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Virtual Brains, Minds and Machines Summer Course 2020



Tomaso Poggio
Course Director



Boris Katz
Course Director



Gabriel Kreiman
Course Director

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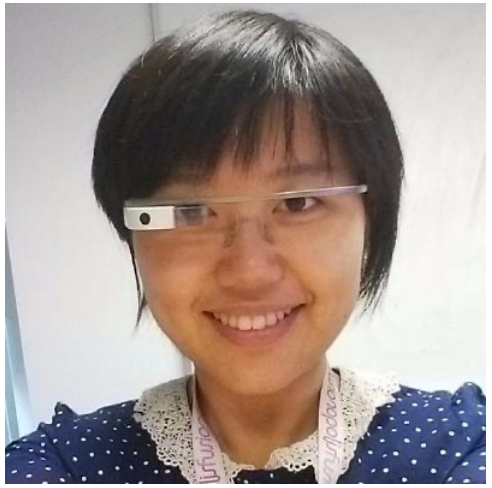
Kathleen Sullivan
Managing Director



Kris Brewer
Director of Technology



Andrei Barbu
Course Head TA



Mengmi Zhang
Course Head TA



Lizanne DiStefano
External Evaluator

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Some relevant links and resources

Information about the summer course:
https://cbmm.mit.edu/summer-school/2020

Links to resources posted by the speakers:
https://cbmm.mit.edu/summer-school/2020/resources

Poster presentations:
https://cbmm.mit.edu/summer-school/2020/poster-sessions

CBMM Learning Hub:
https://cbmm.mit.edu/learning-hub



Ellen Hildreth
Coordinator for Education



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Discussion Panels

Monday 10th.	Hilbert questions in AI
Wednesday 12th.	What is the Relationship Between Biological Brains and AI?
Friday 14th.	Is There Anything Special About Human Intelligence?
Monday 17th.	AI and ethics
Wednesday 19th.	The Path Towards General AI

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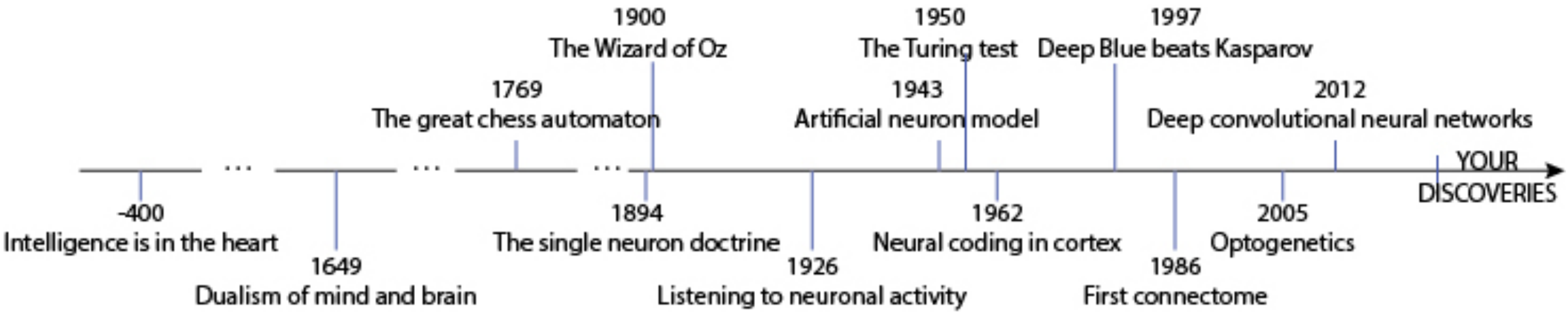
A brief history of AI and Neuroscience



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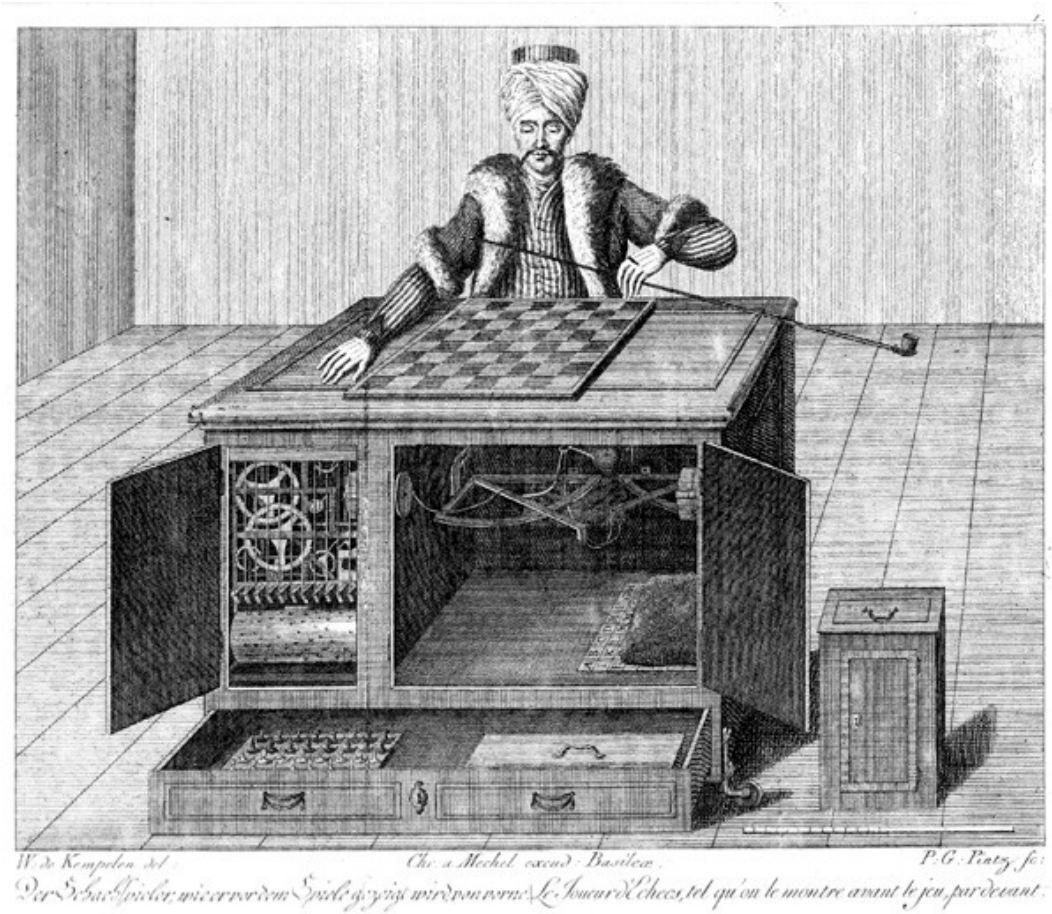
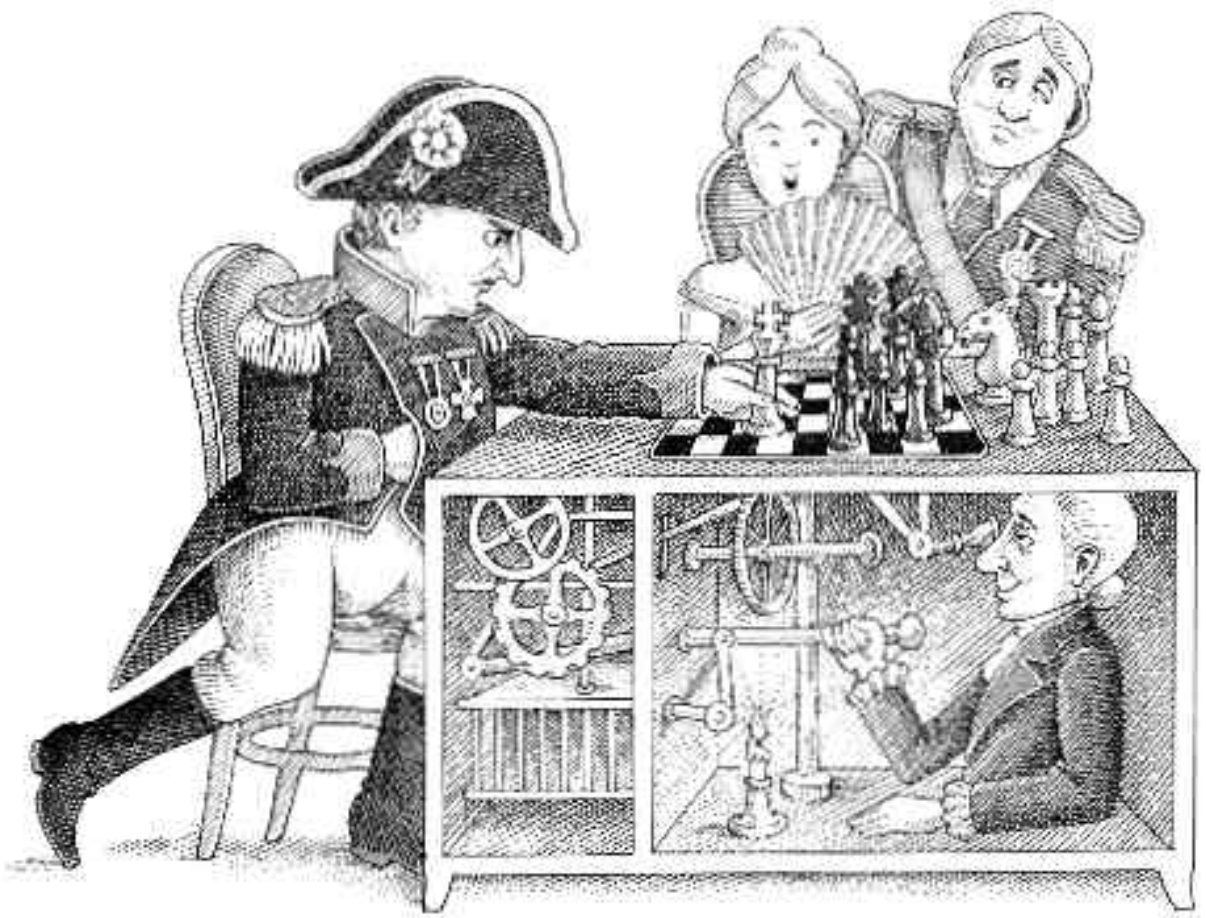
“AI”. 1769: Great Chess Automaton





