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Psychologist Bennet Murdock pioneered mathematical models of human memory

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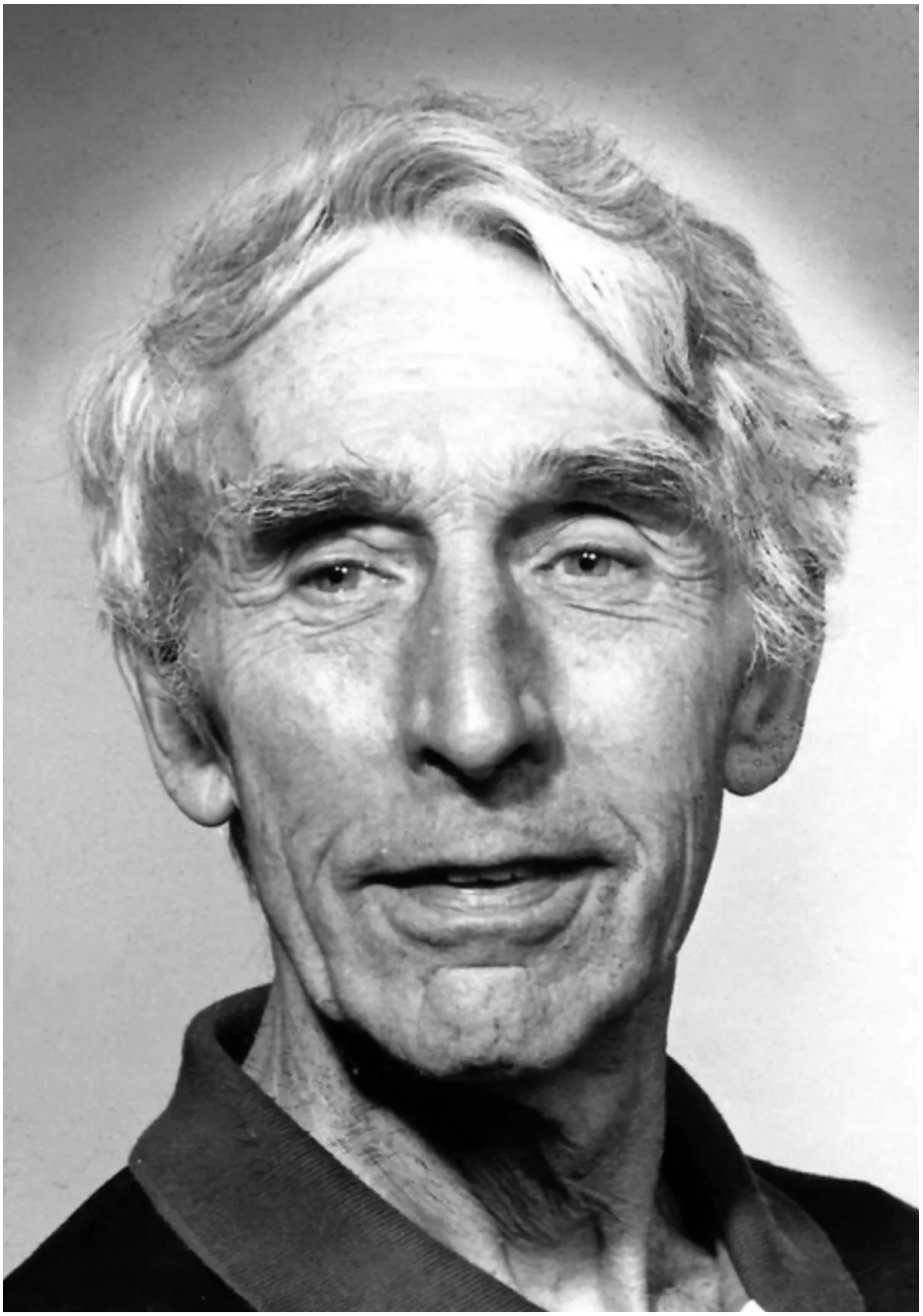


Professor Bennet Murdock.

COURTESY OF UNIVERSITY OF TORONTO PSYCHOLOGY DEPARTMENT

Professor Bennet Murdock, a pioneer in using mathematical models to study human memory, died on March 26 in Toronto at the age of 96. Prof. Murdock, a soft-spoken intellectual giant, was one of the first researchers to transition from studying long-term memory to studying short-term memory. One of his most famous findings, from 1962, was that when presented with a list of words, people are more likely to remember the ones that come first and last. The serial position curve (see Figure) shows the correlation between the position of a word in a list and the probability of its subsequent recall. There is hardly an introductory textbook in psychology or cognitive science that has not reproduced this graph.

