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.

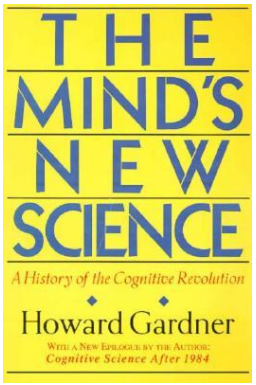
#	Date	Topic	Instructor
1	23.09.2024	Session 1: Introduction	Tisdall
2	30.09.2024	Session 2: Pre-psychology	Mata
3	7.10.2024	Session 3: The birth of psychology	Mata
4	14.10.2024	Session 4: Psychoanalysis	Mata
5	21.10.2024	Session 5: Behaviorism	Mata
6	28.10.2024	Session 6: Gestalt psychology	Mata
7	4.11.2024	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

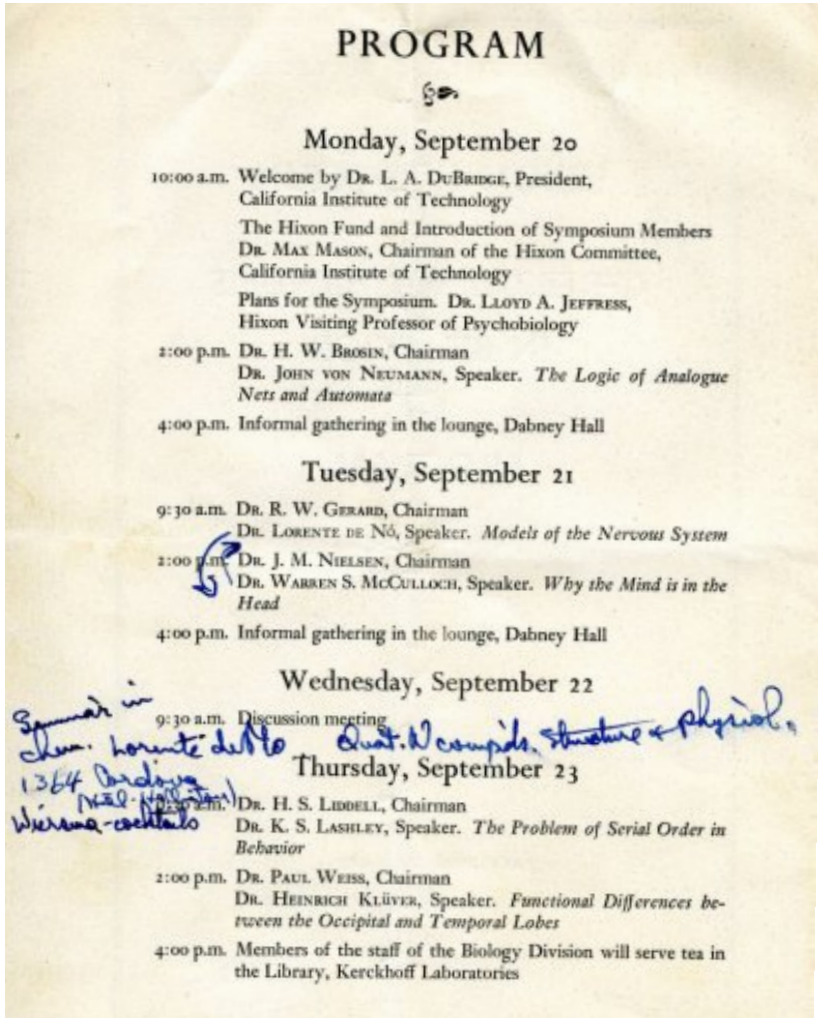
Learning Objectives for Today

- 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…





PROGRAM

Monday, September 20

10:00 a.m. Welcome by Dr. L. A. DuBridge, 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. Brosin, Chairman
Dr. John von Neumann, Speaker. *The Logic of Analogue Nets and Automata*

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 Nó, Speaker. *Models of the Nervous System*

2:00 p.m. Dr. J. M. Nielsen, Chairman
Dr. Warren S. McCulloch, Speaker. *Why the Mind is in the Head*

