Hermann Ebbinghaus's "nonsense syllables" experiments show a method for studying cognitive processes.

Jerome Bruner and Cecile Goodman publish Value and Need as Organizing Factors in Perception, arguing that motivated reasoning affects perception.

Alan Turing publishes Computing Machinery and Intelligence, in which he describes the human Theory of Cognitive brain as an "organized Dissonance suggests through experience.

Leon Festinger's A machine" that learns there is a human drive for consistency of beliefs.







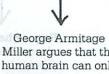




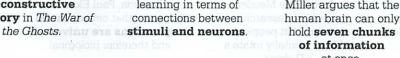
Frederic Bartlett studies Donald Hebb explains George Armitage memory in The War of connections between human brain can only Communication,



1949



1956





Donald Broadbent reconstructive learning in terms of Miller argues that the publishes Perception and introducing the information-processing model of cognition.

he first half of the 20th century was dominated by two strands of thinking in psychology: behaviorism (which concentrated on learning theory) and psychoanalysis (which focused on the unconscious and development in early childhood). The mental processes that had preoccupied psychologists in the previous century, such as perception, consciousness, and memory, were largely neglected.

There were inevitably some exceptions. Psychologists Frederic Bartlett of the UK and Bluma Zeigarnik of Russia were both studying the process of memory in the 1920s and 30s, anticipating the work of later cognitive psychologists. In Germany, Wolfgang Köhler's work on problem-solving and decision-making drew on Gestalt

psychology—a German school of thought that concentrated on perception and perceptual organization—and was also a precursor of cognitive psychology.

The cognitive revolution

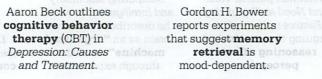
What eventually swung the balance from interest in behavior to the study of mental processes came from outside psychology. Improvements in communications and computer technology, and possibilities opened up by artificial intelligence—then a growing field thanks to advances made during World War II-led to a new way of thinking about the brain: as an information processor. The mental processes, referred to as "cognitive processes" or "cognition," which behaviorism would not or could not examine, now had a model for psychologists

to work from. At the same time, advances in neuroscience led to a greater understanding of the functions of the brain and nervous system. This allowed psychologists, notably Donald Hebb, to examine mental processes directly, rather than merely inferring them from observations of behavior.

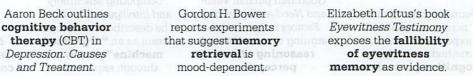
One of the first to apply the information-processing analogy to psychology was a student of Frederic Bartlett's at Cambridge, Donald Broadbent, who had been inspired by the work of computer scientist Alan Turing and communications expert Colin Cherry in the 1940s and 50s. But the turning point came in the US, where behaviorism began to be criticized for its limitations, leading to a so-called "cognitive revolution" in the late 1950s. In the vanguard of this



produces a series of seminal papers on memory and Depression: Causes endorm retrieval processes. Herein and Treatment.



1978



1996



Ulric Neisser coins psychology" in his



able to mentally rotate a 3-D object.



Roger Shepard and In Facial Expressions of In The Seven Sins the term **"cognitive** Jacqueline Metzler Emotion, Paul Ekman of Memory, Daniel publish research suggests that certain facial Schacter details book of the same title. showing that people are expressions are universal and therefore biological.



ways our memories can be erroneous.

dramatic shift of approach were the Americans George Armitage Miller and Jerome Bruner, who in 1960 co-founded the Center for Cognitive Studies at Harvard University.

A new direction

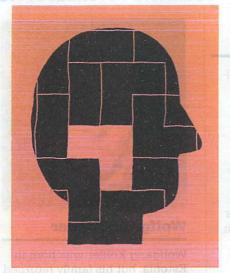
Miller and Bruner's ground-breaking work led to a fundamental change of direction in psychology. Areas that had been neglected by behaviorists, such as memory, perception, and emotions, became the central focus. While Bruner incorporated the concepts of cognition into existing theories of learning and developmental psychology, Miller's application of the information-processing model to memory opened up the field, making memory an important area of study for cognitive psychologists, including Endel Tulving, Elizabeth

Loftus, Daniel Schacter, and Gordon H. Bower. There was also a reappraisal of Gestalt psychology: Roger Shepard reexamined ideas of perception, and Wolfgang Köhler's work on problem-solving and decision-making resurfaced in the theories of Daniel Kahneman and Amos Tversky. And, perhaps for the first time, cognitive psychologists, including Bower and Paul Ekman, made a scientific study of emotion.

But it wasn't only the theories of behaviorists that were overturned; Freud's psychoanalytic theory and its followers were also criticized for being unscientific. Aaron Beck found that cognitive psychology could provide a more effective therapy—and that it was more amenable to objective scrutiny. The cognitive therapy he advocated, later incorporating elements of

behavioral therapy and meditation techniques, soon became standard treatment for disorders such as depression and anxiety, and led to a movement of positive psychology advocating mental wellbeing rather than just treating mental illness.

At the beginning of the 21st century, cognitive psychology is still the dominant approach to the subject, and has had an effect on neuroscience, education, and economics. It has even influenced the nature-nurture debate; in the light of recent discoveries in genetics and neuroscience. evolutionary psychologists such as Steven Pinker have argued that our thoughts and actions are determined by the make-up of our brains, and that they are like other inherited characteristics: subject to the laws of natural selection.



INSTINCT IS A DYNAMIC PATTERN

WOLFGANG KOHLER (1887–1967)

IN CONTEXT

APPROACH
Gestalt psychology

BEFORE

1890 Austrian philosopher Christian von Ehrenfels introduces the concept of Gestalt in his book, On the Qualities of Form.

1912 Max Wertheimer publishes Experimental Studies of the Perception of Movement, a landmark in Gestalt psychology.

AFTER

1920s Edward Tolman brings together ideas from Gestalt and behaviorist psychology in his purposive behaviorism (now cognitive behaviorism).

1935 Psychology of Productive Thinking by Karl Duncker—a German Gestalt psychologist—describes experiments in problemsolving and mental restructuring. If a chimp tries to solve a problem using **trial and error**, but fails...

It then applies this solution to **similar problems** in the future.

This pattern of insightlearning is **active**, not passive. ...it pauses and considers the problem, taking into account everything around it...

.. until it reaches an **insight** that leads to a solution.

Instinct is a dynamic pattern.

n the late 19th century, a group of German psychologists who disagreed with the prevailing schools of thought developed a new, scientific, and distinctly holistic approach, which they called Gestalt. Wolfgang Köhler, who founded the new movement along with Max Wertheimer and Kurt Koffka, explained that the word means both "pattern" and, when applied to their theory, "organized whole."

Gestalt psychology (not to be confused with Gestalt therapy, a much later development) took as its starting point the idea that concepts such as perception, learning, and cognition should be considered as wholes, not studied by investigating their various parts.

Köhler thought the dominant branch of psychology, behaviorism, was too simplistic and overlooked the dynamic nature of perception. See also: Ivan Pavlov 60-61 = Edward Thorndike 62-65 = Edward Tolman 72-73 = Max Wertheimer 335



Köhler studied chimpanzees solving task-related problems. He realized they could actively perceive several possible solutions before finding the answer through a moment of insight.

Pavlov and Thorndike claimed that animals learn by trial and error through simple stimulus—response conditioning, but Köhler believed they were capable of insight and intelligence. He was able to put this to the test when he became director of an anthropoid research center on Tenerife from 1913–20, where he studied chimpanzees tackling a number of problem-solving tasks.

Insightful learning

What Köhler observed confirmed his belief, and also demonstrated that problem-solving and learning could be explained in terms of Gestalt. When faced with a problem, such as how to reach food in an inaccessible place, the chimpanzees were frustrated in their initial attempts, but would then pause and apparently take stock of the situation before attempting some kind of solution. This often involved using toolssuch as sticks or crates that were lying around in their play area—to reach the food. When subsequently faced with the same problem, they instantly applied the same solution. Köhler concluded that the chimps'

behavior showed a cognitive trialand-error process rather than an actual one; they were solving the problem in their minds first, and only after an insight (the "aha" moment) tried out their solution. This is contrary to the behaviorist view that learning is conditioned by response to a stimulus, and reinforced by reward. The chimps learned by perceiving the problem, not by receiving rewards.

