Certificate I: Understanding AI and Machine Learning in Africa

Course AIML01: Artificial Intelligence – Past, Present, and Future

Module 4: Future Challenges

Lecture 4: Intelligence, Brains, and Consciousness

Carnegie Mellon University
Africa

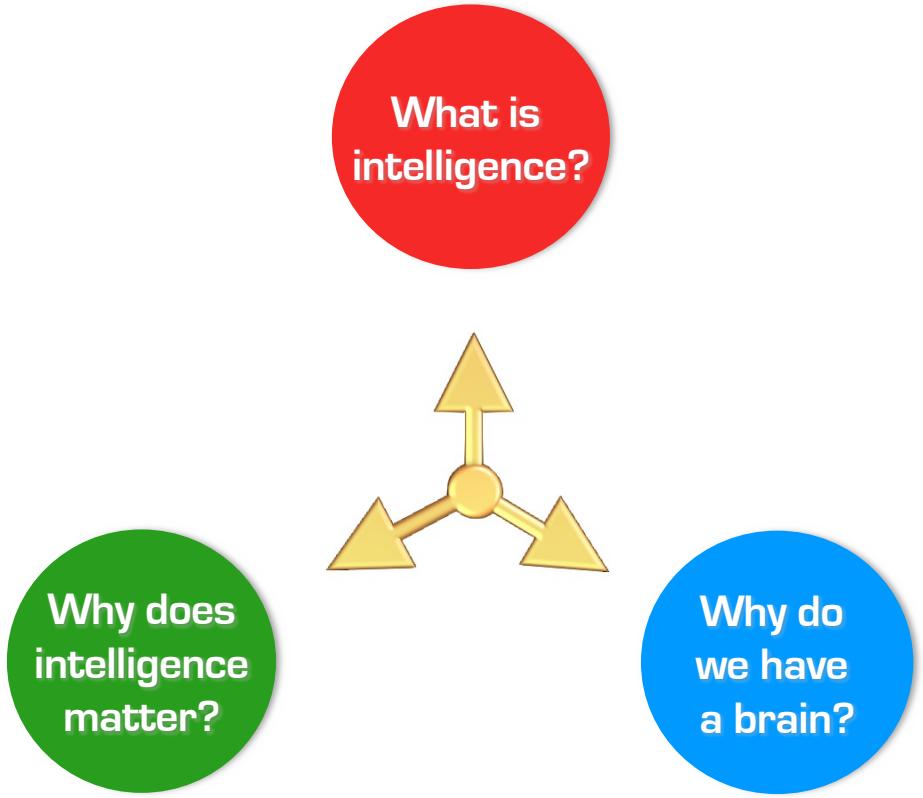
Learning Objectives

1. Explain what it means to be intelligent
2. Explain the reason we have brains
3. Discuss the predictive nature of the brain
4. Discuss the link between the quest to understand consciousness and the original motivation for studying artificial intelligence
5. Discuss what the future might hold as we pursue the challenge of designing artificially-intelligent autonomous systems