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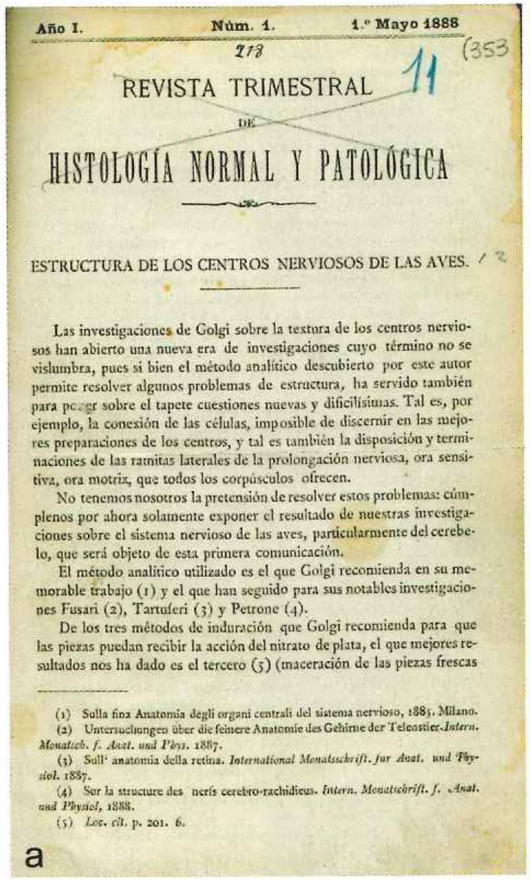
Neuroscience. 1894: The neuron

1894: New ideas on the fine anatomy of the nerve centres



Ramon y Cajal



Año I. Núm. 1. 1.º Mayo 1888

REVISTA TRIMESTRAL

DE

HISTOLOGÍA NORMAL Y PATOLÓGICA

ESTRUCTURA DE LOS CENTROS NERVIOSOS DE LAS AVES.

Las investigaciones de Golgi sobre la textura de los centros nerviosos han abierto una nueva era de investigaciones cuyo término no se vislumbra, pues si bien el método analítico descubierto por este autor permite resolver algunos problemas de estructura, ha servido también para poner sobre el tapete cuestiones nuevas y dificilísimas. Tal es, por ejemplo, la conexión de las células, imposible de discernir en las mejores preparaciones de los centros, y tal es también la disposición y terminaciones de las ramitas laterales de la prolongación nerviosa, ora sensitiva, ora motriz, que todos los corpúsculos ofrecen.

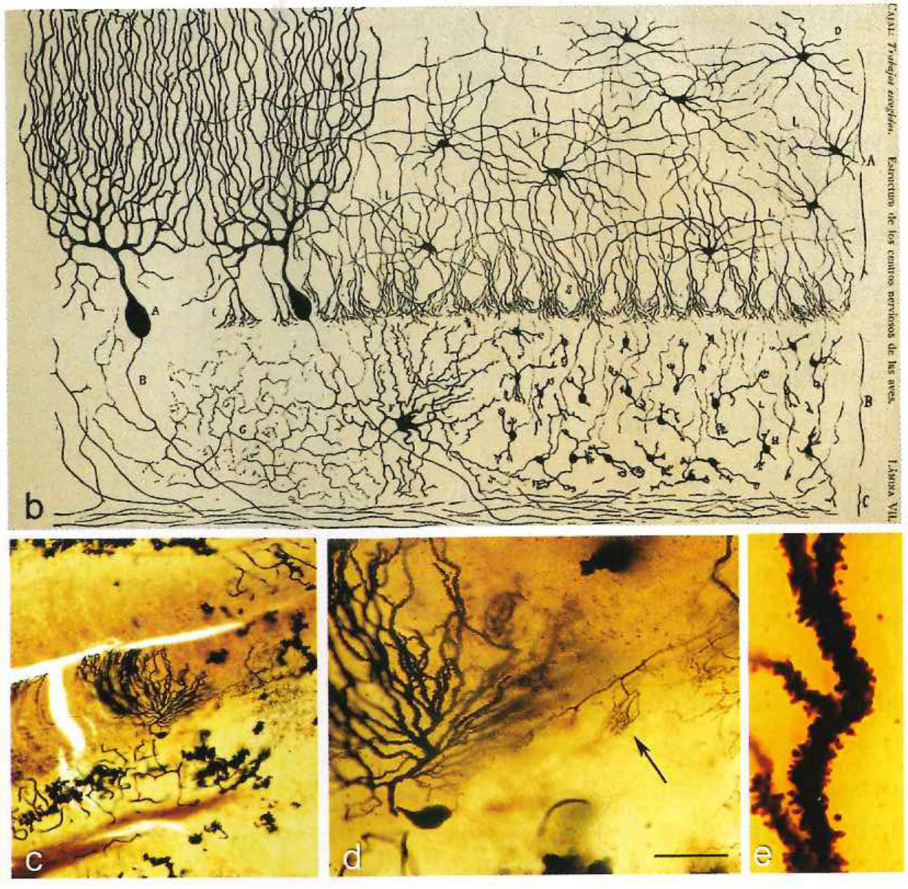
No tenemos nosotros la pretensión de resolver estos problemas: cúmplenos por ahora solamente exponer el resultado de nuestras investigaciones sobre el sistema nervioso de las aves, particularmente del cerebelo, que será objeto de esta primera comunicación.

