Lecture 2: Cognitive Psychology Overview I

- Human Information Processing
- "Classic" Memory Theories
- More Recent Memory Theory
- Applications of Theory to Engineering

Information Processing Approach (1)

- Cognitive psychology
  - Distinct from, & reaction to, stimulus-response psychology
  - Psychology of thinking
    - Memory, learning, comprehension, reasoning, attention, skill acquisition, creativity, perception
    - Ordinary activities - rational, intelligent behavior - normal behavior
  - Theoretical approach: models of intervening processes 'in the head'
    - Describe the 'black box' between stimulus and response
- Information Processing Approach
  - Early development in cognitive psychology, dominant
  - View of the human being as a "processor of information"
  - Actively seek information, transform, process, store it, information drives behavior: communication, action, perception, etc.
  - Mind is a symbol manipulation system

Information Processing Approach (2)

- "Revolution" in psychology 1950s-1960s
  - 1950s-1960s: body of empirical research on learning of word lists
    - Difficult and awkward to explain phenomena in stimulus-response terms
    - Series of seminal papers re-interpreted 'verbal learning' experiments into a computer memory metaphor model (note: 60s-70s vintage computers)
    - Lindsay and Norman (1977) Human Information Processing
  - Empirical research extends to areas not conceptualized under the stimulus-response theories
    - Memory
    - Selective attention
    - Etc.

Information Processing Approach (3)

- Intellectual Antecedents (Lachman, Lachman, & Butterfield, 1979)
  - Psychology, Philosophy, Linguistics, Computer Science, Communications Engineering (signal detection theory, information theory), and
  - Engineering Psychology
    - Post WWII Military problems, e.g. aircraft control
    - Human and machine as a operating unit
    - Borrowed concepts from systems theory
    - "Man-machine system" -- Interaction of human and machine
      - Human operator is a transmitter and processor of information, interacting with the machines' displays and controls
    - Engineering Psychology ⟶ Cognitive Psychology
      - Concept of human as information transmitter, processor, decision maker
    - Examples ...

Cognitive Concepts from Engineering Psychology

- Aviation and Attention
  - Pilots crashing planes, retracted landing gear instead of braking
    - Brake and landing gear levers identical and next to one-another
  - Pilots must keep eyes on runway when landing
    - Motivation, training did not help
  - Problem of divided attention: concentration on choosing lever reduced attention to task of landing
    - Engineering psychology – required research on attention
    - Not an acceptable concept in stimulus-response psychology
  - Solutions: Different felt shapes to lever handles or place handles apart so they require different arm movements
- Touchtone Dialpad Studies: Reaction Time and Errors
  - Measurement of time and errors in deciding telephone key layout
  - Time to do task and errors becomes important measure of mental processes in information processing approach to psychology

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Choice Reaction Time and Mental Processes

- Deininger (1960) – example
  - Engineering psychology introduced idea of measuring time it takes to think and respond
- Choice Reaction Time
- Fitts & Seeger (1953)
  - Stimulus – Response Compatibility
- Back to Cognitive Psychology
  - Sternberg (1966)
    - Memorize digit string
    - Get test digit
    - Was it in or not
    - Respond fast without errors
    - Longer digit string = longer reaction time
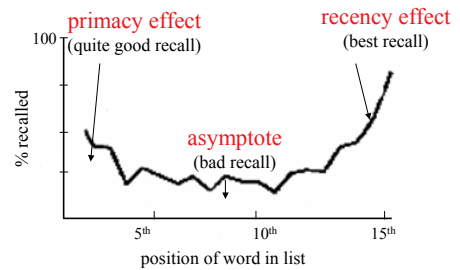   - Yes and no reaction time are the same! = serial search

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Memory Theories (1)

Class Exercise: List Learning

- Glanzer and Kunitz (1966): Serial Position Curve
- Elements:
  - Primacy effect
  - Recency effect
- Serial position curve independent of list length
- Intervening task weakens recency effect
- Craik (1970) learn multiple lists
  - Serial position curve after each list recall
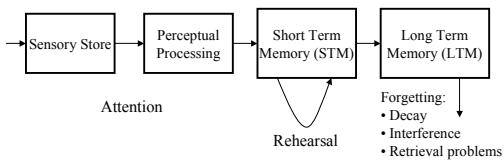 - Final free recall (all lists): no recency effect