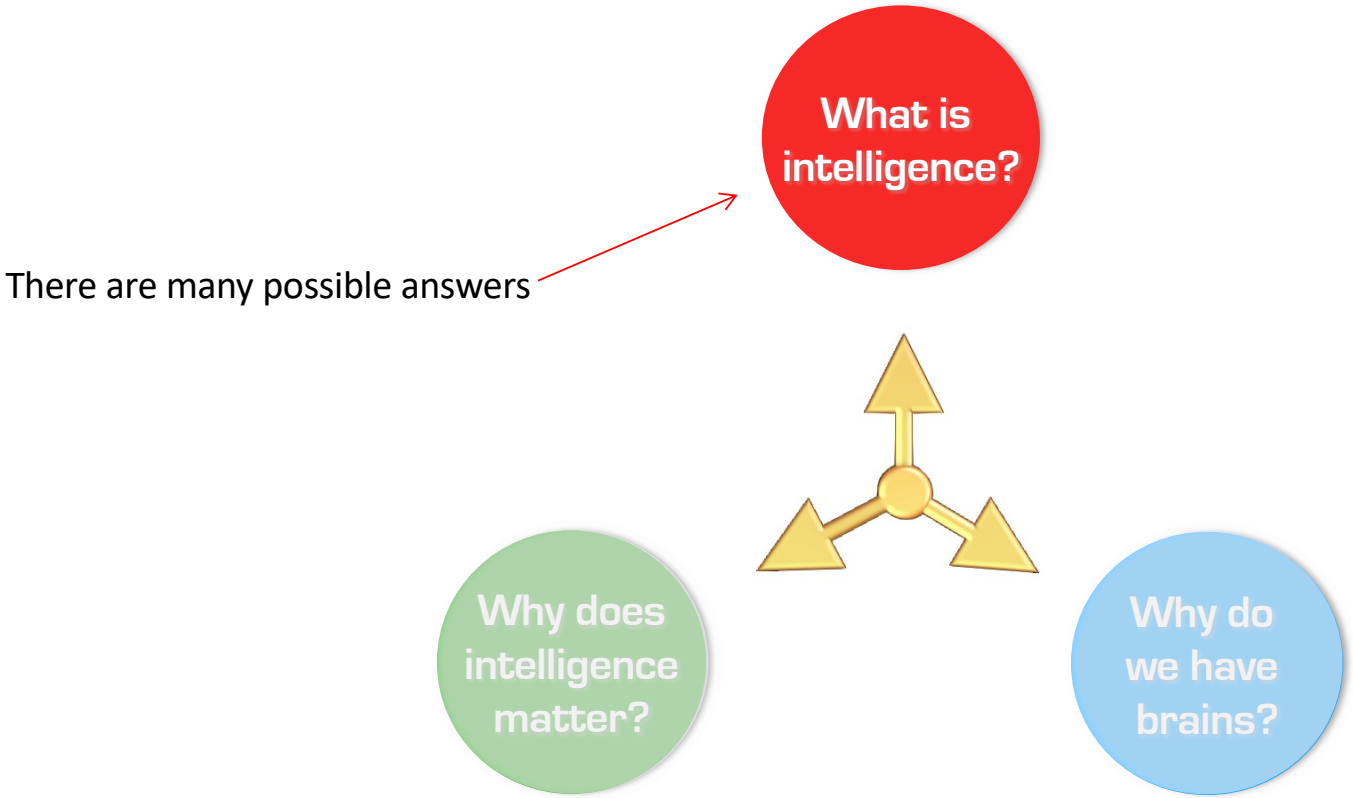
Lecture Contents

1. The nature of intelligence and function of the brain
2. The predictive nature of the brain
3. Consciousness
4. The future of AI
5. Lecture summary
6. Recommended reading & references

