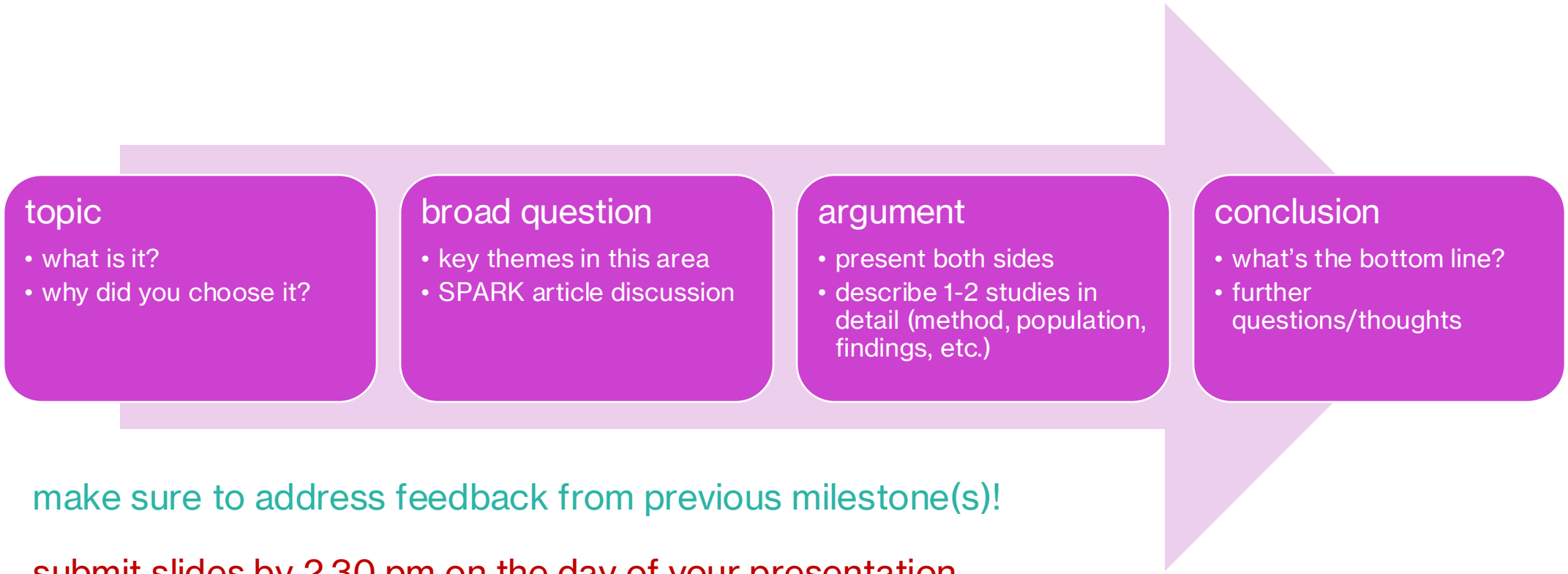
Cognition

PSYC 2040

Intelligence

presentation guidelines / roadmap



make sure to address feedback from previous milestone(s)!

submit slides by 2.30 pm on the day of your presentation

April 29 groups

Ala Memoriae (Alex, Liam, Anna)	• eyewitness testimony reliability
Group 3 (Isaac, Ty, Jacob)	• memory & aging
Mind your Language (Fabiola, Estefania, Gigi)	• bilingualism
KMB (Kassi, Moana, Bryan)	• special-ed classrooms & cognition
KPN (Kyra, Peter, Noah)	• emotion-related memory biases

May 1 groups

Linguistic Learners (Isabella, Ayhorng, Alison)	• bilingualism & sentence processing
OSPAN (Liam, Rima, Asher)	• false memory & mood disorders
Pavlov's dawgs (Kira, Kaylee, Addison)	• multitasking & creativity
Senior Smiles (Bella, Eshani, Maya)	• stress & decision making
JZD (Joseph, Zahren, Daniel)	• gambling & substance use
The Neighborhood (Cole, Kelly, Ryan)	• exercise & cognitive decline

