

Evaluating and Reasoning With and About GPT

John F. Sowa and Arun K. Majumdar
Permion.ai LLC

1 June 2023

Topics Covered

- 1. Strengths and limitations of GPT. 3**
- 2. Theoretical foundation.12**
- 3. From perception to cognition.23**

Part II by Arun Majumdar: Permion technology and applications.

Large Language Models are derived from large volumes of texts stored on the WWW and more texts acquired as they are used. GPT and related systems use the mathematical methods of tensor calculus to process LLMs in a wide range of AI applications.

But the LLM methods are purely verbal. Their only connection to the world and human ways of thinking and acting is through the texts that people produce. Although quite useful, LLMs by themselves cannot support important AI methods of perception, action, reasoning, and cognition. For more general, precise, and reliable methods, they must be integrated with a broader range of AI technology.

1. Strengths and Limitations

GPT and related systems have produced impressive results.

- **For machine translation, they are superior to earlier systems.**
- **They can answer questions and discuss issues about any subject mentioned on the WWW.**
- **Their answers and even their mistakes seem to be human-like.**
- **Some people think they can pass the Turing test, now or soon.**

But the old search engines are reliable and transparent.

- **Readers always know where the information comes from.**
- **They can choose different search strategies or search engines.**

With GPT, no one knows when or whether it's mistaken.

- **Its good grammatical English makes it look authoritative.**
- **But there is no way to evaluate its information or its source.**
- **It may mix correct information with false, plausible, misleading, pornographic, or violent information from unknown sources.**

From a Ted Talk by Yejin Choi

Three short conversations with GPT-4:

Yejin: Suppose I left five clothes to dry out in the sun, and it took them five hours to dry completely. How long would it take to dry 30 clothes?

GPT-4, the newest, greatest AI system says 30 hours.

Yejin: I have 12-liter jug and six-liter jug, and I want to measure six liters.

GPT-4:

- 1. Fill the six-liter jug,**
- 2. pour the water from six to 12-liter jug,**
- 3. fill the six-liter jug again,**
- 4. very carefully, pour the water from six to 12-liter jug.**

But now, you have an overflowing 12 liter jug, and nothing in the 6-liter jug

Continuation by Yejin

Yejin:

Would I get a flat tire by bicycling over a bridge that is suspended over nails, screws and broken glass?

GPT:

Yes, highly likely.

Yejin:

But if a bridge is suspended over the nails and broken glass, then the bicycle wouldn't touch them.

Yejin's conclusion

GPT is unbelievably intelligent and shockingly stupid.

For the complete talk, see

<https://www.youtube.com/watch?v=SvBR0OGT5VI>

Giving GPT Helpful Hints

For the same examples, Stephen Young gave GPT some help.

Stephen: So suppose I left five clothes to dry out in the sun, and it took them five hours to dry completely. How long would it take to dry 30 clothes?

GPT: 30 hours.

Stephen: What if I put all 30 out at once?

GPT: If you put all 30 clothes out at once and they all have the same exposure to the sun as the initial 5 clothes, it would still take 5 hours for them to dry completely.

Stephen: Think about this step by step. I have a 12-liter jug and a six-liter jug, and I want to measure six liters.

GPT: To measure six liters using a 12-liter jug and a 6-liter jug, follow these steps:

(At this point, GPT repeated the answer it gave to Yejin.)

Continuation by Stephen

Stephen: Examine your result. How many liters are in the 6 liter jug?

GPT: I apologize for the confusion in my previous response. Since the 6-liter jug was filled completely in step 3 and then partially poured into the 12-liter jug in step 4, the remaining amount of water in the 6-liter jug would indeed be zero liters, not 6 liters. My previous response contained an error, and I appreciate your attention to detail.

Stephen: Would you like to try again?

GPT: Yes, I apologize for the confusion earlier. Here's the correct method to measure 6 liters using a 12-liter jug and a 6-liter jug:

- 1. Fill the 6-liter jug completely.**
- 2. Pour the water from the 6-liter jug into the 12-liter jug.**
- 3. Since the 12-liter jug now has 6 liters of water, you have successfully measured 6 liters using the two jugs. You do not need to do any more steps, as you already have 6 liters in the 12-liter jug.**

The Third Example by Stephen

Stephen: Think about this step-by-step. Would I get a flat tire by bicycling over a bridge that is suspended over nails, screws and broken glass?

GPT: Here's a step-by-step analysis:

- 1. Approach the bridge: At this point, your tires are not yet in contact with any nails, screws, or broken glass, so they should still be intact.**
- 2. Cross the bridge: As long as the bridge is suspended over the nails, screws, and broken glass, and you are riding on the bridge itself (which should be clear of debris), your tires should not come into contact with these sharp objects. Therefore, your tires should remain intact while crossing the bridge.**
- 3. Leave the bridge: Once you've crossed the bridge, and assuming you don't encounter any nails, screws, or broken glass on the other side, your tires should still be intact.**

Limitations of GPT

GPT has a vast amount of data derived from the WWW.

- It has no built-in methods for reasoning about that data.
- But the data it finds may contain examples of useful reasoning patterns.
- And GPT has methods (tensor calculus) for combining patterns.
- Tensors enable GPT to reuse any patterns of reasoning it may find.

For the examples by Yejin Choi and Stephen Young,

- Yejin showed how GPT failed to use good patterns of reasoning.
- Stephen asked questions and made comments that guided GPT.
- As a result, GPT found and used better patterns for those problems.
- The new patterns would become available for future use and reuse.

But GPT has no way to evaluate anything by itself.

- Any information, good, bad, or dangerous, is used without evaluation.
- GPT determines what to use by similarity of word patterns.
- But when patterns are derived from other sources, such as images, GPT may be misled by the choice of words.

Relating Language to a Situation

A mother talking with her son, about three years old: *

Mother: *Which of your animal friends will come to school today?*

Son: *Big Bunny, because Bear and Platypus are eating.*

The mother looks in his room, where the stuffed bear and the platypus are sitting in chairs at a table and “eating”.

After seeing how her son had arranged those things, she could reconstruct his pattern of thinking:

- **The bear and the platypus are eating.**
- **Eating and going to school cannot be done at the same time.**
- **Big Bunny isn't doing anything else.**
- **Therefore, Big Bunny is available.**

If GPT were connected to an image recognition system, could it do the same kind of reasoning as the mother? Or the child?

* Reported by the psychologist Gary Marcus, in an interview with Will Knight (2015)
<http://www.technologyreview.com/featuredstory/544606/can-this-man-make-ai-more-human/#comments>

Determining the Choice of Words

Suppose GPT had been given the following two sentences:

Mother: *Which of your animal friends will come to school today?*

Son: *Big Bunny, because Bear and Platypus are eating.*

Then suppose an image recognition system had scanned the boy's room and reported an English description to GPT:

- **A description of every object in the room.**
- **The position of every object and its pattern of relations.**
- **Information about how the boy used or played with those things.**

Could that report enable GPT to draw the same conclusions as the mother? Or the child?

Image recognition systems might not know which patterns are the most relevant or what words should be used to describe them.

Mistakes in image recognition, terminology, or relevance have caused accidents by driverless cars, including deaths.

2. Theoretical Foundation

Large Language Models (LLMs) store all the data in GPT.

- **Tensors are the mathematical representation for LLMs.**
- **Tensor calculus supports all operations on LLMs.**
- **It can insert, transform, and combine the LLM tensors.**
- **And it can map vectors, which represent strings of words in a natural or artificial language, to and from other notations.**

Linguists say that LLMs cannot be a language model.

- **Tensors do not make the linguistic information explicit.**
- **They do not distinguish the syntax, semantics, and ontology.**
- **GPT cannot use the 60+ years of AI research and development.**

Solution: Combine GPT with other AI technology.

- **Use GPT for finding and translating linguistic information.**
- **Use other AI systems to do complex, reliable reasoning.**

From VivoMind to Permion

The company VivoMind LLC developed advanced AI technology.

- **Conceptual graphs (CGs) as the representation for language and logic.**
- **The system of Cognitive Memory for indexing and finding CGs.**
- **Ontology for representing the semantics of the CGs.**
- **Prolog as the language for high-speed reasoning and translation.**
- **An impressive range of applications from 2000 to 2010. ***

Permion replaced Cognitive Memory with a system of tensors.

- **Tensors improved the generality and flexibility.**
- **They support a more direct mapping to and from systems like GPT.**
- **A new Prolog supports the full ISO standard.**
- **It includes predicates (implemented in C++) that support high-speed operations on vectors, matrices, tensors, and neural networks.**

Prolog with tensors can interact closely with GPT.

