Cognition

PSYC 2040

L5: Behaviorism / Then and Now

Part 2

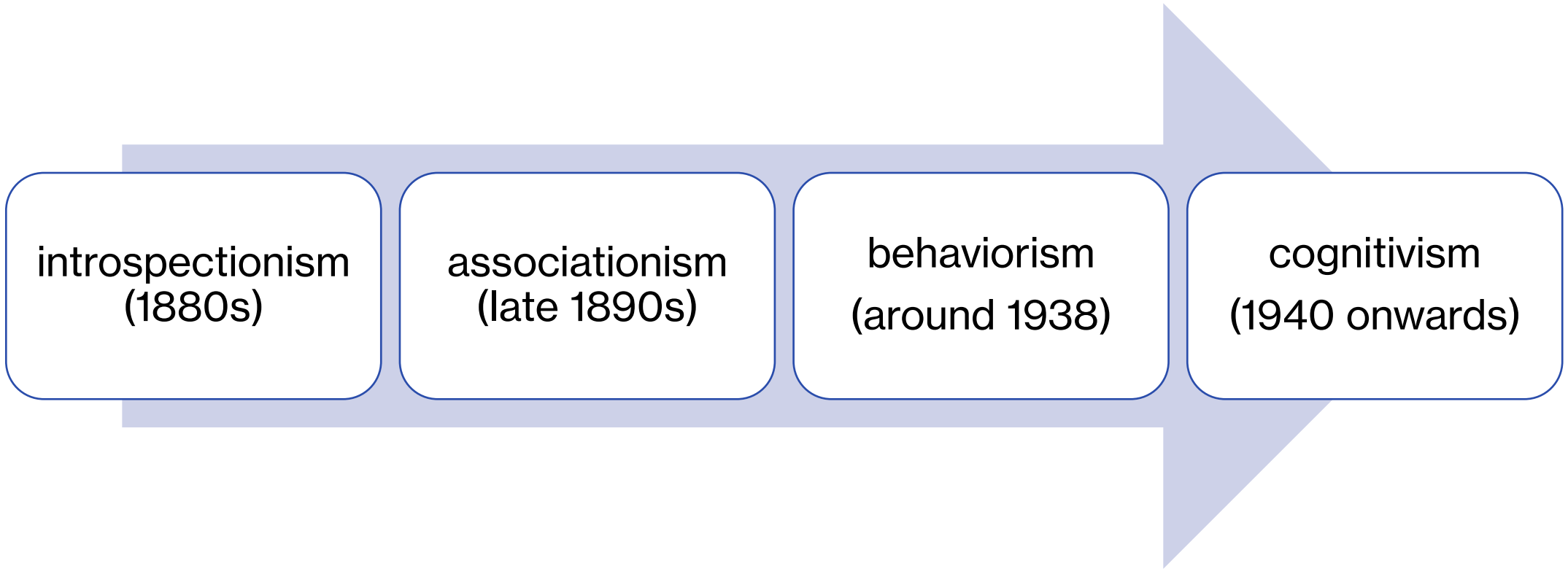
recap

- what we covered:
  - forms and flavors of behaviorism
- your to-dos were:
  - *finish:* L5 (behaviorism) chapter
  - *explore:* L5 writing assignments