El método analítico utilizado es el que Golgi recomienda en su memorable trabajo (1) y el que han seguido para sus notables investigaciones Fusari (2), Tartuferi (3) y Petrone (4).

De los tres métodos de inducración que Golgi recomienda para que las piezas puedan recibir la acción del nitrato de plata, el que mejores resultados nos ha dado es el tercero (5) (maceración de las piezas frescas

(1) Sulla fina Anatomia degli organi centrali del sistema nervioso, 1885, Milano.
(2) Untersuchungen über die feinere Anatomie des Gehirne der Teleostier. *Intern. Monatsch. f. Anat. und Phys.* 1887.
(3) Sull' anatomia della retina. *International Monatsschrift. fur Anat. und Physiol.* 1887.
(4) Sur la structure des nerfs cerebro-rachidiens. *Intern. Monatschrift. f. Anat. und Physiol.* 1888.
(5) *Loc. cit.* p. 201. 6.

a



b

c

d

e

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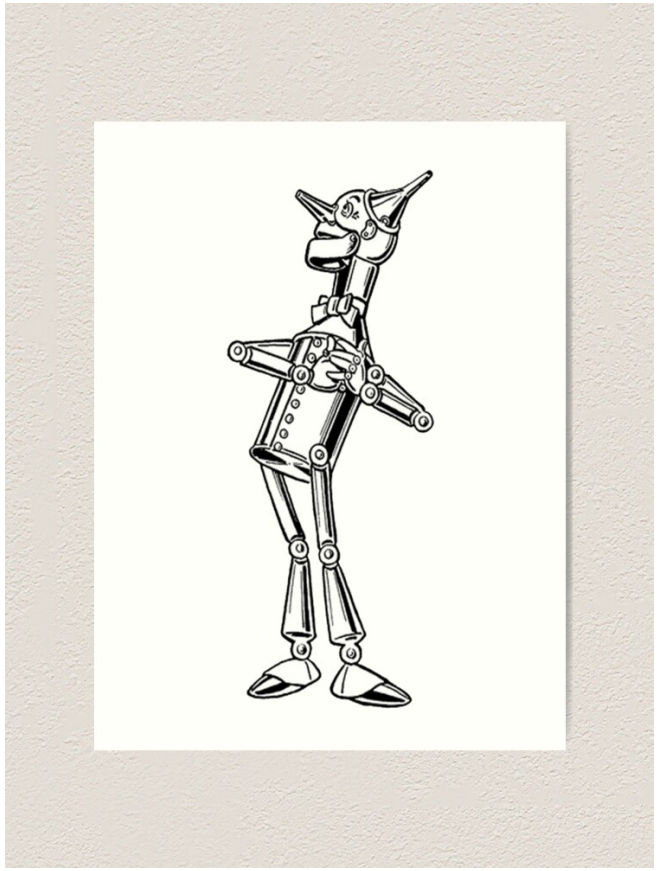
AI. Early 1900s: Proliferation of fiction

1900: The Wizard of Oz



1927: Metropolis



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Neuroscience. 1926: Scrutinizing neurons



Edgar Adrian

Journal of Physiology, 1926

THE IMPULSES PRODUCED BY SENSORY NERVE-ENDINGS. Part 2. The response of a Single End-Organ.

By E. D. ADRIAN and YNGVE ZOTTERMAN[1].

(*From the Physiological Laboratory, Cambridge.*)

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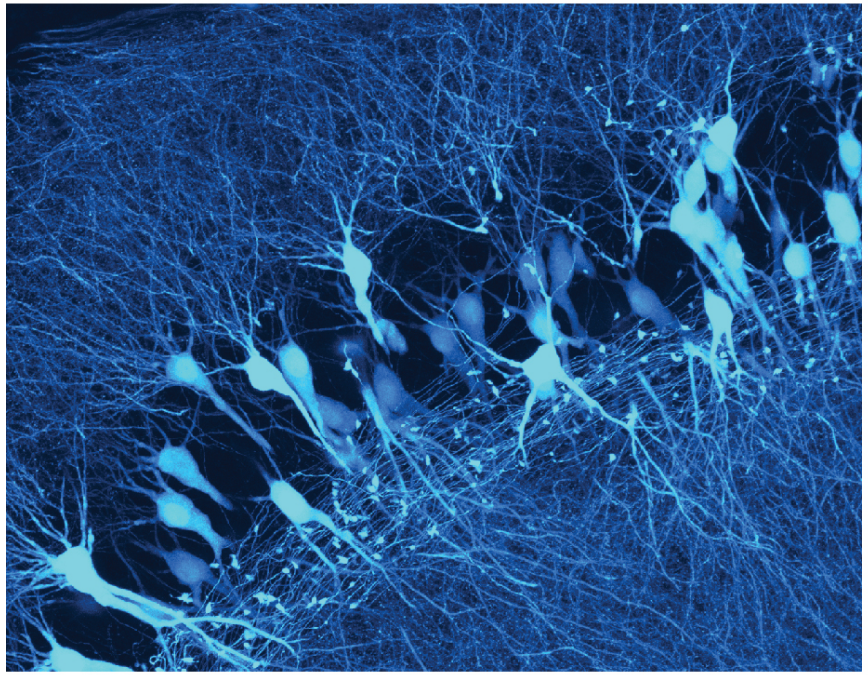
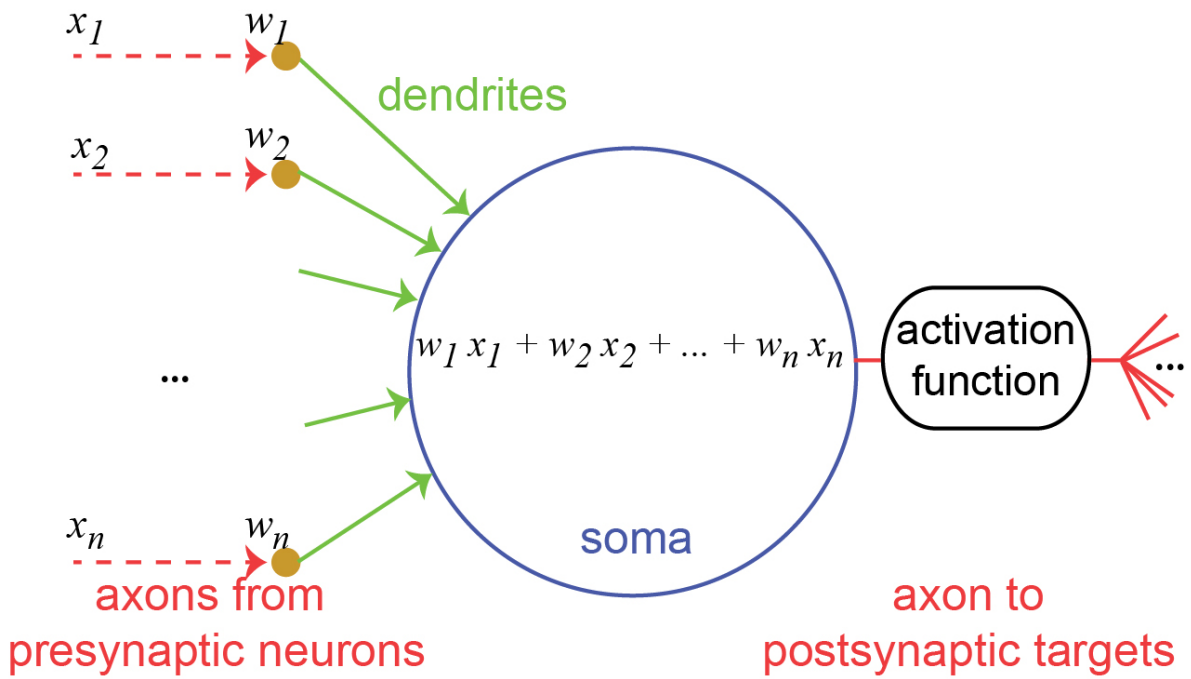
AI and Neuroscience. 1943: Beginning of the dialogue