- **It can get data from GPT or use GPT to translate notations.**
- **Precise deductions can evaluate any reasoning by GPT.**
- **Mathematical probability and statistics can also check GPT methods.**

* See “Cognitive Memory” <https://jfsowa.com/talks/cogmem.pdf>

An article on SARS-Cov-2 (Covid-19)

SARS-CoV-2 (Covid-19): A short update on molecular biochemistry, pathology, diagnosis and therapeutic strategies

Adel AA Ismail <https://orcid.org/0000-0002-5509-9269>

Abstract

The ongoing coronavirus (covid-19) pandemic highlights the need for global scientific cooperation to advance our understanding of the immunological, molecular and biochemical mechanisms causing infection by this virus. Better understanding of key processes has allowed the development of vaccines in record time, and of agents with the potential to treat and neutralize current and future coronavirus outbreaks. To date, clinically effective agents for prevention and treatment of covid-19 infections are limited. This review provides a brief synopsis regarding the molecular biology, pathology and laboratory tests commonly used in the diagnosis and prognosis of covid-19, as well as the development of vaccines and therapeutic strategies to manage its current and future mutations.

Keywords

Coronavirus, SARS-CoV-2, Covid-19, vaccine, treatment, therapy

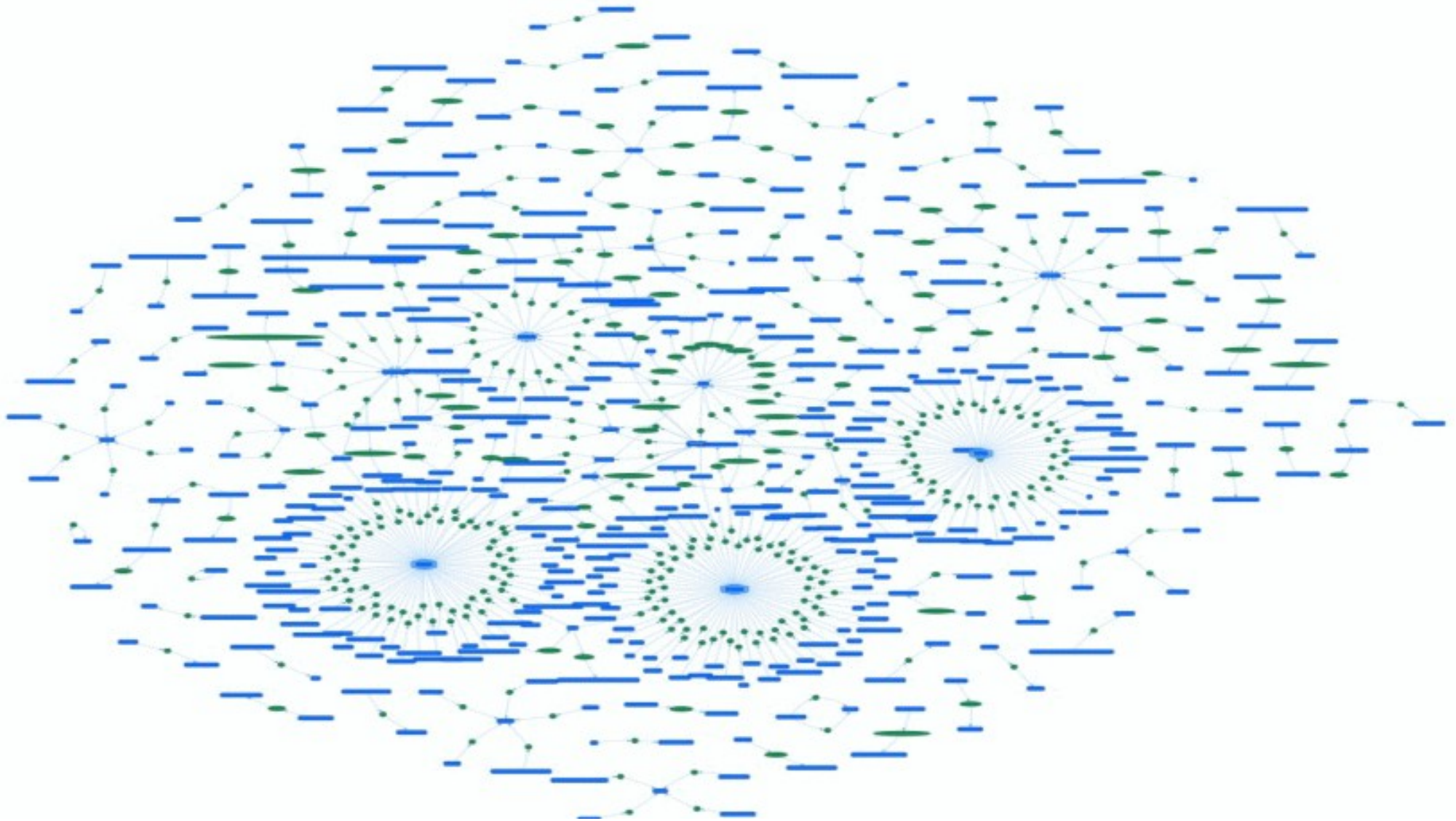
To analyze this article in detail, the Permion system translated it to conceptual graphs (CGs), as shown in the following slides.

For reasoning, Permion uses Common Logic with extensions for metalanguage, modality, and higher-order logic.

To handle vagueness and approximations, Permion uses neural nets and mathematical methods of statistics and probability.

Permion tools can translate CGs to English, but they can also use GPT for translating CGs to a more readable version of English.

An overview of all nodes in the conceptual graph

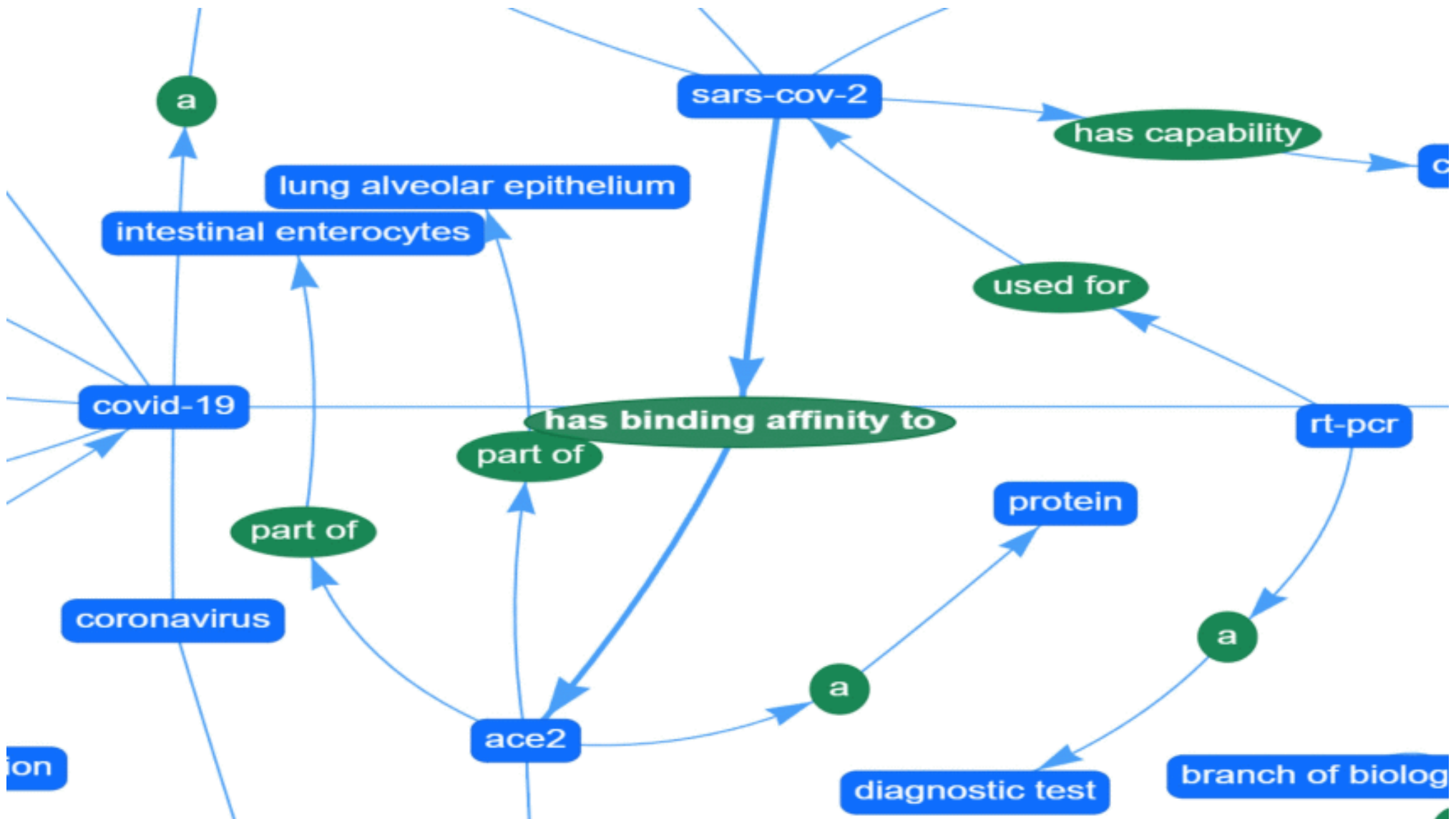


Note several circular patterns with a highly connected concept in the center. The size of the circle indicates the importance of the concept. The largest circle has the concept Virus at its center.