This was a demonstration of Köhler's dynamic model of behavior, involving organization within perception, rather than passive learning through response to rewards. The pattern (Gestalt) of learning by insight—failure. pause, perception, insight, and attempt—is an active one: but this is not necessarily apparent to someone watching the chimps' separate attempts to solve the problem, mainly because it is not possible to see the organization of perception in the chimp's mind. What we call instinct, the apparently automatic response to solving a problem, is affected by this process of insight learning, and is itself an active, dynamic pattern.



Insight has the appearance of a complete solution with reference to the whole layout of the field.

Wolfgang Köhler





Wolfgang Köhler

Wolfgang Köhler was born in Estonia, but his family returned to their native Germany soon after his birth. He studied at various colleges before completing a PhD in Berlin. In 1909, he and Kurt Koffka worked with Max Wertheimer at the Frankfurt Academy on his perception experiments; these formed the basis of Gestalt psychology.

In 1913, Köhler became director of the Prussian Academy of Sciences research station in Tenerife, where he became stranded at the start of World War I, remaining there until 1920. On his return to Berlin, he served as director of the Psychological Institute until 1935, when he emigrated to the US to escape the Nazi regime. He taught at several US colleges, and was elected president of the American Psychological Association for 1959. Ulric Neisser described him as "a genuinely creative thinker as well as a person of great dignity and honor."

Key works

1917 The Mentality of Apes 1929 Gestalt Psychology 1938 The Place of Values in a World of Facts



INTERRUPTION OF A TASK GREATLY IMPROVES ITS CHANCES OF BEING REMEMBERED

IN CONTEXT

APPROACH
Memory studies

BEFORE

1885 Hermann Ebbinghaus publishes his pioneering book, *Memory: A Contribution to Experimental Psychology.*

1890 William James in *The Principles of Psychology* makes the distinction between primary (short-term) and secondary (long-term) memory.

AFTER

1956 George Armitage Miller's The Magical Number Seven, Plus or Minus Two revives interest in the study of memory.

1966 Jerome Bruner stresses the importance of organization and categorization in the learning process.

1972 Endel Tulving
distinguishes between
episodic memory (of specific
events) and semantic memory
(of factual information unrelated
to an event or situation).

hile researching for her doctorate in Berlin, Russian psychologist
Bluma Zeigarnik was told by her professor, Kurt Lewin, that he had noticed waiters could recall details of orders that were still not paid for better than details of orders they had completed. This led Zeigarnik to wonder whether unfinished tasks have a different status in memory, and are remembered better, than finished ones. She devised an

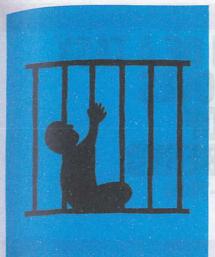


The "Zeigarnik effect" can be demonstrated by the fact that a waiter is more likely to remember details of an order that has not yet been paid for, than one that has been completed.

experiment in which participants were given simple puzzles or tasks to do. They were interrupted during about half these tasks. Later, when asked how well they could remember the activities, it became clear that they were twice as likely to recall details of the interrupted tasks, whether these were ultimately completed or not. Zeigarnik reasoned that this could be due to the task lacking closure, leading to the memory being stored differently, and more effectively.

This phenomenon, which became known as the "Zeigarnik effect," had important implications. Zeigarnik proposed that students, especially children, retained more if they had frequent breaks while studying. But little notice was taken of her ideas until memory once again became a key subject for research in the 1950s. Since then, Zeigarnik's theory has been accepted as a major step in the understanding of memory, and has found practical application not only in education but also in advertising and the media.

See also: Hermann Ebbinghaus 48-49 " Jerome Bruner 164-65 " George Armitage Miller 168-73 " Endel Tulving 186-91 " Daniel Schacter 208-09



WHEN A BABY HEARS FOOTSTEPS, AN ASSEMBLY IS EXCITED

DONALD HEBB (1904-1985)

IN CONTEXT

APPROACH Neuropsychology

BEFORE

1890 William James puts forward a theory about neural networks in the brain.

1911 Edward Thorndike's
Law of Effect proposes that
connections between stimulus
and response are "stamped in,"
creating a neural link, or
association.

1917 Wolfgang Köhler's study of chimps shows that learning by insight is longer-lasting than learning by trial and error.

1929 Karl Lashley publishes Brain Mechanisms and Intelligence.

AFTER

1970s George Armitage Miller coins the term "cognitive neuroscience."

1980s Neuroscientists devise imaging techniques, allowing them to map brain functions.

n the 1920s, a number of psychologists turned to neuroscience for answers to questions about learning and memory. Prominent among these was Karl Lashley, who led the way in examining the role played by neural connections, but it was his student, the Canadian psychologist Donald Hebb, who formulated a theory to explain what actually happens during the process of associative learning.

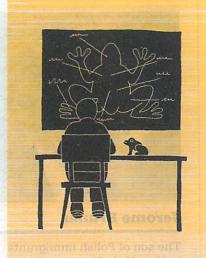
Hebb argued that nerve cells become associated when they are simultaneously and repeatedly active; the synapses, or links, that connect them become stronger. Repeated experiences lead to the formation of "cell assemblies," or groups of connected neurons, in the brain—a theory often summed up as "cells that fire together, wire together." Similarly, separate cell assemblies can also become linked, forming a "phase sequence," which we recognize as a thought process.

This associative process, Hebb found, is especially noticeable in childhood learning, when new cell

assemblies and phase sequences are being formed. In his book, The Organization of Behavior (1949), he gave the example of a baby hearing footsteps, which stimulates a number of neurons in its brain; if the experience is repeated, a cell assembly forms. Subsequently, "when the baby hears footsteps... an assembly is excited; while this is still active he sees a face and feels hands picking him up, which excites other assemblies—so the 'footsteps assembly' becomes connected with the 'face assembly' and with the 'being-picked-up assembly.' After this has happened, when the baby hears footsteps only, all three assemblies are excited." In adults, however, learning tends to involve the rearrangement of existing cell assemblies and phase sequences, rather than the formation of new ones.

Hebb's theory of cell assembly was a cornerstone of modern neuroscience, and his explanation of neural learning, which became known as Hebbian learning, remains the accepted model.

See also: Edward Thorndike 62–65 • Karl Lashley 76 • Wolfgang Köhler 160–61 • George Armitage Miller 168–73 • Daniel Schacter 208–09



KNOWING IS A PROCESS NOT A PRODUCT

revisited and

IN CONTEXT

APPROACH
Cognitive development

BEFORE

1920s Lev Vygotsky develops his theory that cognitive development is a both a social and a cultural process.

1936 Jean Piaget publishes his developmental theories in his book, *Origins of Intelligence in the Child*.

AFTER

1960s The teaching program "Man: A Course of Study (MACOS)," based on Bruner's theories, is adopted in schools in the US, the UK, and Australia.

1977 Albert Bandura
publishes Social Learning
Theory, which looks at
development through a
mixture of behavioral
and cognitive aspects.

...and are finally

We learn things by active experience.

Instructing someone is not just telling them something but encouraging them to participate.

We acquire knowledge through the use of reasoning, by constructing meaning from the information.

This is a form of information processing.

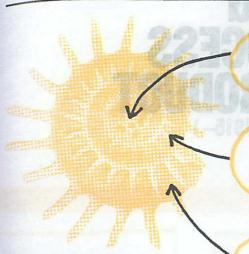
Knowing is a process, not a product.

he field of developmental psychology was dominated throughout much of the 20th century by Jean Piaget, who explained how a child's thinking develops and matures in stages, as a result of a natural curiosity to explore the environment. Lev Vygotsky's theory, which appeared in English shortly after Piaget's, also claimed that a child finds meaning through experience, but

widened the meaning of the word "experience" to encompass cultural and social experience. Children, he said, learn mainly through interaction with other people.