4:00 p.m. Informal gathering in the lounge, Dabney Hall

Wednesday, September 22

9:30 a.m. Discussion meeting

Thursday, September 23

Dr. H. S. Liddell, Chairman
Dr. K. S. Lashley, Speaker. *The Problem of Serial Order in Behavior*

2:00 p.m. Dr. Paul Weiss, Chairman
Dr. Heinrich Klüver, Speaker. *Functional Differences between the Occipital and Temporal Lobes*

4:00 p.m. Members of the staff of the Biology Division will serve tea in the Library, Kerckhoff Laboratories

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

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

The Hixon Symposium (1948)

Karl Lashley
(1890-1958)

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.

Warren McCulloch
(1898-1969)

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.

John von Neumann
(1903-1957)

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)

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).

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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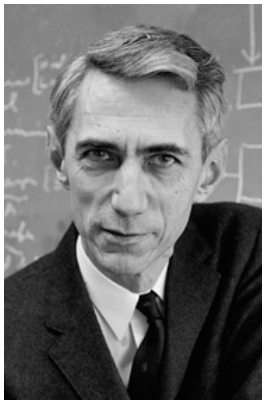


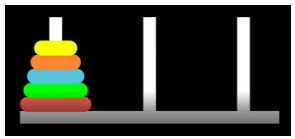
Claude Shannon
(1916-2001)

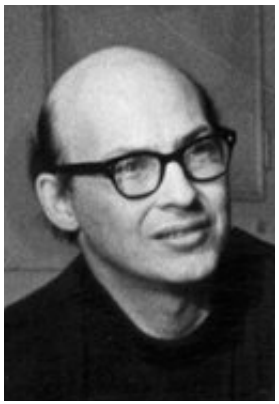
information theory: defined information mathematically, how information can be communicated over (noisy) limited channels, and how it can be reconstructed with low probability of error

Allen Newell
(1927-1992)

Herbert Simon
(1916-2001)

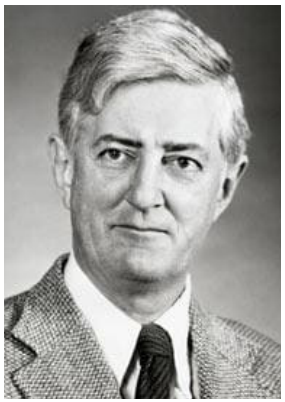
general problem solver: computer program that could solve simple problems (e.g., Tower of Hanoi)





Marvin Minsky
(1927-2016)

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



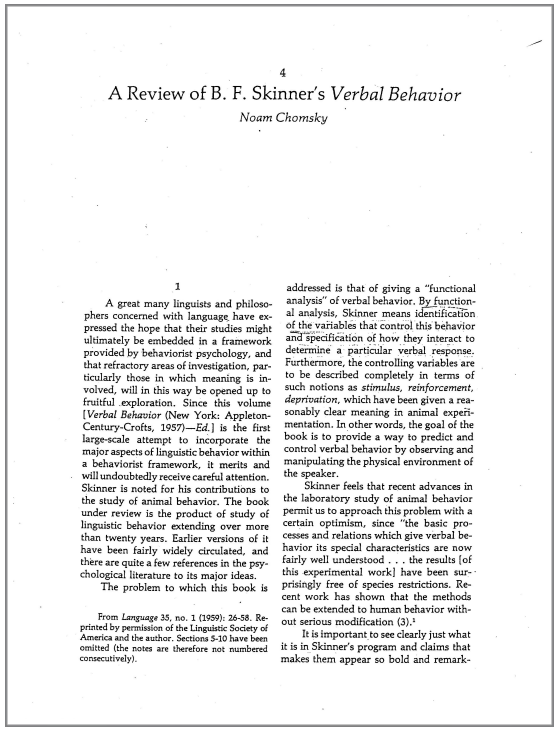
Oliver Selfridge
(1926-2008)