today’s agenda

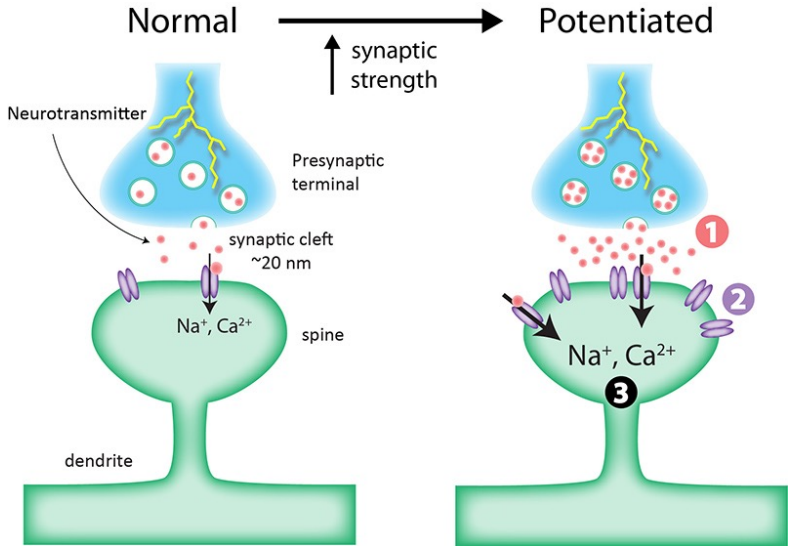
- connecting ideas (then to now)

the cognition timeline



associative learning

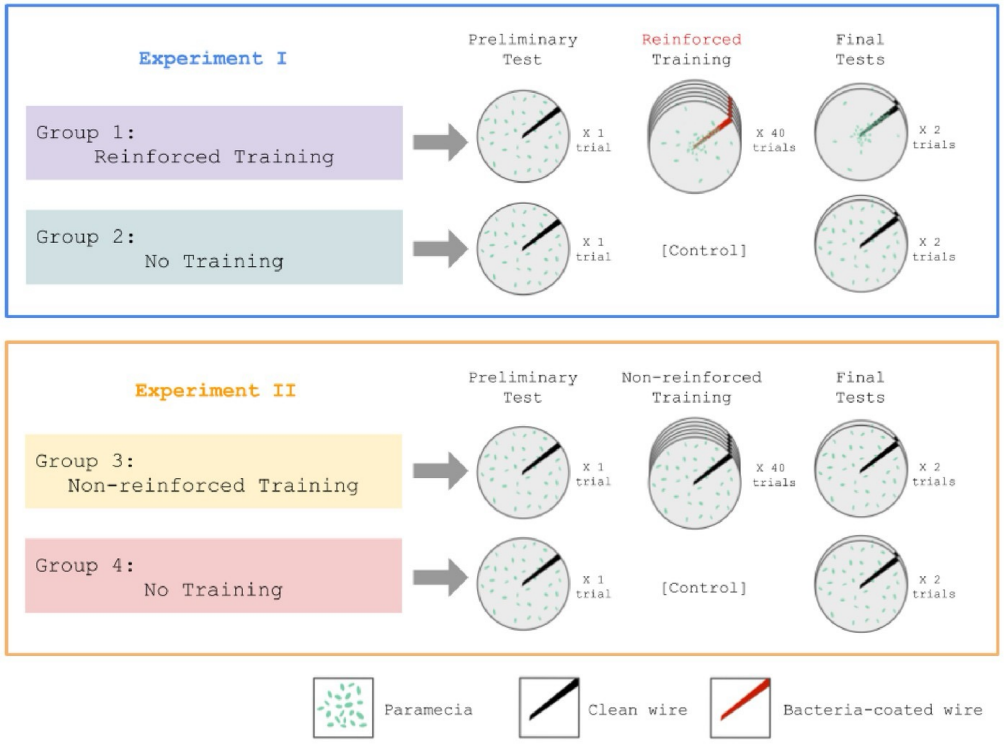
- original idea was that Pavlovian conditioning was about learning associations between two stimuli
- **how/where (implementation)**?
  - synaptic plasticity
  - “neurons that fire together wire together” / Hebbian learning: Dr. Carla Schatz
  - hardware / physical level explanation
- **inference**:
  - what is needed for associative learning?
  - who can demonstrate associative learning?



https://qbi.uq.edu.au/brain-basics/brain/brain-physiology/long-term-synaptic-plasticity

learning in unicellular organisms

- if Pavlovian learning can only be mediated by synaptic processes, unicellular organisms should not be able to demonstrate such learning
- no synapses => no learning!
- Beatrice Gelber's (1952) work with paramecia showed that these organisms demonstrated learning!



learning in unicellular organisms

- more recent work is revisiting these ideas...why?
- if not synapses, then what holds the key to memories / learning / cognition?
- can we extend from unicellular organisms to human cognition?