At this point in the 1960s, the "cognitive revolution" was gaining momentum; mental processes were increasingly being explained by the analogy of the brain as an "information processor." Jerome Bruner was a key figure in this new

see also: Jean Piaget 262-69 " Lev Vygotsky 270 " Albert Bandura 286-91



Ideas are first presented in a simple and intuitive way.

They are continuously revisited and reconstructed in an increasingly formal way...

A spiral curriculum would work best in schools, Bruner suggested. This involves a constant revisiting of ideas, building incrementally until the child reaches a high level of understanding. ...and are finally

connected to other

knowledge for

comprehensive mastery

of the subject.

approach, having previously studied the ways that our needs and motivations influence perception—and concluding that we see what we need to see. He became interested in how cognition develops, and so began to study cognitive processes in children.

The mind as processor

Bruner began his investigations by applying cognitive models to Piaget and Vygotsky's ideas, shifting the emphasis in the study of cognitive development from the construction of meaning to the processing of information: the means by which we acquire and store knowledge. Like Piaget, he believes that acquiring knowledge is an experiential process; but like Vygotsky, sees this as a social occupation, not a solitary one. He maintains that learning cannot be conducted unassisted: some form of instruction is essential to a child's

development, but "to instruct someone... is not a matter of getting him to commit results to mind. Rather, it is to teach him to participate in the process." When we acquire knowledge, we need to actively participate and reason, rather than passively absorb information, because this is what gives knowledge meaning. In terms of cognitive psychology, reasoning is seen as "processing information," so the acquisition of knowledge should be seen as a process, not a product or end result. We need encouragement and guidance in that process, and for Bruner, that is the role of a teacher.

In The Process of Education (1960), Bruner presented the idea that children should be active participants in the process of education. The book became a landmark text, altering educational policy in the US at governmental and schoolteacher level.



Jerome Bruner

The son of Polish immigrants in New York City, Jerome Seymour Bruner was born blind, but regained his sight after cataract operations at the age of two. His father died of cancer when Bruner was 12, and his grief stricken mother moved the family frequently during his subsequent school years. He studied psychology at Duke University, then at Harvard, where he attained a PhD in 1941 alongside Gordon Allport and Karl Lashley.

Bruner served in the US army's Office for Strategic Studies (an intelligence unit) during World War II, then returned to Harvard, where he collaborated with Leo Postman and George Armitage Miller. In 1960, he cofounded the Center for Cognitive Studies with Miller at Harvard, remaining until it closed in 1972. He spent the next ten years teaching at Oxford University in England, before returning to the US. Bruner continued to teach into his nineties.

Key works

1960 The Process of Education 1966 Studies in Cognitive Growth 1990 Acts of Meaning



A MAN WITH CONVICTION IS A HARD MAN TO CHANGE

LEON FESTINGER (1919–1989)

IN CONTEXT

BRANCH
Cognitive psychology

APPROACH
Learning theory

BEFORE

1933 Gestalt psychologist Kurt Lewin leaves the Berlin School of Experimental Psychology and emigrates to the US.

AFTER

1963 Stanley Milgram
publishes his experiments on
willingness to obey authority
figures, even when orders
conflict with one's conscience.

1971 Philip Zimbardo's Stanford prison study shows how people adapt to the roles they are assigned.

1972 US social psychologist Daryl Bem proposes the alternative self-perception theory of attitude change.

1980s Elliot Aronson defends Festinger's theory, conducting experiments into initiation rites. If we hold **strong beliefs** that are undermined by **evidence to the contrary**...

...we find ourselves in an uncomfortable state of "cognitive dissonance."

If we accept the contradiction, this causes further inconsistency between our past and present beliefs.

So instead we may find ways to **make the new** evidence consistent with our beliefs.

A man with conviction is a hard man to change.

See also: Kurt Lewin 218-23 = Solomon Asch 224-27 = Elliot Aronson 244-45 = Stanley Milgram 246-53 = Philip Zimbardo 254-55 = Stanley Schachter 338

y the end of World War II, social pscychology had become an important field of research, spearheaded in the US by Kurt Lewin, the founder of the Research Center for Group Dynamics at the Massachusetts Institute of Technology in 1945.

On the staff at the center was one of Lewin's former students, Leon Festinger. Originally attracted by Lewin's work in Gestalt psychology, he later took an interest in social psychology. In the course of his research, Festinger observed that people continually seek to bring order to their world, and a key part of that order is consistency. To achieve this, they develop routines and habits, such as establishing regular mealtimes and choosing favorite seats on their daily commute to work. When these routines are disrupted, people feel very uneasy. The same is true, he found, of habitual thought patterns or beliefs. If a very strong opinion is met with contradictory evidence, it creates an uncomfortable internal inconsistency; Festinger called this "cognitive dissonance." He reasoned that the only way to overcome this discomfort is to somehow make the belief and the evidence consistent.

Unshakeable conviction

After reading a report in a local newspaper in 1954, Festinger saw an opportunity to study the reaction to just such a cognitive dissonance. A cult claimed to have received messages from aliens warning of a flood that would end the world on December 21; only true believers would be rescued by flying saucers. Festinger and some of his colleagues at the University of Minnesota gained access to the group, interviewing them before the designated apocalyptic date and again afterward, when the events had failed to transpire.

The now-famous Oak Park study of this group, written up by Festinger, Henry Riecken, and Stanley Schachter in *When Prophecy Fails*, describes the reaction of the cult members. Where common sense might lead us to expect that the failure of

their prediction and consequent cognitive dissonance would cause cult members to abandon their beliefs, the opposite occurred. As the day of reckoning drew near, another "message" came through, declaring that, due to the group's dedication, the world was to be spared. Cult members became even more fervent believers. Festinger had anticipated this; to accept the contradictory evidence would set up an even greater dissonance between past belief and present denial, he argued. This effect was compounded if a great deal (reputation, jobs, and money) had been invested in the original belief.

Festinger concluded that cognitive dissonance, or at least the avoidance of it, makes a man of strong conviction unlikely to change his opinion in the face of contradiction; he is immune to evidence and rational argument. As Festinger explains: "Tell him you disagree and he turns away. Show him facts or figures and he questions your sources. Appeal to logic and he fails to see your point."

