بسم الله الرحمن الرحیم

علوم شناختی

جلسه ۴

مدل‌های پردازش-اطلاعاتی در روان‌شناسی

Information-Processing Models in Psychology

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http://courses.fouladi.ir/cogsci

PART 1:
HISTORICL LANDMARKS

Chapter 1:
The Prehistory of Cognitive Science

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Chapter 1.4: Information-processing models in psychology

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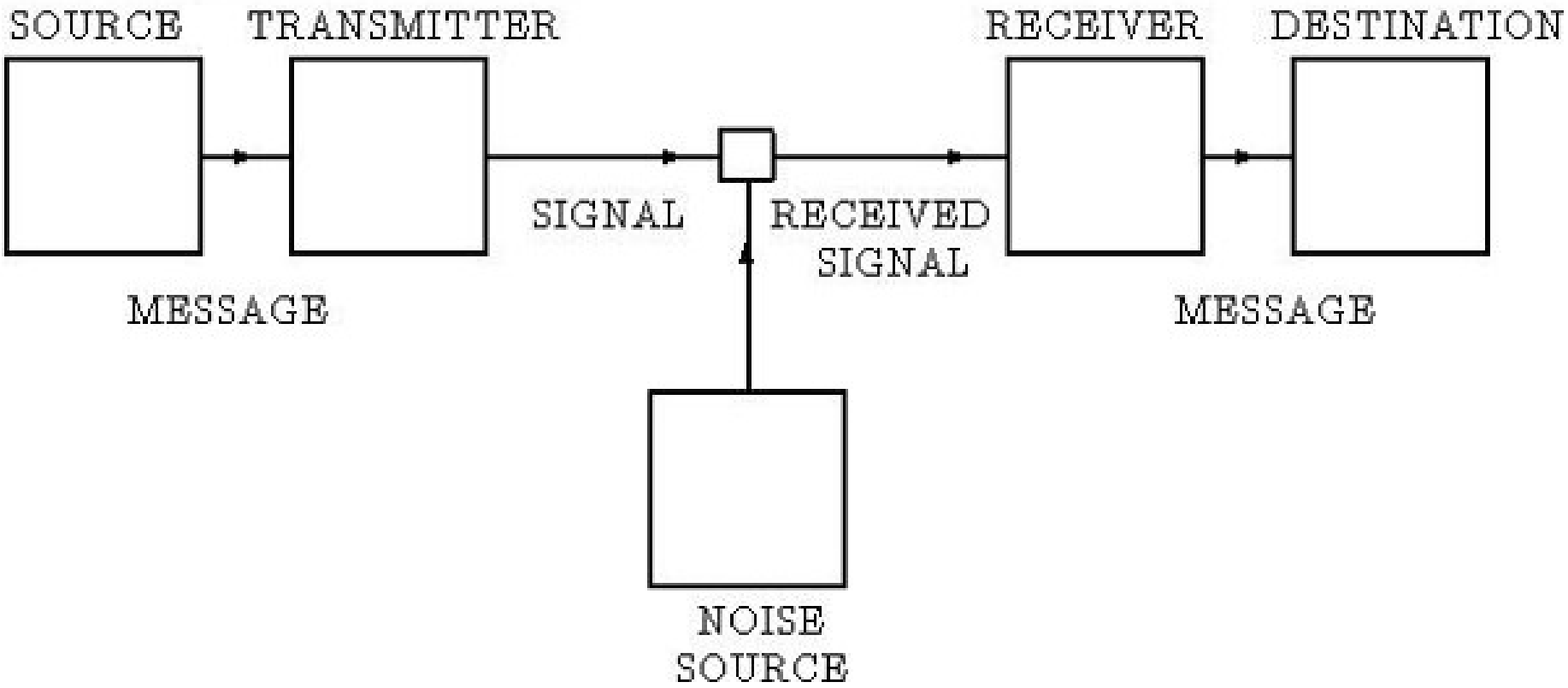
Introduction

- Behaviorism couldn't explain things like basic motor plans

- **Problems:**
  - These plans obviously draw upon information about the body and about the environment. How is this information stored?
  - How are the plans themselves "coded"?
  - What sort of "processing" is involved in the execution of a plan?