1943
The McCulloch-Pitts model of a neuron

A



B



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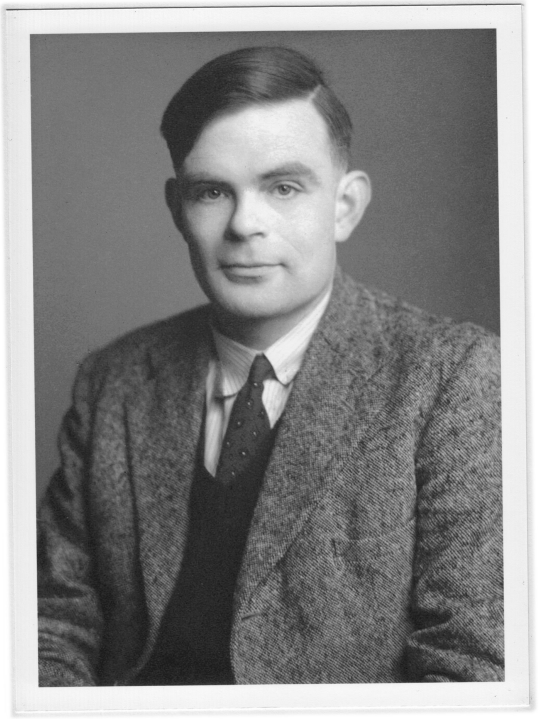
AI. 1950: The Turing test



A. M. Turing (1950) Computing Machinery and Intelligence. *Mind 49:* 433-460.

COMPUTING MACHINERY AND INTELLIGENCE

By A. M. Turing

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AI. 1956: The Dartmouth Conference

1956: Dartmouth Summer Research Project on Artificial Intelligence



Including
Claude Shannon, John McCarthy,
Marvin Minsky, Ray Solomonoff,
Nathaniel Rochester

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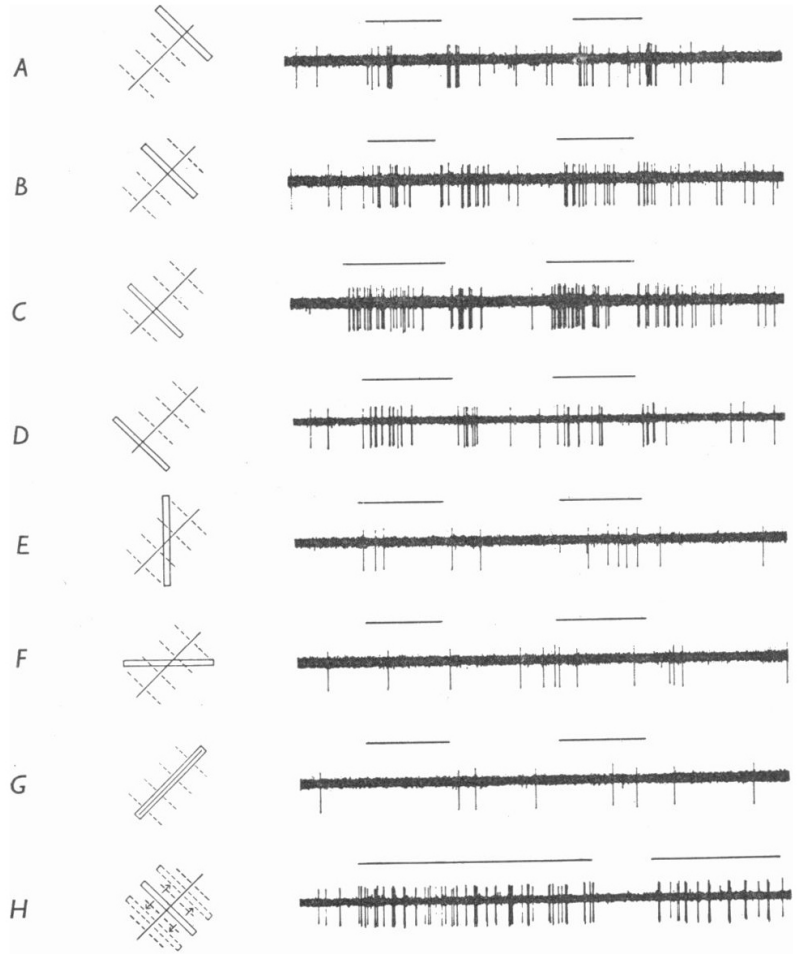
Neuroscience. 1962: Neural code for vision



Hubel and Wiesel
Journal of Physiology, 1962



Text-fig. 4. Responses of a cell with a complex field to stimulation of the left



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AI. 1966. The optimism of youth

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PROJECT MAC

Artificial Intelligence Group
Vision Memo. No. 100.