Leon Festinger



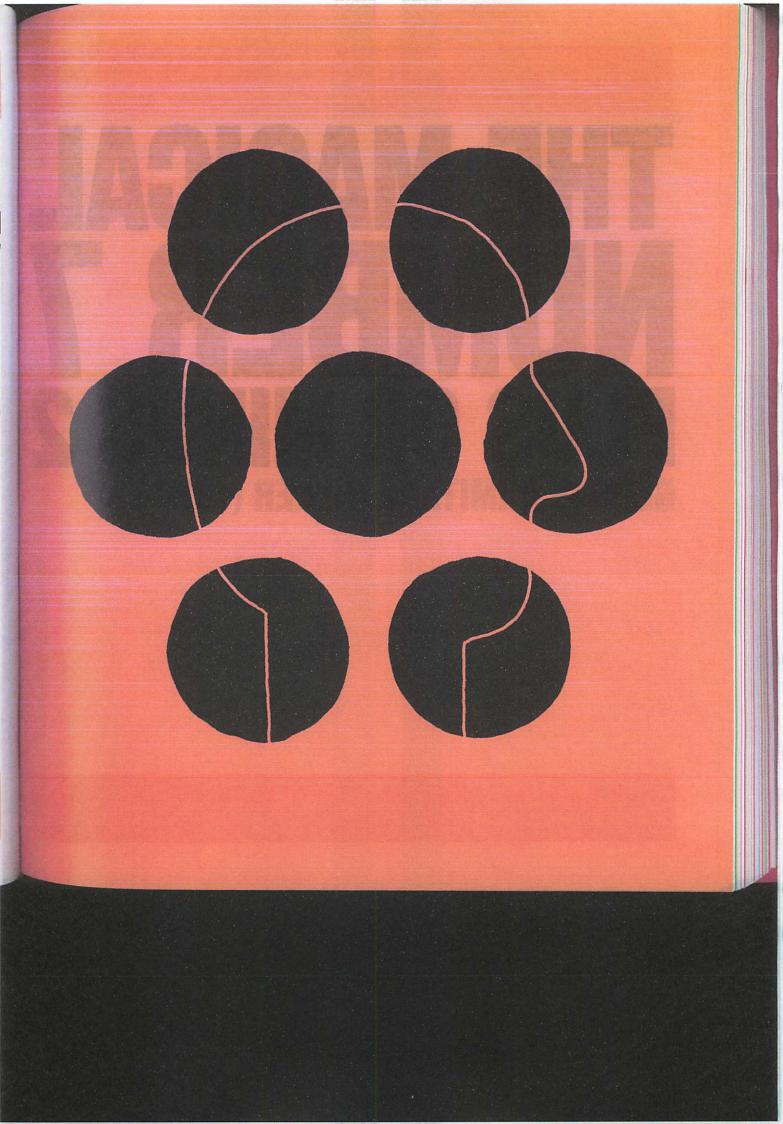
Leon Festinger was born in Brooklyn, New York, to a Russian immigrant family. He graduated from City College of New York in 1939, then studied at the University of Iowa under Kurt Lewin, finishing his PhD in Child Psychology in 1942. After spending the later years of World War II in military training, he rejoined Lewin in 1945 at the Research Center for Group Dynamics at the Massachusetts Institute of Technology (MIT).

It was during his appointment as professor at the University of Minnesota that Festinger made his famous Oak Park study of a cult predicting the end of the world. He moved to Stanford University in 1955, continuing his work in social psychology, but in the 1960s he turned to research into perception. He later focused on history and archaeology at the New School for Social Research in New York. He died of liver cancer, aged 69.

Key works

1956 When Prophecy Fails 1962 A Theory of Cognitive Dissonance 1983 The Human Legacy

THE MAGICAL NUMBER 7 PLUS OR MINUS 2 GEORGE ARMITAGE MILLER (1920-)



IN CONTEXT

APPROACH Memory studies

BEFORE

1885 Hermann Ebbinghaus publishes his pioneering book *Memory: A Contribution to Experimental Psychology.*

1890 William James makes the distinction between primary (short-term) and secondary (long-term) memory in *The Principles of Psychology*.

1950 Mathematician Alan Turing's test suggests that a computer can be considered a thinking machine.

AFTER

1972 Endel Tulving makes the distinction between semantic and episodic memory.

2001 Daniel Schacter proposes a list of the different ways we misremember in *The Seven Sins of Memory.*

Before information is stored in long-term memory, it is processed by working memory.

Working memory has a limited capacity—about seven (plus or minus two) elements.

If individual "bits" of information are organized into "chunks" (meaningful patterns) of information they are easier to store.

Working memory can then hold seven (plus or minus two) of these larger chunks of information.

eorge Armitage Miller once famously complained: "My problem is that I have been persecuted by an integer. For seven years this number has followed me around." So begins his now famous article The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information. He goes on: "There is... some pattern governing its appearances. Either there really is something unusual about the number or I am suffering from delusions of persecution." Despite the whimsical nature of his title

and introduction, Miller had a serious intent, and the article was to become a landmark of cognitive psychology and the study of working memory (the ability to remember and use pieces of information for a limited amount of time).

Miller's paper was published in The Psychological Review in 1956, when behaviorism was being superseded by the new cognitive psychology. This fresh approach—which Miller wholeheartedly embraced—focused on the study of mental processes, such as memory and attention. At the same time,

advances in computer science had brought the idea of artificial intelligence closer to reality, and while mathematicians, such as Alan Turing, were comparing computer processing with the human brain, cognitive psychologists were engaged in the converse: they looked to the computer as a possible model for explaining the workings of the human brain. Mental processes were being described in terms of information processing.

Miller's main interest was in the field of psycholinguistics, stemming from his work during World War II on

See also: Hermann Ebbinghaus 48-49 = Bluma Zeigarnik 162 = Donald Broadbent 178-85 = Endel Tulving 186-91 = Gordon H. Bower 194-95 = Daniel Schacter 208-09 = Noam Chomsky 294-97 = Frederic Bartlett 335-36

66

The persistence with which this number plagues me is far more than a random accident.

George Armitage Miller

99

speech perception, which formed the basis for his doctoral thesis. This led him to take an interest in the growing field of communications, which in turn introduced him to information theory. He was particularly inspired by Claude Shannon, a leading figure in communications, who was investigating effective ways of turning messages into electronic signals. Shannon's communication model, which involved translating ideas into codes made up of "bits," underpins all digital communication. Miller was inspired to look at mental processes in a similar way, and to establish the ground rules for the modern field of psycholinguistics in his 1951 book, Language and Communication.

Seven categories

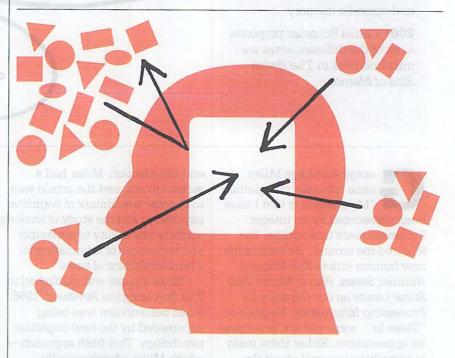
Miller took Shannon's method of measuring information and his idea of "channel capacity" (the amount of information that can be processed by a system) and applied it to the model of short-term memory as an information processor. This was when he began to be "persecuted"

by the recurrence and possible significance of the number seven; "sometimes a little larger and sometimes a little smaller than usual, but never changing so much as to be unrecognizable."

The first instance of the "magical" number came from experiments to determine the span of absolute judgment—how accurately we can distinguish a number of different stimuli. In one experiment cited in Miller's paper, the physicist and acoustic specialist Irwin Pollack played a number of different musical tones to participants, who were then asked to assign a number to each tone. When up to around seven different tones were played, the subjects had no difficulty in

accurately assigning numbers to each of them, but above seven (give or take one or two), the results deteriorated dramatically.

In another experiment, by Kaufman, Lord, et al, in 1949, researchers flashed varying numbers of colored dots on to a screen in front of participants. When there were fewer than seven dots. participants could accurately number them; when there were more than seven, participants were only able to estimate the number of dots. This suggests that the span of attention is limited to around six, and caused Miller to wonder whether the same basic process might be involved in both the span of absolute judgment and the span of attention. »



An experiment into the span of attention presented participants with random patterns of dots flashed on a screen for a fraction of a second. Participants instantly recognized the number if there were fewer than seven.

The tones and dots in these experiments are what Miller calls "unidimensional stimuli" (objects that differ from one another in only one respect): but what interested Miller is the amount of information in speech and language we can effectively process, and items such as words are "multidimensional stimuli." He looks to later studies by Pollack in which the simple tones were replaced by tones that varied in six ways (such as pitch, duration, volume, and location). Surprisingly, despite the apparently larger amount of information, the results still pointed to a differential limit of seven, plus or minus two. The difference is that as more variables are added, accuracy slightly decreases. Miller claims this allows us to make "relatively crude judgments of several things simultaneously." It may explain how we are able to recognize and distinguish such complex things as spoken words and people's faces, without having to process the individual sounds or features.