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

Noam Chomsky: (innate) Universal Grammar

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

Noam Chomsky: (innate) Universal Grammar



4

A Review of B. F. Skinner's *Verbal Behavior*

Noam Chomsky

1

A great many linguists and philosophers concerned with language have expressed the hope that their studies might ultimately be embedded in a framework provided by behaviorist psychology, and that refractory areas of investigation, particularly those in which meaning is involved, will in this way be opened up to fruitful exploration. Since this volume [*Verbal Behavior* (New York: Appleton-Century-Crofts, 1957)—*Ed.*] is the first large-scale attempt to incorporate the major aspects of linguistic behavior within a behaviorist framework, it merits and will undoubtedly receive careful attention. Skinner is noted for his contributions to the study of animal behavior. The book under review is the product of study of linguistic behavior extending over more than twenty years. Earlier versions of it have been fairly widely circulated, and there are quite a few references in the psychological literature to its major ideas.

The problem to which this book is addressed is that of giving a "functional analysis" of verbal behavior. By functional analysis, Skinner means identification of the variables that control this behavior and specification of how they interact to determine a particular verbal response. Furthermore, the controlling variables are to be described completely in terms of such notions as *stimulus, reinforcement, deprivation*, which have been given a reasonably clear meaning in animal experimentation. In other words, the goal of the book is to provide a way to predict and control verbal behavior by observing and manipulating the physical environment of the speaker.

Skinner feels that recent advances in the laboratory study of animal behavior permit us to approach this problem with a certain optimism, since "the basic processes and relations which give verbal behavior its special characteristics are now fairly well understood . . . the results [of this experimental work] have been surprisingly free of species restrictions. Recent work has shown that the methods can be extended to human behavior without serious modification (3).[1]

It is important to see clearly just what it is in Skinner's program and claims that makes them appear so bold and remark-

From *Language* 35, no. 1 (1959): 26-58. Reprinted by permission of the Linguistic Society of America and the author. Sections 5-10 have been omitted (the notes are therefore not numbered consecutively).

"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."

Graham, G. (2017), "Behaviorism", The Stanford Encyclopedia of Philosophy. Edward N. Zalta (ed.). Retrieved from https://plato.stanford.edu/archives/spr2017/entries/behaviorism/

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.

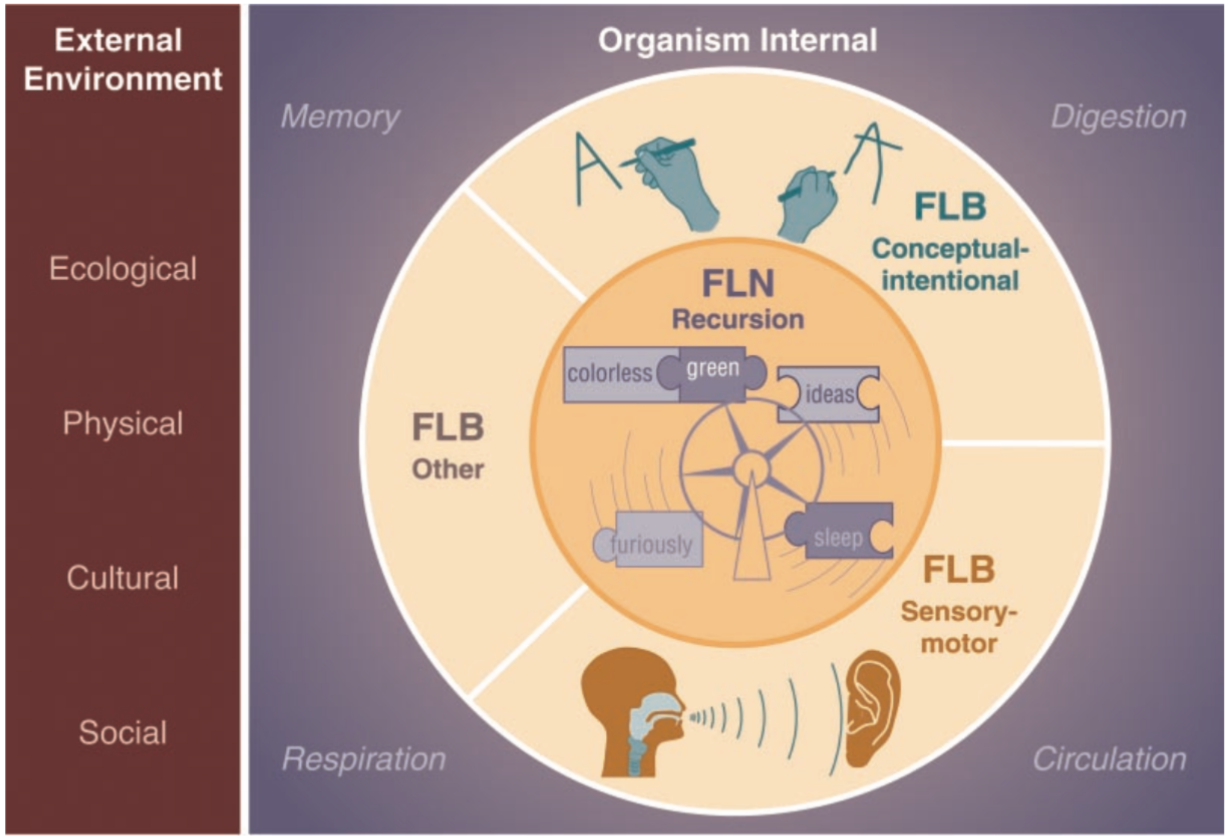
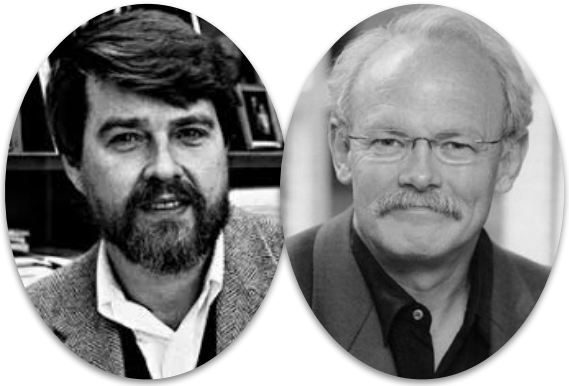


