

# **History of Psychology**

## Session 7: Cognitive Psychology

Rui Mata, Center for Cognitive and Decision Sciences  
November 4, 2024

# Session information

Sessions take place Mondays, 8.15-9.45, Chemie, Organische, Grosser Hörsaal OC.

#	Date	Topic	Instructor
1	23.09.2024	Session 1: Introduction	Tisdall
2	30.09.2024	Session 2: Pre-psychology	Mata
3	7.10.2024	Session 3: The birth of psychology	Mata
4	14.10.2024	Session 4: Psychoanalysis	Mata
5	21.10.2024	Session 5: Behaviorism	Mata
6	28.10.2024	Session 6: Gestalt psychology	Mata
7	4.11.2024	Session 7: Cognitive psychology	Mata
8	11.11.2024	Session 8: Psychology today	Tisdall
9	18.11.2024	Session 9: Psychotherapy research	Tisdall
10	25.11.2024	Session 10: Psychological testing	Tisdall
11	2.12.2024	Session 11: Decision science	Tisdall
12	9.12.2024	Session 12: What kind of science is psychology?	Mata

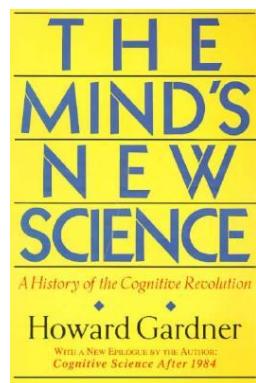
# Learning Objectives for Today

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- Identify key figures and ideas leading to the emergence of cognitive psychology
- Discuss tensions between nativist and associationist perspectives within cognitive psychology
- Discuss the impact of the “cognitive revolution” and cognitive science

# The Hixon Symposium (1948)

The **1948** Hixon Symposium marks the beginning of a period in which scientists, including mathematicians and neurophysiologists, proposed a parallel between mind and machine (i.e., information-processing logical devices) and strongly criticised behavioural theories...



"Hixon Symposium on Cerebral Mechanisms in Behavior," California Institute of Technology, Pacific State Hospital, Pomona, California. September 20, 1948

PROGRAM	
<i>See</i>	
Monday, September 20	
10:00 a.m.	Welcome by Dr. L. A. DuBanger, President, California Institute of Technology The Hixon Fund and Introduction of Symposium Members Dr. MAX MASON, Chairman of the Hixon Committee, California Institute of Technology
	Plans for the Symposium. Dr. LLOYD A. JEFFRESS, Hixon Visiting Professor of Psychobiology
2:00 p.m.	Dr. H. W. BROSN, Chairman Dr. JOHN von NEUMANN, Speaker. <i>The Logic of Analogue Nets and Automata</i>
4:00 p.m.	Informal gathering in the lounge, Dabney Hall
Tuesday, September 21	
9:30 a.m.	Dr. R. W. GERARD, Chairman Dr. LORENTE de Nò, Speaker. <i>Models of the Nervous System</i>
2:00 p.m.	Dr. J. M. NIELSEN, Chairman Dr. WARREN S. McCULLOCH, Speaker. <i>Why the Mind is in the Head</i>
4:00 p.m.	Informal gathering in the lounge, Dabney Hall
Wednesday, September 22	
<i>Symposium in Dr. Lorente de Nò, Dr. W. compiles, structure &amp; physical, 1364 Dabney, Niel. Nielsen, Wierne-cocktail</i>	
Thursday, September 23	
9:30 a.m.	Discussion meeting
2:00 p.m.	Dr. H. S. LIDDELL, Chairman Dr. K. S. LASLLEY, Speaker. <i>The Problem of Serial Order in Behavior</i>
4:00 p.m.	Dr. PAUL WEISS, Chairman Dr. HEINRICH KLÜVER, Speaker. <i>Functional Differences between the Occipital and Temporal Lobes</i>
	Members of the staff of the Biology Division will serve tea in the Library, Kerckhoff Laboratories

Gardner, H. (1985). The mind's new science: A history of the cognitive revolution. New York: Basic Books.

# The Hixon Symposium (1948)

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Karl Lashley  
(1890-1958)



Warren McCulloch  
(1898-1969)



John von Neumann  
(1903-1957)

Zoologist/Psychologist, worked with John Watson on learning in rats, conducted studies to observe the effects of cortical lesions on trained rats. In 1951, Lashley published a famous paper called "The Problem of Serial Order in Behavior," in which he pointed out that complex sequential behavior (such as playing a piece on the piano) could not be executed by one response sending a proprioceptive signal back to the brain which would then trigger the next response in the sequence – as there wasn't enough time for the neural signals to travel up to the brain and back down. Instead, behavior had to be controlled by a central, hierarchically organized program.