Miller sees the human mind as a communication system: as the input information increases, the amount transmitted to the brain also increases initially, before leveling off at an individual's "channel capacity." Miller then

took this idea of channel capacity a stage further, applying it to the model of short-term memory. William James first proposed the notion of short-term memory, and it had long been an accepted part of the model of the brain as an information processor, coming between the sensory input of information and long-term memory. Hermann Ebbinghaus and Wilhelm Wundt had even suggested that short-term memory had a capacity limited to around seven items (seven, again). Miller believed that what he called working memory had a capacity that corresponded to the limits of absolute judgment and span of attention.

Bits and chunks

In terms of our ability to process information, if working memory is limited to about seven elements, there is a potential bottleneck restricting the amount that can be put into long-term memory. But Miller suggested that there was more to the correspondence than just the number seven, no matter how magical it appeared. The multidimensional stimuli of previous experiments could be seen as composed of several "bits" of related information, but treated as a single item. Miller believed

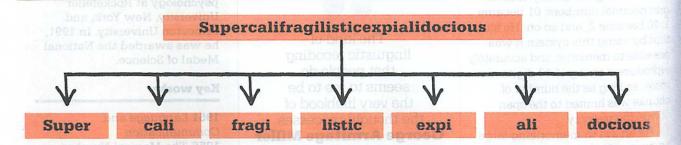


The process of memorizing may be simply the formation of chunks... until there are few enough chunks so that we can recall all the items.

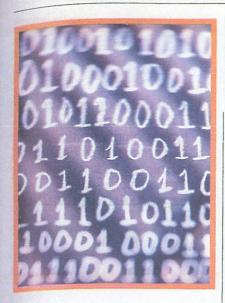
George Armitage Miller



that by the same principle, working memory organizes "bits" of information into "chunks," to overcome the informational bottleneck caused by our limited spans of absolute judgment and short-term memory. A chunk is not, however, just an arbitrary grouping, but an encoding of bits into a meaningful unit; for example, a string of 21 letters represents 21 bits of information, but if this can be broken down into a sequence of three-letter words, it becomes seven chunks. Chunking is dependent on our ability to find patterns and relationships in the



Miller's theory of chunking says that by building up or breaking down long streams of numbers or letters into memorable chunks, we increase the amount of information we can hold in working memory.



bits of information. To someone who does not speak the same language, the seven words might be meaningless, and would not constitute seven chunks, but 21 bits.

Miller's theory was backed up by earlier experiments by other psychologists. In 1954, Sidney Smith conducted experiments in memorizing a sequence of binary digits—a meaningless string of ones and zeroes to anyone unfamiliar with the binary system. Smith broke the series down into chunks, at first into pairs of digits. and then in groups of three, four, and five, and then "recoded" them by translating the binary chunks into decimal numbers: 01 became 1, 10 became 2, and so on. He found that by using this system it was possible to memorize and accurately reproduce a string of 40 digits or more, as long as the number of chunks was limited to the span of working memory.

As an aid to memorizing large amounts of information, chunking and recoding is an obvious boon, but it is more than a mnemonic trick. Miller pointed out that this form of recoding is an "extremely

Binary code is a way of recoding information into ever-more tightly packed parcels (through multibase arithmetic). Miller claims our chunking process operates in a similar way.

powerful weapon for increasing the amount of information we can deal with." It effectively stretches the informational bottleneck.

The study of memory

Miller himself moved away from the subject of memory in his later research, but his theory prompted others to examine it in more detail. Donald Broadbent argued that the real figure for working memory is probably less than seven, and this was later confirmed in experiments by Nelson Cowan, who found it to be around four chunks, depending on the length and complexity of the chunks, and the age of the subject.

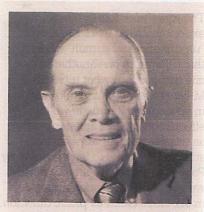
In the conclusion to his paper, Miller is dismissive of the significance of the number that originally prompted it. He concludes by saying: "Perhaps there is something deep and profound behind all these sevens... but I suspect that it is only a pernicious, Pythagorean coincidence."



The kind of
linguistic recoding
that people do
seems to me to be
the very lifeblood of
the thought processes.

George Armitage Miller





George Armitage Miller

George Armitage Miller was born in Charleston, WV. After graduating from the University of Alabama in 1941 with an MA in speech pathology, he earned a PhD at Harvard in psychology, working in Stanley Smith Stevens' Psychoacoustic Laboratory, with Jerome Bruner and Gordon Allport. During World War II the laboratory was asked to help with military tasks such as radio jamming.

In 1951, Miller left Harvard for Massachusetts Institute of Technology (MIT), then returned to Harvard in 1955, where he worked closely with Noam Chomsky. In 1960, he cofounded the Harvard Center for Cognitive Studies. He later worked as a professor of psychology at Rockefeller University, New York, and Princeton University. In 1991, he was awarded the National Medal of Science.

Key works

1951 Language and
Communication
1956 The Magical Number
Seven, Plus or Minus Two
1960 Plans and the Structure
of Behavior (with Eugene
Galanter and Karl Pribram)

THERE'S MORE TO THE SURFACE THAN MEETS THE EYE THE EYE THERE'S MORE TO THE SURFACE THE SURFACE THERE'S MORE TO THE SURFACE THERE'S MORE THE

Less not in the unconscious

Less not in the transporter of the state of the state

IN CONTEXT

APPROACH
Cognitive therapy

BEFORE

1890s Sigmund Freud proposes an analytic approach to psychotherapy.

1940s and 1950s Fritz Perls, with Laura Perls and Paul Goodman, develops Gestalt therapy—a cognitive approach to psychotherapy.

1955 Albert Ellis introduces Rational Emotive Behavior Therapy (REBT), breaking with the tradition of analysis.

AFTER

1975 Martin Seligman defines "learned helplessness" in Helplessness: On Depression, Development, and Death.

1980s A blend of Beck's ideas and the behavior therapies of Joseph Wolpe give rise to new cognitive behavioral therapies.

fter psychology had become established as a distinct field of study, around the turn of the 20th century, two main schools, or approaches, emerged. These were experimental psychology, which was dominated by the behaviorism originating from Ivan Pavlov's experiments, and which was enthusiastically championed in the US; and clinical psychology, which was largely based on the psychoanalytical approach of Sigmund Freud and his followers. The two had little in common. Behaviorists rejected the introspective, philosophical approach of earlier psychologists, and strove to put the subject on a

See also: Joseph Wolpe 86–87 • Sigmund Freud 92–99 • Fritz Perls 112–17 • Albert Ellis 142–45 • Martin Seligman 200–01 • Paul Salkovskis 212–13

psychoanalytic therapy places an emphasis on delving into the patient's unconscious to solve current disorders.

The evidence for the success of psychoanalytic therapy is based on **personal accounts** rather than facts or research.

Cognitive therapy places an emphasis on examining people's perceptions of their experiences.

There is **strong empirical evidence** for
the success of cognitive
therapy.

The key to **effective treatment** lies not in the unconscious, but in the examination of **how a disorder manifests itself** in a patient's perceptions.

There's more to the surface than meets the eye.

more scientific, evidence-based footing. The psychoanalysts explored those very introspections, with theories, rather than proof, to support their case.

Cognitive revolution

By the mid-20th century, both approaches to psychology were being critically examined. But although behaviorism was being overtaken by cognitive psychology in experimental work, the clinical sphere was offering no alternative to the psychoanalytical model. Psychotherapy had evolved into many forms, but the basic idea of psychoanalysis and exploration of the unconscious was common

to all of them. Some psychologists were beginning to question the validity of this kind of therapy, and Aaron Beck was among them.