Shannon on information



Measuring information in bits

A bit is the quantity of information required to distinguish 2 equally likely (and incompatible) states of affairs

- 1 bit of information is required to communicate the fact that a coin has landed heads
- 4 bits to communicate the winning ticket in a 16 ticket lottery

- Generally, when we have equally likely alternatives each with probability p, we require $-\log_2(p)$ bits of information to identify which one holds

Miller's magical number 7

Exploring the channel capacity of a perceiver
(considered as a communication channel)

Distinction between:

- span of absolute judgment
- span of immediate memory

Both are circumscribed by the number 7 - but in different ways.

Span of absolute judgment

Absolute judgments of unidimensional stimuli – e.g. categorizing colors or identifying pitches of sounds

- as opposed to relative judgments (darker/lighter or higher/lower)

Subjects are systematically limited in the number of bits of information that they can process

- Limitation seems more or less constant across different sensory modalities

Pollack on identifying tones

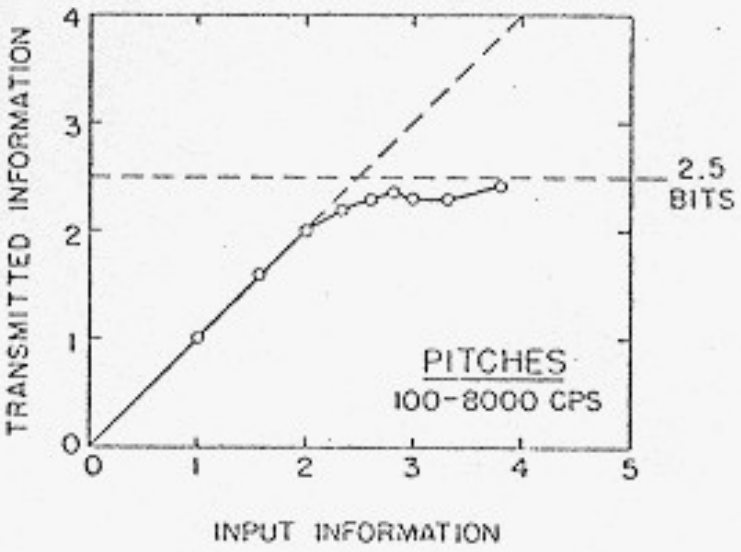


FIG. 1. Data from Pollack (17, 18) on the amount of information that is transmitted by listeners who make absolute judgments of auditory pitch. As the amount of input information is increased by increasing from 2 to 14 the number of different pitches to be judged, the amount of transmitted information approaches as its upper limit a channel capacity of about 2.5 bits per judgment.

The auditory channel seems to be an information channel with a built-in information processing bottleneck – around 2.5 bits

From Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological review*, *63*(2), 81.

Overcoming the bottleneck

Increasing the number of dimensions along which objects are compared

- discrimination gets cruder as number of dimensions increases
- distinctive features distinguishing phonemes are binary

Making successive judgments in addition to simultaneous ones (as in language) – i.e. presenting a range of items successively and then asking the subject to make the identifications

- short-term memory

The span of absolute memory

- The issue here is the number of items that can be immediately recalled
    - Index of number of items that can be stored in short-term memory
- This is not the same as the span of immediate judgment – not a test of categorization
- Known that here too we have a limit of 7, more or less

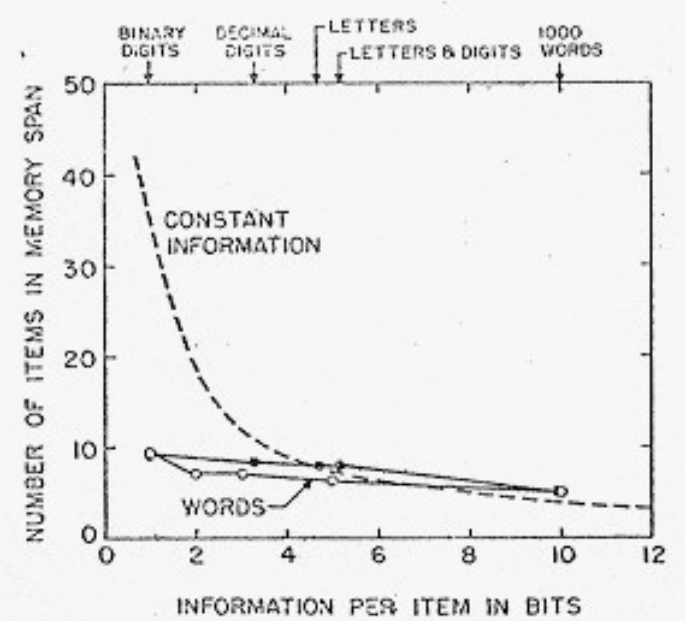


FIG. 7. Data from Hayes (10) on the span of immediate memory plotted as a function of the amount of information per item in the test materials.

