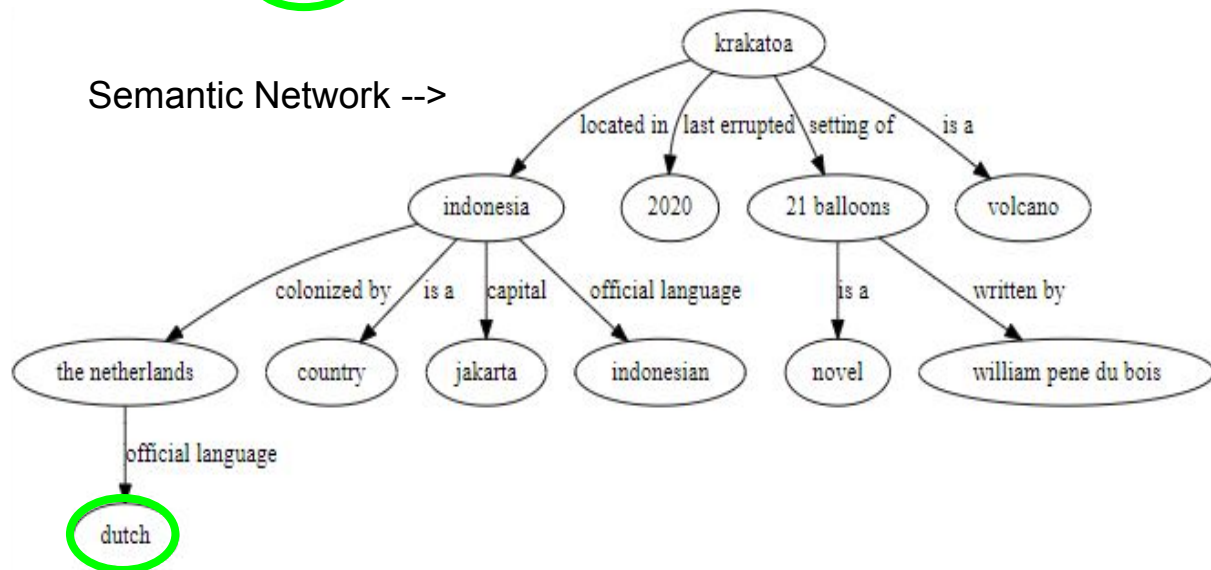
Multi-step Trivia Question

I coded up several recall tasks inspired by archived Jeopardy questions

Example: What is the official language of the European nation that formerly occupied the modern country that encompasses the active volcano island that last erupted in 2020 and is the setting for *The 21 Balloons* by William Pène du Bois?



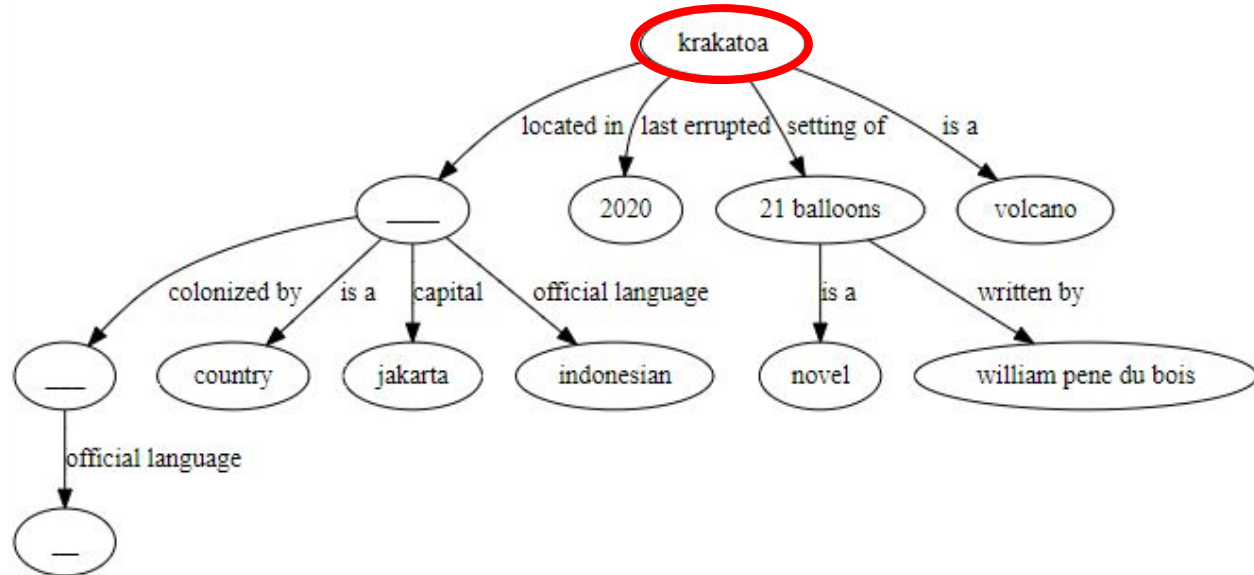
Semantic Network -->



Multi-Step Trivia Question Example

1. Query semantic memory in order to solve for the first unknown node

Establish that this query matches a region of semantic memory where the blank can only be “krakatoa”