When Beck qualified as a psychiatrist in 1953, experimental psychology was focused on the study of mental processes—it was the dawn of the "cognitive revolution." However, the practical approach of cognitive psychologists remained much the same as that of the behaviorists. If anything, they were frequently even more rigorous in establishing evidence for their theories. Beck was no exception to this. He had trained in and practiced psychoanalysis, but grew skeptical of its effectiveness as a »



Aaron Beck

Born in Providence, Rhode Island, Aaron Temkin Beck was the son of Russian Jewish immigrants. Athletic and outgoing as a young child, he became far more studious and introspective after suffering a serious illness at the age of eight. He also acquired a fear of all things medical and. determined to overcome this. decided to train as a doctor, graduating from Yale in 1946. Beck then worked at Rhode Island Hospital, before qualifying as a psychiatrist in 1953. Disillusioned with the psychoanalytical approach to clinical psychology, he instigated cognitive therapy and later established the **Beck Institute for Cognitive** Therapy and Research in Philadelphia, now run by his daughter, Dr. Judith Beck.

Key works

1972 Depression: Causes and Treatment 1975 Cognitive Therapy and the Emotional Disorders 1980 Depression: Clinical, Experimental, and Theoretical 1999 Prisoners of Hate: The Cognitive Basis of Anger, Hostility, and Violence



I concluded that psychoanalysis was a faith-based therapy.

Aaron Beck



therapy. He could find no reliable studies of the success rates of psychoanalysis—only anecdotal evidence of case reports. In his experience, only a minority of patients showed improvement under analysis, and the general consensus among therapists was that some got better, some got worse, and some stayed about the same, in almost equal numbers.

Of particular concern was the resistance of many psychoanalysts to objective scientific examination. Compared with experimental psychology, or with medicine, psychoanalysis seemed largely faith-based, with widely different results between individual practitioners. Reputation was frequently based solely on the charisma of a particular analyst. Beck concluded that "the psychoanalytic mystique was overwhelming... It was a little bit like the evangelical movement." Many psychoanalysts regarded criticism of their theories as a personal attack, and Beck soon discovered that any questioning of the validity of psychoanalysis was likely to be countered with universal denouncement. At one time, he was turned down for membership of the American

Psychoanalytic Institute on the grounds that his "desire to conduct scientific studies signaled that he'd been improperly analyzed." Those who found fault with the idea of analysis did so, some analysts argued, because of insufficient analysis of themselves.

Beck was suspicious of both the circularity of these arguments, and the link with the therapist's own personality. Coupled with his personal experience as a practicing psychoanalyst, this led him to examine thoroughly every aspect of therapy, looking for ways in which it could be improved. He carried out a series of experiments designed to evaluate the basis and treatment of depression, one of the most common reasons for seeking psychotherapy, and found that far from confirming the idea that this condition could be treated by examination of unconscious emotions and drives, his results pointed to a very different interpretation.

Changing perceptions

In describing their depression, Beck's patients often expressed negative ideas about themselves, their future, and society in general, which came to them involuntarily. These "automatic thoughts," as Beck called them, led him to conclude that the way the patients perceived their experiences—their cognition of them—was not just a symptom of their depression, but also the key to finding an effective therapy. This idea, which came to him in the 1960s, chimed with concurrent developments in experimental psychology, which had established the dominance of cognitive psychology by studying mental processes such as perception.

When Beck applied a cognitive model to treatment, he found that helping his patients to recognize and evaluate how realistic or distorted their perceptions were was the first step in overcoming depression. This flew in the face of conventional psychoanalysis, which sought and examined underlying drives, emotions, and repressions. Beck's "cognitive therapy" saw this as unnecessary or even counterproductive. The patient's perception could be taken at face value because, as he was fond of putting it, "there's more to the surface than meets the eye."

What Beck meant by this was that the immediate manifestations of depression—the negative "automatic thoughts"—provide all the information needed for therapy. If these thoughts are examined and compared with an objective, rational view of the same situation, the patient can recognize how his perception is distorted. For example, a patient who has been offered a promotion at work might express negative thoughts such as "I'll find the new job too difficult, and fail," a perception of the



A distorting mirror creates a view of the world that can seem terrifying and ugly. Similarly, depression tends to cast a negative perspective on life, making sufferers feel more hopeless.



By correcting erroneous beliefs, we can lower excessive reactions.

Aaron Beck



situation that leads to anxiety and unhappiness. A more rational way of looking at the promotion would be to see it as a reward, or even a challenge. It is not the situation that is causing the depression, but the patient's perception of it. Cognitive therapy could help him to recognize how distorted it is, and find a more realistic and positive way of thinking about the situation.

Empirical evidence

Beck's cognitive therapy worked. for a large number of his patients. What is more, he was able to demonstrate that it worked, as he applied scientific methods to ensure that he had empirical evidence for his findings. He designed special assessments for his patients, so that he could monitor their progress closely. The results showed that cognitive therapy was making his patients feel better, and feel better more quickly, than was the case under traditional psychoanalysis. Beck's insistence on providing evidence for any claims he made for his therapy opened it up to objective scrutiny. Above all, he was most anxious to avoid acquiring the guru-like status of many successful psychoanalysts, and was at great

Some people would view this glass as half full.

For others, who view their situation in a more negative light, the glass is half empty.

How people assess the same situation varies with temperament. Beck's cognitive therapy can help patients question their perceptions, leading to a more positive outlook.

pains to demonstrate that it was the therapy that was successful, and not the therapist.

Beck was not the only, or even the first, psychologist to find traditional psychoanalysis unsatisfactory, but his use of a cognitive model was innovatory. He had been influenced in his reaction against psychoanalysis by the work of Albert Ellis, who had developed Rational Emotive Behavior Therapy (REBT) in the mid-1950s, and he was no doubt aware of the work of behaviorists elsewhere in the world, including the South Africans Joseph Wolpe and Arnold A. Lazarus. Although different in approach, their therapies shared with Beck's a thoroughly scientific methodology and a rejection of the importance of unconscious causes of mental and emotional disorders.

Once the success of cognitive therapy had been established, it was used increasingly for treating depression, and later Beck found that it could also be helpful for other conditions, such as personality disorders and even schizophrenia. Always open to new ideas—as long as it could be shown that they were effective—Beck also incorporated elements of behavior therapy into

his treatments, as did many other psychotherapists in the 1980s. This has resulted in the varied forms of cognitive behavioral therapy that are used by psychologists today.

Beck's pioneering work marked a turning point for psychotherapy. and his influence is considerable. As well as bringing a cognitive approach into clinical psychology. Beck subjected it to scientific scrutiny, exposing the weaknesses of psychoanalysis. In the process. he introduced several methods for assessing the nature and severity of depression that are still used: the Beck Depression Inventory (BDI), the Beck Hopelessness Scale, the Beck Scale for Suicidal Ideation (BSS), and the Beck Anxiety Inventory (BAI).