July 7, 1966

THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

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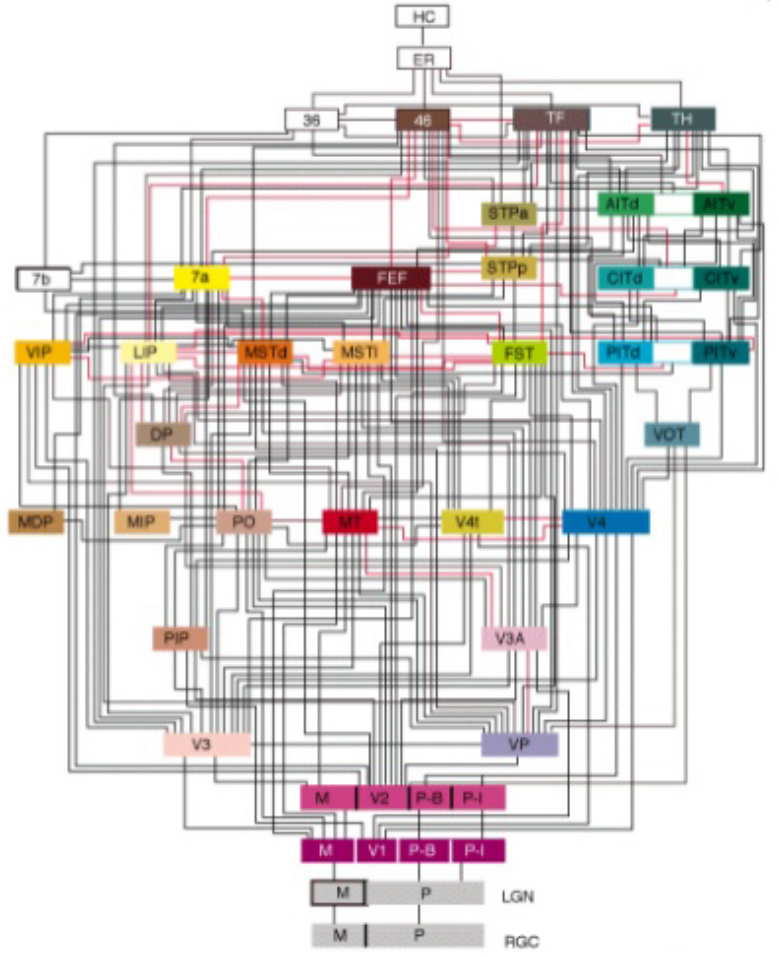
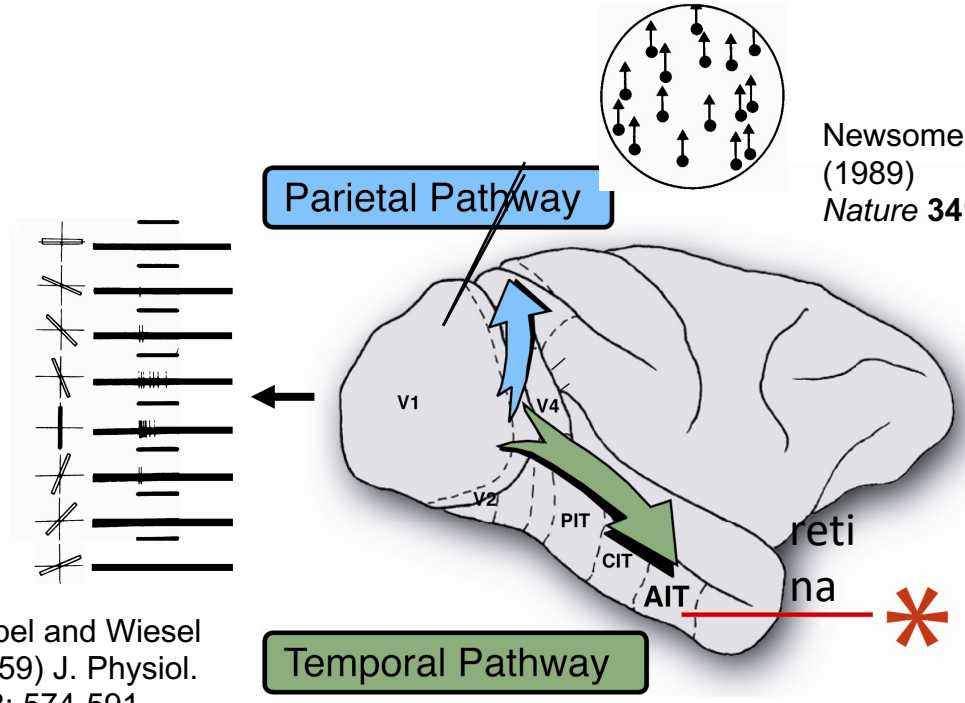
Neuroscience. 60s-90s. Systematic investigation of visual cortex

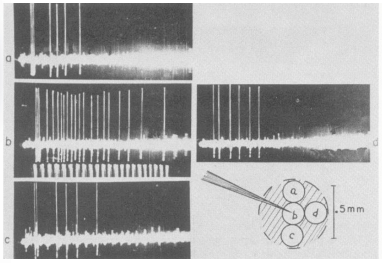




Newsome *et al* (1989) *Nature* **341**:52-54

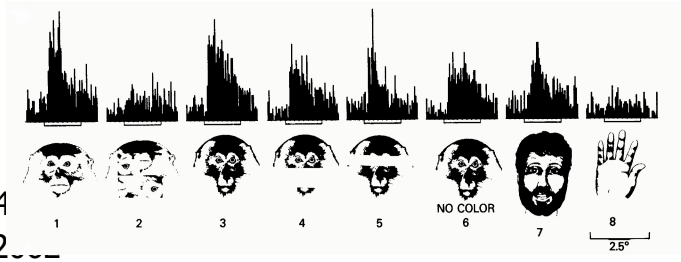
Color, Curvature, Gratings, Hyperbolic gratings

Hubel and Wiesel (1959) J. Physiol. **148**: 574-591



Kuffler, S. (1953) *J. Neurophys.* **16**: 37-68

3D curves, natural objects, fractals, paperclips, faces



Desimone *et al* (1984 *J. Neurosci. 4:*2051-2



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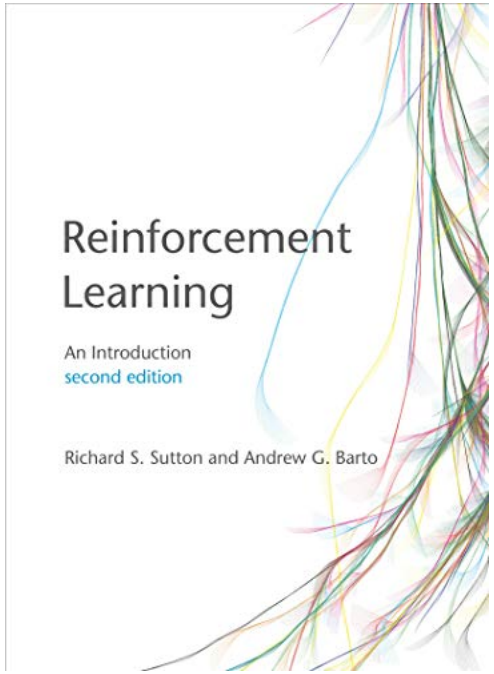
AI. 1986. 1998: Backprop and RL

Learning representations by back-propagating errors

David E. Rumelhart*, Geoffrey E. Hinton†
& Ronald J. Williams*

* Institute for Cognitive Science, C-015, University of California, San Diego, La Jolla, California 92093, USA
† Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Philadelphia 15213, USA

Nature 1986: Backpropagation



MIT Press. 1998: Reinforcement Learning

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AI. 1997. 2016. Machines beat humans in chess and Go