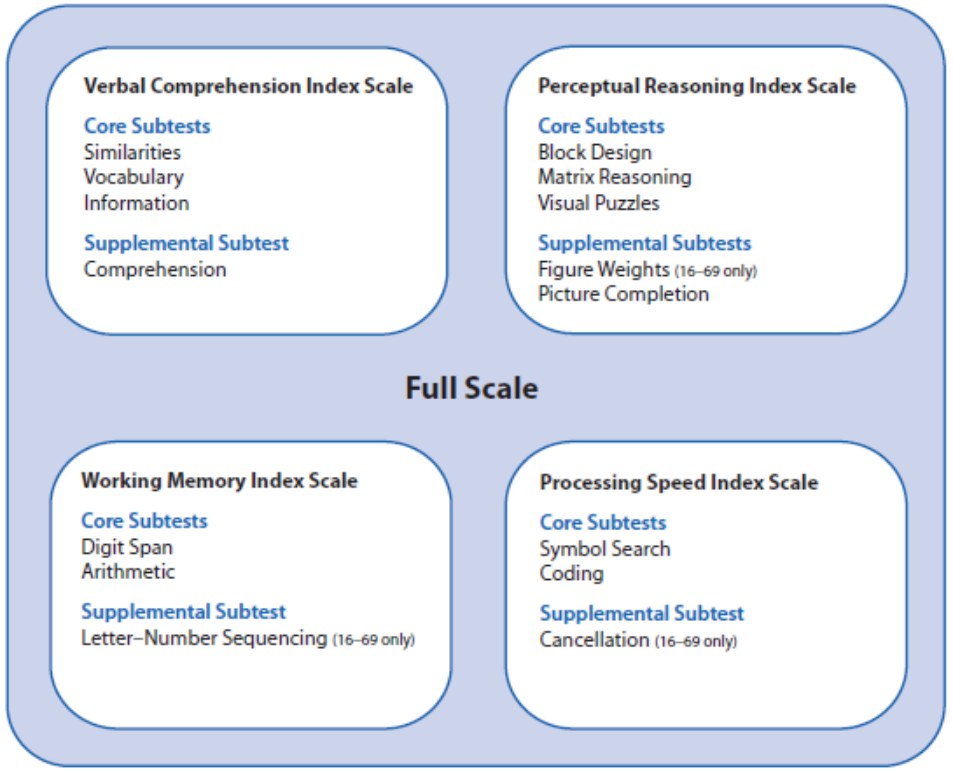
logistics

- last week to submit memes

14	T: April 22, 2025	W14: Intelligence
14	Th: April 24, 2025	W14 continued…
14	Su: April 27, 2025	**Week 14 Quiz due**
11	S: April 27, 2025	**Jennifer's Office Hours (7-9 pm, Kanbar 200)**
15	T: April 29, 2025	W15: Project Presentations
15	Th: May 1, 2025	Project presentations
16	T: May 6, 2025	W16: Last Class / Final Review
17	T: May 13, 2025	**Final Exam (1.30-3 pm, VAC North)**

measuring intelligence

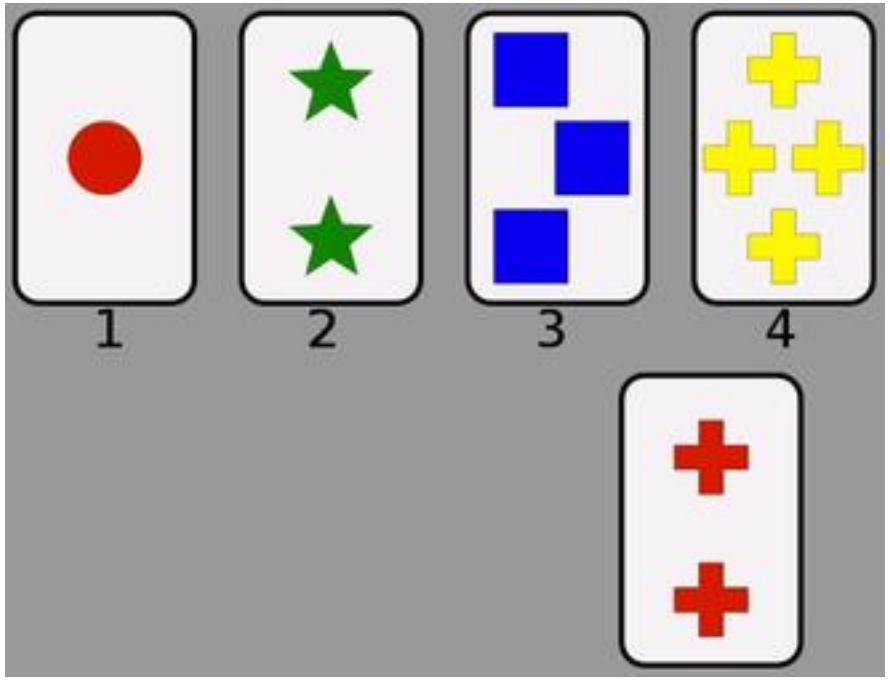
- verbal comprehension
- working memory
- processing speed
- reasoning



WAIS IV

Wisconsin Card Sorting Test (WCST)

- neuropsychological test of cognitive flexibility, abstract reasoning, and executive functioning
- patients with brain damage typically have more perseveration errors



modern conversations on intelligence

- intelligence continues to remain a popular and scientifically important topic in the field but the goals have evolved over time
- intelligence is thought to be multifaceted, and the study of intelligence has many different motivations and goals
  - what makes humans different/unique?
  - how can we build artificial intelligence?

Building machines that learn and think like people

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W14 reflection prompt 1

- On Canvas, fill out the reflection yourself and then discuss
  - think about all the cognitive abilities we've learned about this semester
  - do you think any of these abilities are uniquely human? which ones?
  - how do we compare to non-human animals?
  - how do we compare to artificial intelligence?