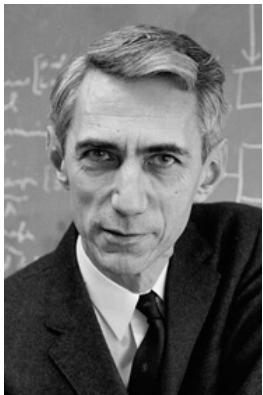
Neurophysiologist, made contributions to cybernetics. For example, wrote with Walter Pitts "A Logical Calculus of the Ideas Immanent in Nervous Activity" (1943) to demonstrate that a Turing machine program could be implemented in a finite network of formal neurons, that the neuron was the base logic unit of the brain. Later, Pitts and McCulloch suggested how "nervous nets" can be used to recognise visual inputs despite changes in orientation or size.

Mathematician, physicist, computer scientist, made major contributions to a number of fields, including foundations of mathematics, computing of self-replicating machines (cells), and game theory.

# The Dartmouth Workshop (1956)

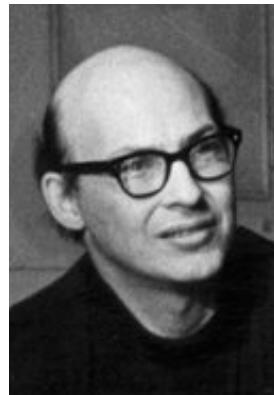
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A summer workshop initiated by John McCarthy (University of Dartmouth, USA) considered by many the seminal event for artificial intelligence, convened key figures in the artificial intelligence and cognitive psychology movement (the names below are just some of those who attended).



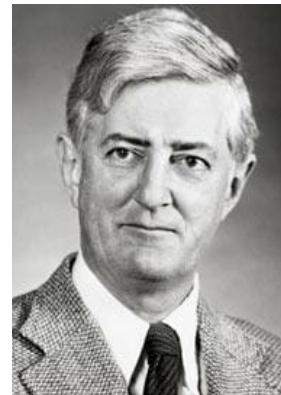
Claude Shannon  
(1916-2001)

information theory: defined information mathematically, how information can be communicated over (noisy) limited channels, and how it can be reconstructed with low probability of error



Marvin Minsky  
(1927-2016)

artificial neural networks: computing systems inspired by the biological neural networks that constitute animal brains



Oliver Selfridge  
(1926-2008)

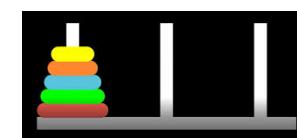


Allen Newell  
(1927-1992)

general problem solver: computer program that could solve simple problems (e.g., Tower of Hanoi)



Herbert Simon  
(1916-2001)

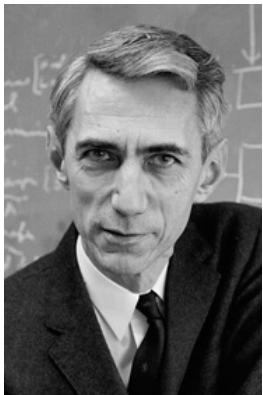


Solomonoff, G.. Ray Solomonoff and the Dartmouth Summer Research Project in Artificial Intelligence, 1956.  
Retrieved from <http://raysolomonoff.com/dartmouth/dartray.pdf>

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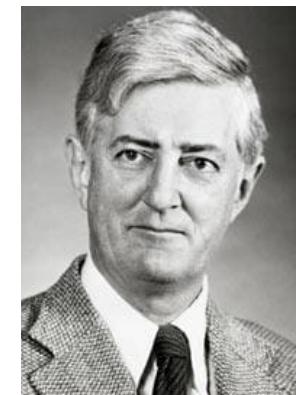
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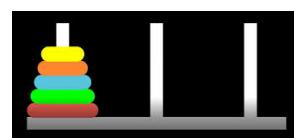


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# Noam Chomsky: (innate) Universal Grammar