The Hayes experiments show that the span of absolute memory is not constrained by the amount of information carried by the items that are being recalled

From Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological review*, *63*(2), 81.

Chunking

- Exploits the distinction between
    - Constraints upon absolute judgments
    - Constraints upon short-term memory
- We can only hold 7 items in STM - but we can use chunking/recoding to hold far more than 7 bits of information
- Information is processed relative to a particular coding/format

TABLE 1

WAYS OF RECODING SEQUENCES OF BINARY DIGITS

	Binary Digits (Bits)	1	0	1	0	0	0	1	0	0	1	1	1	0	0	1	1	1	0
2:1	Chunks	10		10		00		10		01		11		00		11		10	
	Recoding	2		2		0		2		1		3		0		3		2	
3:1	Chunks	101			000			100			111			001			110		
	Recoding	5			0			4			7			1			6		
4:1	Chunks	1010				0010				0111				0011				10	
	Recoding	10				2				7				3					
5:1	Chunks	10100					01001					11001						110	
	Recoding	20					9					25							

From Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological review*, *63*(2), 81.

Information in information theory

- The mathematical theory of communication

1) Centred on concept of **information channel**

2) Studies how messages are encoded into **signals** and then transmitted to a receiver

3) Concerned primarily with **information gain** (defined probabilistically in terms of reduction of uncertainty)

Information in cognitive science

- Cognitive scientists are more concerned with how information is transformed (processed) than with how it is transmitted
- Information understood in terms of representations
- Major concern is how information-processing is physically implemented in particular mental architectures

Key ideas

- Idea of cognition as information-processing
  - latent learning and place learning
  - rule-based conception of language

- Idea that information-processing is sensitive to the format in which information is coded

- Idea that information-processing is a computational process

Information-processing models

- Miller's work suggests that the senses are information-processing channels with limited capacity
- But he had nothing to say about the details of how those information-processing channels actually work
- The next step towards cognitive science came with the development of particular information-processing models of sensory systems and cognitive abilities

Selective attention

- Operational understanding (e.g. for behaviorist)
- Selective attention is simply the fact that an organism responds to a single stimulus when there are several stimuli present to which it would otherwise respond [cocktail party phenomenon]
- But for a cognitive scientist this fact is something that needs to be explained with an information-processing model

Model-building

Basic components

- experimental data to be explained
- task analysis
- information-processing account of how the task can be performed

Cocktail party phenomenon: Cherry's experiments

- inspired by demands placed upon air traffic controllers
- aimed to discriminate between different possible factors for separating out different voices

1. The voices come from different directions
2. Lip-reading, gestures, and the like
3. Different speaking voices, mean pitches, mean speeds, male vs. female, and so forth
4. Different accents
5. Transition probabilities (based on subject matter, voice dynamics, syntax ...)

Cherry experiments (2)

- Eliminated all factors except the last by recording two messages from the same speaker on one tape
- Result – the messages could still be discriminated
- Cherry offered an information–theoretic analysis
- We can predict word sequences because of stored knowledge of transition probabilities

More data

Subjects were asked to shadow messages (repeating words after hearing them)

- spoken phrases were strings of cliches separated by simple conjunctions
- subjects found it almost impossible to discriminate messages