W1: What is Cognition?
W2: Building blocks
W3: Cognitive limitations
W4: Learning and association
W5: Categorization
W6: Language
W7: Review/Midterm
W10: Problem solving
W11: Decision making
W12: Social cognition
W13: Culture
W14: Intelligence

the candidates

- mental time travel
- tool use
- complex problem solving
- complex social cognition
- flexible communication

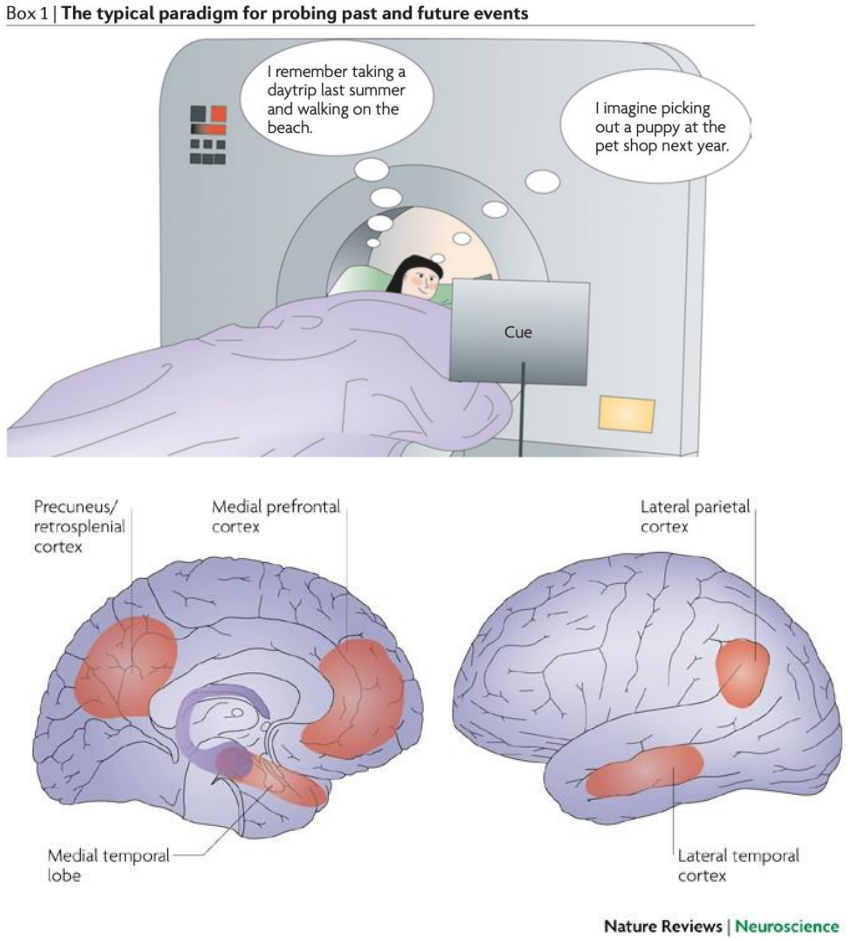
Dr. Kevin Lala/Laland
Evolutionary biologist
University of St. Andrews, Scotland

Dr. Amanda Seed
Professor, Psychology & Neuroscience
University of St. Andrews, Scotland

paper

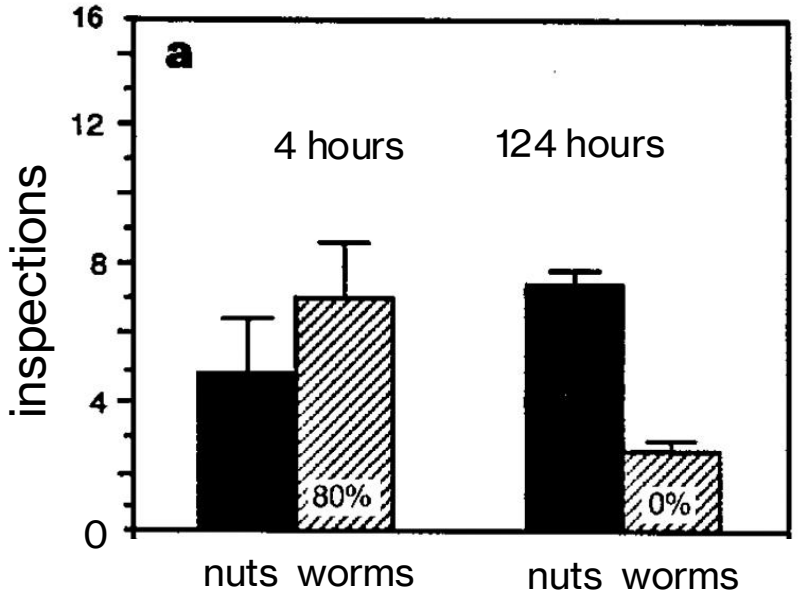
mental time travel: humans

- humans remember the past (episodic memory) and plan for the future (episodic future thinking, prospective memory)
- evidence for same brain networks
- “a crucial function of the brain is to use stored information to imagine, simulate and predict possible future events” (Schacter et al., 2007)



mental time travel: animals

- Clayton & Dickinson (1998) tested scrub jays
- pretraining: learned that worms degrade over time
- jays looked for worms when recovery was shortly after caching, but peanuts after significant time had passed
- inference: jays can remember what food they cached, where, and when