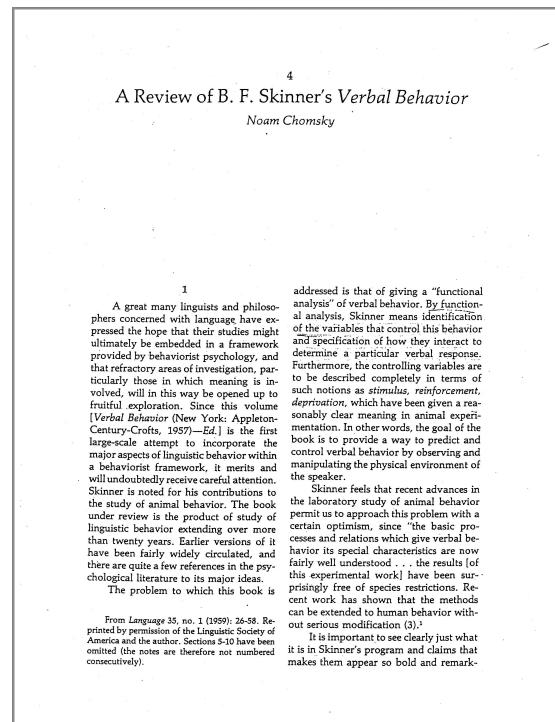
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<https://www.youtube.com/watch?v=MLk47AMBdTA>

# Noam Chomsky: (innate) Universal Grammar

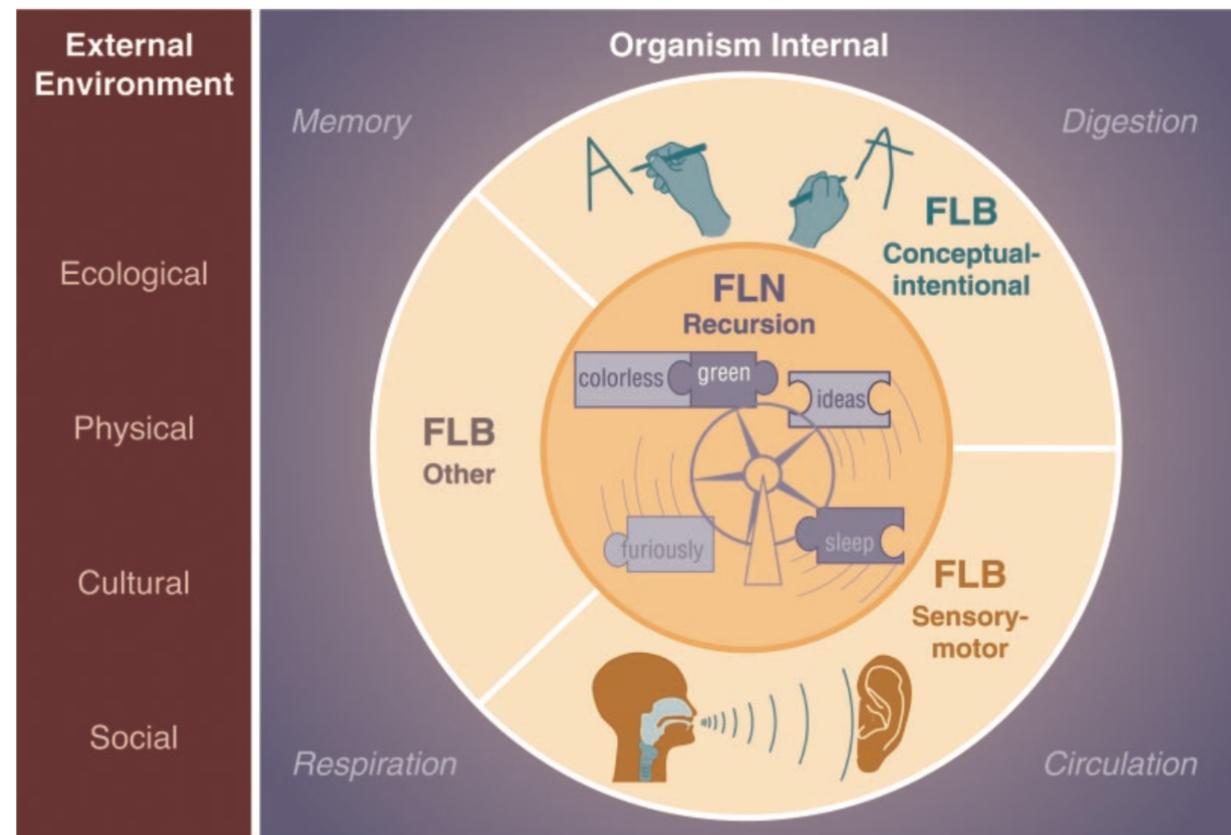
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"Chomsky has been one of behaviorism's most successful and damaging critics. In a review of Skinner's book on verbal behavior, **Chomsky (1959)** charged that behaviorist models of language learning cannot explain various facts about language acquisition, such as the rapid acquisition of language by young children, which is sometimes referred to as the phenomenon of "lexical explosion." A child's linguistic abilities appear to be radically underdetermined by the evidence of verbal behavior offered to the child in the short period in which he or she expresses those abilities. By the age of four or five (normal) children have an almost limitless capacity to understand and produce sentences which they have never heard before. Chomsky also argued that it seems plainly untrue that language learning depends on the application of reinforcement. A child does not, as an English speaker in the presence of a house, utter "house" repeatedly in the presence of reinforcing elders. Language as such seems to be learned without, in a sense, being explicitly taught or taught in detail, and behaviorism doesn't offer an account of how this could be so. (...) Our history of reinforcement is often too impoverished to determine uniquely what we do or how we do it. Much learning, therefore, seems to require pre-existing or innate representational structures or principled constraints within which learning occurs."