Review Article

Computational and Systems Biology, Neuroscience

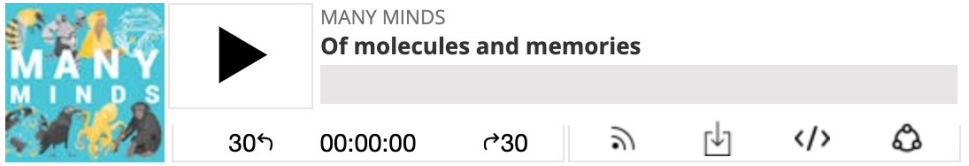
Reconsidering the evidence for learning in single cells

Samuel J Gershman, Petra EM Balbi, C Randy Gallistel, Jeremy Gunawardena

Department of Psychology and Center for Brain Science, Harvard University, United States; Center for Brains, Mind and Machines, MIT, United States; Department of Systems Biology, Harvard Medical School, United States; Rutgers Center for Cognitive Science, Rutgers University at New Brunswick, United States

Jan 4, 2021 · https://doi.org/10.7554/eLife.61907

Of molecules and memories



https://manyminds.libsyn.com/of-molecules-and-memories

levels of explanation

- biological explanations help ground higher-level explanations
- in the absence of biology, can we replicate behavior?
- what are the implications of such efforts?

Turing's "thinking" machines

- Alan Turing wrote a paper about whether or not machines can "think" in 1950 where he proposed the imitation game (AKA The Turing Test)
- the broad idea was that if a machine and a human are asked questions by a third interrogator, and the interrogator is unable to decipher which one is human and which is the machine
- the paper has been highly influential in setting the tone for AI as well as the study of cognition

let’s do a turing test!

- group 1: Amanda, Paul, Piper, Muzi, Emely, Michelle
- group 2: Jane, Mary, Anushka, Alex, Judith, Emily
- group 3: Cole, Laila, May, Miya, Thomas, Eoin
- group 4: Emilia, Nicholas, Yesfreily, Holliss, Naomi, Nate

let’s do a turing test!

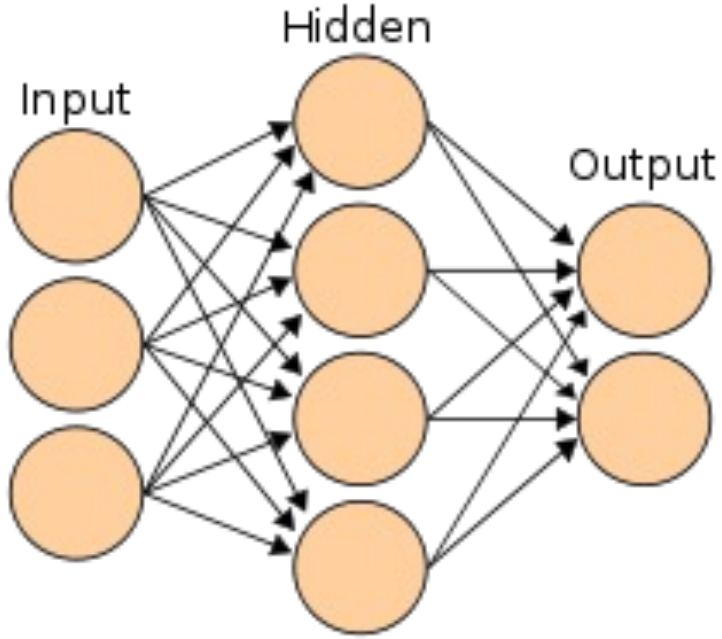
- can you spot the human vs. AI?
- view transcripts corresponding to your groups
- decide if LHS is human/AI and RHS is human/AI
- come back and debrief

behavior...is all we need?