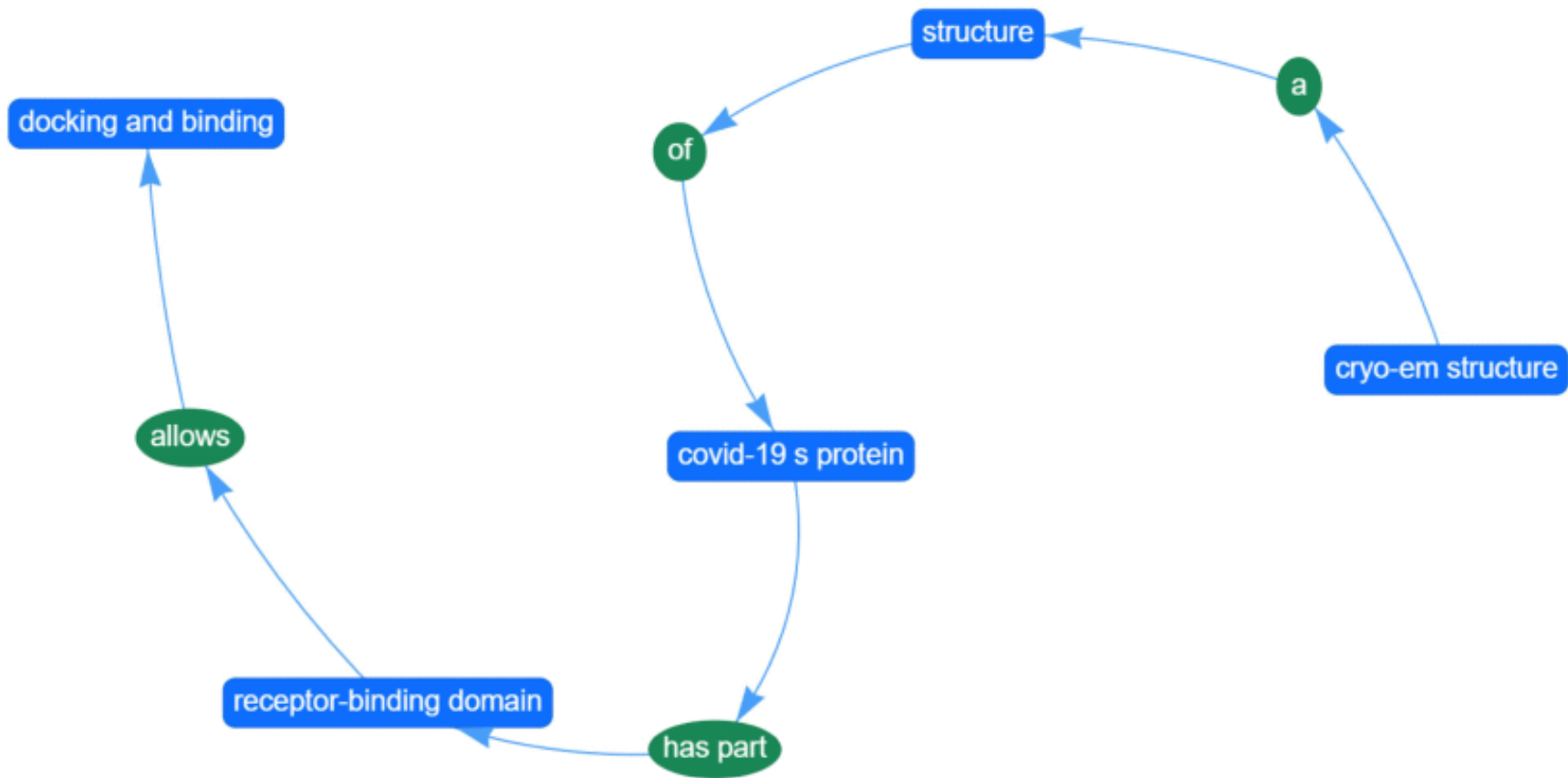
A view of the circle with Virus at the center



Another part of the same CG



A CG for a single sentence



“A cryo-em structure is a structure of Covid-19s protein that has a part which is a receptor binding domain that allows docking and binding.”

A summary generated from CGs by Permion

Permion NLP: Summarization and Question-Answering

SUMMARY: SARS-CoV-2 (Covid-19) : A short update on molecular biochemistry, pathology, diagnosis and therapeutic strategies Adel AA Ismail<https://orcid.org/0000-0002-5509-9269>.
Abstract. Introduction. The molecular biology of SARS. Conclusion. Structural basis for the recognition of the SARS-CoV-2 by full-length human ACE2..

KEYWORDS: therapeutic strategies adel aa ismail[https](https://orcid.org/0000-0002-5509-9269), full-length human ace2, short update, molecular biochemistry, molecular biology

This does not have enough content, and it's not very readable. But it does have references to the sources.

The summary translated from CGs by GPT

Permion NLP: Summarization and Question-Answering

SUMMARY: This text provides an update on the molecular biochemistry, pathology, diagnosis, and therapeutic strategies related to the ongoing COVID-19 pandemic, emphasizing the need for global scientific cooperation and intensive research to better understand the virus and develop effective treatments.

More precisely: Laboratory testing, particularly RT-PCR-based tests, has played a critical role in managing the pandemic, despite its limitations and costs. The research focus has been on understanding the mechanisms of coronavirus infectivity and developing agents to reduce or ameliorate its effects, as well as effective therapeutics to improve recovery, shorten hospital stays, and reduce complications and mortality. The urgent need to address the COVID-19 pandemic has led to intensive multidisciplinary research and cooperation worldwide.

KEYWORDS: molecular biochemistry, pathology, diagnosis, therapeutic strategies, COVID-19 pandemic

Answer about ACE-2 and Vitamin D by Permion

Permion NLP: Summarization and Question-Answering

SUMMARY: ACE2 is present mainly but not exclusively in the lung alveolar epithelium and intestinal enterocytes.. An alternative approach has focused on the prophylactic benefits of natural supplements, e.g. vitamin D^{30,31} and zinc.^{32,33}. Meta-analysis of patient data from 11,321 participants in 25 randomized controlled trials showed that vitamin D supplementation protected against acute respiratory tract infections and that patient with very low serum concentrations gain the most.. Mitchell F. Vitamin -D and covid-19 : do deficient risk a poor outcome?. *Nutrients* 2020 ; 12 : 1181. 32. Uwitonze A-M, Ojeh N, Murererehe J, et al.. *Nutrients* 2020 ; 12 : 949. 33..

KEYWORDS: 25 randomized controlled trials showed, acute respiratory tract infections, low serum concentrations gain, lung alveolar epithelium, intestinal enterocytes

Without GPT, this is less readable, but it does cite sources.

The answer translated from CGs by GPT

Permion NLP: Summarization and Question-Answering

SUMMARY: This text provides an update on the molecular biochemistry, pathology, diagnosis, and therapeutic strategies related to the ongoing COVID-19 pandemic, emphasizing the need for global scientific cooperation and intensive research to better understand the virus and develop effective treatments.

More precisely: Laboratory testing, particularly RT-PCR-based tests, has played a critical role in managing the pandemic, despite its limitations and costs. The research focus has been on understanding the mechanisms of coronavirus infectivity and developing agents to reduce or ameliorate its effects, as well as effective therapeutics to improve recovery, shorten hospital stays, and reduce complications and mortality. The urgent need to address the COVID-19 pandemic has led to intensive multidisciplinary research and cooperation worldwide.