# Noam Chomsky: (innate) Universal Grammar

Chomsky's views evolved considerably. Chomsky first proposed a set of innate (universal) syntactic structures and grammatical principles. More recently, Chomsky and colleagues described a grammar that included only one feature, called computational recursion.

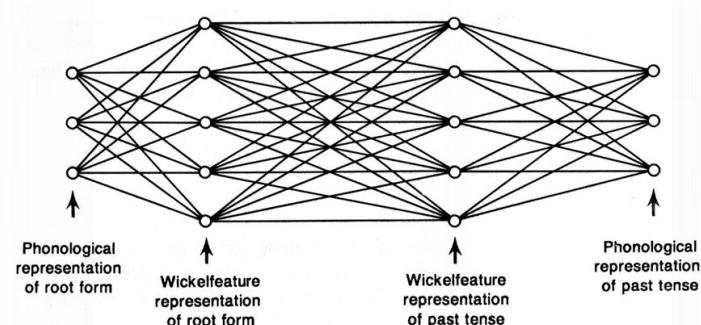
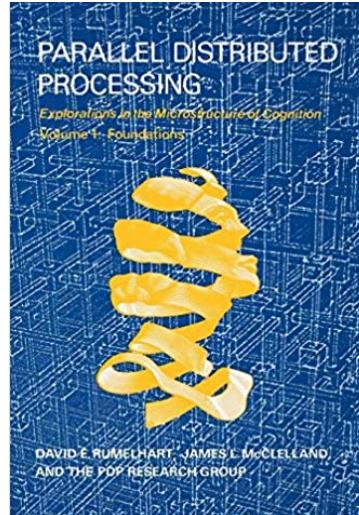


**Fig. 2.** A schematic representation of organism-external and -internal factors related to the faculty of language. FLB includes sensory-motor, conceptual-intentional, and other possible systems (which we leave open); FLN includes the core grammatical computations that we suggest are limited to recursion. See text for more complete discussion.

# Connectionism (Parallel distributed processing)



David  
Rumelhart      James  
McClelland  
1986



“Connectionism is a movement in cognitive science that hopes to explain intellectual abilities using artificial neural networks (also known as “neural networks” or “neural nets”). Neural networks are simplified models of the brain composed of large numbers of units (the analogs of neurons) together with weights that measure the strength of connections between the units. These weights model the effects of the synapses that link one neuron to another. Experiments on models of this kind have demonstrated an ability to learn such skills as face recognition, reading, and the detection of simple grammatical structure.”

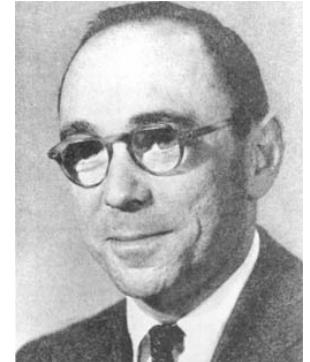
**Connectionism presented itself as a plausible, mechanistic alternative to innate (grammatical) principles....**

# The Harvard Center for Cognitive Studies (1960)

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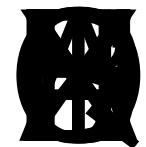
George Miller  
(1920-2012)



Jerome Bruner  
(1915-2016)

“Whatever we called it, the cognitive counter-revolution in psychology brought the mind back into experimental psychology. I think it is important to remember that the mind had never disappeared from social or clinical psychology. It was only experimentalists in the US who really believed that behaviorism would work. In my own case, when I became dissatisfied at Harvard between B.F. Skinner’s strict behaviorism and S.S. Stevens’ psychophysics, I turned to Jerry Bruner’s social psychology, and in 1960 that led to the creation at Harvard of the Center for Cognitive Studies. Bruner’s group at Bow Street had been calling themselves the ‘Cognition Project’ for some time, so we simply changed it from a project to a center. Bruner obtained a grant from the Carnegie Corporation of New York and Dean Bundy gave us space to house the enterprise. (...) Behaviorism flourished primarily in the US and this cognitive revolution in psychology reopened communication with some distinguished psychologists abroad. In Cambridge, UK, Sir Frederic Bartlett’s work on memory and thinking had remained unaffected by behaviorism. In Geneva, Jean Piaget’s insights into the minds of children had inspired a small army of followers. And in Moscow, A.R. Luria was one of the first to see the brain and mind as a whole. None of these three spent time at the Center but we knew their work well. Whenever we doubted ourselves we thought of such people and took courage from their accomplishments. (...) The bright young graduates grew up to become important psychologists unafraid of words like *mind* and *expectation* and *perception* and *memory*.