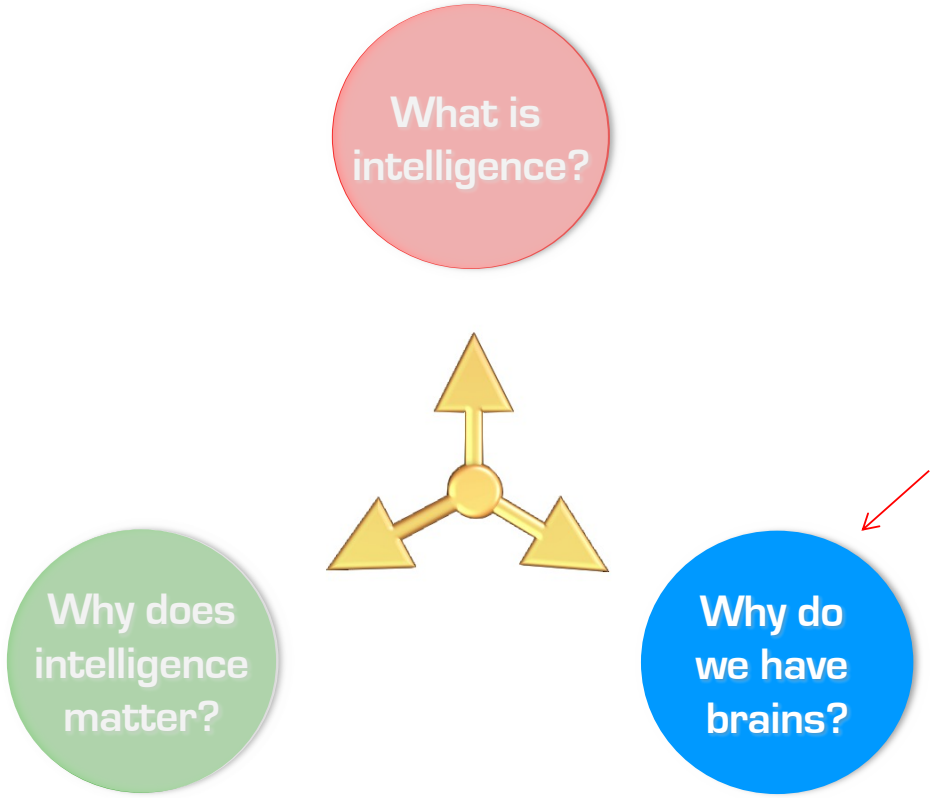
Intelligence and the Brain



Intelligence and the Brain

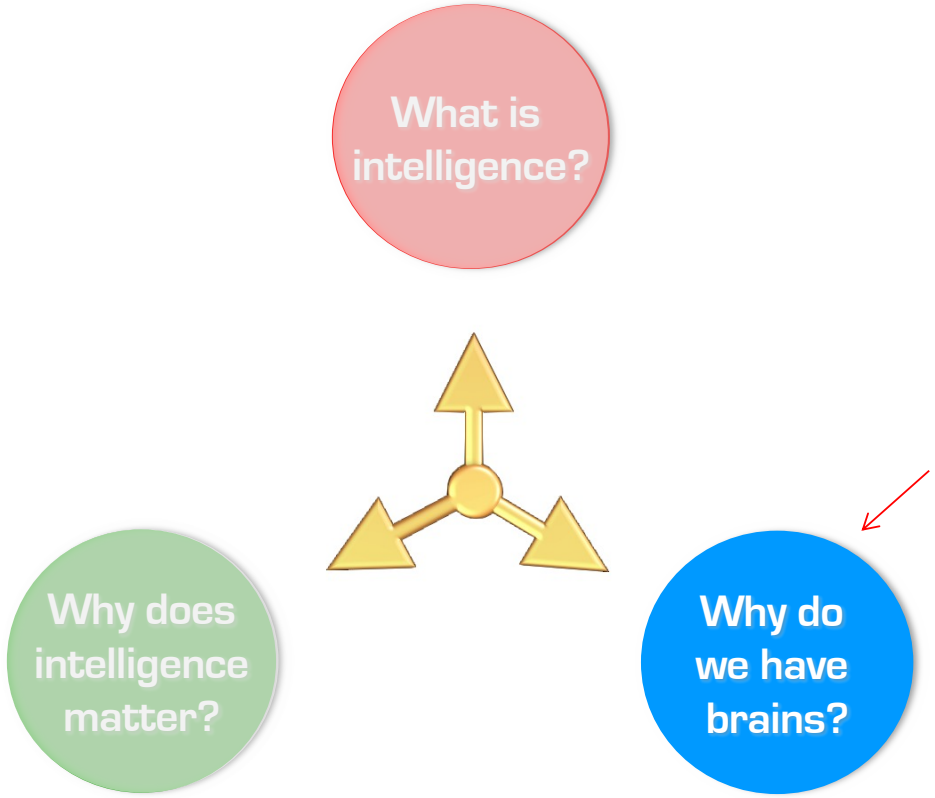


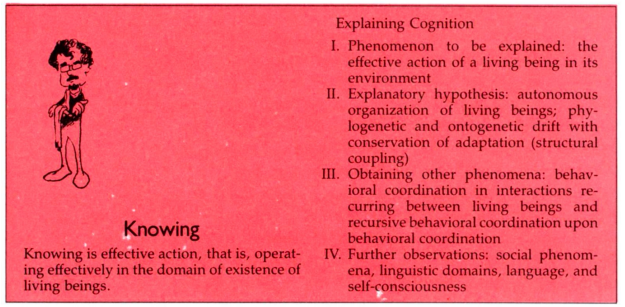
Intelligence and the Brain



We have brains to allow us to control movement (Wolpert, 2011)

Intelligence and the Brain

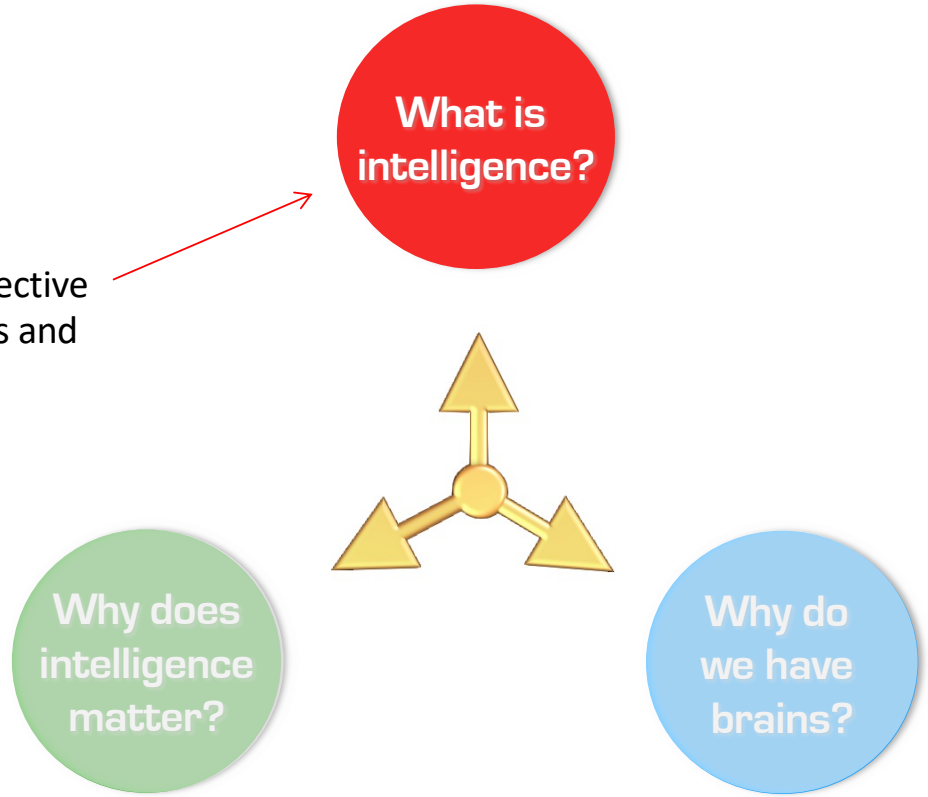




"Knowing is effective action"
(Maturana and Varela, 1987)