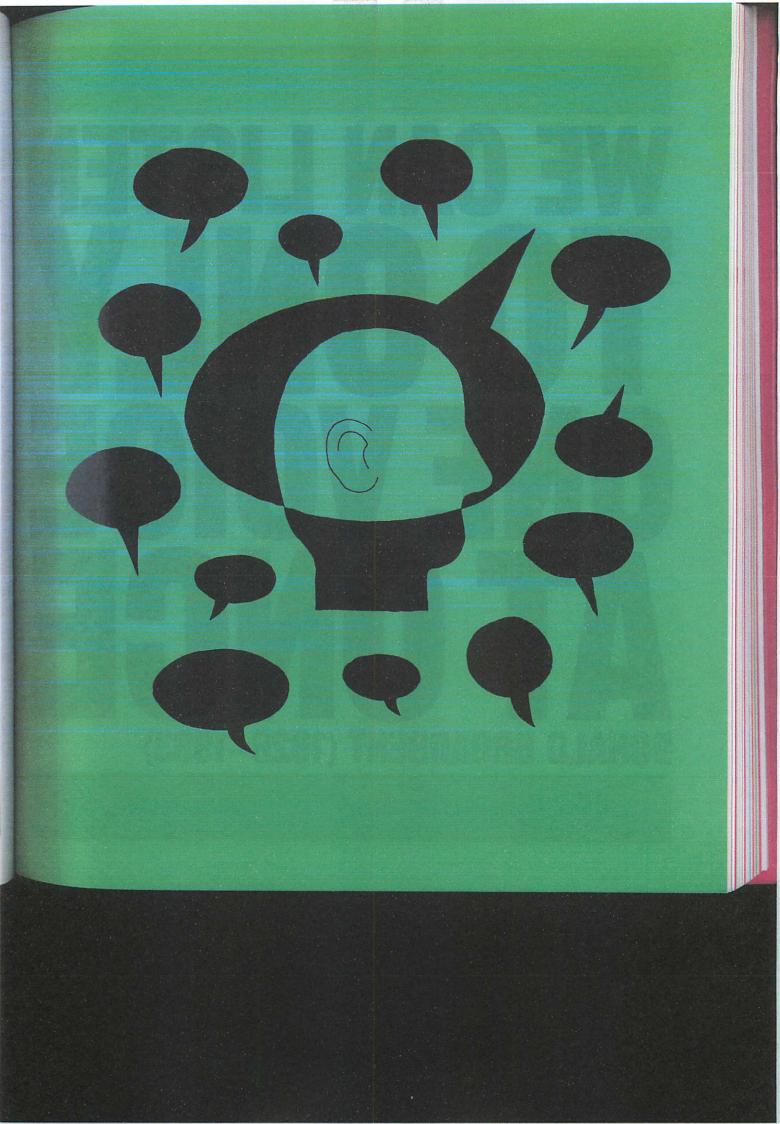
Don't trust me, test me.

Aaron Beck



EGANLSTEN

DONALD BROADBENT (1926-1993)



IN CONTEXT

APPROACH
Attention theory

BEFORE

1640s René Descartes says the human body is a kind of machine with a mind, or soul.

1940s British psychologist and APU director Kenneth Craik prepares flow diagrams comparing human and artificial information processing.

AFTER

1959 George Armitage Miller's studies suggest that short-term memory can hold a maximum of seven pieces of information.

1964 British psychologist
Anne Treisman suggests that
less important information is
not eliminated at the filter
stage but attenuated (like
turning down the volume)
so it can still be "shadowed"
by the mind.

puritanical streak" led him

a privilege and should a

remained until his re

n Britain prior to World War II, psychology as an academic discipline lagged behind Europe and the US. Britain's psychologists had tended to follow in the footsteps of the behaviorist and psychotherapeutic schools of thought that had evolved elsewhere. In the few university psychology departments that existed, the approach followed that of the natural sciences: the emphasis was on practical applications rather than theoretical speculations.

It was in this unpromising academic environment that Donald Broadbent, who went on to become one of the most influential of the early cognitive psychologists, found himself when he left the Royal Air Force after the war and decided to study psychology. However, the practical approach proved ideal for Broadbent, who was able to make perfect use of his wartime experience as an aeronautical engineer and pilot.

Practical psychology

Broadbent had enlisted in the RAF when he was 17, and he was sent to the US as part of his training.

Here he first became aware of

psychology and the kind of problems it addresses, which led him to look at some of the problems encountered by pilots in a different way. He thought these problems might have psychological causes and answers, rather than simply mechanical ones, so after leaving the RAF, he went to Cambridge University to study psychology.

Broadbent's mentor at Cambridge. Frederic Bartlett, was a kindred spirit: a thoroughgoing scientist, and England's first professor of experimental psychology. Bartlett believed that the most important theoretical discoveries are often made while attempting to find solutions to practical problems. This idea appealed to Broadbent, and prompted him to continue working under Bartlett at the new Applied Psychology Unit (APU) after it opened in 1944. It was during his time there that Broadbent was to do his most groundbreaking work. He chose to ignore the thendominant behaviorist approach to psychology and to concentrate on the practical problems he had come across in his time in the RAF. For example, pilots sometimes confused similar-looking controls; in some

Information from the senses...

...is briefly held in the Short-term memory store...

11111

...so that only one piece of information is selected for attention.

...then passed through a **filter**...

See also: René Descartes 20-21 = George Armitage Miller 168-73 = Daniel Schacter 208-09 = Frederic Bartlett 335-36



A World War II plane incorporates a dazzling display of informational data; Broadbent was interested in discovering how pilots prioritized information and what design changes would aid this.

planes, the lever for pulling up the wheels was identical to the one for pulling up the flaps, and the two were situated together under the seat; this led to frequent accidents. Broadbent thought these incidents could be avoided if the capacities and limitations of the pilots were taken into consideration during the design process, rather than surfacing at the point of use.

Broadbent was interested in using psychology not only to design better equipment, but also to reach a better understanding of what affected the pilots' capabilities. They clearly had to cope with large amounts of incoming information, and then had to select the relevant data they needed to make good decisions. It seemed to him that mistakes were often made when there were too many sources of incoming information.

Broadbent was influenced in his thinking about how we process information by another product of wartime research: the development of computers and the idea of "artificial intelligence." The first director of the APU, Kenneth Craik, had left the unit important manuscripts and flow diagrams comparing human and artificial information processing, which Broadbent clearly studied.

At the same time, code breakers such as the mathematician Alan Turing had been tackling the notion of information processing, and in the postwar period he applied this to the idea of a "thinking machine." The comparison of a machine to the workings of the brain was a powerful analogy, but it was Broadbent who turned the idea around, considering the human brain as a kind of informationprocessing machine. This, in essence, is what distinguishes cognitive psychology from behaviorism: it is the study of mental processes, rather than their manifestation in behavior. »



Donald Broadbent

Born in Birmingham, England, Donald Broadbent considered himself to be Welsh, since he spent his teenage years in Wales after his parents' divorce. He won a scholarship to the prestigious Winchester College, then joined the Royal Air Force aged 17, where he trained as a pilot and studied aeronautical engineering.

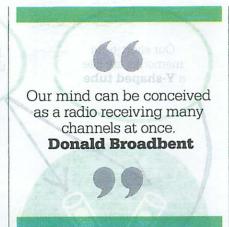
After leaving the RAF in 1947, he studied psychology under Frederic Bartlett at Cambridge, then joined the newly founded Applied Psychology Unit (APU). becoming its director in 1958. Married twice, he was a shy, famously generous man whose "puritanical streak" led him to believe that his work was a privilege and should always be of real use. In 1974, he was awarded the CBE and appointed a fellow of Wolfson College, Oxford, where he remained until his retirement in 1991. He died two years later of a heart attack, aged 66.

Key works

1958 Perception and Communication 1971 Decision and Stress 1993 The Simulation of Human Intelligence To study how our attention works, Broadbent needed to design experiments that would back up his hunches. His background in engineering meant that he would not be satisfied until he had evidence on which to base a theory, and he also wanted that research to have a practical application. The APU was dedicated to applied psychology, which for Broadbent referred not only to therapeutic applications, but also to applications that benefited society as a whole; he was always very conscious that his research was publicly funded.

One voice at a time

One of Broadbent's most important experiments was suggested by his experience with air traffic control. Ground crew often had to deal with several streams of incoming information simultaneously, sent from planes arriving and departing, which was relayed to the operators by radio and received through headphones. The air traffic controllers then had to make quick decisions based on that information, and Broadbent had noticed that they



could only effectively deal with one message at a time. What interested him was the mental process that must take place in order for them to select the most important message from the various sources of incoming information. He felt that there must be some kind of mechanism in the brain that processes the information and makes that selection.

The experiment that Broadbent devised, now known as the dichotic listening experiment, was one of the first in the field of selective attention—the process our brains

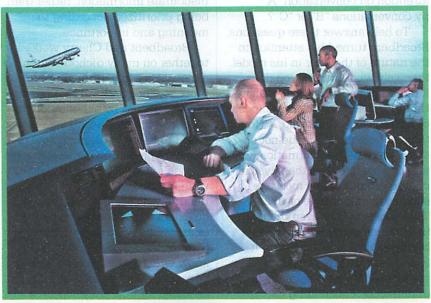
use to "filter out" the irrelevant information from the masses of data we receive through our senses all the time. Following the air traffic control model, he chose to present aural (sound-based) information through headphones to the subjects of his experiment. The system was set up so that he could relay two different streams of information at the same time—one to the left ear and one to the right—and then test the subjects on their retention of that information.

