

Psychology Turns Cognitive: Information processing

"In the course of my work I seem to have become a very old-fashioned kind of psychologist. I now believe that mind is something more than a four letter, Anglo Saxon word - human minds exist, and it is our job to study them." (Miller, 1962)

Dominance of Behaviorism only in North America

- Germany: Gestalt Psychology—what are the mental processes that determine perception?
- England: Frederick Bartlett's studies of memory
- Russia: Lev Vygotsky and Alexander Luria—a sociocultural perspective on development
- France/Switzerland: Jean Piaget

Deviations among Behaviorists



Edward Tolman: Argued for a molar, not molecular perspective (reflexes, S-R pairs are molecular)

Articulated an intervening variable theory of learning, not a stimulus-response theory
Animals and humans engage in *latent learning*: they build up knowledge of their environment from engaging the environment

- rats running mazes—with and without rewards—developed *cognitive maps*
- if rat learns to go from A to B, where will it go when released from C?

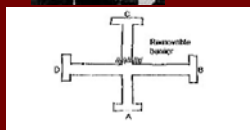


Fig. 1 The apparatus used in one of Tolman's experiments illustrating the process by which he obtained evidence of latent learning.

Why did American Psychologists Finally Turn Away from Behaviorism?

The challenge of explaining complex behavior

Some behaviorists postulated ever more complex mediational S-R connections to account for more complex behavior

Charles Osgood

Results were less compelling than first exemplars of behaviorism

Behaviorism's Legacy

Even as psychology rejected behaviorism's opposition to appealing to inner mental events to explain behavior, it retained behaviorism's strictures on what it sought to explain and what could count as evidence

- What was to be explained was how people behaved
- The evidence for proposed explanations had to come from behavior
- Hypothetical-Deductive (H-D) Method:
hypothesize the existence of inner states to explain behavior
Evaluate those hypotheses by the correctness of the predictions made from them

Jerome Bruner: A sociopsychological perspective on cognition



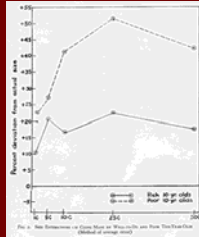
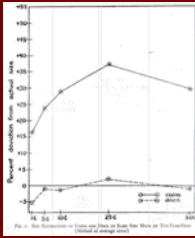
"... we were not out to 'reform' behaviorism, but to replace it" (Bruner, 1990, 3)

Bruner's contention was that the way people understood their situation affected the way they behave.

With George Miller, created the Harvard Center for Cognitive Studies

New Look Accounts of Perception

Bruner and Goodman (1947) : the value of an object (coin) affected a child's perception of its size. Perception influenced by internal mental states, not just the stimulus



Anomalous Cards



A Study of Thinking (1956) Bruner, Goodnow, and Austin

Focus on concepts and how they are learned

Construed concepts as defined by rules and focused on how subjects figured out the rules

Stimuli: arrays of cards with geometric patterns
Strategy: find a positive instance and then test cards that vary in one attribute at a time

- If positive instance, then attribute doesn't matter
- If not, attribute does matter, so revise definition

George Miller

Graduate student in psychophysics with S. S. Stevens, conducting classified military research on signal jamming.



Adapted for his dissertation by focusing on the effect of noise on the intelligibility of a signal

To xllxstxatx, I cxn rxplcx vxexy txrx lxtex of x sextexce xitx an x, anx yox stll xan xanxge xo rxad xt wixh sxme xifxixltx.

Some stimuli were ordinary grammatically correct and meaningful sentences

Others were grammatical but nonsensical: *Furry jewelers create distressed stains*

Others were completely ungrammatical

George Miller Meets Information Theory

Claude Shannon's information theory

- Information measured in terms of ability to distinguish alternatives
- A binary unit (bit) could distinguish between two alternatives, two (e.g., 10) could distinguish between four
- Signals were redundant to the degree one unit could permit reliable guessing of the next
- What is the next letter (in the word)?
 - a
 - ar
 - arb

Miller: redundant signals were less affected by noise

Miller and Frank (1949): "statistical behavioristics"

Turning to Memory

Read the following and remember it until I tell you to write it down:

4 8 1 2
5 3 2 8 2 5 3
5 1 3 4 7 4 3 2 7 4 1 5

Compare:

I B M C I A B B C U S A

With

I B M C I A B B C U S A

George Miller and the Magical Number 7

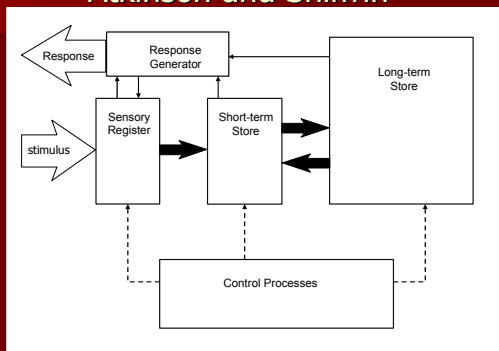
"My problem is that I have been persecuted by an integer. For seven years this number has followed me around, has intruded in my most private data, and has assaulted me from the pages of our most public journals" (1956, p. 81)

- Distinguishing phonemes
- Making absolute distinctions among items
- Remembering distinct items

"There seems to be some limitation built into us either by learning or by design of our nervous system, a limit that keeps our channel capacity in this general range" (p. 86)

Surmounted limit by "chunking"

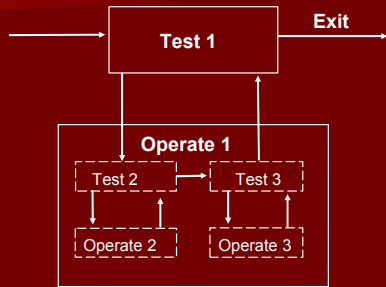
Different Memory Stores: Atkinson and Shiffrin



Miller, Galantner, & Pribram: *Plans and the Structure of Behavior*

At one point, George proposed that we examine some intentional human act.
'Flying a plane,' I suggested.
'No - too much. How about crossing a street. An equally dangerous act in the bay area,' Karl responded. I went to the blackboard and started a flow chart. The boxes, lines, and arrows snaked around the board as step after step was drawn. 'No,' George said, 'all that stuff on the board is only a string of reentrant reflexes. Let a whole piece of the action be repeated until it's finished.'
'How will it know?' from Karl.
'With a cybernetic test,' replied George.
'But how do I draw it?' I asked.
'Like this,' said George, and the TOTE replacement for the reflex was designed." (p. 40)

TOTE Units



Neisser and *Cognitive Psychology* (1967)

“By 1964, it had come together in my head. In principle, I thought, one could follow the information inward from its first encounter with the sense organ all the way to its storage and eventual reconstruction in memory. The early stages of processing were necessarily wholistic (an idea I borrowed from Gestalt psychology) and the later ones were based on repeated recoding (an idea borrowed, even more obviously, from George Miller). But the processing sequence was by no means fixed; at every point there was room for choice, strategy, executive routines, individual constructive activity. Noam Chomsky's linguistic arguments had shown that an activity could be rule governed and yet indefinitely free and creative. People were not much like computers (I had already sketched out some of the differences in a 1963 *Science* paper), but nevertheless the computer had made a crucial contribution to psychology: It had given us a new definition of our subject matter, a new set of metaphors, and a new assurance” (Neisser, 1988, p. 86).

The Epistemological Challenge for Cognitive Psychology

The characterization of cognitive psychology is *information processing psychology*

- How do psychologists determine the processes involved in manipulating information?

Flanagan's Kantian interpretation—postulate processes to explain how an organism could possibly generate behavior from its inputs

- This is, more generally, the Hypothetical-Deductive Method

Inferring Process from Behavioral Evidence

Advance proposals as to the kinds of procedures would generate the behavior

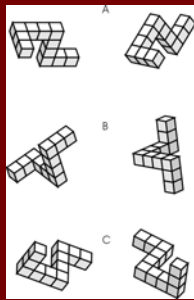
Make additional behavioral predictions from these hypotheses—additional behaviors, reaction times, error patterns—and evaluate according to the success of the predictions

- Sternberg on exhaustive serial search—RTs correlate with number of items to be searched
- Shepard and Metzler on mental rotation—RTs correlate with angle of rotation

Shepard on Mental Rotation

The time it takes someone to decide whether one figure is in fact a rotation of another correlates with the degree of rotation

Suggestion—you perform in your head an operation corresponding to rotation



Kosslyn on mental scanning

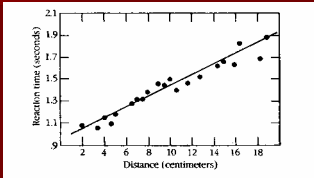
Subjects memorize this map with landmarks such as a hut, a swamp, and a well.