- if a machine shows the exact same response as a human, can we say that it is thinking or has cognition? Why or why not?
- how do we go about building such a machine?

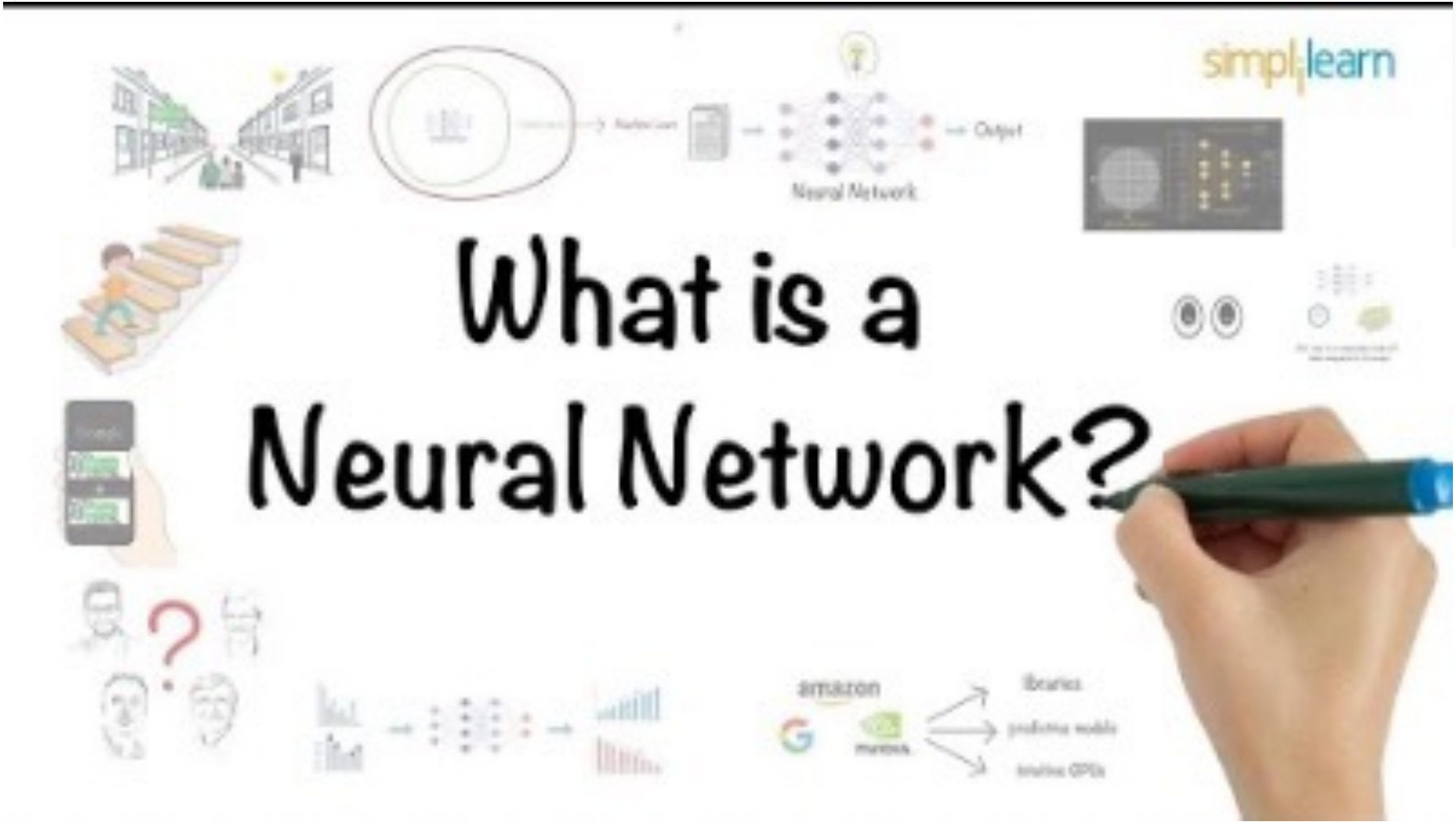
associative learning and connectionism

- connectionism was an approach to study cognition using mathematical models, inspired by the neuronal model of learning and ideas of association and behaviorism
- started around the 1950s with McColloch and Pitts' neuronal model, furthered by McClelland and Rumelhart in 1980s, continues to be relevant today
- basic idea: mental phenomena can be described through an interconnected network of units
  - units could represent neurons
  - connections could represent synapses
- learning can emerge through prediction



