

IS2300

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requirements:

3 exams

assignments

CLIPS

participation, attendance

academic integrity

sign up for the listserv

Introduction to Human Information Processing

OUTLINE

1. Motivations
2. Cognitive Psychology and Science (nature of)  
& introduction to cognitive simulation
3. History of Cognitive Psychology / Science
4. Role of Neuroscience

## 1. Motivations

Intellectual Curiosity

Foundations for Other Fields

clinical, social psychology

political science

economics

sociology

linguistics

Information Science:

Humans are at center of information systems

(which are extensions of human functionality)

⇒ What are those functions

⇒ Human Factors Issues

Information Systems carry out or involve human  
functionality

⇒ Intelligent Systems Issues

# Human Information Processing

## Inputs

- Sensation
- Attention
- Perception
- Pattern Recognition

## Storage

- Interpretation
- Memory Storage and Retrieval
- Knowledge Representation

## Processing & Utilization

- Learning
- Decision Making
- Problem Solving
- Reasoning
- Planning

## Communication

- Language

## Information Systems Involve:

- problem solving & decision making
- information storage and retrieval
  - databases
  - text retrieval
- knowledge representation
  - declarative knowledge
  - procedural knowledge
- analysis of textual information and knowledge

## Cognitive engineering:

- information capacity
- limits of attention
- pragmatics of communication
- cognitive task analysis

## Direct Applications and Implications

### Education, training and performance

- Computer-based education & testing
  - Computer Aided Instruction
  - Intelligent Computer Aided Instruction
  - Intelligent Tutoring Systems (ITS)

### Human Computer Interaction (HCI),

- interface design
- natural language interfaces
- visual interfaces
- multimedia/multimodal interfaces

### Human Factors

### Expert Systems, Knowledge Engineering, Robotics

### Heuristic vs. Algorithmic Programming

## 2. Cognitive Psychology and Cognitive Science

Mature Systems vs. Research Science

Need for Abstract Analysis

Formal Information Processing Models

separation from physical instantiation  
patterns and manipulations of patterns  
finite "rules"  $\Rightarrow$  infinite applicability

Cognitive Psychology vs Cognitive Science

Research Techniques:

### 1. Experimental

Independent and Dependent Variables  
patterns of errors  
reaction time  
memory performance

functional relations between variables

### 2. Formal Theories

linguistics, philosophy, comp. science

### 3. Computer Simulation

Production Systems

Newell & Simon 1972

Architecture: three parts

1. KB Knowledge Base (aka working memory, fact list)  
facts and/or objects known to the system  
(including goals)
2. RB Rule Base  
set of rules system uses to reach conclusions  
based on contents of the KB
3. Inference Engine  
how the system works (using KB and RB)

KB and RB are problem specific (written by programmer)

Inference Engine is very general (provided to programmer)

1. KB Knowledge Base (aka working memory)  
facts and/or objects known to the system

facts: (connected input1 output3)

objects: (typical syntax)

```
(deftemplate person
  "This defines the concept person"
  (slot name)
  (slot age)
  (slot eye-color)
  (slot hair-color)
  (slot weight)
  (slot height)
  (multislot hobbies)
  (multislot address) )
```

```
(person
  (name John)
  (age 30)
  (eye-color brown)
  (hair-color brown)
  (hobbies programming hiking) )
```

## 2. RB Rule Base

set of rules system uses to reach conclusions based on contents of the KB

rule: condition(s) -> action(s)

condition: pattern of objects/properties

action: changes KB  
add, delete, modify representations  
cause I/O, external action

```
(defrule find-houses-with-same-name
  ?f1 <- (house (name ?n1))
  ?f2 <- (house (name ?n2))
  (test (neq ?f1 ?f2))
  (test (= ?n1 ?n2))
  =>
  (print ?n1) )
```

```
(defrule change-valve-status
  ?f1 <- (status (valve open))
  ?f2 <- (close-valve)
  =>
  (retract ?f2)
  (modify ?f1 (valve closed)))
```

### 3. Inference Engine

1. selects which rules (operators) match into KB  
-> instantiations
2. selects instantiation (conflict resolution)
3. takes action of instantiation  
which generates new states

So: Heuristic Problem Solving:

Model facts and objects

Model what is done under different circumstances

Run rules until solution or nothing else to do

### 3. History of Cognitive Psychology & Science

#### 3.1 Greeks: Plato and Aristotle

memory and thought  
empiricist vs. nativist (rationalist) views  
associationism

#### 3.2 Classical Philosophy:

Nativism                      Descartes, Kant

British Empiricism      Locke, Hume, Mill, Berkeley  
associationism:  
    direct perceptions ->  
        faint copies of percepts ->  
            associations of copies

Rationalism              Leibniz, Hobbes  
    thinking as formal reasoning,  
    manipulation of non-numeric symbols  
    e.g., Boole

#### 3.3 Structuralist Psychology (19th century)

Wundt 1879 first laboratory  
    elementarism, reductionism  
    reduction screen, introspection,

Wurzburg School, Kulpe  
    imageless thought debate

⇒ need for objective methods

### 3.4 Behaviorism      Watson, Skinner

mistake: since all that is objective is external  
can only study environment and behavior

further: that is all that is real - anti-mentalism,

study stimulus-response bonds,  
reinforcement  
a simple version of associationism

### 3.5 Reemergence of Cognitive Psychology Effects of WWII, Developments in 1950's

Failure of Behaviorism  
WWII evaluation and training of personnel

Human Factors  
instrumentation, aviation, detection  
Broadbent - theories of attention  
active role of individual

Information Theory  
information theory: Shannon  
coding, translation etc.  
signal detection theory  
cybernetics (Wiener), technology  
missiles, radar, communication etc.

Computer Science  
flow and structure of information  
control analogies  
neural analogy: perceptrons  
formal algorithms for cognitive procedures  
1956 Newell and Simon

Linguistics Chomsky 1957  
productivity, regularity  
formal theoretic nature  
rules, plans, organization  
deep vs surface structure  
criticism of Skinner (behaviorism)  
lack of objectivity  
unanimity in linguistics

#### 4. Neuroscience and Cognition

differentiating between cognitive theories  
vs. explaining how things work:

neural representation?

levels of abstraction/analysis

computer analogy

example: perception

low level – lines, edges, etc.

very explicit neural models

mid level – interpreting vectors of world shapes

that cause retinal shapes

very sketchy neural models

high level – interpreting known objects

no neural models