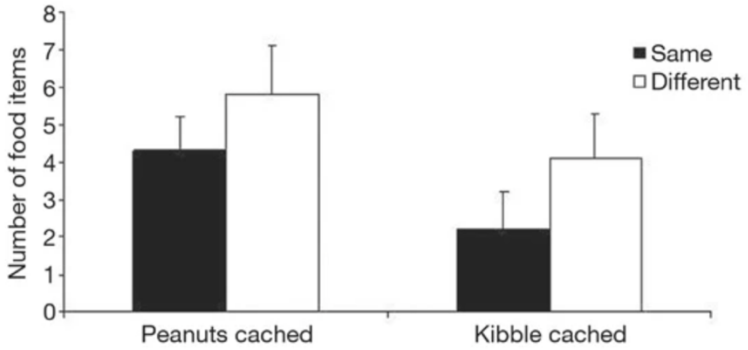


Mean number of inspections directed to the peanut and worm sides of the storage trays

mental time travel: animals

- Raby et al. (2007) tested 8 scrub jays
- two different compartments (peanut vs. kibble breakfast)
- after training, jays were unexpectedly given food to eat and cache in the evening
- jays cached the item they did not receive (i.e., a *different* item), i.e., evidence of future planning and preference for choice

Figure 2: Mean number of peanuts and kibble cached in the 'breakfast choice' experiment.



The scenario in which peanuts were cached in the 'peanuts-for-breakfast' compartment and kibble was cached in the 'kibble-for-breakfast' compartment is denoted as 'same'. The scenario in which peanuts were cached in the 'kibble-for-breakfast' compartment and kibble was cached in the 'peanuts-for-breakfast' compartment is denoted as 'different'. The jays cached significantly more items of the food type that was different to the food that they had previously received for breakfast in that compartment relative to the number of items they cached of the food that was the same as they received for breakfast in that compartment ($F_{(1,8)} = 5.48$; $P = 0.047$). There was no overall difference between the amount of food cached in each compartment ($F < 1$), nor did the jays cache either food type more than the other overall ($F_{(1,8)} = 2.29$, non-significant), ($n = 9$). Error bars, ± s.e.m.

mental time travel: machines

- techniques such as hippocampal replay (critical for memory consolidation) and memory are being actively incorporated into artificial agents

Towards mental time travel: a hierarchical memory for reinforcement learning agents

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DeepMind podcast

tool use: animals

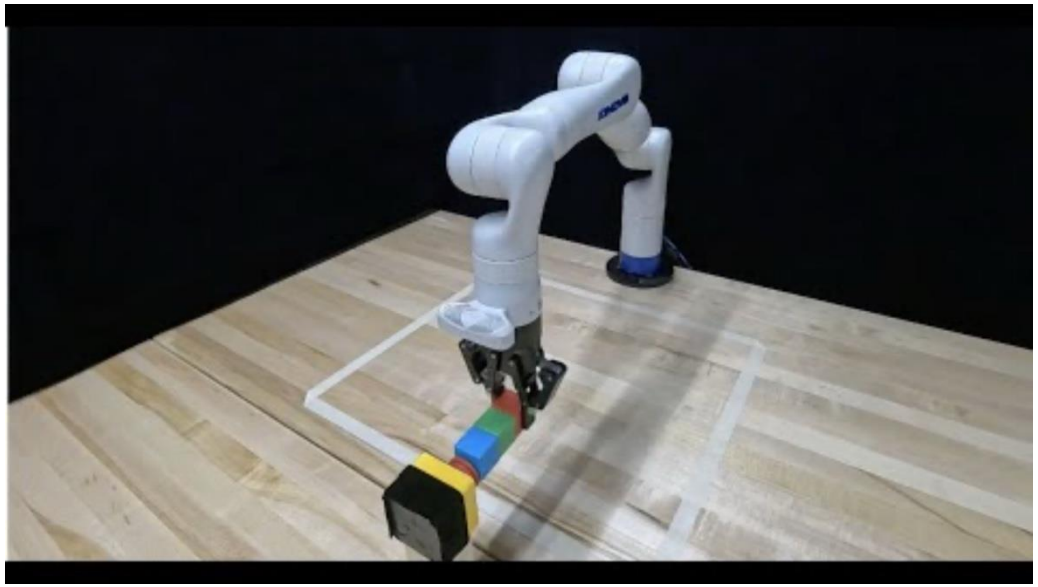
- what qualifies as a tool has been difficult to nail down
  - “a tool [should] be unattached to the substrate”
- several animals exhibit “tool use” when the definitions are relaxed but most of it is stereotypical, not “flexible”
- innovative tool use is strongly correlated with brain size in both birds and primates