1997: Deep Blue beats Kasparov



2016: Alpha Go beats Lee Sedol



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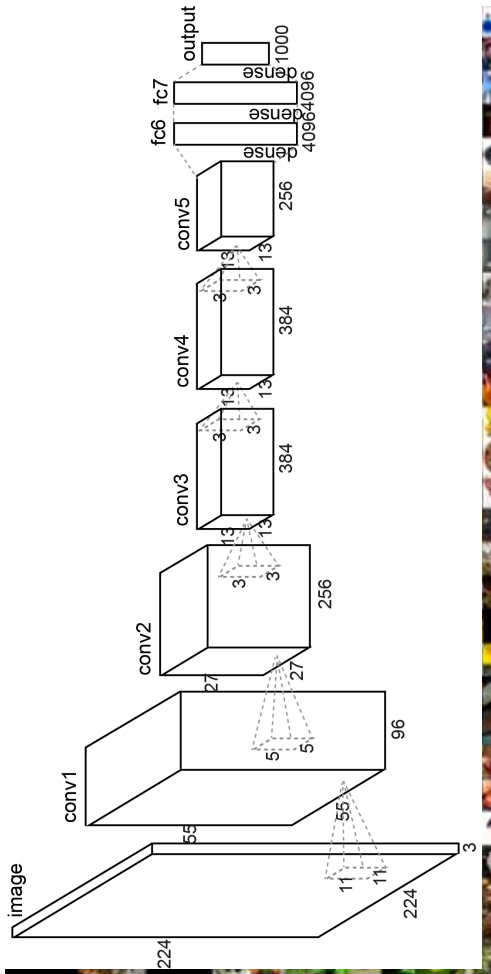
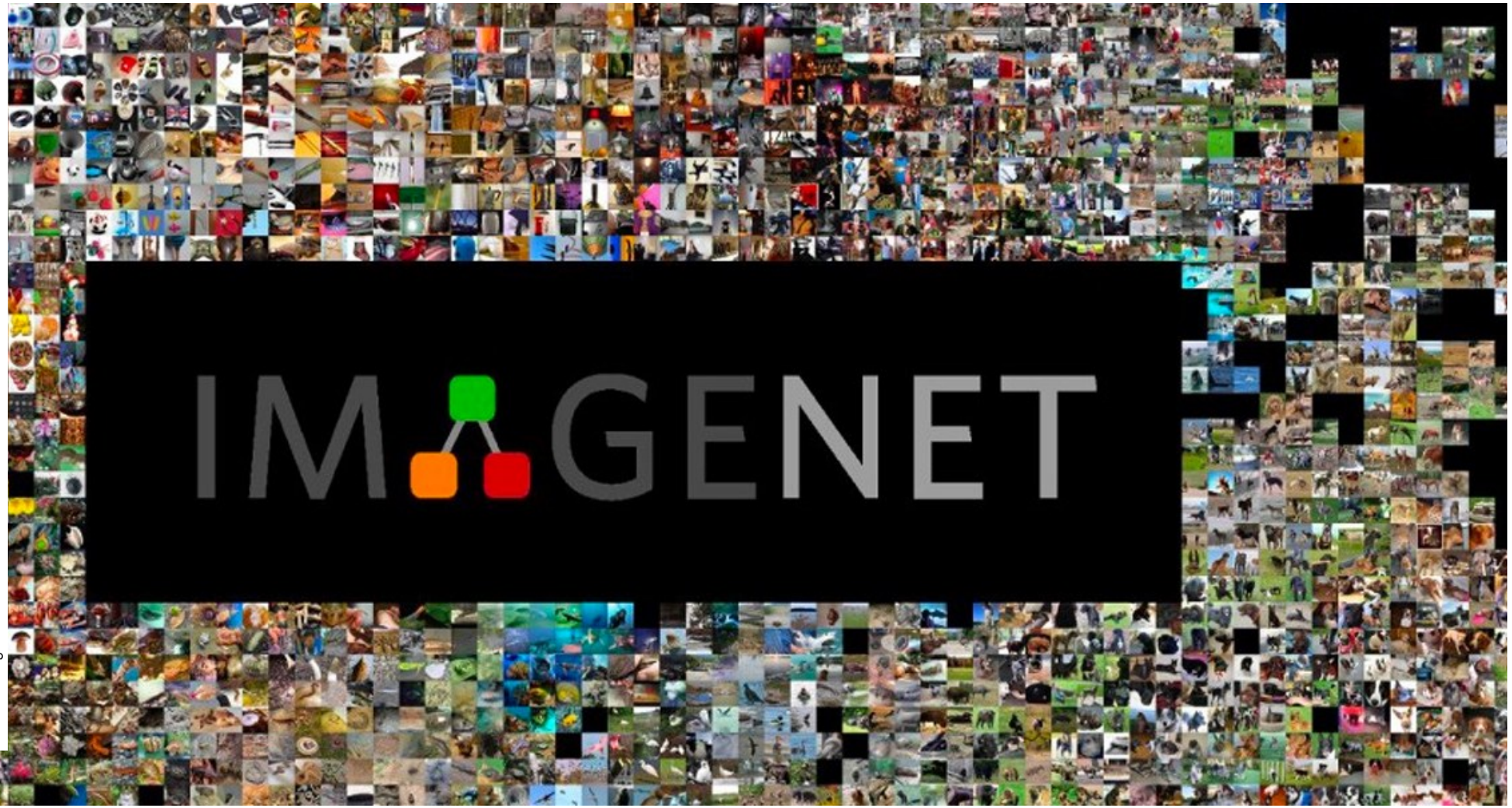
AI and Neuroscience. 2012: Deep convolutional neural networks