Prof. Murdock's seminal investigations of short-term memory in the early 1960s led to mathematical models that conceived of a memory system in which short-term and long-term memory interact, much like in a computer system. In this manner, his work advanced an information processing revolution in cognitive psychology that drew on the newly emerging fields of computer science and information theory, spawned by military research during and immediately following the Second World War.

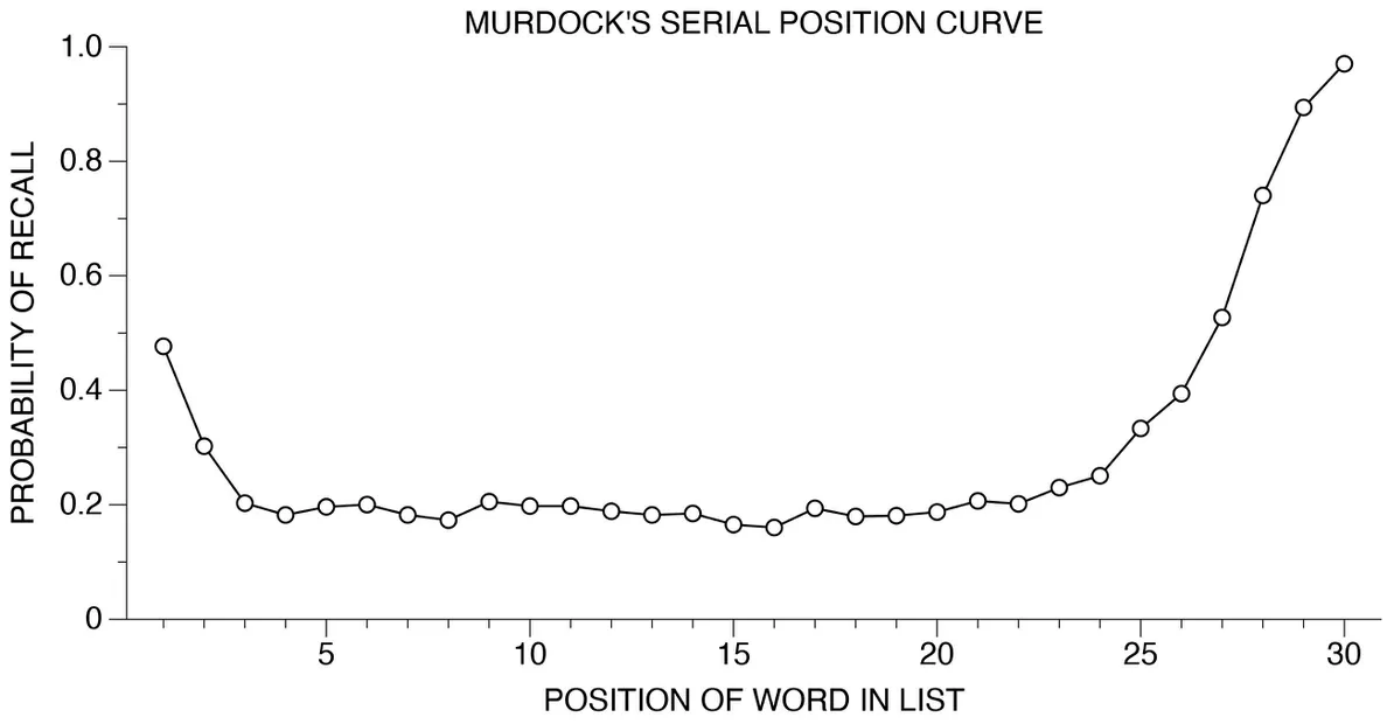
Prof. Murdock's 1974 monograph *Human Memory: Theory and Data* meticulously chronicled the first two decades of mathematically rigorous theoretical investigations of memory. This book inspired a generation of memory scholars to create new models and design experiments to test them.

Bennet Bronson Murdock Jr. was born in New Haven, Conn., on Oct. 18, 1925, the only child of Dr. Bennet Bronson Murdock Sr., a Yale-trained mathematician and Ruth (née Dewsbury) Murdock, an accomplished pianist and teacher. Ben's paternal uncle, Prof. George Peter Murdock, was a founder of cultural anthropology and a major influence on Ben's academic interests.

Following naval officer training during the Second World War, Ben Murdock Jr. received his BA and PhD from Yale (in 1947 and 1951 respectively), a major centre for the study of animal and human learning. He married Anne Suttie in 1948 at the Yale Chapel in New Haven, Conn., and in 1951 they moved to Burlington, Vt., where Ben launched his academic career at the University of Vermont. After briefly teaching at the University of Missouri, Ben

joined the faculty at the University of Toronto, where he continued to carry out research into his 80s.

Prior to Prof. Murdock's work, memory scientists measured how quickly people learned lists of items, and then they measured the circumstances that led to slower or faster forgetting of those lists (quantified by the time they required to relearn the previously mastered lists). Prof. Murdock demonstrated how one could study learning and forgetting on a much shorter time scale by tracing the history of a person's memory for the individual items within a list.