How many can you recall?



# The Harvard Center for Cognitive Studies (1960)

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George Miller  
(1920-2012)

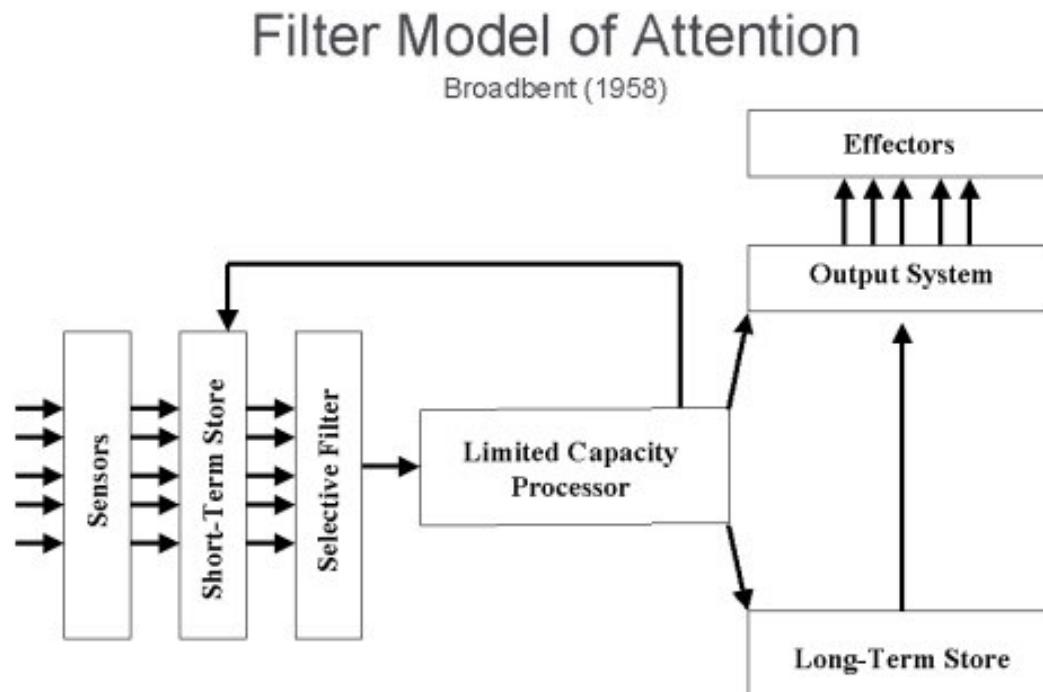
Miller observed that memory span of young adults is approximately seven items and noticed that memory span is approximately the same for stimuli with vastly different amount of information (e.g., letters, digits, words). Miller concluded that memory span is not limited in terms of bits but rather in terms of chunks. More importantly, his paper became an important manifesto for the idea that the mind could be studied and described like an information processing system with significant capacity limitations.

Miller, G. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, 81-97.

# Cognitive Psychology: Theses and Methods

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Psychology became fascinated with information-processing diagrams, in which boxes and arrows stand for (temporary) stores of information and/or processes that transform the information and the transmission of information.



Broadbent, D. (1958). *Perception and Communication*. London: Pergamon Press.

# **WHAT DO YOU THINK?**

**Compare and contrast the schools:  
behaviourism, gestalt, cognitive psychology**



# Cognitive Psychology: Theses and Methods

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Cognitivism and cognitive psychology is the movement in psychology which explains behaviour as a function of mental processes (e.g., thinking, remembering, planning, attending) and representations (such as Noam Chomsky's generative grammar). Cognitivism gained importance and **acceptance** in psychology based on the analogy of information processing carried out by computers.