Fig. 2. A schematic representation of organism-external and -internal factors related to the faculty of language. FLB includes sensory-motor, conceptual-intentional, and other possible systems (which we leave open); FLN includes the core grammatical computations that we suggest are limited to recursion.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

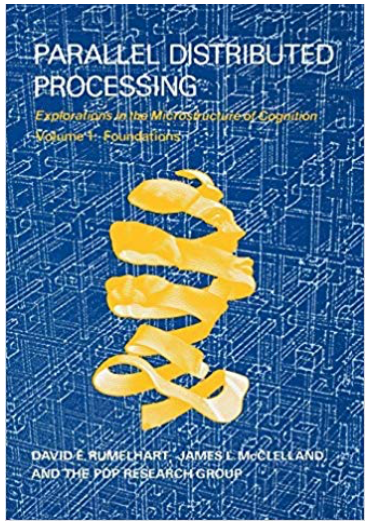
Hauser, M. D., Chomsky, N., & Fitch, W. T. (2002). The Faculty of Language: What Is It, Who Has It, and How Did It Evolve? *Science*, *298*(5598), 1569–1579. http://science.sciencemag.org/content/298/5598/1569

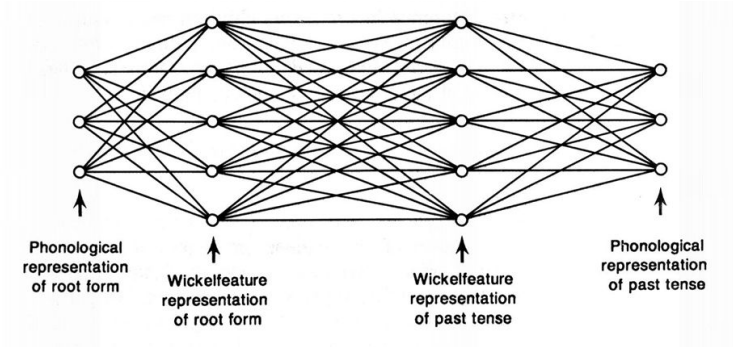
Connectionism (Parallel distributed processing)



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….