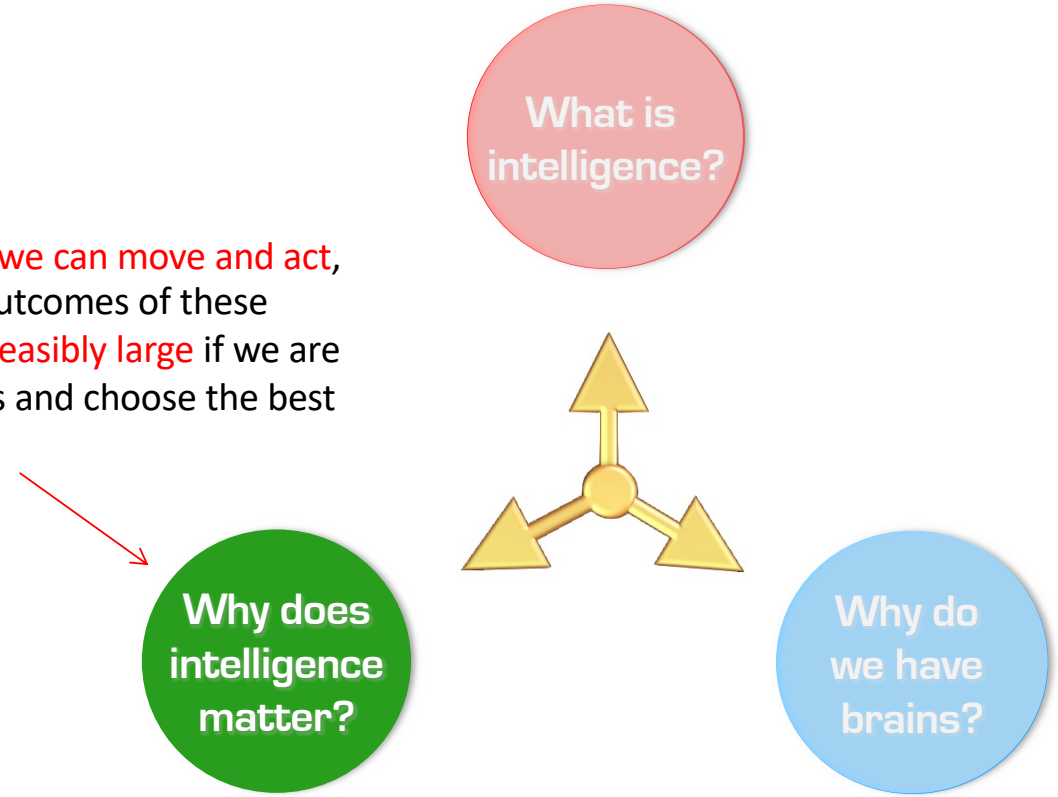
Intelligence and the Brain

Intelligence as the way to be effective in our control of our movements and in the way we act in the world

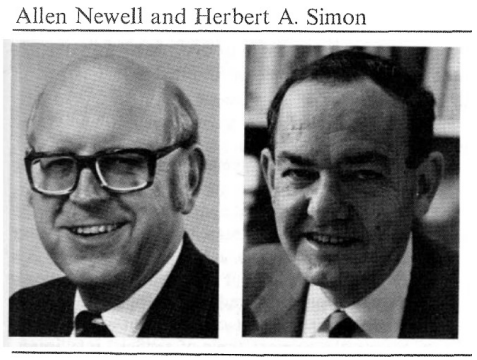


Intelligence and the Brain

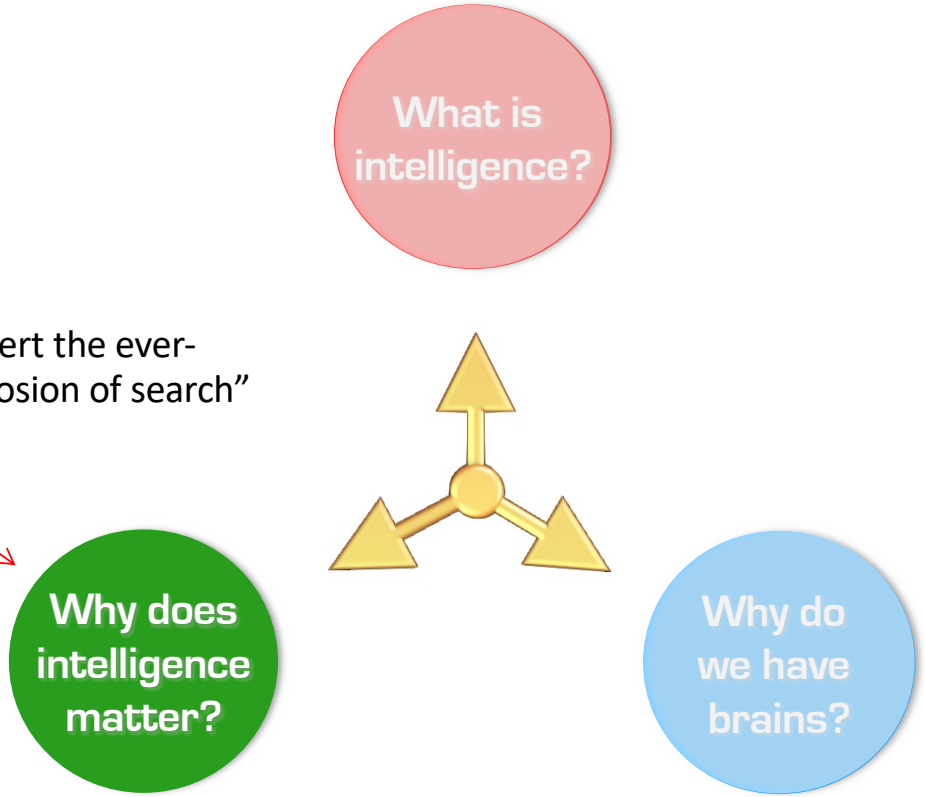
The number of possible ways we can move and act, and the number of possible outcomes of these movements and actions, is infeasibly large if we are to consider all the possibilities and choose the best one, or even a good one