Dichotic listening tasks

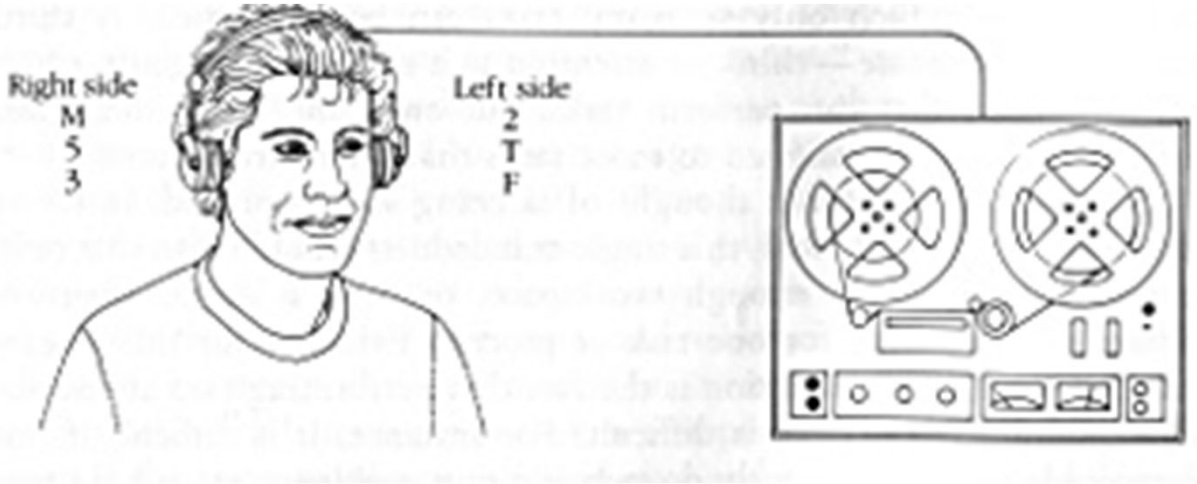
Dichotic listening tasks present subjects with different information in each ear

Subjects can be asked to monitor one signal and ignore the other

Monitoring typically involves shadowing the signal (i.e. repeating it verbatim)

Then their recall is probed

Attention-switching



When subjects were asked to report the stimuli in any order they typically did best when they reported them ear by ear

By-ear accuracy = 65%
By-time accuracy = 20%

Type of message

Drastic difference between two types of message:

- differing in physical properties (e.g. female vs male voice)
- differing in semantic properties (e.g. English vs German – or meaningless babble vs speech)

Physical vs semantic

- Subjects able to perform the shadowing task = application of selective attention
- Variability in what could be recalled about the ignored signal
  - Subjects were typically unable to report the content of the ignored signal
  - But could report changes in the physical properties of ignored signal

Model-building

Basic components

- experimental data to be explained
- task analysis
- information-processing account of how the task can be performed

Task analysis

- Selective attention is the process of "filtering out" irrelevant sensory information

- We can only verbally report on things to which we are selective attending

1) The first set of results show that each ear is a distinct information channel

2) The second set shows that the filtering takes place before semantic information is extracted – based on the physical properties of the stimulus