Buckner, C. & Garson, J. (2019), "Connectionism", The Stanford Encyclopedia of Philosophy. Edward N. Zalta (ed.). Retrieved from https://plato.stanford.edu/archives/spr2017/entries/connectionism/

The Harvard Center for Cognitive Studies (1960)

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 re-opened 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*.

Miller, G. (2003). The cognitive revolution: A historical perspective. *Trends in Cognitive Sciences, 7*(3), 141-144.

How many can you recall?

The Harvard Center for Cognitive Studies (1960)

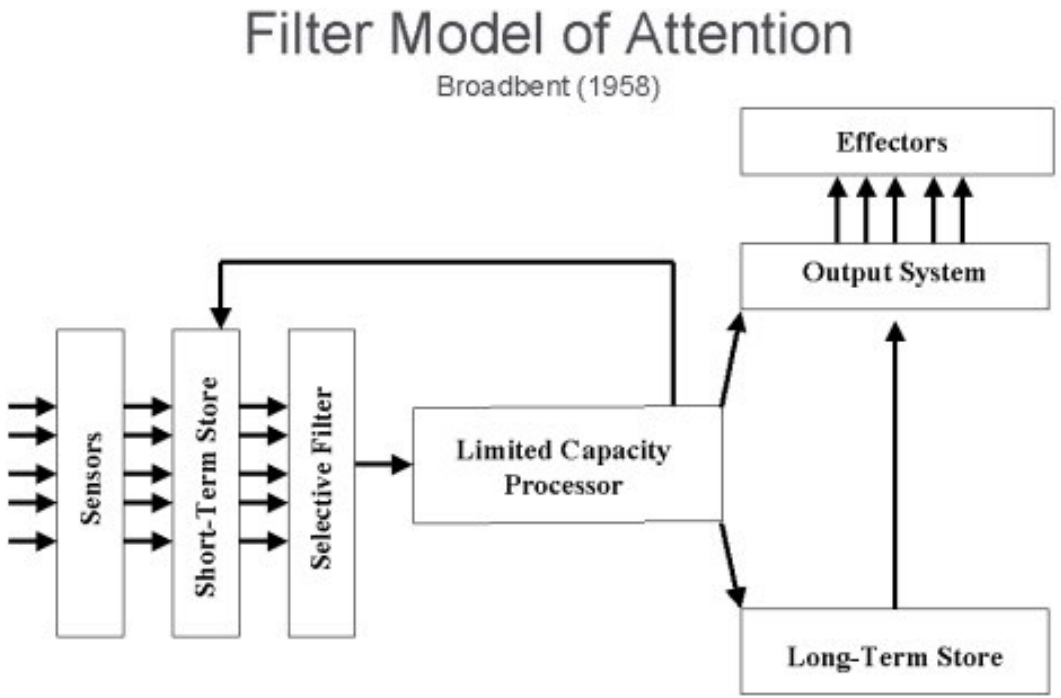
George Miller
(1920-2012)

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

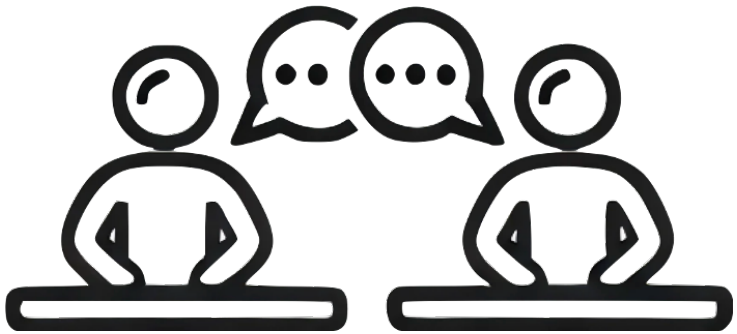
Psychology became fascinated with information-processing diagrams, in which boxes and arrows stand for (temporary) stores of information and/or processes that transform the information and the transmission of information.