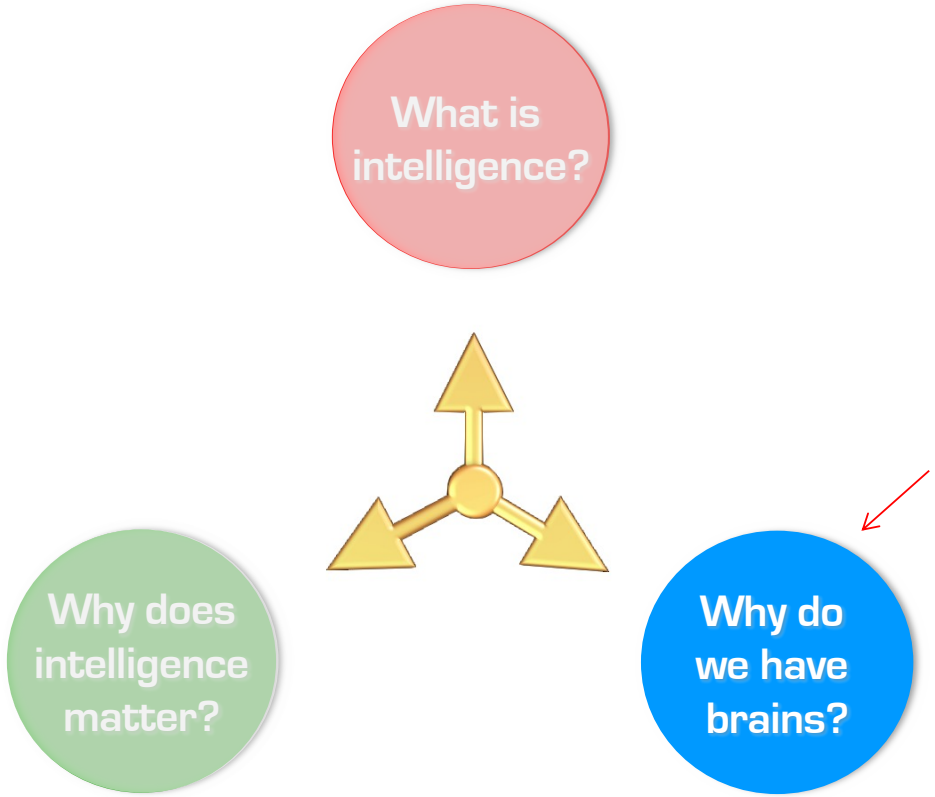
Intelligence and the Brain



"The task of intelligence, then, is to avert the ever-present threat of the exponential explosion of search" (Newell and Simon, 1976)