KEYWORDS: molecular biochemistry, pathology, diagnosis, therapeutic strategies, COVID-19 pandemic

2. From Perception to Cognition

Minsky: Cognition is a society of interacting processes.

“What magical trick makes us intelligent? The trick is that there is no trick. The power of intelligence stems from our vast diversity, not from any single, perfect principle. Our species has evolved many effective although imperfect methods, and each of us individually develops more on our own. Eventually, very few of our actions and decisions come to depend on any single mechanism. Instead, they emerge from conflicts and negotiations among societies of processes that constantly challenge one another.” *

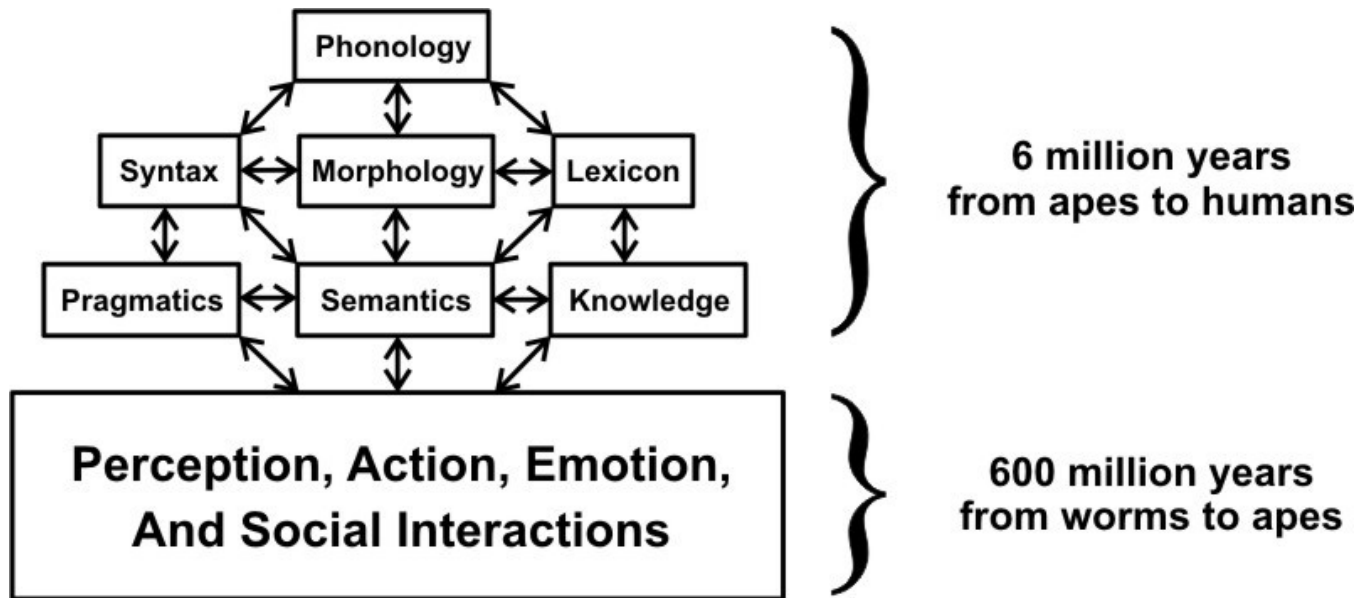
Barsalou: Cognition is a coordinated system of systems.

Cognition “emerges from deep dependencies between all the basic systems in the brain, including goal management, perception, action, memory, reward, affect, and learning. We also believe that human cognition greatly reflects its social evolution and context.” **

*** Marvin Minsky (1986) *The Society of Mind*, New York: Simon & Schuster.**

**** L. W. Barsalou, C. Breazeal, & L. B. Smith (2007) Cognition as coordinated non-cognition, http://barsaloulab.org/Online_Articles/pdf**

Foundation for Language



The human verbal system evolved in an unusually short time.

- The foundation from worms to apes took 99% of evolutionary time.
- As a result, human methods of perception, action, emotion, and social interactions remain similar to the chimpanzee and bonobo versions.

The shared cognitive systems could support a protolanguage.

- The great apes can learn and use a subset of human sign language.
- Australopithecus may have had a vocal extension of sign language.
- Homo habilis and erectus probably had protolanguages that enabled them to teach tool making and other skills to their children.

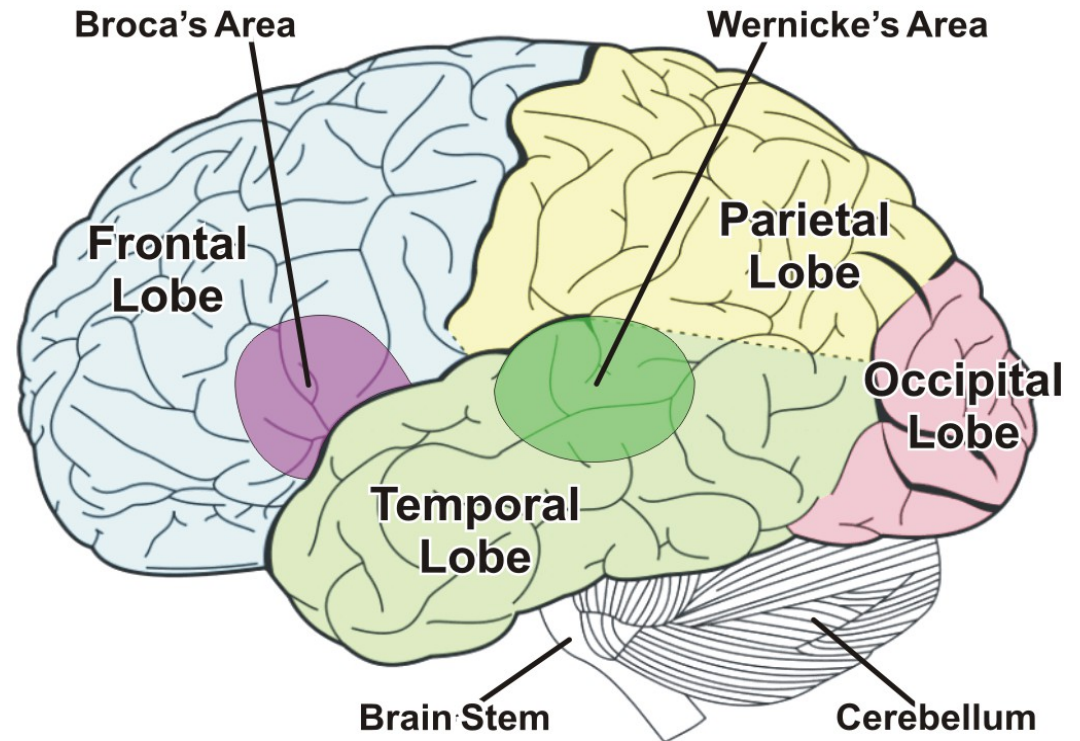
Cognitive Learning

The areas of the cerebral cortex are highly specialized.

Studies with fMRI scans show which areas are active in various kinds of thinking and learning. *