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

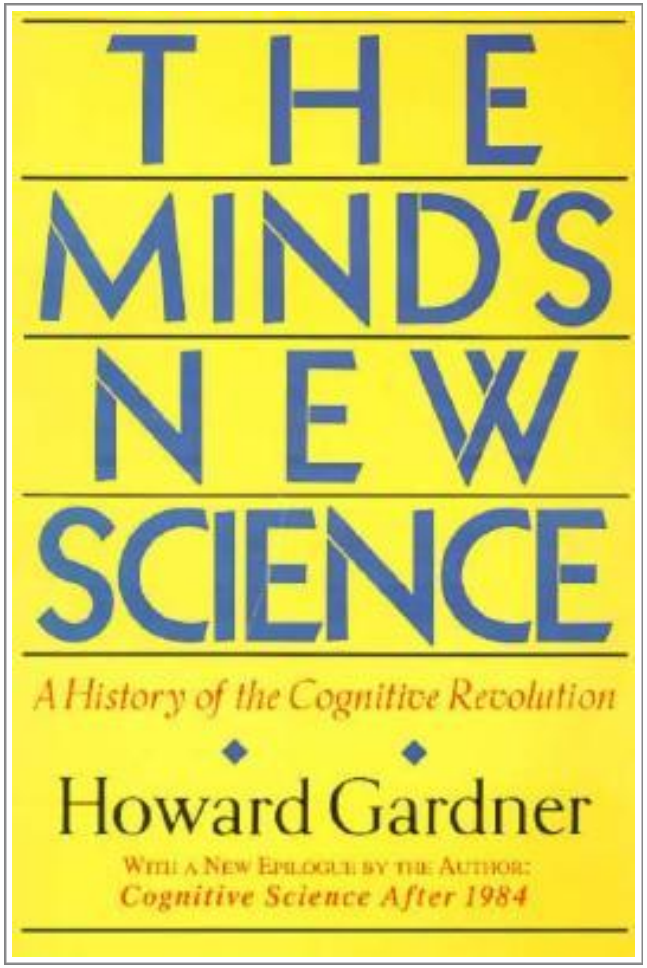
Cognitivism and cognitive psychology is the movement in psychology which explains behaviour as a function of mental processes (e.g., thinking, remembering, planning, attending) and representations (such as Noam Chomsky's generative grammar). Cognitivism gained importance and **acceptance** in psychology 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 rigourous 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

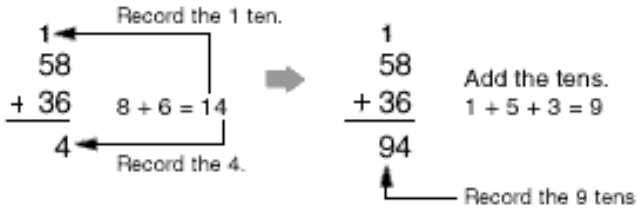
Marr's Levels

- *Computational level*: What is the goal of a given process/ computation?

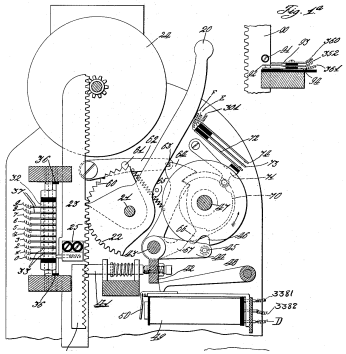
Addition

$S_T = Z_1 + \ldots + Z_N$

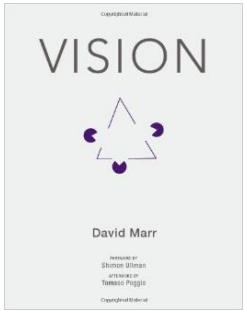
- *Algorithmic level*: How can a goal be achieved using a particular set of inputs/outputs, which algorithm describes the required transformations?



- *Implementational level*: How is an algorithm physically implemented (e.g., neural activity)?



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



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.

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."