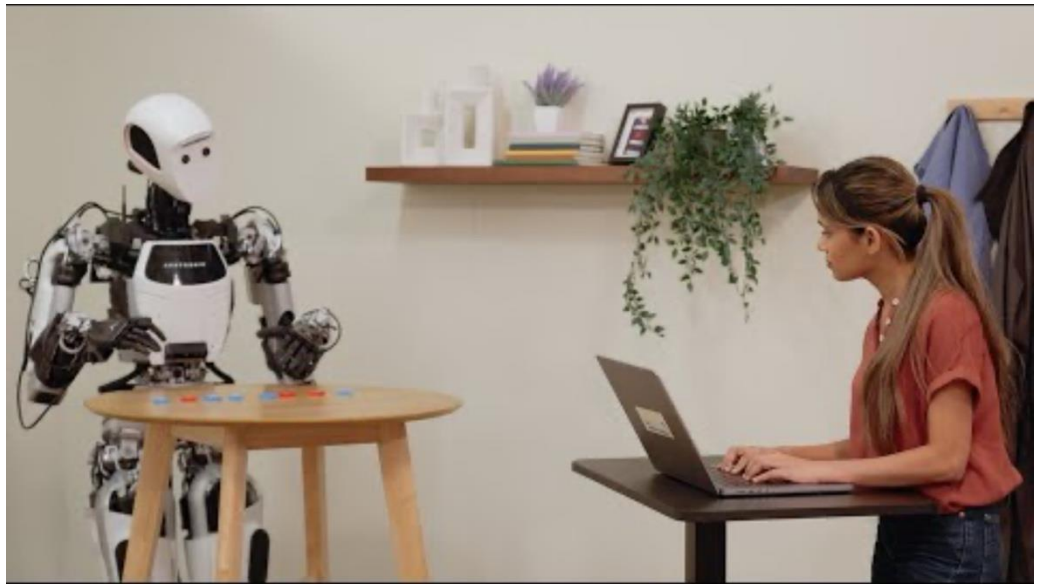
https://youtu.be/KFbqeVXzra0

https://youtu.be/UZM9GpLXepU

https://youtu.be/Y2EboVOcikI

tool use: machines





https://youtu.be/ikZeU3wKVjM

problem solving: animals

Prof. Alison Miller

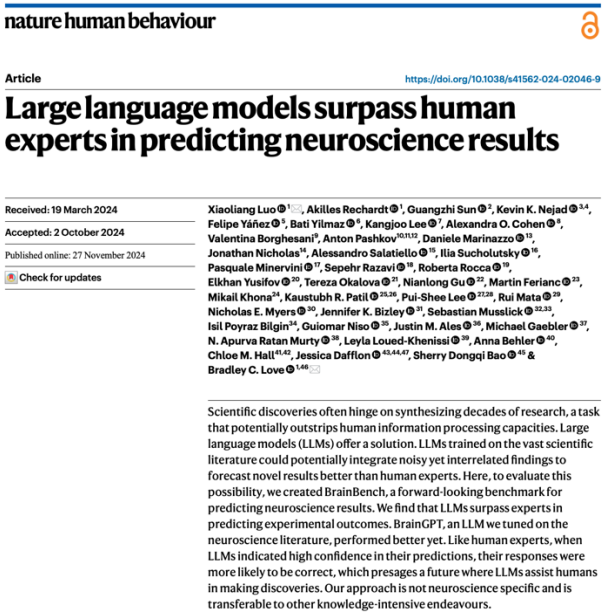
- most early work was in primates, but now, lots of work in birds, dolphins, etc.
  - first-order relations (same/different): chimps, monkeys, rats, bees
  - second-order relations (X:Y::A:??): chimps
- causal understanding is harder to demonstrate in animals (chimps and corvids)
- play seems to be critical in encouraging problem solving, and species that engage in play seem to be better problem solvers

https://youtu.be/fPz6uvlbWZE

https://youtu.be/cbSu2PXOTOc

problem solving: machines

- increasingly, we see more and more examples of novel problems being solved by AI models
- but...each problem requires training, data, and typically human input



nature human behaviour

Article

https://doi.org/10.1038/s41562-024-02046-9

Large language models surpass human experts in predicting neuroscience results

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Check for updates

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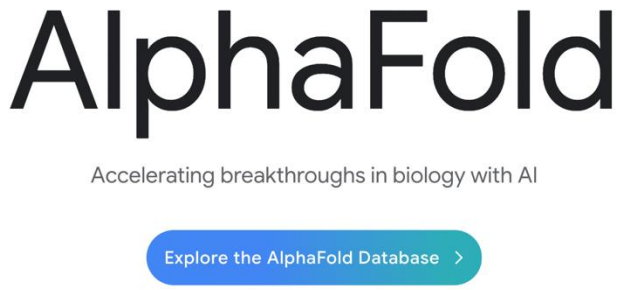
Scientific discoveries often hinge on synthesizing decades of research, a task that potentially outstrips human information processing capacities. Large language models (LLMs) offer a solution. LLMs trained on the vast scientific literature could potentially integrate noisy yet interrelated findings to forecast novel results better than human experts. Here, to evaluate this possibility, we created BrainBench, a forward-looking benchmark for predicting neuroscience results. We find that LLMs surpass experts in predicting experimental outcomes. BrainGPT, an LLM we tuned on the neuroscience literature, performed better yet. Like human experts, when LLMs indicated high confidence in their predictions, their responses were more likely to be correct, which presages a future where LLMs assist humans in making discoveries. Our approach is not neuroscience specific and is transferable to other knowledge-intensive endeavours.