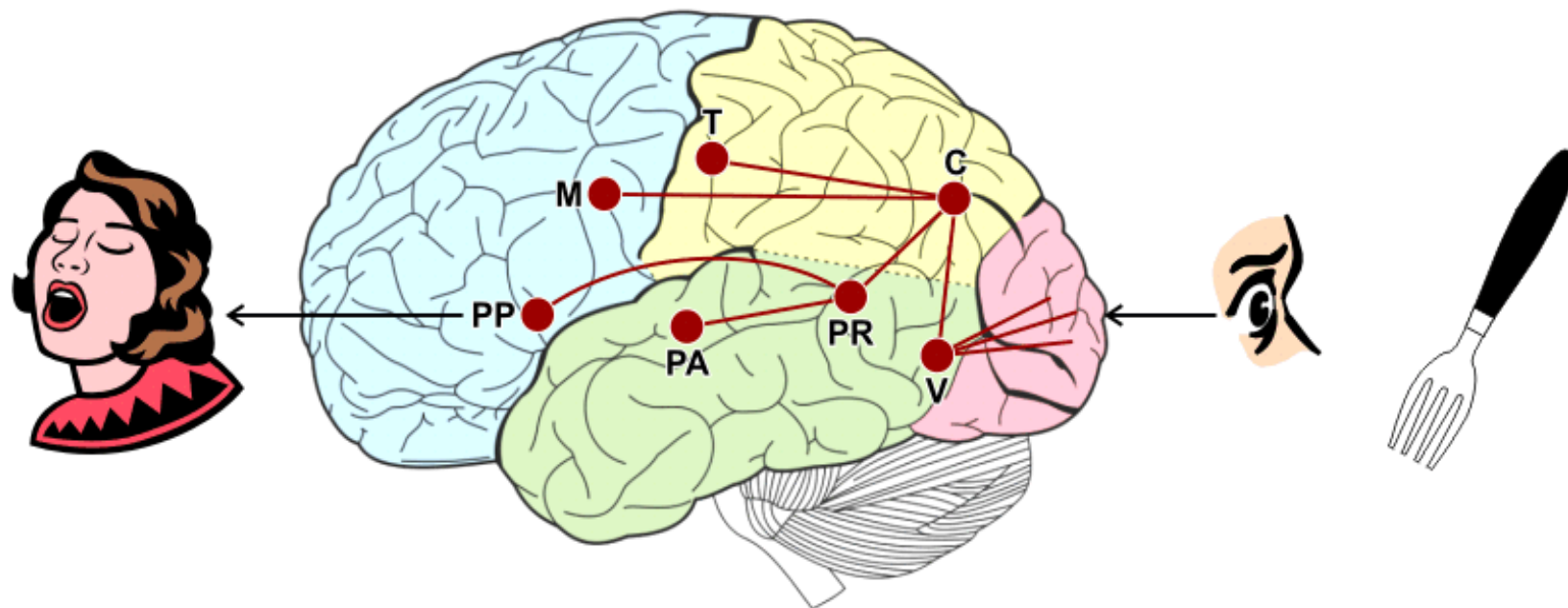
Human learning is deeper than deep neural nets:

- Occipital lobes are active in perception and recognition.
- Parietal lobes are active in learning patterns and structures.
- Frontal lobes are active in anticipation and intentionality.
- All lobes become active as participants analyze a system and consider causal hypotheses about how it works.



* R. A. Mason & M. A. Just (2015) <http://medicalxpress.com/news/2015-03-science-brain.html>

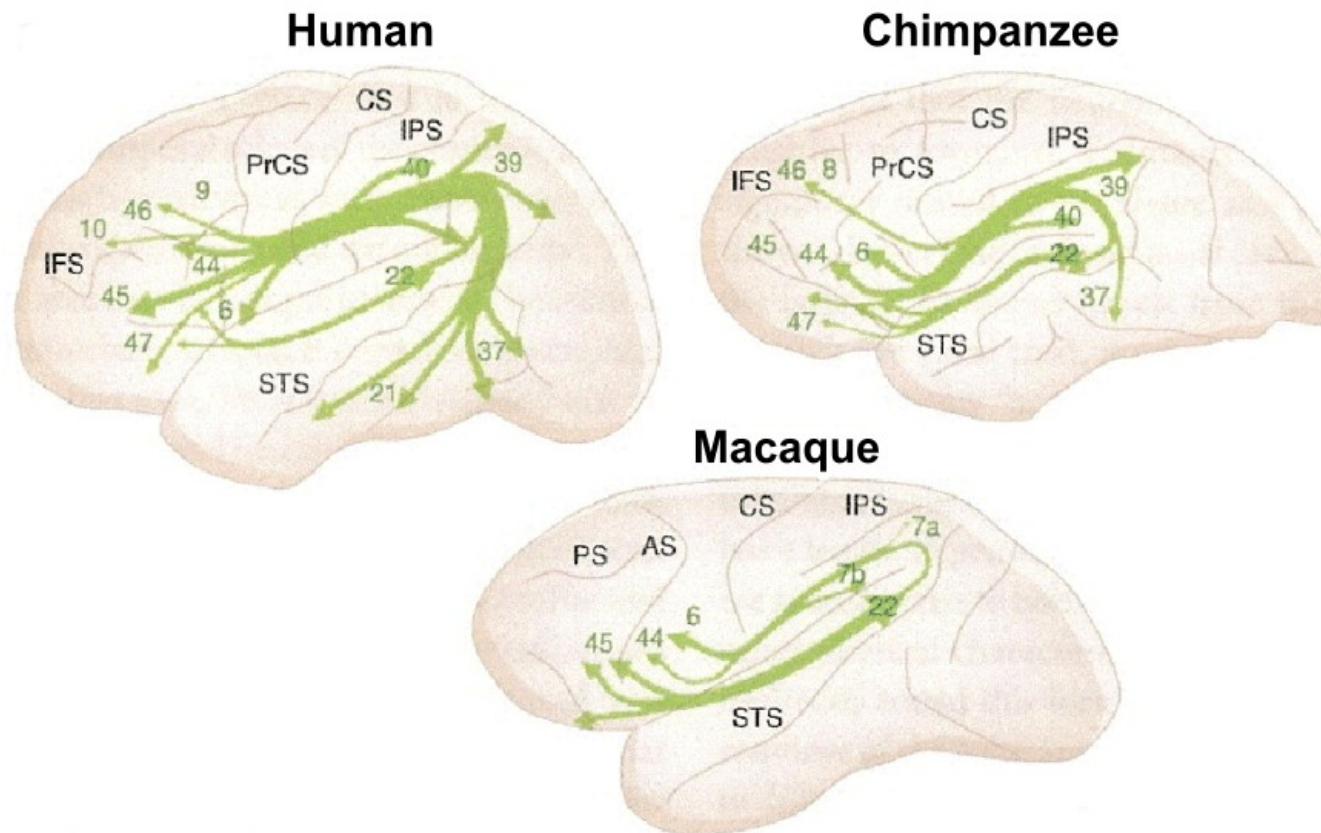
Neurocognitive Network for the Word 'fork'



Network of locations in the LH (adapted from Lamb, 2011):

- **C:** Concept of a fork in the parietal lobe has links to all other areas.
- **V:** Visual recognition in the temporal lobe links to the visual cortex.
- **T:** Tactile feel of a fork in the sensory area of the parietal lobe.
- **M:** Motor schemata for manipulating a fork in the frontal lobe.
- **PR:** Phonology for recognizing the word 'fork' in Wernicke's area.
- **PA:** Phonology for the sound /fork/ in the primary auditory cortex.
- **PP:** Controls for producing the sound /fork/ in Broca's area.

Arcuate Fasciculus



The arcuate fasciculus is a bundle of fibers that connect Broca's area and Wernicke's area in the human brain. It has branches that link to verb patterns (BA47), cognitive maps in the parietal lobe, and nouns in the temporal lobe.

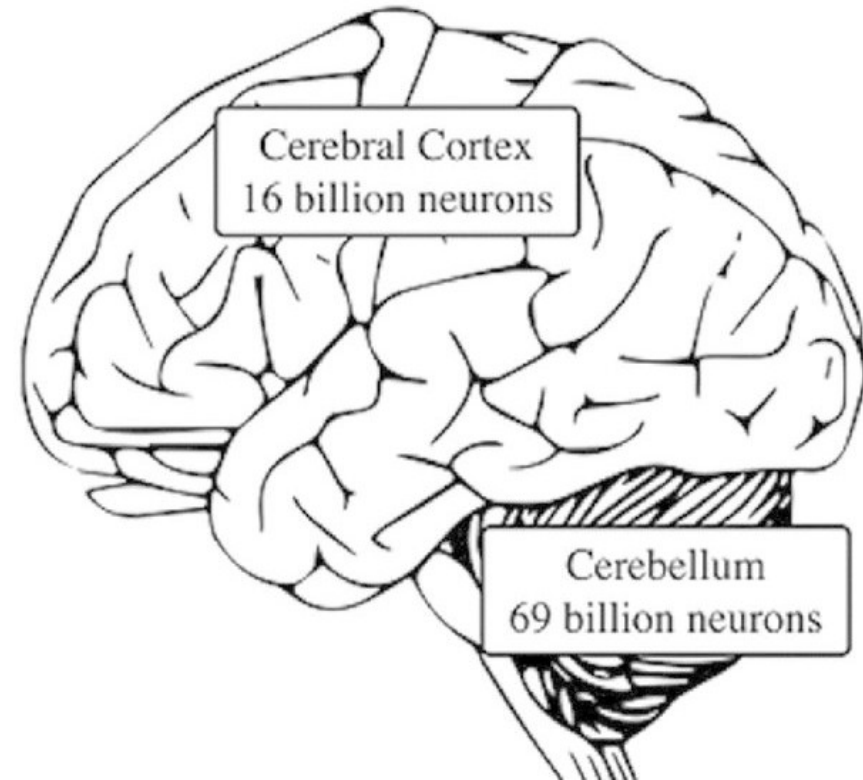
The rich connectivity to all lobes of the human brain enables humans to relate all regions to language. Monkeys have much less, but apes have enough connectivity to support their sign language.