Multi-Step Trivia Question Example

2. Take a step to fill in the next unknown node: the **location** of the volcano Krakatoa

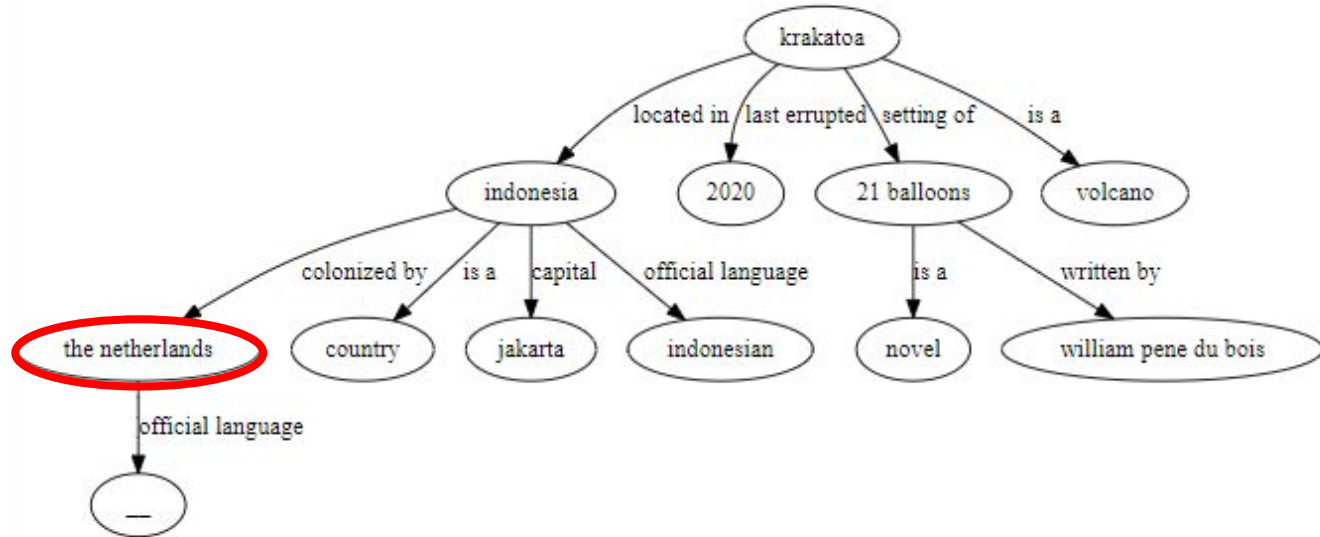
Establish that the unknown node is Indonesia



Multi-Step Trivia Question Example

3. Take a step to fill in the next unknown node: the **former European occupiers of Indonesia**

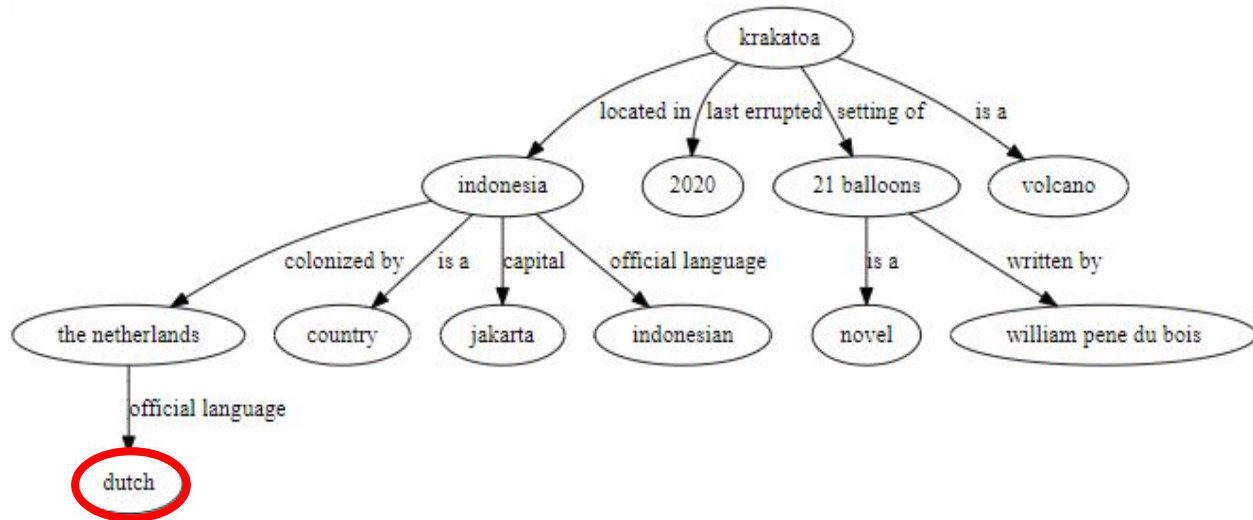
Establish that the next unknown node is equal to The Netherlands