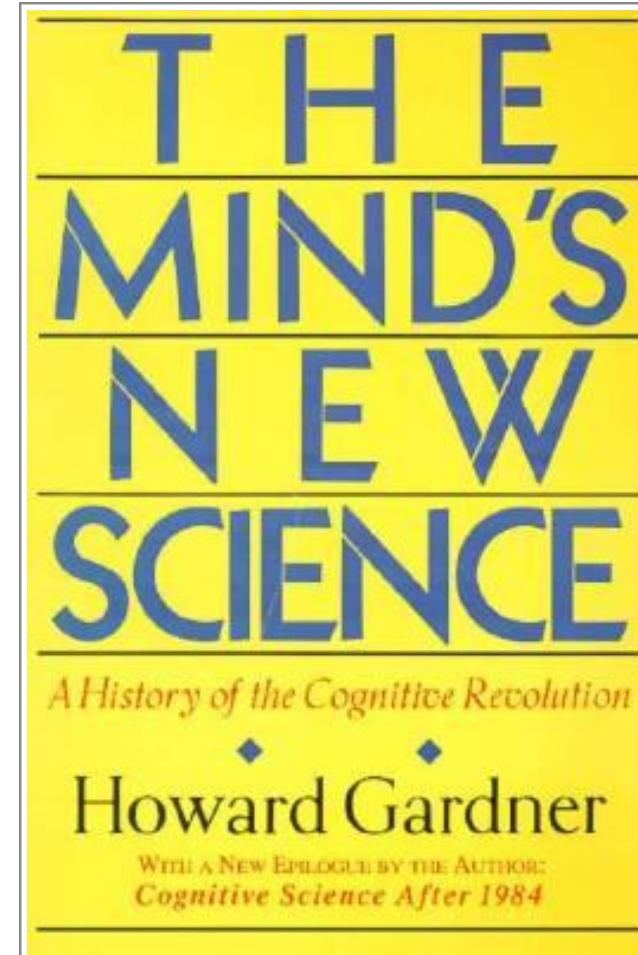
- Cognitive psychology stands in contrast to behaviorism by focusing on trying to understand internal representations and processes while the latter focused on theorising about observable behaviour. Both schools agreed on the importance of rigorous experimental methods.
- Cognitive psychology stands in contrast to Gestalt psychology in its ambition to provide mechanistic models of cognition.

Improvements in computing gave rise to new methods, such as computational models that simulated cognition based on rules (e.g., Newell & Simon's General Problem Solver) or through learning of associations (e.g., neural networks)

# Cognitive Science and the cognitive revolution



(1977)



(1985)

Gardner, H. (1985). *The mind's new science: A history of the cognitive revolution*. New York: Basic Books.

# Cognitive Science and the cognitive revolution

## Marr's Levels

- Computational level: What is the goal of a given process/computation?
- Algorithmic level: How can a goal be achieved using a particular set of inputs/outputs, which algorithm describes the required transformations?
- Implementational level: How is an algorithm physically implemented (e.g., neural activity)?

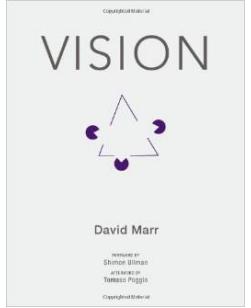
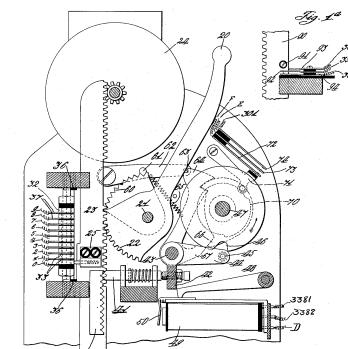


Addition  
 $S_T = Z_1 + \dots + Z_N$

$$\begin{array}{r} 58 \\ + 36 \\ \hline \end{array}$$

Record the 1 ten.  
8 + 6 = 14  
Record the 4.