The Cerebellum is a GPU

The cerebellum has more than 4 times the number of neurons as the cerebral cortex. It is a Graphic Processing Unit (GPU) for controlling movement.

But fMRI scans show that it's also active when people are thinking about motion or imagining complex imagery.

In comparisons of mathematicians and non-mathematicians, researchers found a major difference in their brain scans in response to sentences about math. For mathematicians, fMRI scans light up as though they were thinking about imagery. For non-mathematicians, the cerebellum is quiet. *



* S. Feng et al. (2008) [The cerebellum connectivity in mathematics cognition.](#)
M. Almaric & S. Dehaene (2016) [Brain networks for advanced mathematics.](#)

Mathematics and Imagery

Paul Halmos, mathematician:

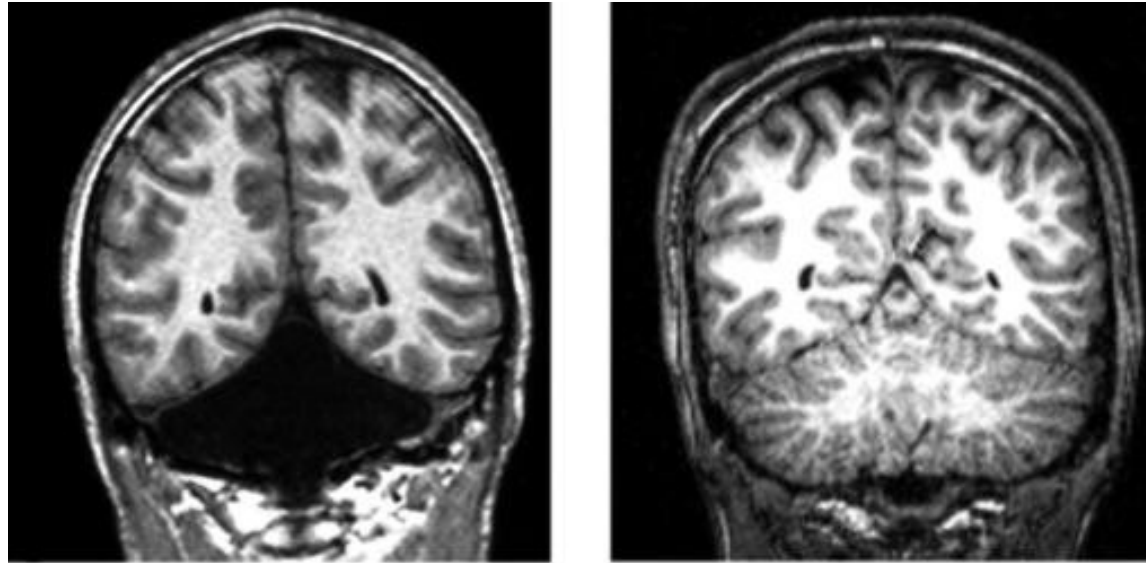
“Mathematics — this may surprise or shock some — is never deductive in its creation. The mathematician at work makes vague guesses, visualizes broad generalizations, and jumps to unwarranted conclusions. He arranges and rearranges his ideas, and becomes convinced of their truth long before he can write down a logical proof... the deductive stage, writing the results down, and writing its rigorous proof are relatively trivial once the real insight arrives; it is more the draftsman’s work not the architect’s.” *

Albert Einstein, mathematical physicist:

“The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be *voluntarily* reproduced and combined... The above-mentioned elements are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in a secondary stage, when the mentioned associative play is sufficiently established and can be reproduced at will.” **

* Halmos (1968). ** Quoted by Hadamard (1945). See also Peirce (CP 2.778).

Cerebellar Agenesis



Jonathan Keleher was born without a cerebellum.

- On the right is an MRI scan of the brain of a normal male at age 33. *
- On the left is an MRI scan of JK's brain at the same age. The black space filled with fluid is where the cerebellum should be.
- As a child, JK's developmental stages were long delayed.
- After many years of physical therapy, speech therapy, and special education, JK is now a cheerful, friendly, but awkward adult.
- He is able to hold **an office job**, but he still has cognitive, emotional, social, and learning deficits.

* See [A Man's Incomplete Brain Reveals Cerebellum's Role In Thought And Emotion](#), NPR.

American Sign Language



MANY

DEAF

LEARN

AGENT



ENTER



SPEAK



COLLEGE

Many deaf students enter hearing colleges.

**The order of signs in ASL is similar to English word order.
But many syntactic features are absent; others use 3-D space.**

Diagram adapted from Lou Fant (1983) *The American Sign Language Phrase Book*.

Spoken and Signed Language

The same neural mechanisms are used to produce and interpret spoken and signed languages. (Petitto 2005)

Studies of bilingual infants of parents with different languages:

- **All pairs of four languages: English, French, American Sign Language (ASL), and Langue des Signes Québécoise (LSQ).**
- **Monolingual and bilingual babies go through the same stages and at the same ages for both spoken and signed languages.**
- **Hearing babies born to profoundly deaf parents babble with their hands, but not vocally.**
- **Babies bilingual in a spoken and a signed language babble in both modalities – vocally and with their hands.**
- **And they express themselves with equal fluency in their spoken and signed language at every stage of development.**
- **Petitto's conclusion: Any hypothesis about a Language Acquisition Device (LAD) must be independent of modality.**

Multidimensional Syntax

Signed and spoken languages have a time-ordered sequence.

But signed languages can also take advantage of 3-D space:

- **For anything visible, pointing serves the role of pronouns.**
- **But references to people and things that left the scene are also possible by pointing to where they had been.**
- **The signer can also introduce new people and things, place them in fixed locations in the air, and refer to them by pointing.**
- **For spatial relations, signing is more “natural” than spoken language.**
- **People with normal hearing supplement language with gestures.**

Is there a language of thought?

- **How could it include the geometry of the subject matter?**
- **If it does, should it still be called a “language” of thought?**
- **Options: *cognitive map, mental model, stereoscopic moving image.***
- **In a computer, those maps, models, or images may be represented by the graphs, networks, or diagrams used in AI systems.**

Long-Distance Connections

Most neurons have short links to nearby neurons.

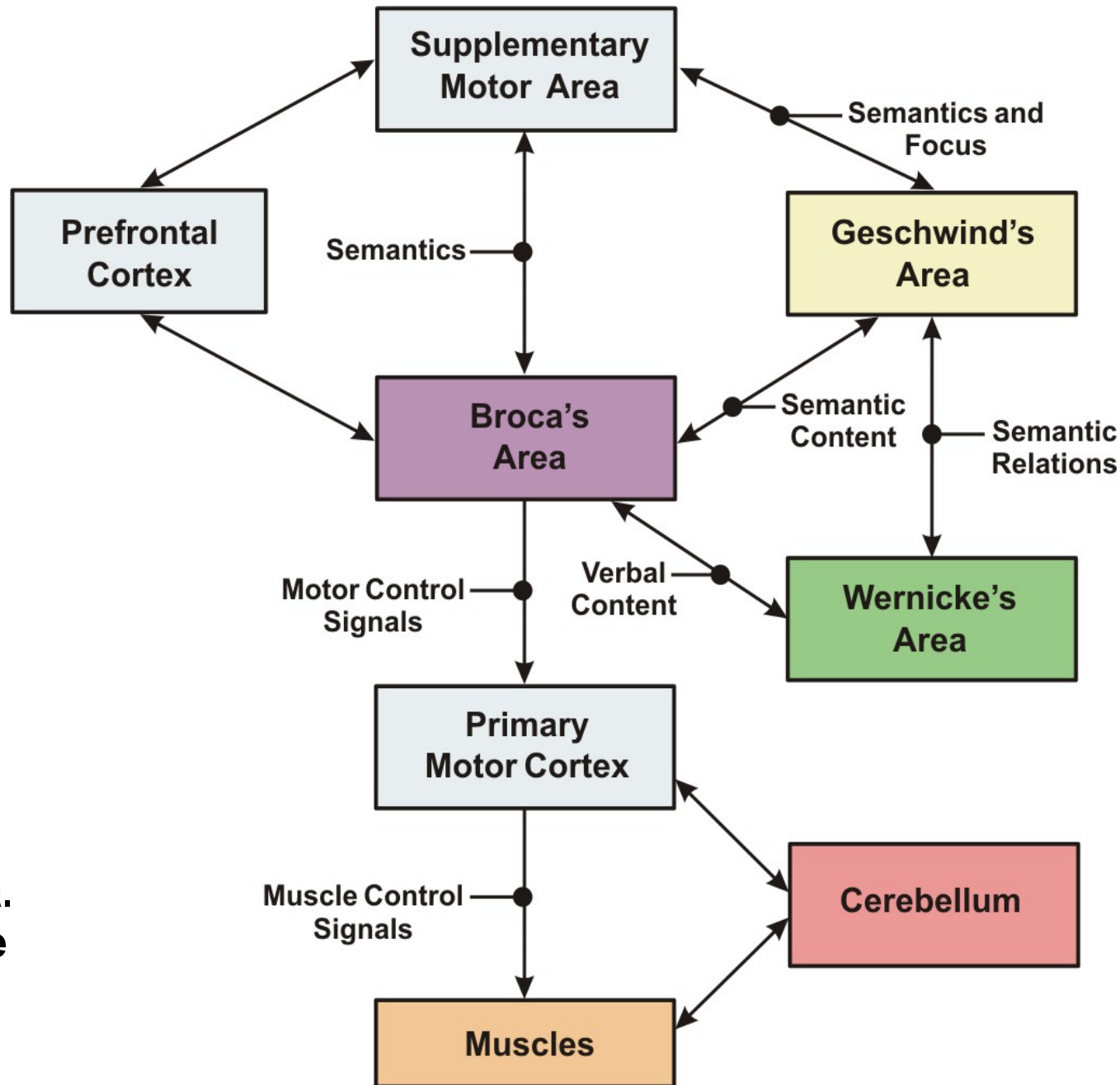
But others make long-distance connections from one lobe to another.