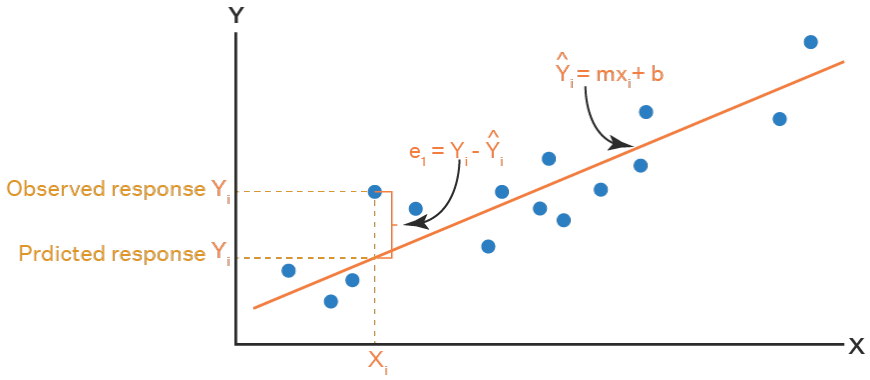
neural network activity

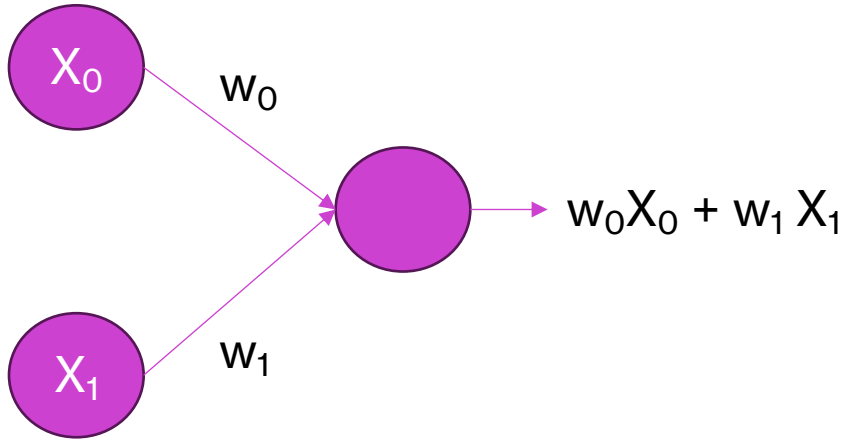
- test a neural network
- discuss your impressions
- what do you think it takes to recognize digits?


simplilearn
Neural Network
What is a
Neural Network?
amazon

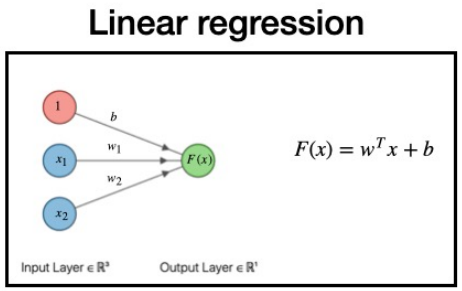
what is a neural network really?

- a function that is fit to a set of data
- example: fitting a line to a set of data, i.e., linear regression
  - $Y = a + bX$
  - $Y = w_0 + w_1 X_1$
  - $Y = w_0X_0 + w_1 X_1$ where $X_0 = 1$
- the neural network attempts to learn the values of w_0 and w_1 that best fit Y via prediction
- basic process: start at random values, produce a prediction and compute the prediction error, and adjust the future predictions accordingly until a minimum error threshold has been reached
- what it takes? MANY iterations
- what's the benefit? more complex/non-linear functions can be learned





from regression to neural networks...