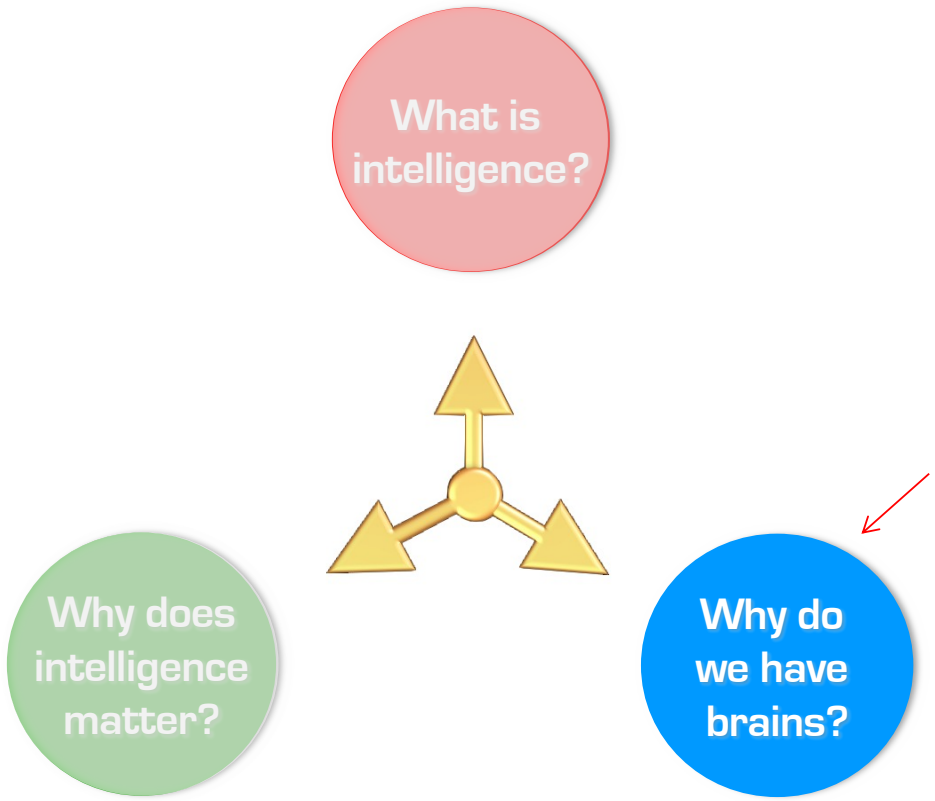


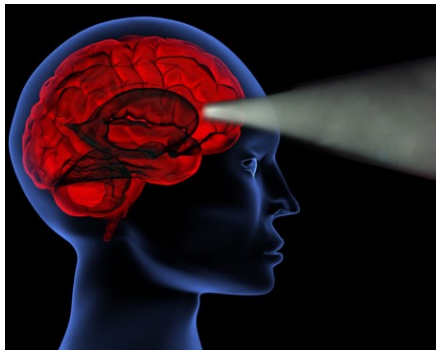
The Predictive Nature of the Brain



Brains also predict the need to act and the outcome of those actions, and they do so all the time, as we act and as we anticipate the future, milliseconds ahead, seconds ahead, hours, days, years

The Predictive Nature of the Brain





Future A

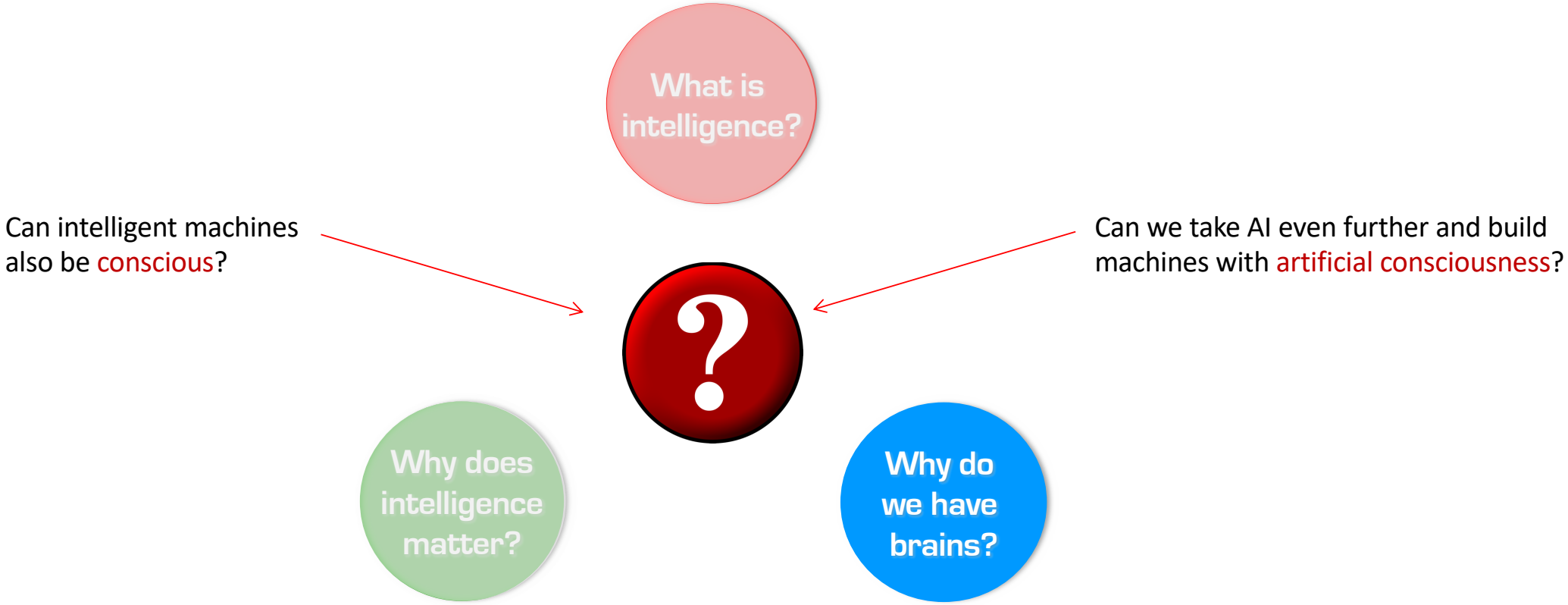
Future B

Future C

...