https://www.youtube.com/watch?v=gg7WjuFs8F4

https://deepmind.google/research/breakthroughs/

complex social cognition: animals

- chimpanzees struggle to cooperate outside of preferred groups (Melis et al., 2006), will typically not distribute rewards equally (Jensen et al., 2006), and abandon tasks after receiving their reward (Tomasello 2009)
- humans are more cooperative, imitate actions more faithfully, heavily rely on teaching, and show a wider breadth of behaviors indicative of CCE

complex social cognition: machines

From a multi-agent perspective, CTF requires players to both successfully cooperate with their teammates as well as compete with the opposing team, while remaining robust to any playing style they might encounter.

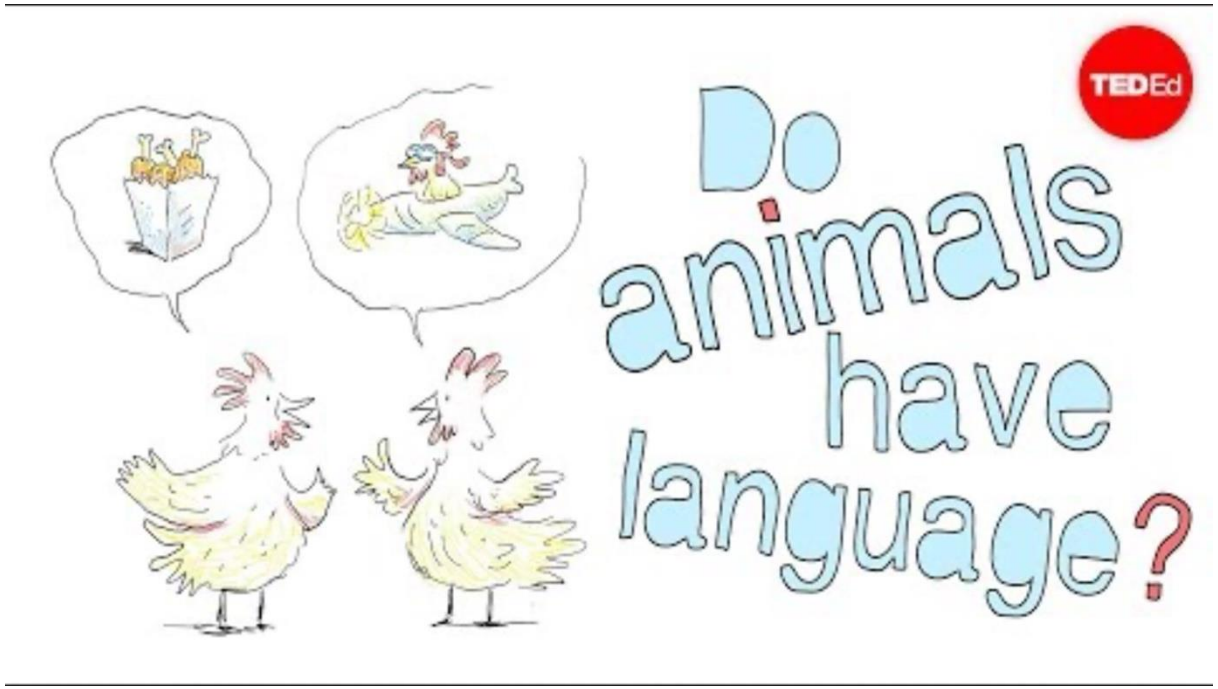
To make things even more interesting, we consider a variant of CTF in which the map layout changes from match to match. As a consequence, our agents are forced to acquire general strategies rather than memorising the map layout. Additionally, to level the playing field, our learning agents experience the world of CTF in a similar way to humans: they observe a stream of pixel images and issue actions through an emulated game controller.