Multi-Step Trivia Question Example

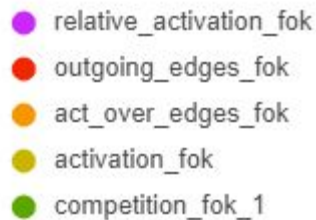
4. Take a step to fill in the last unknown node: the **official language of** The Netherlands

Establish that the final answer is Dutch!

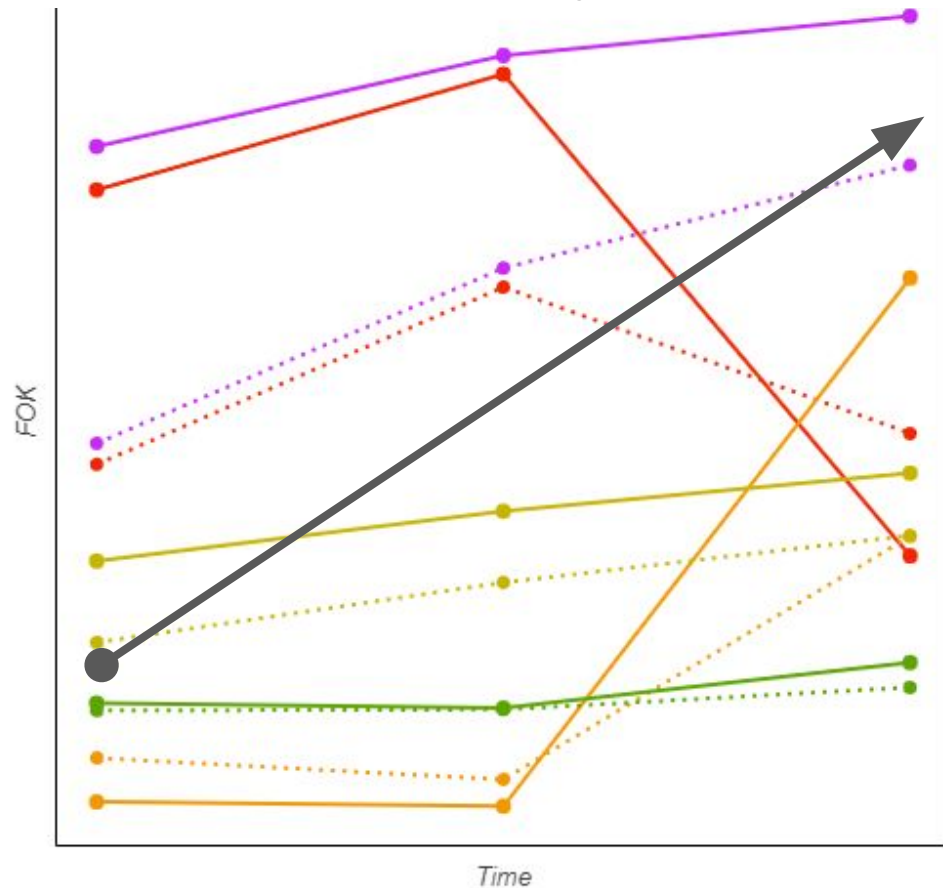


Trivia Results

- Activation, relative activation, activation over edges, and competition all increase as the answer nears
 - As do their historic counterparts
- Relative edges (red) decreases because of the blind spots in the graph



Q: What is the official language of the European nation that formerly occupied the modern country that encompasses the active volcano island that last erupted in 2020 and is the setting for *The 21 Balloons*?