1  
58  
+ 36  
94  
Add the tens.  
1 + 5 + 3 = 9  
Record the 9 tens



## David Marr (1945-1980)

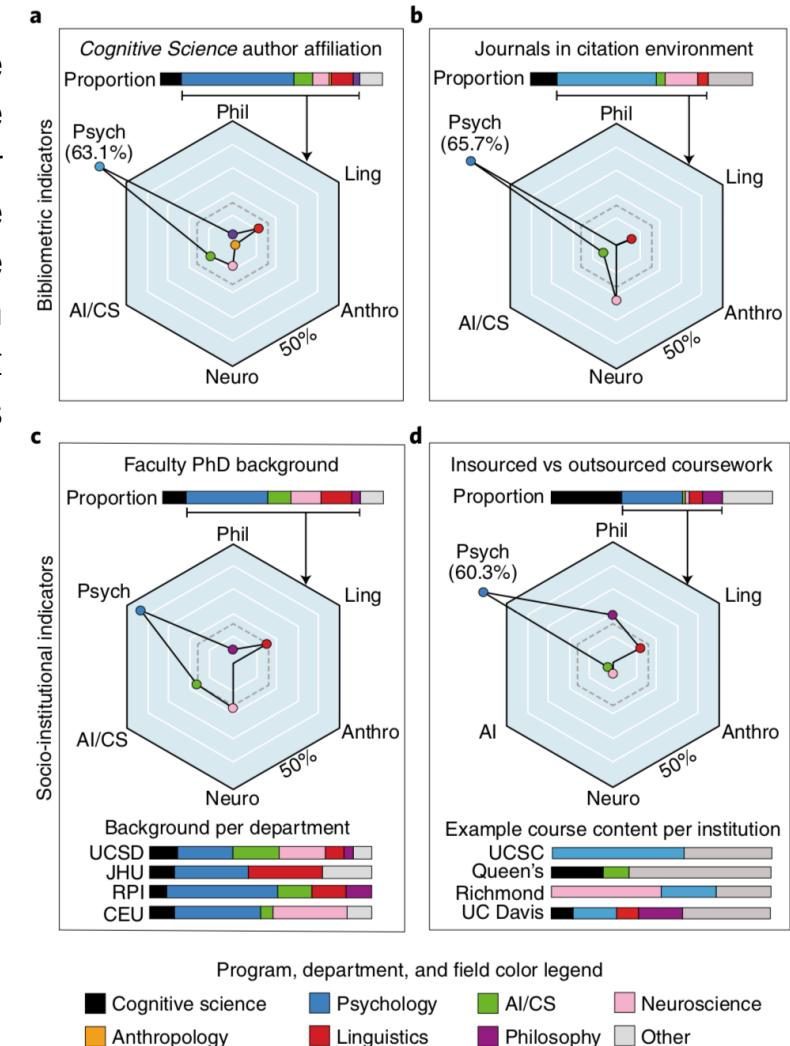
Studied mathematics and physiology but later worked as a professor of Psychology at MIT. He integrated results from psychology, artificial intelligence, and neurophysiology to produce a new model of vision. He is particularly famous for proposing a three level view of how to understand information processing systems.

Marr, D. C., & Poggio, T. (1977). From understanding computation to understanding neural circuitry. *Neurosciences Research Program Bulletin*, 15(3), 470–488.

# Cognitive science and the cognitive revolution

"More than a half-century ago, the 'cognitive revolution', with the influential tenet 'cognition is computation', launched the investigation of the mind through a multidisciplinary endeavour called cognitive science. (...) indicators consistently show that the devised multi-disciplinary program failed to transition to a mature inter-disciplinary coherent field. Bibliometrically, the field has been largely subsumed by (cognitive) psychology, and educationally, it exhibits a striking lack of curricular consensus, raising questions about the future of the cognitive science enterprise."

**Fig. 2 | Four indicators of the status of cognitive science. a-d.** The top two are bibliometric indicators; the bottom two are socio-institutional indicators. **(a)** The affiliation of authors in the journal *Cognitive Science*, **(b)** the citation environment of this journal, **(c)** the doctoral training of current cognitive science faculty and **(d)** the curriculum composition of current undergraduate cognitive science programs in North America. The top bars show the overall distribution of disciplinary contributions to each indicator. The hexagons represent the relative contribution from the six core disciplines. Moving outwards, each hexagonal ring represents a 10% increment. A balanced distribution across core disciplines would follow the pattern indicated by segmented lines (i.e., ~16.6% per discipline), corresponding to the ideal cognitive science hexagon (Fig. 1a).