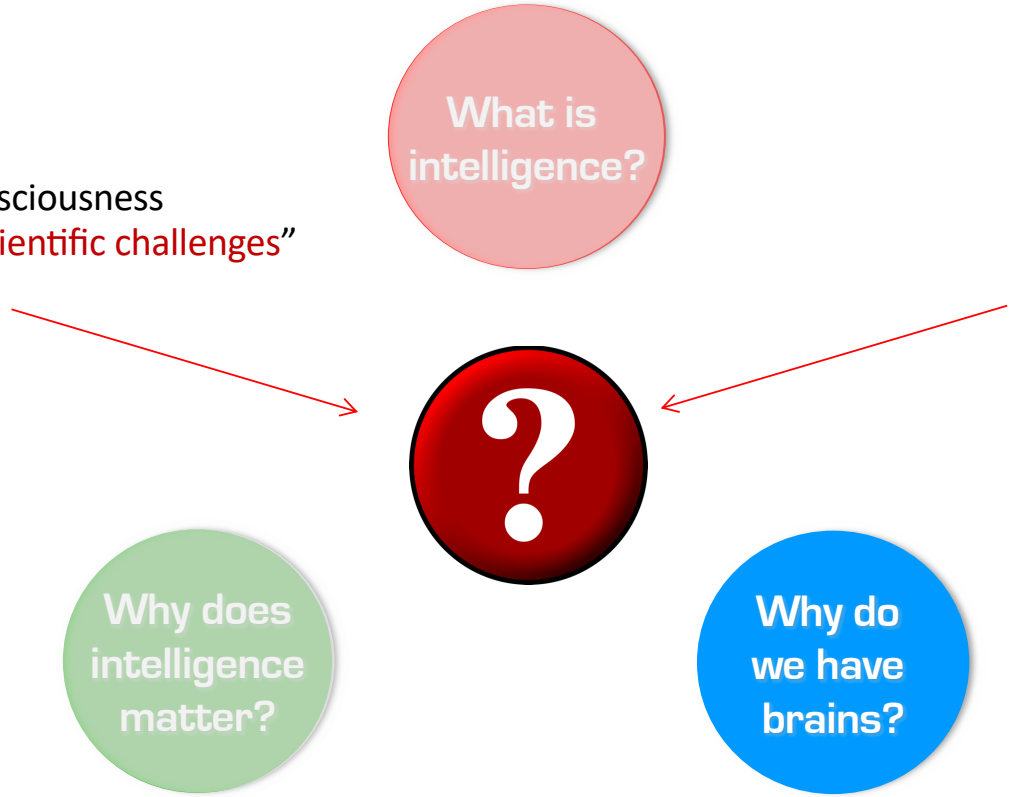
Brains are probabilistic prediction machines (Friston, 2010; Downing, 2009; Seth, 2015).

Consciousness



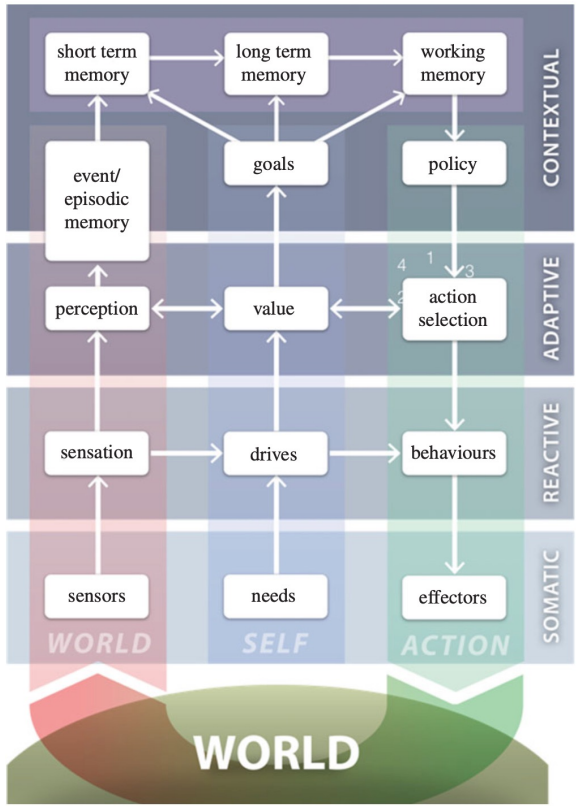
Consciousness

"Understanding the nature of consciousness
is one of the grand outstanding scientific challenges"
(Verschure, 2016).



What is consciousness?
How can physical systems give rise to it?