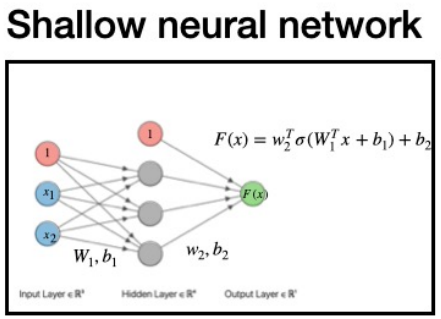


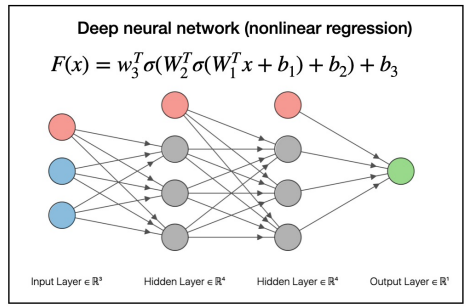
https://joshuagoings.com/2020/05/05/neural-network/

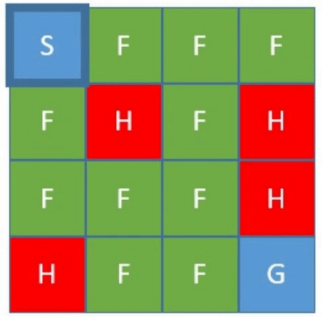
questions about neural networks

connectionism today

- deep learning
  - adding MANY intervening hidden layers to propagate activity
  - applications: vision/image recognition, language, speech, etc.
- reinforcement learning
  - learning through rewards that are coded via a mathematical function
  - applications: complex behavior (game play / cooperation / protein structure)







$$Q(s,a) = R(s,a) + \gamma \sum_{s'} \left(P\left(s,a,s'\right) \max_{a'} Q\left(s',a'\right) \right)$$

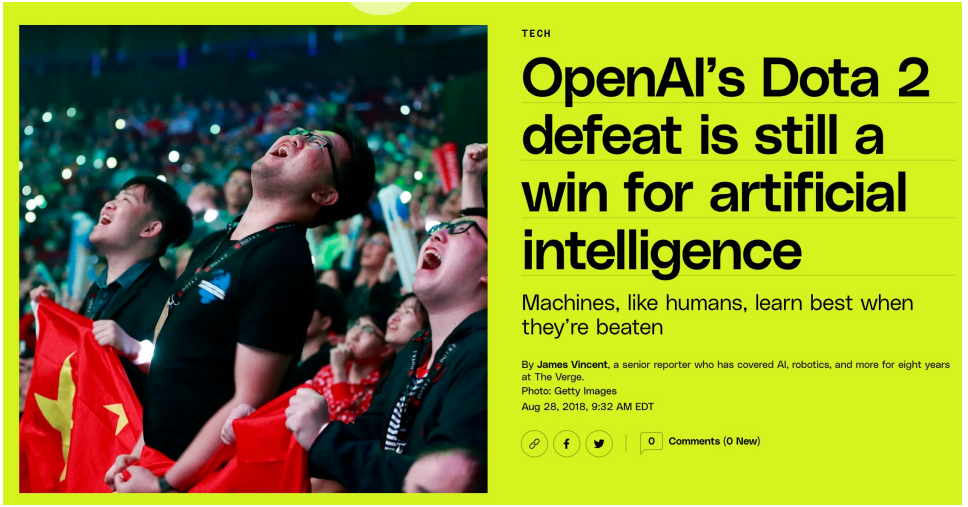
unlocking mysteries!

April 19, 2023

Reinforcement learning: from board games to protein design

A new protein design software adapts a strategy proven adept at board games like chess and Go.