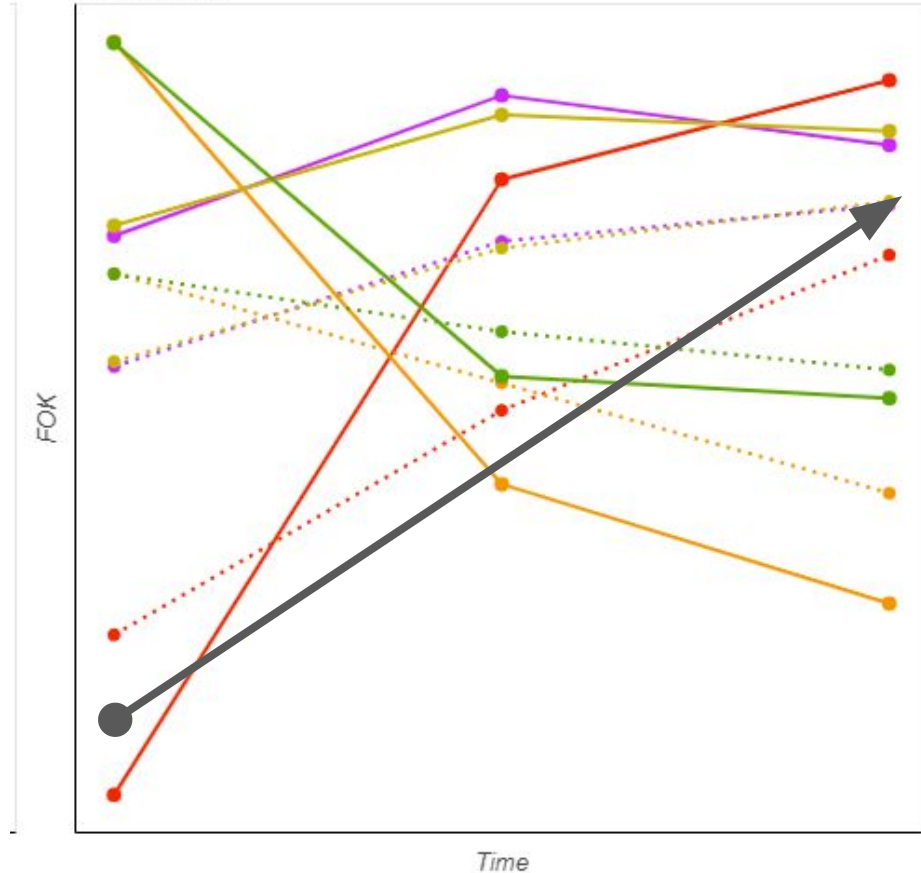
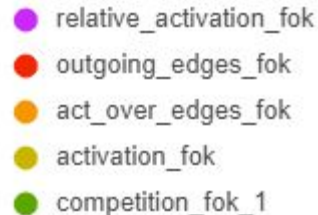


Q: What is the predominant color of the flag of the country that built the largest man-made structure in the world?

Trivia Results

- Inconsistent!
- **Edges** trends upward, correctly
- Other methods trend downward!

largest man made structure → great wall of china → china → chinese flag → red



Discussion of Trivia Results

- FOK method results varied by question and knowledge network
- I constructed each semantic memory network-- not standardized

Leibert & Nelson: Paired Associative Recall Task

The experiment:

- Study this pair: [A, B]
- Study another pair: either [A, B]; [A, D]; [C, B]; or [C, D]
- Give your feeling of knowing (out of 6) for how likely you will be able to recall the word that was originally paired with A
- A B C D are common, unrelated words

Findings:

Paradigm:	AB-AB	AB-AD	AB-CB	AB-CD
Reported FOK;	5.1	4.1	4.1	4.2

Paired-Associative Results

None of my methods complied completely with the trend represented in the results of Leibert & Nelson's 1998 FOK experiment

	FOK by paradigm			
FOK Method	ABAB	ABCB	ABCD	ABAD
Actual Results	5.1	4.1	4.2	4.1
activation_fok	0.706	0.645	0.642	0.706
relative_activation_fok	1.644	1.560	1.570	1.650
outgoing_edges_fok	-0.960	-0.965	-0.956	-0.272
act_over_edges_fok	2.383	2.352	2.345	1.787
competition_fok	1	1	1	0.5

What does this mean?

- Each FOK hypothesis has its merits, but...
- FOK is more complicated than any one of the hypotheses can explain
- This is a difficult problem to solve!
 - Even cognitive scientists haven't been able to pin down what exactly FOK is
- Gap in the literature! FOK is always presented as a one-time measurement, but I believe it should be more deeply explored as a check-in at every step of the retrieval process
 - “Will I find the answer if I keep searching?”
 - “How confident was I two steps ago?”
- Future work
 - Explore more combinatory methods of feeling of knowing
 - Explore the potential utility of giving an artificially intelligent agent a working Feeling of Knowing

Thank you for your time!

Paper: Modeling Feeling Of Knowing

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