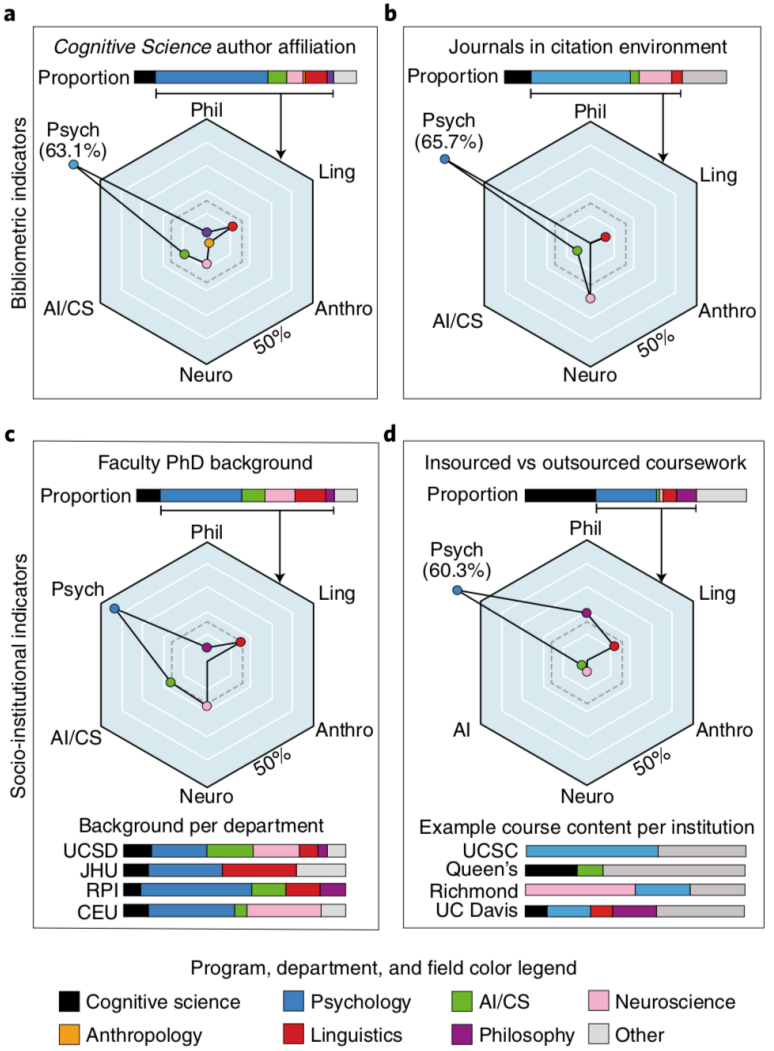


Fig. 2 | Four indicators of the status of cognitive science. a–d, The top two are bibliometric indicators; the bottom two are socio-institutional indicators. (**a**) The affiliation of authors in the journal *Cognitive Science*, (**b**) the citation environment of this journal, (**c**) the doctoral training of current cognitive science faculty and (**d**) the curriculum composition of current undergraduate cognitive science programs in North America. Th top bars show the overall distribution of disciplinary contributions to eac 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).

Núñez, R., Allen, M., Gao, R., Miller Rigoli, C., Relaford-Doyle, J., & Semenuks, A. (2019). What happened to cognitive science? *Nature Human Behaviour*, *3*(8), 782–791. http://doi.org/10.1038/s41562-019-0626-2

The myths of revolutions?