Media Contact: Leila Gray, 206.475.9809, leilag@uw.edu



TECH

OpenAI's Dota 2 defeat is still a win for artificial intelligence

Machines, like humans, learn best when they're beaten

By **James Vincent**, a senior reporter who has covered AI, robotics, and more for eight years at The Verge.
Photo: Getty Images
Aug 28, 2018, 9:32 AM EDT

0 Comments (0 New)

Article | Published: 20 December 2023

Discovery of a structural class of antibiotics with explainable deep learning

Felix Wong, Erica J. Zheng, Jacqueline A. Valeri, Nina M. Donghia, Melis N. Anahtar, Satotaka Omori, Alicia Li, Andres Cubillos-Ruiz, Aarti Krishnan, Wengong Jin, Abigail L. Manson, Jens Friedrichs, Ralf Helbig, Behnoush Hajian, Dawid K. Fiejtek, Florence F. Wagner, Holly H. Soutter, Ashlee M. Earl, Jonathan M. Stokes, Lars D. Renner & James J. Collins

Nature **626**, 177–185 (2024) | Cite this article

38k Accesses | **3** Citations | **1906** Altmetric | Metrics

potential issues / concerns

- scale and nature of data
  - humans learn from significantly fewer examples
  - most powerful NNs are trained on a single modality
- biases and risks
- is the Turing test, i.e., behavior sufficient?

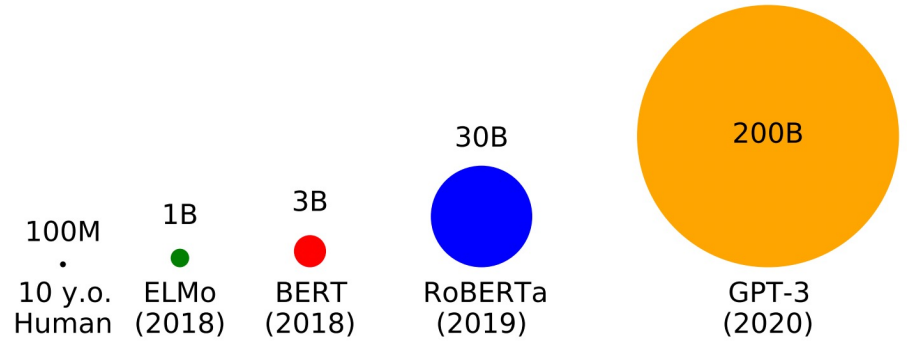


Figure 1: Comparison of human and model linguistic input (# of word tokens).

On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? 🦜

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The Aether

a thought experiment

- Searle (1999) Chinese room argument / also Harnad (1990)
- Imagine a native English speaker who knows no Chinese locked in a room full of boxes of Chinese symbols (a data base) together with a book of instructions for manipulating the symbols (the program). Imagine that people outside the room send in other Chinese symbols which, unknown to the person in the room, are questions in Chinese (the input). And imagine that by following the instructions in the program the man in the room is able to pass out Chinese symbols which are correct answers to the questions (the output). The program enables the person in the room to pass the Turing Test for understanding Chinese but he does not understand a word of Chinese.

another thought experiment

- The Octopus Test, Bender and Koller (2020)
- Imagine that person A and B are independently stranded on two deserted islands, but they can communicate with each other via an underwater cable and often send text messages in english to each other. Without either person A or B's knowledge another entity O (a very clever octopus) who cannot speak english but has a very advanced knowledge of statistics and pattern matching. After some very long time, O decides to cut the wire so that they can speak directly to each person. The question is, could O have learned enough from the form (the text messages) so that neither person knows that anything has changed?

big takeaways

- understanding cognition is a complex puzzle!
- understanding the mental processes that contribute to behavior, starting from the stimulus being presented, is a first step
- AI is also an interesting approach with multiple uses, one of which may be ideas/signals about how humans learn, but important differences exist between the two

next class

- **before** class:
  - *finish:* L5 quiz + writing assignments
  - *read:* L6 (information processing) chapter
- **during** class:
  - the rise of cognitivism via information processing