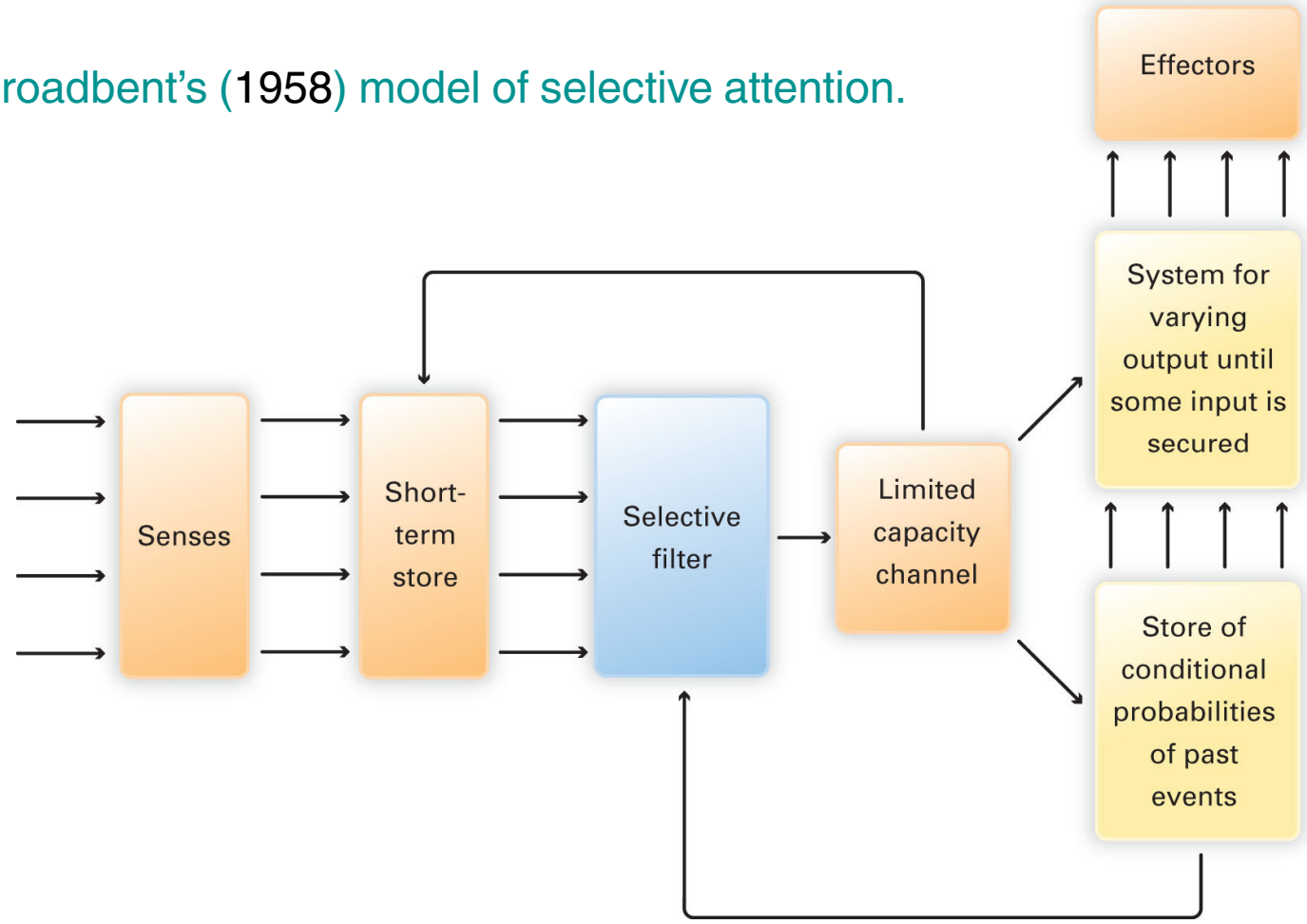
Model-building

Basic components

- experimental data to be explained
- task analysis
- information-processing account of how the task can be performed

Broadbent's model

Donald Broadbent's (1958) model of selective attention.



Features of Broadbent's model

- Breaks information-processing task into a series of stages [each carried out by a separate system]
- The information-processing task is achieved by the flow of information across and between these separate systems
- Rests upon an unexplained notion of what it is to process information

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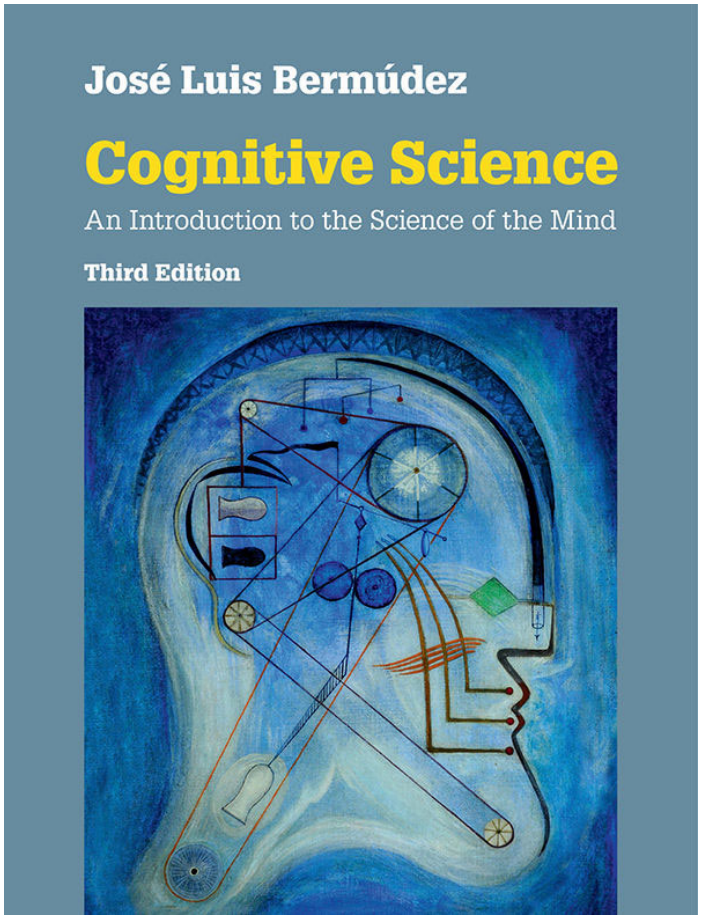