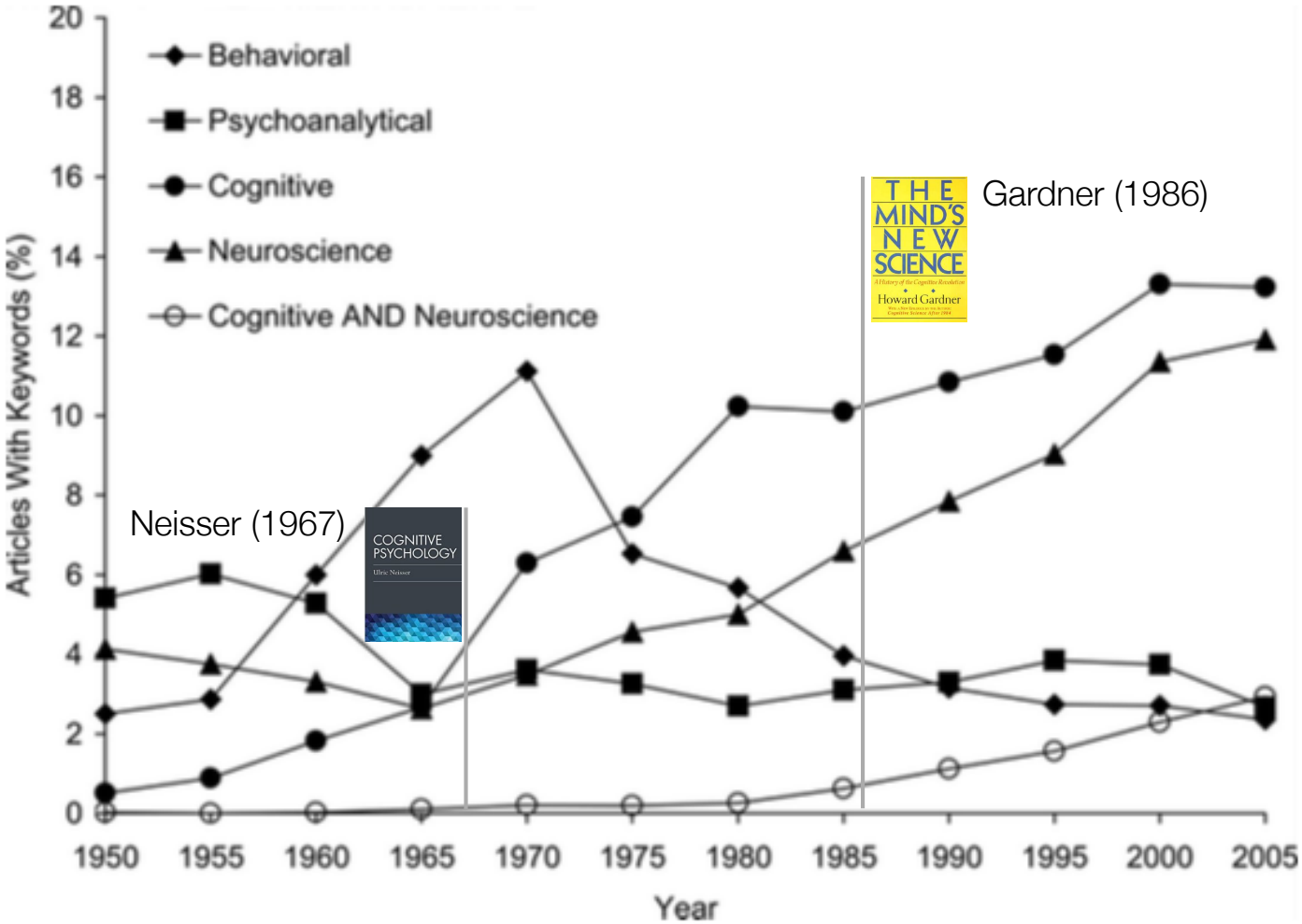
“The history of experimental psychology in America is typically told as a series of two Kuhnian revolutions separating three periods of normal science dominated by the mentalist, then behaviorist, and finally today's cognitivist paradigm. (…) The history of the behaviorist and cognitivist "revolutions" 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.”

Leahey, 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”

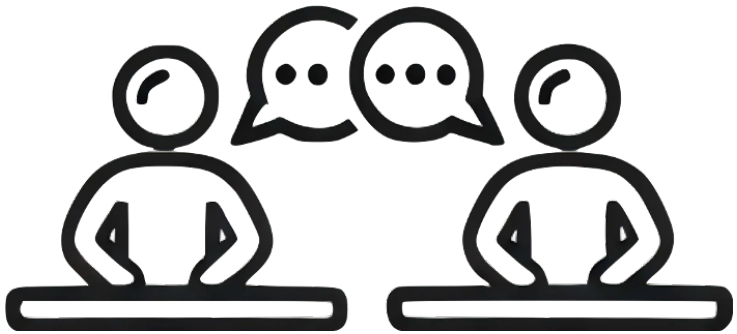
Keyword searches on all refereed journal articles in PyscINFO



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

- **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±2)

- **Cognitive Science**: interdisciplinary enterprise; Marr's levels; boom/peak in the 80s and 90, 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