# The myths of revolutions?

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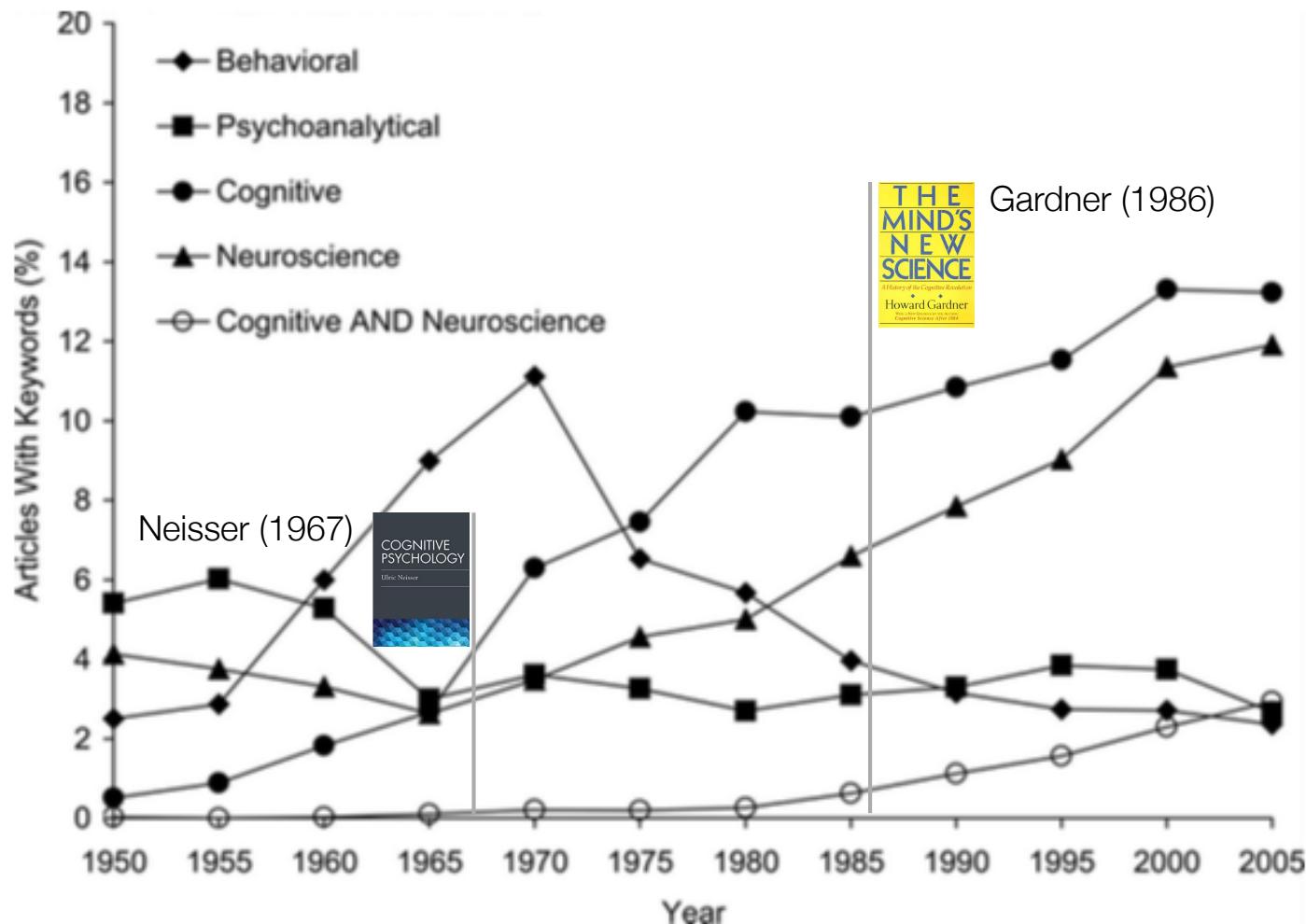
“The history of experimental psychology in America is typically told as a series of two Kuhnian revolutions separating three periods of normal science dominated by the mentalist, then behaviorist, and finally today's cognitivist paradigm. (...) The history of the behaviorist and cognitivist “revolutions” as seen by contemporaries shows that each was in fact a period of rapid but continuous and nonrevolutionary change.”

“Save for Wundt's founding of psychology, revolution in psychology is a myth.”

Leahy, T. H. (1992). The mythical revolutions of American psychology. *American Psychologist*, 47(2), 308–318. <http://doi.org/10.1037/0003-066X.47.2.308>

# An empirical approach to the impact of “Schools”

Keyword searches on all refereed journal articles in PsycINFO



Spear, J. H. (2007). Prominent schools or other active specialties? A fresh look at some trends in psychology. *Review of General Psychology*, 11(4), 363–380.

# **WHAT DO YOU THINK?**

**Things missing in this history of psychology...**



# Summary

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- **Cognitive psychology:** focus on computation and information processing; mental representation; formal/computational models of different nature (algorithmic, if-then rules) and connectionist (parallel distributed processing); experimental methods with a focus on attention, language, memory
- **Lashley:** critique of behaviourism based on principles of plausibility and empirical results in the domain of motor learning and memory
- **Chomsky:** critique of behaviourism regarding language (poverty of the stimulus argument); computational principles in linguistics; universal grammar
- **Miller:** introduction of information-processing principles to the study of attention ( $7 \pm 2$ )
- **Cognitive Science:** interdisciplinary enterprise; Marr's levels; boom/peak in the 80s and 90s, at present mostly a branch of cognitive psychology;
- **Impact:** cognitive psychology became the predominant school in the second half of the 20th century; debate about implementation questions (neuroscience) and other neglected aspects of psychology (e.g., affect) increase at the end of the 20th century 24