AlextNet, 2012

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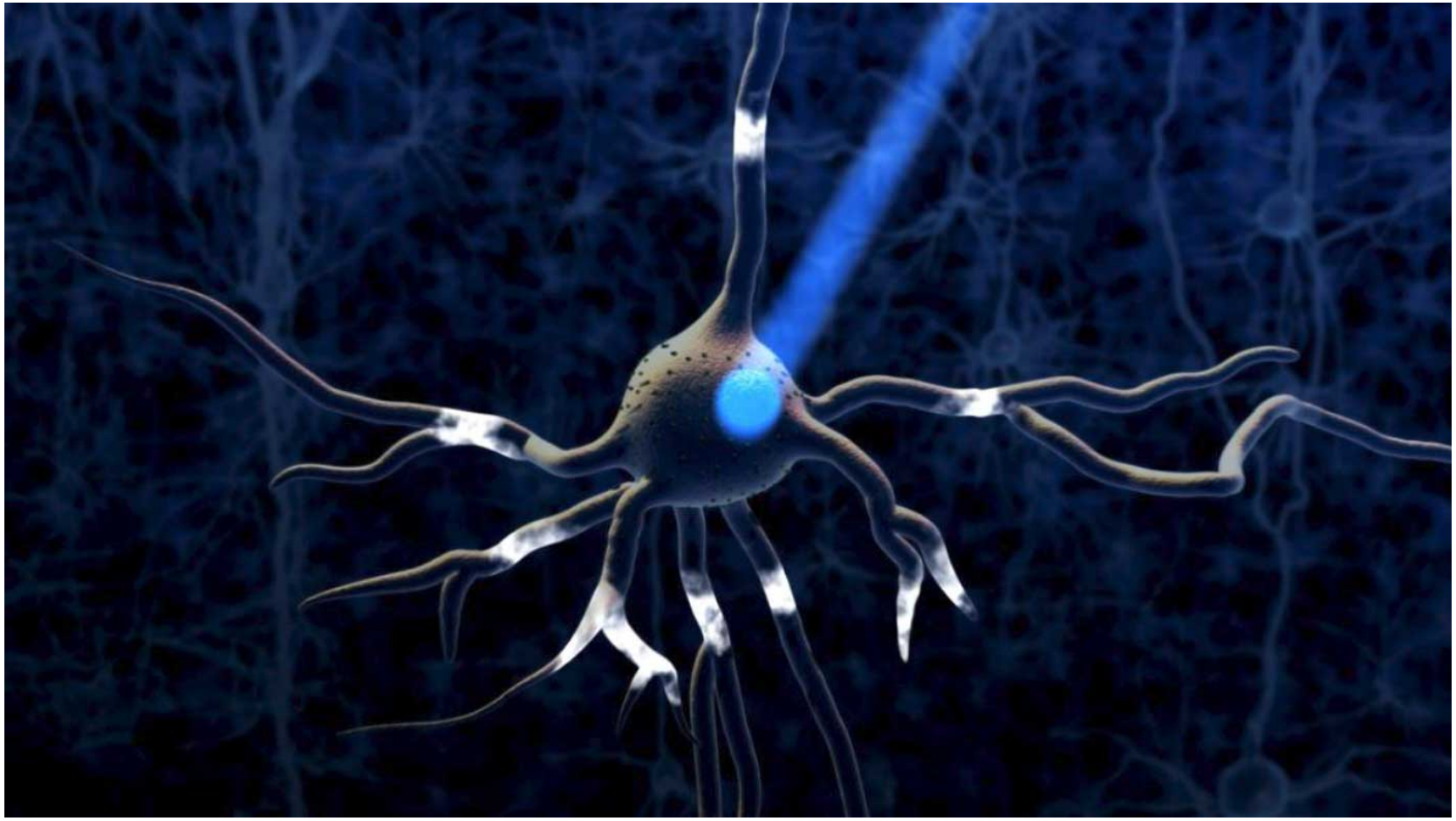
Neuroscience. 2005. Optogenetics



Optogenetics:
Turning specific neuronal circuits on and off

Boyden et al 2005

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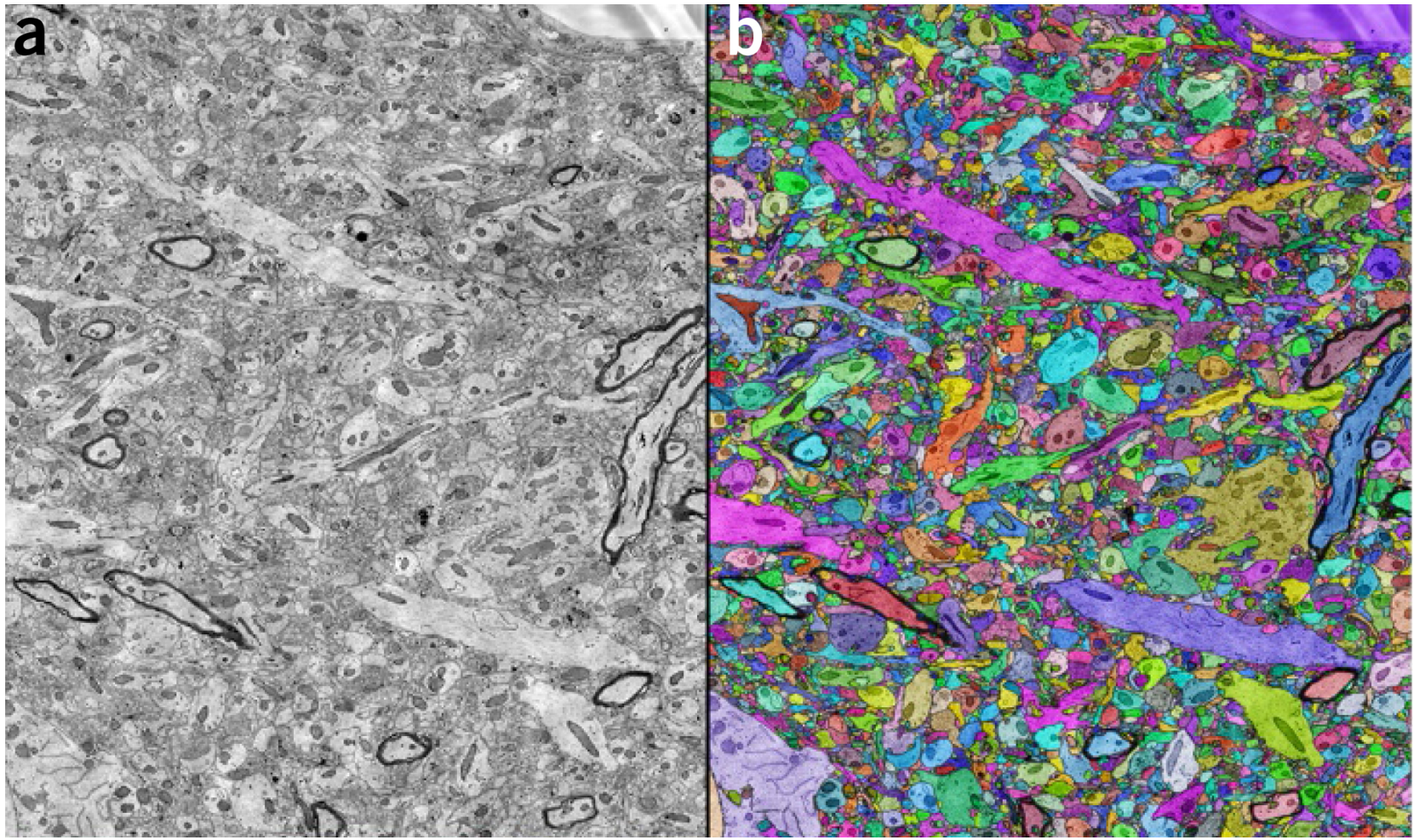
Neuroscience. 2014: Large-scale connectomics



Connectomics at scale:
Unprecedented ability to scrutinize connectivity in the nervous system

Lichtman et al 2014

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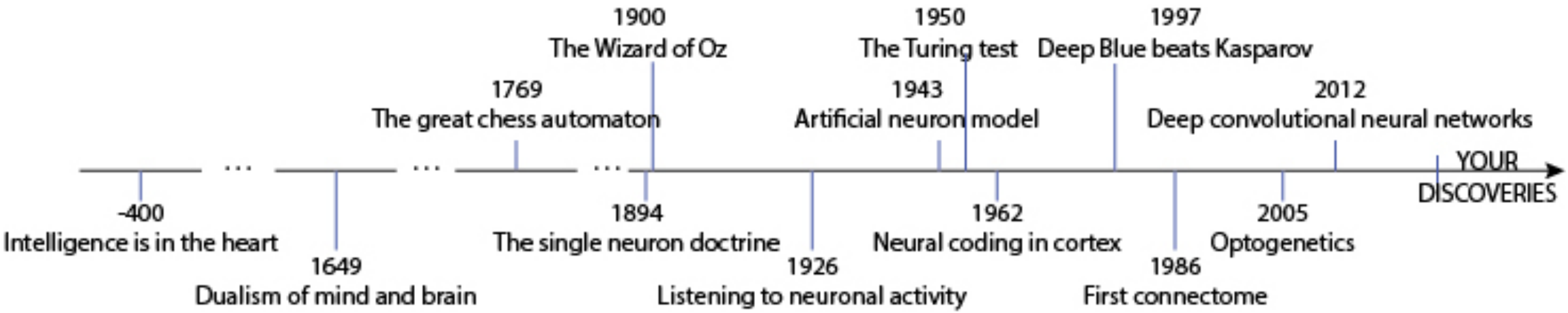
A brief history of AI and Neuroscience