A graph showing Professor Bennet Murdock's Serial Position Curve, which shows the correlation between the position of a word in a list and the probability of its subsequent recall.

MICHAEL JACOB KAHANA

He drew inspiration for this work from 19th-century research in physical chemistry. Just as increasing temperature speeds the rate of chemical reactions (the Arrhenius equation) so too, Prof. Murdock surmised, one might be able to study the learning and forgetting process very rapidly; not by increasing the temperature in the testing room, but by measuring retention of individual items rather than entire lists. Prof. Murdock's work on short-term memory provided crucial scientific support to the concept of "chunking"– the notion that people form groups of items in memory and those groups come to act as individual items.

These studies of short-term memory also demonstrated that the distinctiveness of items in a list serves a fundamental principle governing the organization of memory, an idea that has directly or indirectly influenced nearly every major theory of memory developed in the past half century.

Prof. Murdock's experimental work led him to conclude that any complete theory of memory would have to grapple with differences in the way people encode and retrieve three types of information: information about individual items, information about associations between items, and information about the temporal order in which items occur.

Professor Bennet Murdock was a scholar's scholar.

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He believed that a model of memory should have routines for storing and retrieving each of these basic types of information, much like a computer operates on different types of variables, such as integers, strings, and arrays. Prof. Murdock came to strongly advocate for this information-processing view of the human memory system following a 1962 sabbatical

in the Cambridge University laboratory of the famous British psychologist Donald Broadbent. Prof. Broadbent (1926-1993) was arguably the strongest proponent of the view that basic principles of information processing account for the way people perceive and remember their experiences.

Prof. Murdock was also one of the first psychological researchers to embrace the digital computer, not only as a tool for analyzing data and building mathematical models, but also for refining the methodology used to present stimuli to research subjects and to measure the speed and accuracy of their responses. Prof. Murdock continuously sought to refine the experimental methods used in his laboratory, and his work came to set the high bar for experimental rigour.

As one example, Prof. Murdock's serial position curve, demonstrating the beneficial effects of being first and being last on the accuracy of immediate recall, led to his creation of a mathematical formula that precisely described this relation – a result that has been replicated countless times in the past 60 years.

Although quantitative modelling can be found in many of Prof. Murdock's early papers, it was in the late 1970s that he pivoted his research program away from experimental studies and toward the quest for a complete theory of memory.

The field had reached a critical point, Prof. Murdock noted, in which the key facts were well established but little was known about how they all fit together. In particular, there were no existing theories that could account for even the most basic data from recognition, associative recall and serial order memory in a common framework.

In four papers published between 1981 and 1983, Prof. Murdock and his then-graduate student, Janet Metcalfe (now a professor at Columbia University) developed a holographic memory model which could accomplish this feat. His work during the 1980s set a new standard for theoretical work in human memory. Together with Prof. Metcalfe and others, Prof. Murdock demonstrated the analytic power of modelling a wide range of memory phenomena within a single computational framework. This work ushered in an era of work on so-called "global memory models" which continued to define theoretical work over the past three decades.

Prof. Murdock was a scholar's scholar. He shunned the limelight, preferring to focus his energies on the pursuit of scientific truths without seeking publicity or accolades. In 2003

he was recognized with the Norman Anderson Lifetime Achievement Award from the Society of Experimental Psychologists. Despite his academic stature, he deliberately avoided accepting positions in academic or research administration. He neither wrote popular books nor gave Ted Talks. Yet, at scientific meetings, leading experts lined up to ask him questions on broad-ranging topics. His crop of white hair atop his 6-foot-4 athletic frame served as a beacon, rising above those surrounded him. For his students, he was always ready for a long walk to talk about science and life; but he religiously avoided academic gossip. He wanted to learn, and was always ready to teach.

Apart from his academic pursuits, Prof. Murdock took great joy in sports and the outdoors. He was an avid cyclist and tennis player, and a lifelong hiker. He taught each of his children to ski at the age of 2, and was an avid skier in Vermont and the Tetons until he was 89. He and his wife, Anne, were on the Albacore sailing team representing Canada in three world championships. Prof. Murdock adored classical music, particularly opera, which continued to inspire and sustain him through his last days.

Prof. Murdock leaves his loving partner, Jonye Feldman; Anne, his wife of 35 years, with whom he remained friends; three of his four children, Gregory, Katherine and Martha; grandchildren, Julian, Emily and Liana; and step-grandchildren, Caleb and Sarah. He was predeceased by his daughter Sarah. In addition, he has left behind more than 100 academic children and grandchildren – scientists who carry on his tradition of rigorous scholarship in the study of memory.