This diagram shows connections among areas of the brain involved in language. *

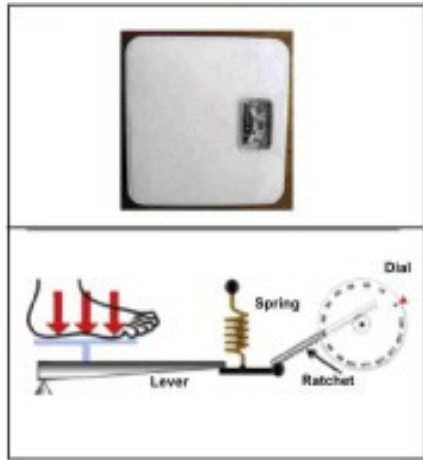
The colors of the boxes correspond to the colors of the brain areas in the previous slides.

Patterns can be learned and recognized in one area. But cognition links diverse areas across the brain.

* Diagram by MacNeilage (2008).



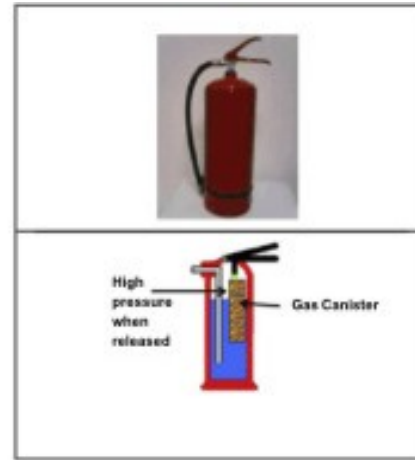
Perceptual and Cognitive Learning



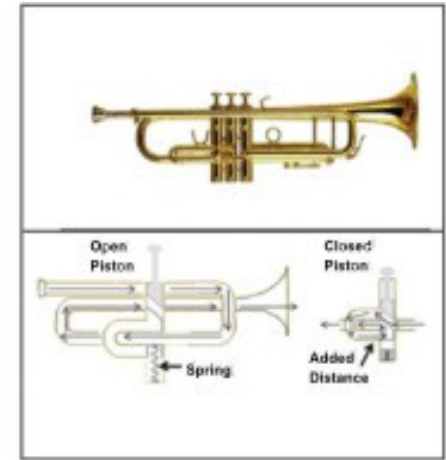
Bathroom Scale



Disc Brake System



Fire Extinguisher



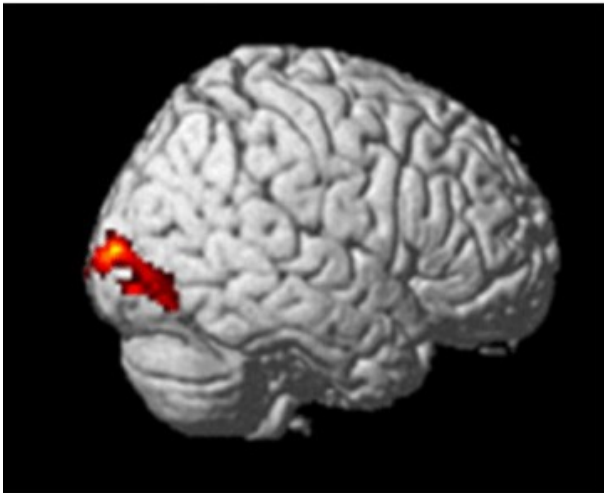
Trumpet

14 participants studied how four devices work: bathroom scale, fire extinguisher, disc brake system, and trumpet. *

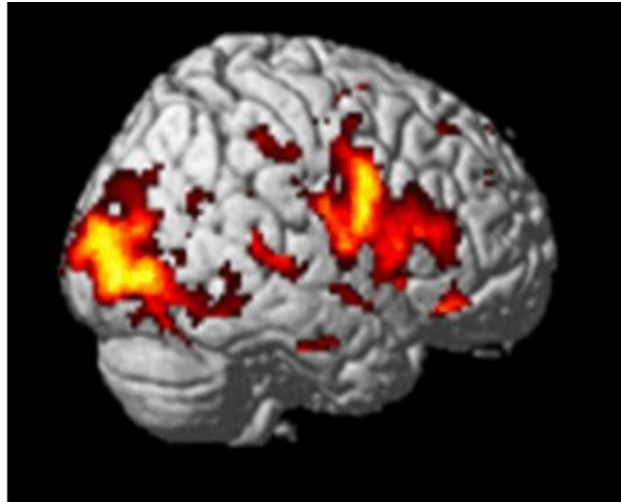
- **Subjects:** college students who were not science or engineering majors.
- They had multiple training sessions with each of the four devices.
- During test sessions, an fMRI scanner recorded patterns of brain activity.
- An early training session just showed pictures and named the parts: *A bathroom scale consists of a spring, a lever, a ratchet, and a dial.*
- Later sessions explained structural and causal relations: *The spring pulls a ratchet which rotates a gear attached to a measurement dial.*

* R. A. Mason & M. A. Just (2015) [Physics instruction induces changes in neural representation.](#)

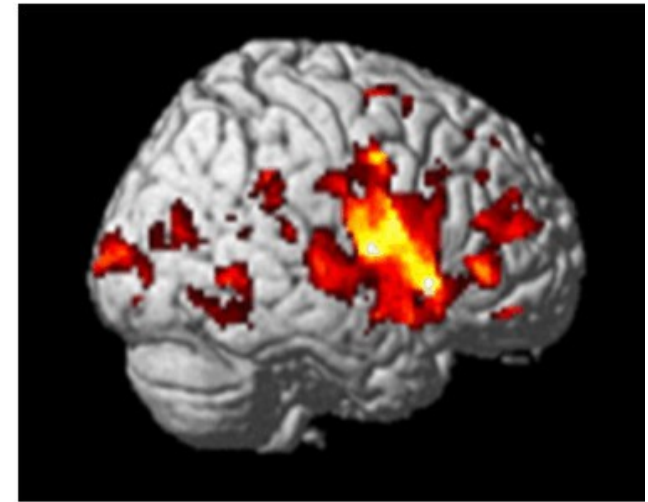
Cognitive Learning



1. Visual perception



2. Thinking about structure



3. Thinking about causality

Neural activity in the right hemisphere during test sessions:

- All 14 students showed similar neural activations.
- Questions about the objects and parts activated the visual cortex, the occipital lobes in the back of the brain (fMRI image #1 above).
- Questions about structural relations activated the parietal lobes, which link vision to all sensory and motor regions (image #2).
- Questions about the causal effects of someone operating the system activated the frontal lobes and connections across the brain (image #3).
- Summary: Cognitive learning involves structural and causal relations that link and coordinate perception, action, and reasoning.