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Brains, Minds and Machines Summer Course. Towards the next generation of scholars in AI









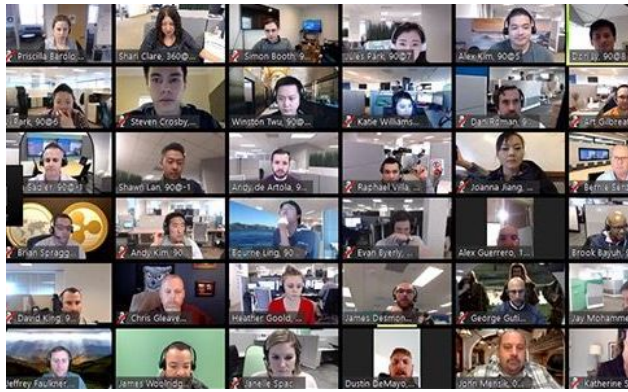
2017



2018



2019



2020

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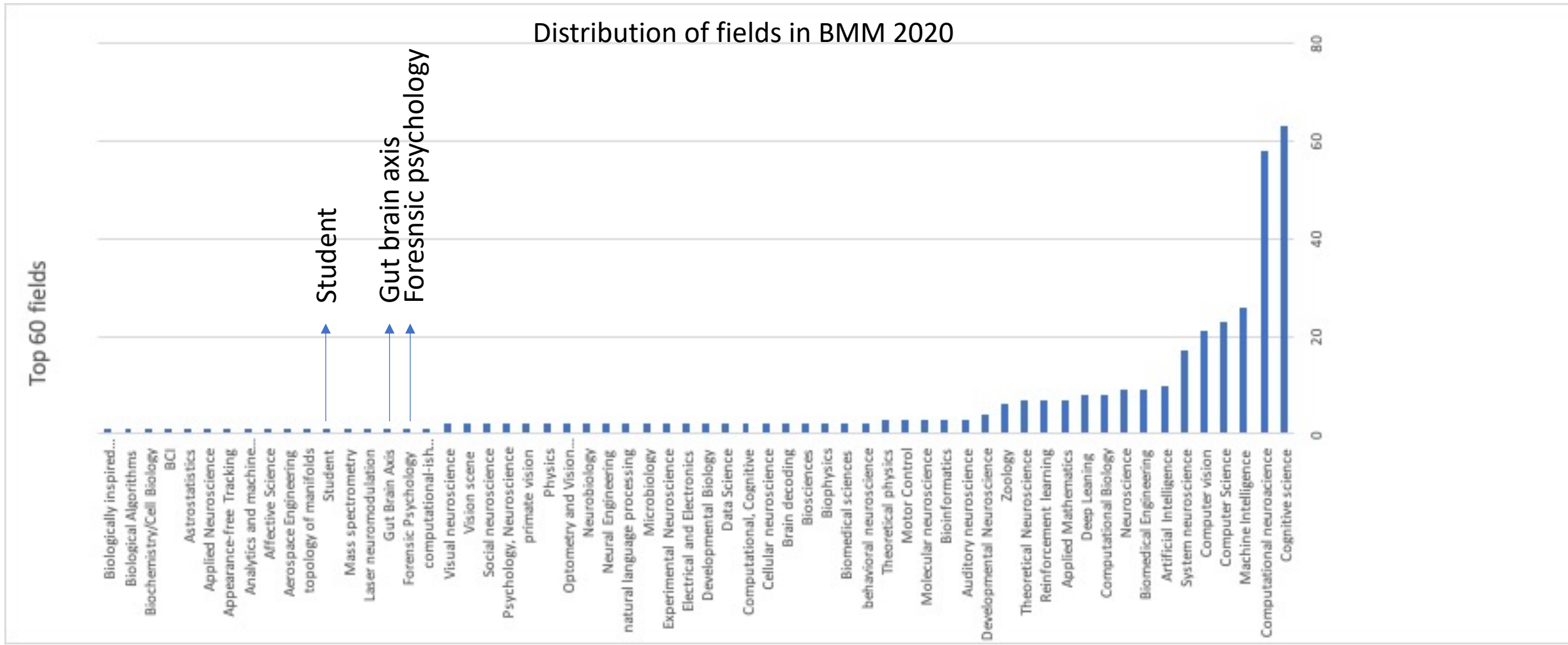
It takes a village



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It takes a village





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Summer Course 2020

		12-1pm	1-1:15pm	1:15-2:15pm	2:15-2:30pm	2:30-3:30pm	3:30-3:45pm	3:45-4-45pm
08/10/2020	Monday	Tommy Poggio: Introduction to CBMM | Gabriel Kreiman | Boris Katz | Others: Introduction to the summer course	BREAK	Jim DiCarlo: Visual recognition	BREAK	Tutorial. Ethan Meyers: Using population decoding to understand neural content and coding	BREAK	Panel Discussion: Hilbert questions in AI [Kreiman, Poggio, Tellex]
08/11/2020	Tuesday	Christof Koch: Relating the structure of the brain to its function by tracking a net-wave of spikes up the visual hierarchy	BREAK	Aleksander Madry	BREAK	Gabriel Kreiman: Recurrent computations to the rescue		Virtual poster ses
08/12/2020	Wednesday	Tomaso Poggio: A theory of deep learning: explaining the approximation, optimization and generalization puzzles	BREAK	Tutorial: Andrei Barbu, Colin Conwell, David Mayo: From zero to machine vision to mouse brains	BREAK	Antonio Torralba: Computer Vision	BREAK	Panel Discussion: What is the relationship between biological brains and AI algorithms? [Kanwisher, Serre, Tenenbaum]
08/13/2020	Thursday	Pietro Perona	BREAK	Boris Katz: AI / Language 2	BREAK	Andrei Barbu: Vision + Language	BREAK	Virtual poster ses
08/14/2020	Friday	Josh Tenenbaum: Computational models of cognition	BREAK	Constantinos Daskalakis	BREAK	Nancy Kanwisher: functional specificity of the human brain	BREAK	Panel Discussion: Is there anything special about human intelligence? (vs. non-human animals, vs. machines) [Schulz, Wilson, Roy, Murthy]

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FAQ about the virtual summer course

How do I use zoom?

Are the talks going to be recorded?

Will you be issuing participation certificates?

Will there be any type of interaction?

Is there a slack channel?

What is the format for the poster sessions?

I registered for the virtual course, can I defer to take the residential course in 2021?

Are there any coding or experimental projects this year?

I have another question…