Consciousness



Synthetic consciousness: the distributed adaptive control perspective
(Verschure, 2016)

The Birth of AI

The challenge of artificial consciousness is at the center of knowing what it is to be human

It has been the same for artificial intelligence since its inception over sixty-five years ago:

To understand human intelligence and use AI to support the way humans live, work, and relate to one another

(Moor, 2006)

Refer back to Lecture AIML01-01-02 The Early Years of AI

Lecture Summary

1. The brain allows agents to control their movements

2. Intelligence is the way to be effective in controlling our movement and the way we act in the world

3. Intelligence allows us to consider how we can act most effectively, without having to search through the intractably-large number of choices

4. Brains can be viewed as probabilistic prediction machines

5. Understanding the nature of consciousness is one of the grand challenges of science and is closely linked to the challenge of creating artificial intelligence

Recommended Viewing

Wolpert D (2011) The Real Reason for Brains.

https://www.youtube.com/watch?v=7s0CpRfyYp8

Recommended Reading

Cangelosi A and Vernon D (2022). "Artificial Intelligence: Powering the Fourth Industrial Revolution", in *EPS Grand Challenges: Physics for Society at the Horizon 2050,* coordinated by the European Physical Society.

http://vernon.eu/publications/2022_Cangelosi_Vernon.pdf

Delmus Alupo C, Omeiza D, and Vernon D (2022) "Realizing the Potential of AI in Africa", in *Towards Trustworthy Artificial Intelligence Systems*, M. I. Aldinhas Ferreira, O. Tokhi (Eds.), Intelligent Systems, Control and Automation: Science and Engineering. Springer.

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https://open-mind.net/papers/the-cybernetic-bayesian-brain/at_download/paperPDF

Sun R (2016) Anatomy of the Mind: Exploring Psychological Mechanisms and Processes with the Clarion Cognitive Architecture. Oxford University Press.
https://oxford.universitypressscholarship.com/view/10.1093/acprof:oso/9780199794553.001.0001/acprof-9780199794553

Verschure PFMJ (2016) Synthetic consciousness: the distributed adaptive control perspective. Philosophical Transactions of the Royal Society of London, Series B 371.
https://royalsocietypublishing.org/doi/full/10.1098/rstb.2015.0448

Summary and Conclusion

We have reached the end of the course

We hope you enjoyed it

We will wrap up with a summary of the story of AI so far

and a brief insight into what might lie ahead

We present this as a narrative

We hope you will take the time to read it and reflect

Artificial intelligence impacts on all aspects of human activity:

it automates tasks, it assists with decision-making,
it augments and extends our cognitive capabilities,
and it can even operate autonomously, if we allow it,
without recourse to human oversight.

AI began as an attempt to understand and replicate human intelligence, initially taking two routes to that goal,
one via connectionism, and one via symbolic computationalism,
reflecting their inspiration by behaviorist and constructivist psychology, respectively.

These two approaches waxed and waned in their own respective ways over the decades, to be joined in the 1980s by machine learning and in the 1990s by statistical machine learning, probabilistic inference networks, and other established disciplines in computer science.

Breakthroughs in deep neural network learning and deep neural network topologies, aided by very large data sets and equally large increases in processing power, yielded great success in many application domains.

The symbolic knowledge representation and reasoning approach also developed rapidly, especially in cognitive architectures, as knowledge bases and ontologies increased greatly in size and sophistication.

The hybrid paradigm, combining symbolic approaches and sub-symbolic connectionist approaches, became prevalent, e.g., in cognitive architectures such as Soar (Laird, 2012), ACT-R (Anderson et al., 2004), CLARION (Sun, 2016), among others.

While the success of statistical machine learning in narrow targeted applications yielded great success, it did so at the expense of losing focus on AI's original goal of understanding and replicating human-level intelligence.

There has been a resurgence of interest in what is now known as Artificial General Intelligence (AGI) in cognitive science and cognitive systems. Still, the ultimate goal of replicating the versatility of human cognition remains elusive and it is unclear when it will be achieved.

What is certain is that the AI quest will continue and AI in its many guises will continue to permeate our lives, change them, hopefully for the better.

In seeking to steer the path to the future, it is likely that other strands of thinking will be woven into the fabric of AI, especially concerning the trustworthiness of AI in autonomous systems.

AI will play an important role in serving the bigger agenda of creating self-maintaining systems that can operate robustly and prospectively in the face of uncertainty and that can continually develop through self-programming as they interact with and learn from the world and the people in it.

While there is much important work yet to be done to promote the development of democratized, trustworthy, ethical AI in the developed and developing worlds, an equal challenge will be how to control the role of AI in autonomous systems, possibly conscious ones, where the relationship with humans is no longer symbiotic.

We are far from that point at present, but it is likely we will reach it, and everything will change quickly when we do.

In Ernest Hemingway's novel *The Sun Also Rises* there is a dialog between two characters which goes as follows.

“How did you go bankrupt?” Bill asked.
“Two ways,” Mike said.
“Gradually and then suddenly.”

And so too it will be with autonomous AI:
it will happen gradually and then suddenly.

Our collective responsibility is to work together in a directed manner during the present gradual phase so that,
when the full impact of AI is suddenly felt,
it will be for the greater good of all humankind.