With the map gone, subjects were asked to form an image of the map. Focus on the well and image a speck there.

Now move the speck in a straight line to the tree.



Kosslyn on mental scanning - 2

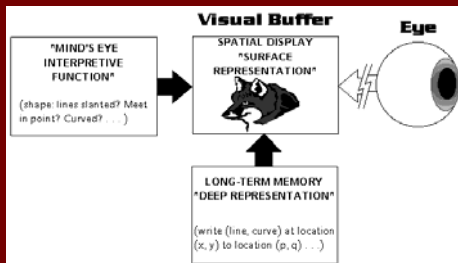


Kosslyn, Ball, and Reiser (1978) showed that reaction times corresponded to the distance between objects, suggesting that they were actually performing an operation comparable to scanning a map.

Kosslyn's proposal

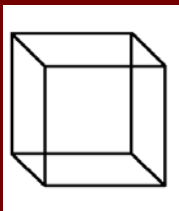
Image processing reactivates areas of visual cortex involved in visual processing

Long-term storage in a propositional format—comparable to computer code that generates an image on the CRT



Mental images not processed like pictures

Chambers and Reisberg found that subjects who were briefly exposed to reversible figures could not find the alternate interpretation from a mental image, but could if they were allowed to draw a picture from their image.



Can we monitor accurately how our minds work?

Cognitivists generally share behaviorists suspicion of introspection

Yet, sometimes we seem to be aware of steps we take in thinking

Verbal protocols while solving cryptarithmic problems

$$\begin{array}{r} \text{DONALD} \\ + \text{GERALD} \\ \hline \text{ROBERT} \end{array} \quad D=5$$

Nisbett and Wilson—"Telling More Than We Can Know: Verbal Reports on Mental Processes"

Our self reports are often demonstrably wrong

"knowledge of the self is produced by the same strategies as knowledge of other social objects. . . Collecting, coding, and recalling data, assessing covariations, inferring causal relations, and testing hypotheses."

Status of our own ability to report on our conscious activities

- **Process Cartesianism:** we are aware of our mental processes.
 - But—there are many processes of which we are not aware, such as Sternberg's exhaustive search.
- **Content Cartesianism:** we are aware of the contents of our mental states.
 - But—there are contents we use but are not aware of, e.g., in dichotic listening experiments. Cannot list all the things we believe. And sometimes a third person is better situated to tell us what we believe than we are ourselves.
- **Causal Cartesianism:** Even if we are not aware of the whole process responsible for our behavior, we are aware of the causes of our behavior.
 - But—Nisbett and Wilson's results: we tell more than we can know.
- **State Cartesianism:** I know whether I am believing or doubting.

Cognitive Psychology at UCSD



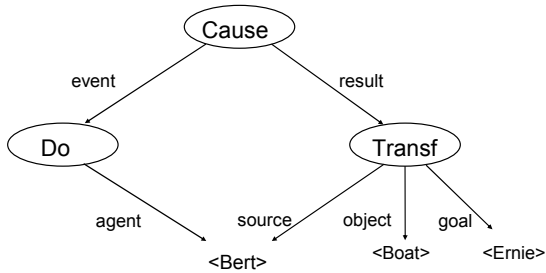
UCSD was a new university in the 1960s, admitting its first undergraduates in 1964

First psychology faculty were first generation *cognitive* psychologists: George Mandler, Donald Norman, David Rumelhart, Peter Lindsay



Explorations in Cognition (1975)

LNR Analysis of Verb Structure: Bert gives a boat to Ernie



Cognitive psychology begins to challenge cherished beliefs

Socrates' legacy: Terms have definitions, and we can find them
Definitions specify necessary and sufficient conditions

What is the definition of *game*? Of *bird*?

Eleanor Rosch: Concepts have a prototype structure:
Some examples of a concept are better than others
What is a prototypical bird?

How good a bird is a
Chicken
Cat?
Airplane
Chair?

Cognitive Psychology Challenges our Rationality

Which of the following cards do you need to turn over to either confirm or falsify the hypothesis that
if a card has an even number on one side, it has a vowel on the other?