As Broadbent had suspected, the subjects were unable to reproduce all the information from both channels of input. His feeling that we can only listen to one voice at once had been confirmed, but still the question remained as to exactly how the subject had chosen to retain some of the incoming information and effectively disregard the rest.

Thinking back to his initial training as an engineer, Broadbent suggested a mechanical model to explain what he felt was happening in the brain. He believed that when there are multiple sources of input, they may reach a "bottleneck" if the brain is unable to continue to process all the incoming information; at this point, there must be some kind of "filter" that lets through only one channel of input. The analogy he uses to explain this is typically practical: he describes a Y-shaped tube, into which two flows of ping pong balls are channeled. At the junction of the two branches of the tube, there is a flap that acts to block one flow of balls or the other; this allows balls from the unblocked channel into the stem of the tube.

this allows balls from the unblocked channel into the stem of the tube.

Air traffic controllers have to deal with a multitude of simultaneous signals. By re-creating this problem in listening experiments, Broadbent was able to identify attention processes.



A question still remained, however: at what stage does this filter come into operation? In a series of experiments that were variations on his original dichotic listening tasks, Broadbent established that information is received by the senses and then passed on in its entirety to some kind of store, which he called the short-term memory store. It is at this stage, he believes, that the filtering occurs. His description of how and when information is selected for attention is known as the "Broadbent Filter Model," and it demonstrated a completely new approach to experimental psychology, not only in combining the theoretical with the practical, but also in considering the workings of the brain as a form of information processing.

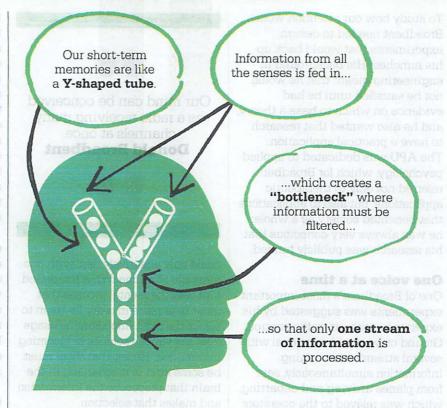
The cocktail party problem

Broadbent was not the only person to address the problem of selective attention. Another British scientist, Colin Cherry, also investigated the subject during the 1950s. Working in communication rather than psychology, Cherry posed what he called the "cocktail party problem:" how, at a party where lots of people are talking, do we select which of



One of the two voices is selected for response without reference to its correctness, and the other is ignored. **Donald Broadbent**





many conversations to give our attention to, and which to ignore?

And how is it possible to be distracted from our focused attention on conversation "A" by conversations "B" or "C"?

To help answer these questions, Broadbent turned his attention to the nature of the filter in his model. Precisely what information does it filter out, and what does it allow through? Following another process of rigorous experimenting, he found that the selection is made not on the content of the information (what is being said), but on the physical characteristics of any message, such as clarity or tone of voice. This suggests that even though information is stored, albeit very briefly, in short-term memory, it is only after filtering that it is processed for meaning and actually understood. This finding had

important implications when applied to air traffic control, for example, where decisions could be made on possibly irrelevant or inaccurate information, rather than being prioritized according to meaning and importance.

Broadbent and Cherry worked together on many dichotic listening experiments to test the filtering process. They realized that filtering is also affected by expectation. In one experiment, participants were asked to listen to different sets of numbers presented simultaneously to each ear. In some cases they were instructed which ear (the information channel) they would be asked about first; in others no instructions were given. The results showed that when people know which ear is receiving the stream of information they will be asked for first, they switch »

184 DONALD BROADBENT

attention to that ear, and the information that enters the other ear is not always accurately retrieved from memory. In all cases the information that people chose or were asked to remember first seemed to be processed more accurately than the later material; it was thought this might be due to parts of the information being lost from the short-term memory store before the participant tried to retrieve it. In 1957, Broadbent wrote: "We can listen to only one voice at once, and the first words we hear are the best recalled."

Modifying the model

In 1958, Broadbent published the results of his research in a book, *Perception and Communication*, which effectively outlined a framework for studying attention,

comprehension, and memory. The timing was significant, as it coincided with a divergence of opinion about the importance of behaviorism in the US, and the book slowly became known as one of the landmarks in the development of the new cognitive psychology. As a result, Broadbent was recognized, by his peers if not the public, as the first major psychologist Britain had produced, and was rewarded the same year by being appointed director of the APU to succeed Bartlett.

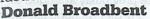
Not one to rest on his laurels, however, Broadbent saw his new appointment as an opportunity to continue his work on attention, widening the scope of his research and refining the theory. From the starting point of his filter model, he returned to the cocktail party problem, and in particular one phenomenon Cherry had identified concerning the nature of information that is selected for attention. When an overheard conversation includes information that has some kind of special significance for a person—such as a personal name—the attention is switched toward that conversation, and away from the one previously attended to.

Further dichotic listening experiments at the APU bore out Cherry's findings: attention is filtered by physical characteristics but also by meaning, using feedback from memory stores, prior experience, and expectations. The sound of a siren, for instance, would divert attention on to that stream of sound. This suggests that information is in some way understood before being selected for attention.





The test of a psychological theory, as well as its moral justification, lies in its application to concrete practical considerations.

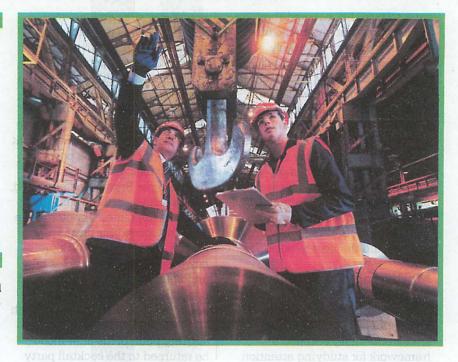




Complex industrial processes could be transformed in efficiency, Broadbent thought, through the application of psychology. He was committed to producing genuinely useful research.

Broadbent realized that his filter model needed modification, but was pleased rather than dismayed to have to make the changes. As a scientist, he felt that all scientific theories are temporary, derived from the evidence available at the time, and so susceptible to change in the light of new evidence; this is how science progresses.

The work of the APU centered around Broadbent's research into attention, but this allowed for a constantly widening range of applications. Broadbent worked tirelessly to ensure that his work was practically useful, examining the effects of noise, heat, and stress on attention in work environments. and he constantly reviewed his ideas as he worked. In the process, he gained government support for his ideas, and the respect of many industries whose practices were improved by his work. This led to yet more research into areas such as differences of attention between individuals, and lapses of attention



and their causes. In each case the results of his experiments led to refinements of his theories. In 1971, he published a second book, *Decision and Stress*, which detailed an extended version of his filter theory. Like its predecessor, this book became a classic textbook of cognitive psychology.

The cognitive approach

Broadbent's books did not reach the general public, but were widely read by scientists from other disciplines. His comparison of the workings of the human brain with electronic machines became more and more relevant as interest in computing increased. His model of the various stages of human information processing—acquisition, storage, retrieval, and use—echoed the work on artificial intelligence at that time.

Broadbent was instrumental in setting up a Joint Council Initiative on Cognitive Science and Human-Computer Interaction, which helped shape the development of cognitive science. His work also established applied psychology as an important approach for problem-solving, increasing its impact well beyond the confines of the laboratory. A key figure in the founding of cognitive psychology, his research into attention laid the groundwork for a new field of enquiry that continues to yield rich results today.



His psychology was intended for society and its problems, not merely for the dwellers in ivory towers.

Fergus Craik and Alan Baddely