Our agents must learn from scratch how to see, act, cooperate, and compete in unseen environments, all from a single reinforcement signal per match: whether their team won or not. This is a challenging learning problem, and its solution is based on three general ideas for reinforcement learning:

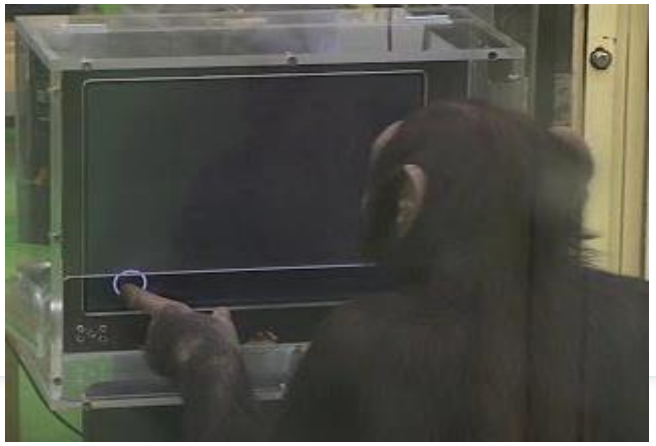
- Rather than training a single agent, we **train a population of agents**, which learn by playing with each other, providing a diversity of teammates and opponents.
- Each agent in the population **learns its own internal reward signal**, which allows agents to generate their own internal goals, such as capturing a flag. A **two-tier optimisation process** optimises agents' internal rewards directly for winning, and uses reinforcement learning on the internal rewards to learn the agents' policies.
- Agents **operate at two timescales**, fast and slow, which improves their ability to use memory and generate consistent action sequences.

DeepMind article

communication: humans vs. animals



working memory



Working memory of numerals in chimpanzees

Sana Inoue, Tetsuro Matsuzawa ✉

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https://doi.org/10.1016/j.cub.2007.10.027 ↗

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Summary

Chimpanzee memory has been extensively studied 1, 2. The general assumption is that, as with many other cognitive functions, it is inferior to that of humans [3]; some data, however, suggest that, in some circumstances, chimpanzee memory may indeed be superior to human memory [4]. Here we report that young chimpanzees have an extraordinary working memory capability for numerical recollection — better even than that of human adults tested in the same apparatus following the same procedure.

Do young chimpanzees have extraordinary working memory?

Notes and Comment | Published: August 2010

Volume 17, pages 599–600, (2010) Cite this article

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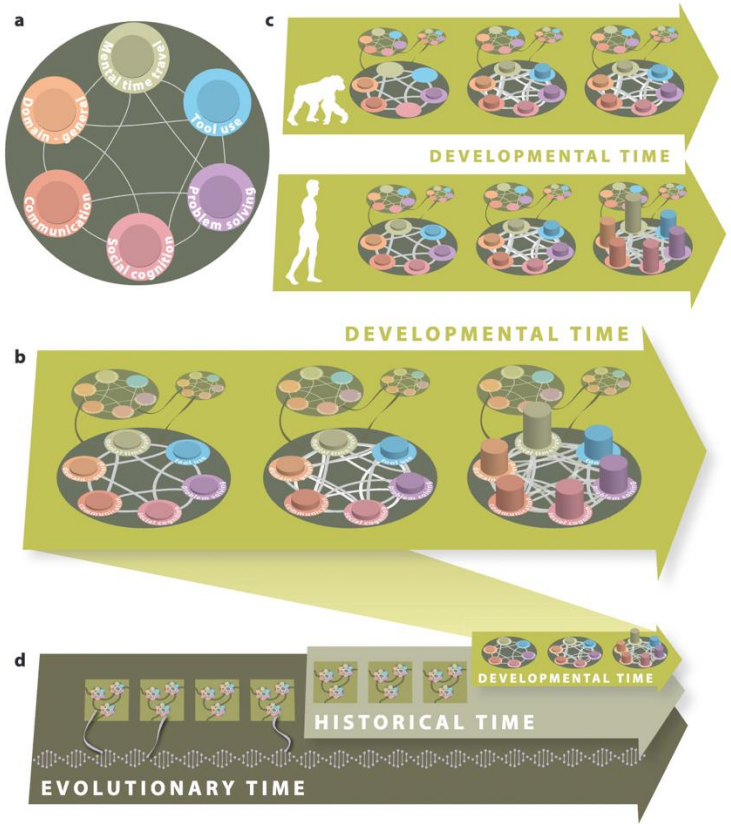
Peter Cook ✉ & Margaret Wilson

Abstract

Do chimpanzees have better spatial working memory than humans? In a previous report, a juvenile chimpanzee outperformed 3 university students on memory for briefly displayed digits in a spatial array (Inoue & Matsuzawa, 2007). The authors described these abilities as extraordinary and likened the chimpanzee's performance to eidetic memory. However, the chimpanzee received extensive practice on a non-time-pressured version of the task; the human subjects received none. Here we report that, after adequate practice, 2 university students substantially outperformed the chimpanzee. There is no evidence for a superior or qualitatively different spatial memory system in chimpanzees.

domain general thinking?