Peirce's Analysis of Mental Experience

While studying Kant, Charles Sanders Peirce analyzed the patterns of triads in Kant's table of 12 categories (4 x 3).

He analyzed the triadic classification implicit in Kant's patterns:

- First: Quality expressible by a monadic predicate.
- Second: Reaction expressible by a dyadic relation.
- Third: Reason or intention that relates a first and a second.

Peirce coined the word *phaneron* for the mental experience. *

- The phaneron: "whatever is throughout its entirety open to direct observation" (Peirce, MS 337, 1904).
- Peirce compared *phaneroscopy* to the work of artists who can draw exactly what they see prior to any interpretation.
- That talent enables artists to imagine what people will see and feel as they walk through buildings that have not yet been built.
- The phaneron is the raw data that AI systems must interpret.

* See [Signs and Reality](#) (Sowa 2015) for examples and discussion of Peirce's categories. For more detail, see Sowa (2018) <http://www.collegepublications.co.uk/downloads/ifcolog00025.pdf>

Intentionality

Without life, there is no meaning in the universe.

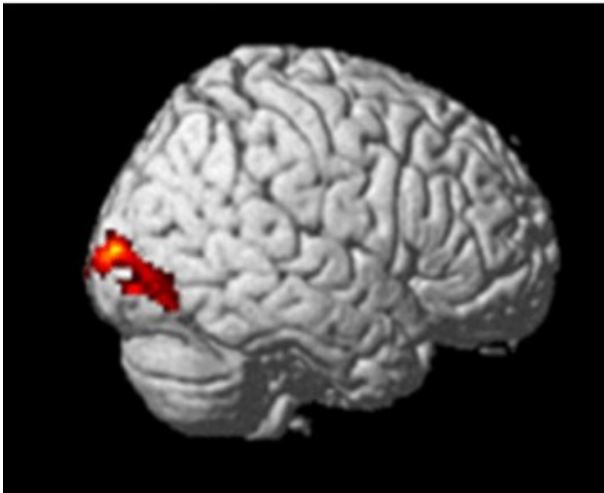
- **Philosopher Franz Brentano:** Intentionality is *“the directedness of thought toward some object, real or imagined.”*
- **Biologist Lynn Margulis:** *“The growth, reproduction, and communication of these moving, alliance-forming bacteria become isomorphic with our thought, with our happiness, our sensitivities and stimulations.”* *
- **A bacterium swimming upstream in a glucose gradient marks the beginning of goal-directed intentionality.**

In Peirce’s categories, intentionality is a mediating Third.

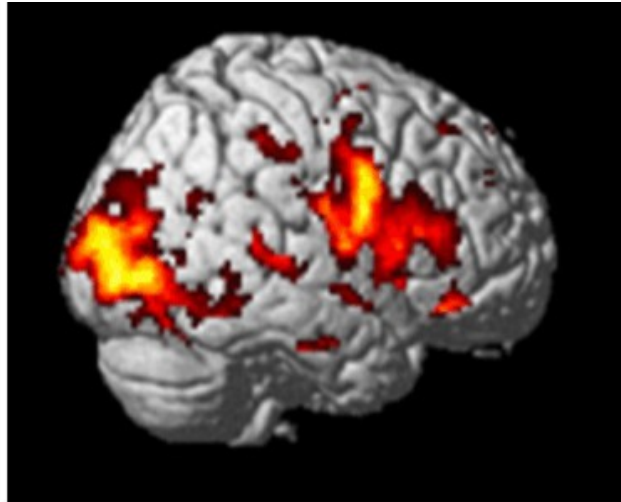
- **It’s the reason why some mind or quasi-mind directs attention toward some mark, which it interprets as a token of some type.**
- **Some interpretation by some agent makes some mark (an aspect of the universe) meaningful in some way for that agent.**
- **All laws, communications, explanations, value judgments, and social relations depend on the intentions of some agent.**

* Margulis (1995) Gaia is a tough bitch, <http://edge.org/documents/ThirdCulture/n-Ch.7.html>

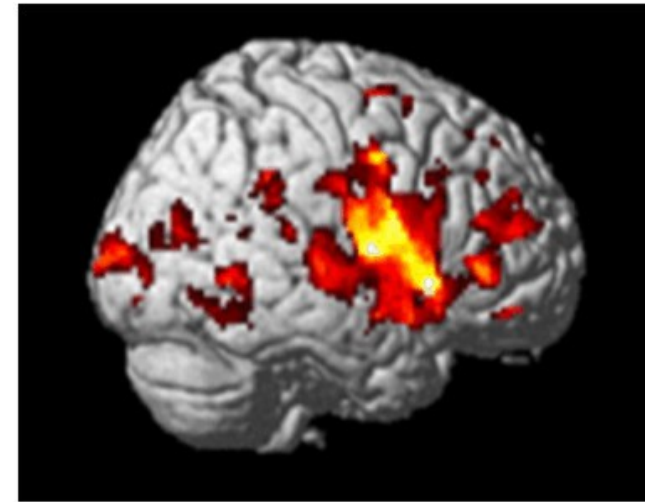
Monads, Dyads, and Triads in the Brain



1. Visual perception



2. Thinking about structure



3. Thinking about causality

Neural correlates of Peirce's First, Second, and Third:

- Perception is based on localized percepts or prototypes. It classifies phenomena by monadic predicates (fMRI image #1).
- Long-distance connections in the parietal lobes support dyadic relations that connect all sensory and motor modalities (image #2).
- The frontal lobes process the mediating triadic relations in reasoning, planning, causality, and intentionality (image #3).
- Much more detail must be analyzed and explained, but these examples show fundamental issues that AI systems must address.

Intentions, Emotions, and Empathy

Observation by the linguist Zellig Harris:

“We understand what other people say through empathy – imagining ourselves to be in the situation they were in, including imaging and wanting to say what they wanted to say.”

That sentence shows a deeper understanding of language than anything his star pupil, Noam Chomsky, ever wrote.

Subsets of language that map to formal logics are essential for mathematical precision in science and engineering.

But empathy depends on a deep emotional connection of people with other people – or even with their pets.

Could AI systems have intentions, emotions, and empathy?

Observation by the comedian George Burns: “Sincerity is everything. Once you can fake that, you've got it made.”

For a discussion of related issues, see <https://jfsowa.com/pubs/cs7.pdf>

References

Research on AI methods that complement LLMs:

Majumdar, Arun K., John F. Sowa, & John Stewart (2008) Pursuing the goal of language understanding, <http://www.jfsowa.com/pubs/pursuing.pdf>

Majumdar, Arun K., & John F. Sowa (2009) Two paradigms are better than one and multiple paradigms are even better, <http://www.jfsowa.com/pubs/paradigm.pdf>

Majumdar, Arun K., & John F. Sowa (2018) Relating language, logic, and imagery, <http://jfsowa.com/pubs/relating.pdf>

Sowa, John F. (2002) Architectures for intelligent systems, <http://www.jfsowa.com/pubs/arch.pdf>

Sowa, John F., & Arun K. Majumdar (2003) Analogical reasoning, <http://www.jfsowa.com/pubs/analog.htm>

Sowa, John F. (2005) The challenge of knowledge soup, <http://www.jfsowa.com/pubs/challenge.pdf>

Sowa, John F. (2006) Worlds, models, and descriptions, <http://www.jfsowa.com/pubs/worlds.pdf>

Sowa, John F. (2008) Conceptual graphs, http://www.jfsowa.com/cg/cg_hbook.pdf

Sowa, John F. (2010) Role of Logic and Ontology in Language and Reasoning, <http://www.jfsowa.com/pubs/rolelog.pdf>

Sowa, John F. (2011) Cognitive architectures for conceptual structures, <http://www.jfsowa.com/pubs/ca4cs.pdf>

Sowa, John F. (2013) From existential graphs to conceptual graphs, <http://www.jfsowa.com/pubs/eg2cg.pdf>

Sowa, John F. (2018) Reasoning with diagrams and images, *Journal of Applied Logics* 5:5, 2018, pp. 987-1059, <http://www.collegepublications.co.uk/downloads/ifcolog00025.pdf>

ISO/IEC standard 24707 for Common Logic (which includes conceptual graphs as one of the dialects), [http://standards.iso.org/ittf/PubliclyAvailableStandards/c039175_ISO_IEC_24707_2007\(E\).zip](http://standards.iso.org/ittf/PubliclyAvailableStandards/c039175_ISO_IEC_24707_2007(E).zip)