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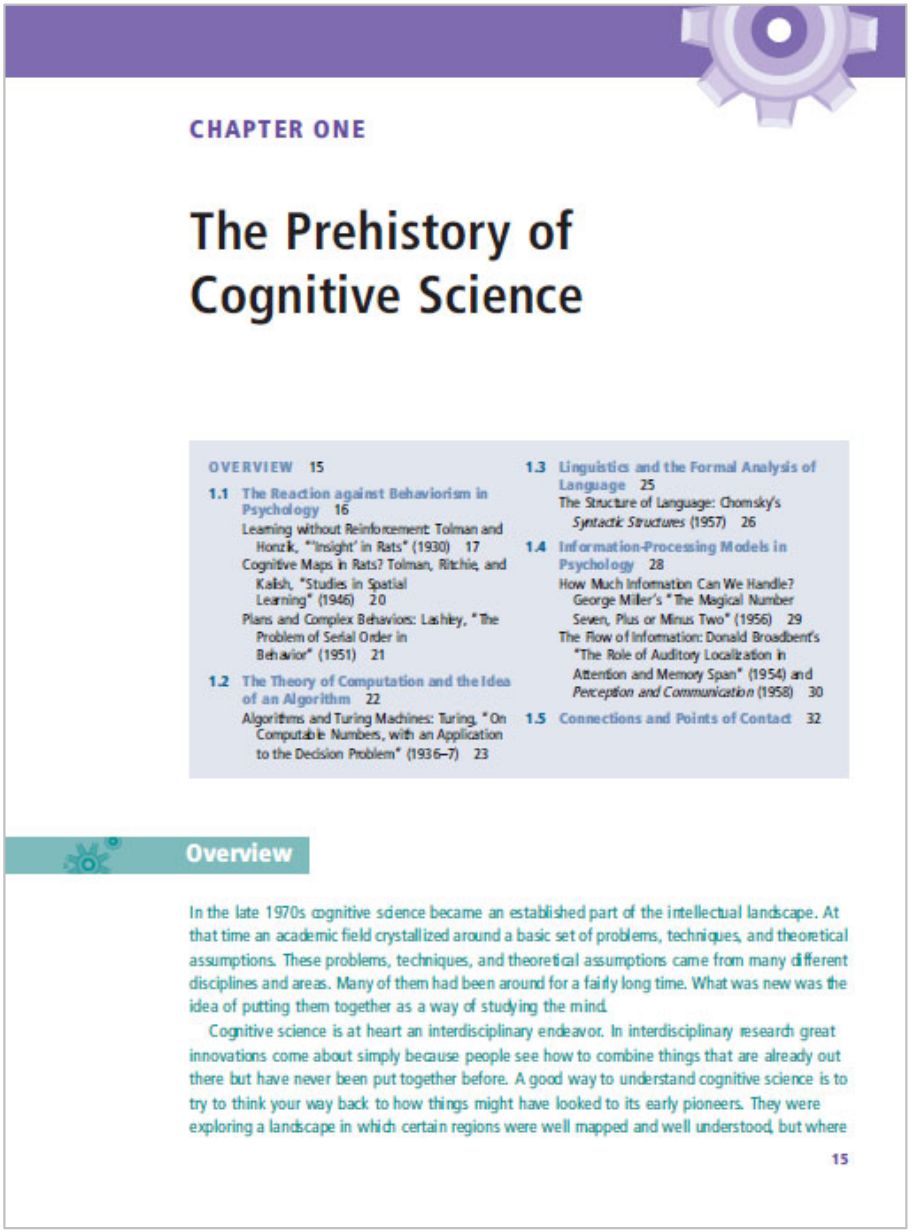
Chapter 1 (Section 1.4)



CHAPTER ONE

The Prehistory of Cognitive Science

Overview

In the late 1970s cognitive science became an established part of the intellectual landscape. At that time an academic field crystallized around a basic set of problems, techniques, and theoretical assumptions. These problems, techniques, and theoretical assumptions came from many different disciplines and areas. Many of them had been around for a fairly long time. What was new was the idea of putting them together as a way of studying the mind.

Cognitive science is at heart an interdisciplinary endeavor. In interdisciplinary research great innovations come about simply because people see how to combine things that are already out there but have never been put together before. A good way to understand cognitive science is to try to think your way back to how things might have looked to its early pioneers. They were exploring a landscape in which certain regions were well mapped and well understood, but where

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