- “similarities between humans and other animals in signatures of working memory such as duration of retention, ability to resist interference, and active rehearsal of information (e.g., Brady & Hampton 2018, Lind et al. 2015, Roberts & Santi 2017, Völter et al. 2018).” (Laland & Seed 2021, p. 702)
- But...human brains are bigger, more connected, have more newer brain areas



paper

intelligence on a continuum

- “While the origin of human cognition is not explained by a single magic bullet, key innovations such as joint attention and language could have been game changers that integrated and greatly enhanced the performance of other elements of human cognition” (Laland & Seed, 2021; p. 704)
- “We may not be the only innovators, tool makers, or general-process thinkers in the animal kingdom, nor are we alone in possessing culture and rich collaboration, but we do ***excel*** in all these regards.” (Laland & Seed, 2021; p. 705)

paper

W14 reflection prompt 2

- On Canvas
- when do humans *not* excel?
- now reflect on aspects of cognition that humans may not necessarily excel at, and perhaps non-human animals or machines excel at

intelligence on a continuum

Trends in Cognitive Sciences

CellPress REVIEWS

Series: Machine Behavior

Opinion

Understanding Human Intelligence through Human Limitations

Thomas L. Griffiths[1,2,*]

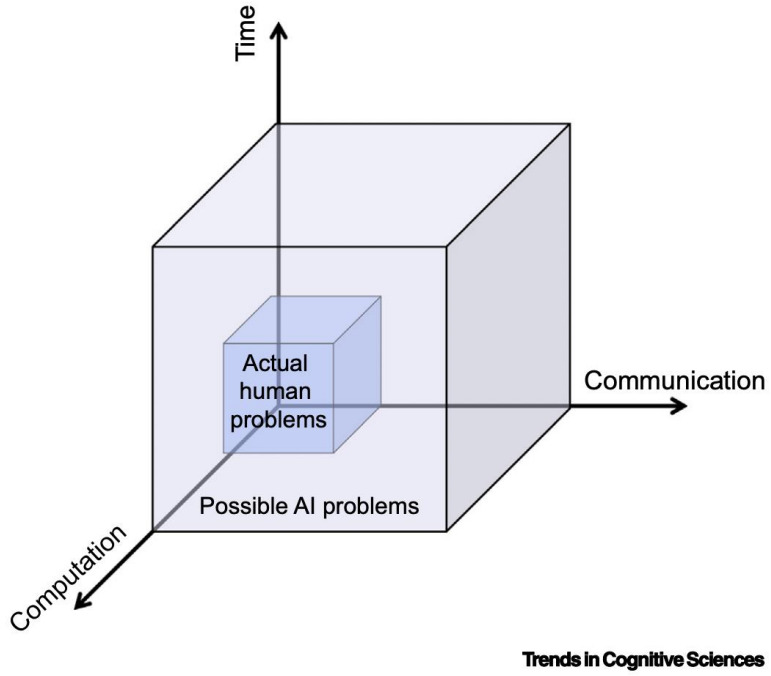
Recent progress in artificial intelligence provides the opportunity to ask the question of what is unique about human intelligence, but with a new comparison class. I argue that we can understand human intelligence, and the ways in which it may differ from artificial intelligence, by considering the characteristics of the kind of computational problems that human minds have to solve. I claim that these problems acquire their structure from three fundamental limitations that apply to human beings: limited time, limited computation, and limited communication. From these limitations we can derive many of the properties we associate with human intelligence, such as rapid learning, the ability to break down problems into parts, and the capacity for cumulative cultural evolution.

Highlights

Humans are limited in time, computation, and communication, defining a set of computational problems that human intelligence has to solve.

Considering the structure of these computational problems can help us to understand why human minds have some of the characteristics that they do.

The solutions to these problems involve mathematical formalisms such as Bayesian inference and meta-learning, rational meta-reasoning, and distributed algorithms, which may be particularly relevant to cognitive science.



paper

beyond anthropocentrism

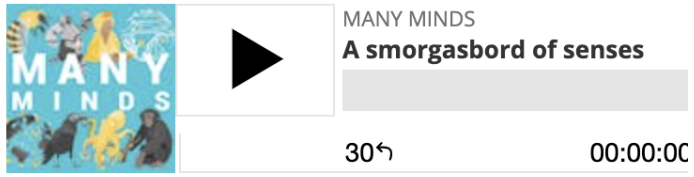
A hidden world of sound

Dec 14, 2022

Minding plants

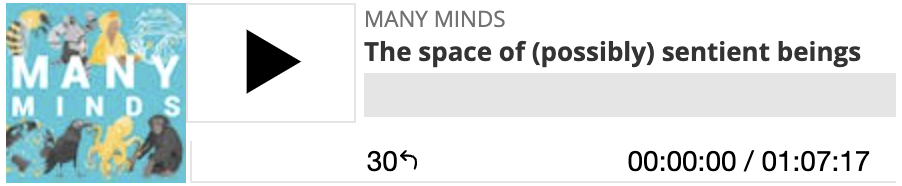
Apr 19, 2023

A smorgasbord of senses



Jul 20, 2022

The space of (possibly) sentient beings



Aug 22, 2024

exit ticket

Here are the to-do's for the week:

- Week 14 Exit Ticket (due Thursday)
- Week 14 Quiz (due Sunday)
- Post any lingering questions here
- Extra credit opportunities:
    - Submit Exra Credit Questions (1 point for 8 submissions)
    - Submit Optional Meme Submission (1 point for winners!)

Before Tuesday

- Submit your project presentation slides!

Before Thursday

- Submit your project presentation slides!