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horse

window

yesterday

plate

silly

rabbit

sleep

official

sanguine

meeting

sable

information

portal

rug

matrix

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Serial position curve

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Memory Theories (2)

Simple "1970s Vintage" Memory Theory

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Memory Theories (3)

- Mutlistore Memory Model - Antecedents
  - William James (1890)
    - Prior to S-R psychology
    - Primary memory = what's in consciousness now
    - Secondary memory = what's permanent in our head
  - Resemblance to 1970s computer architecture
    - Not coincidental
    - Core memory
    - Winchester disk, magnetic tape storage

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Memory Theories (4)

- Multistore Memory Concepts
  - Sensory Memory
    - Veridical sensory-level representation
    - Rapid loss due to decay, quick transfer to STM
  - Short Term Memory
    - Verbal based representation
    - Items must be rehearsed to stay in memory
    - Limited store: Magic number 7 plus/minus 2 (Miller, 1956)
  - Long Term Memory
    - Retrieval strategies are the most important factor in getting information out of LTM
    - Memories can be forgotten simply because they can't be retrieved
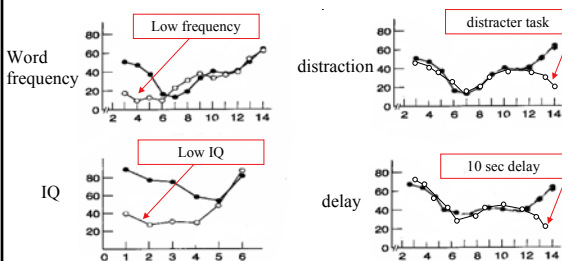
Memory Theories (5)

- Evidence
  - Dissociate effects on each part of curve
    - Different characteristics of each "sotrage system"
    - Many list learning experiments from old S-R psychology
    - New memory interpretation – unified explanation – more parsimony
  - Primary Effect changed by
    - Word frequency
      - Rare words cause less primacy
    - IQ
      - Lover IQ, smaller primacy effect
  - Recency Effect changed by
    - Distracter task lowers recall of last items in list
    - Time delay – longer delay makes lover recall

Memory Theories (6)

Applications of Memory Theories (1)

- (Mis)Application to HCI
  - Short Term Memory and Magic Number 7 plus/minus 2
    - Shneiderman (1st ed text): Menus and memory
    - Has been applied to
      - Place only 7 items on a menu bar
      - Place only 7 items on a pull-down menu
      - Have only 7 bulleted items in a list
      - Never have more than 7 radio buttons or check boxes in a unit
      - Place on seven tabs on top of a website
    - What is wrong with this?

- How much is memory involved?
- Memory Theory has moved on since 1956
  - Working memory: more than just rehearsal area
  - Seven +/- 2 may be wrong: May different estimates, empirical data now in disagreement, may depend upon type of task and material

Applications of Memory Theories (2)

- Application to HCI: Automated Telephone Services
  - If you have a problem with your bill, press 1
        vs.
  - Press 1 if you have a problem with your bill
  - Direct applied research shows Object-Action order is better
  - Could there be a memory reason for this?

  - Golden rule – 4-5 items in each voice menu
  - Memory reason?
  - Virzi & Huitema (1997) – Broader better than deeper

Recent Memory Theories

Theoretical Developments over Last 2 Decades

- Levels of Processing Theory (Craik and Lockhart, 1972)
- Episodic and Semantic Memory (Tulving)
- Constructive Memory - Schema Theory
  - All memories (particularly texts and experiences) are constructed from memory (Applied Psych: Eyewitness testimony)
- Computational Approaches (Preece et al. term)
  - Production systems
  - Movement away from "multistore" models
- Connectionist Approaches (Rumelhart & Norman, many more)
  - Computer simulation of neural network
  - Spreading activation among nodes in network (directed graphs)
  - Extremely loosely based upon neurology
  - Simulations sometimes mimic older symbolic models

Levels of Processing Theory

Levels of Processing

- Information can be processed to different depths or levels
- Replaces old theory of 'rehearsal'
- Shallow processing
  - Stimulus analysis, physical properties such as a word's sound
- Deep processing
  - Semantic analysis (meaning)
  - familiarly
  - imagery
- Deeper processing provides stronger storage of item in LTM

Levels of Processing Theory Applications

Game: Name that Unix Command

- cat
- grep
- ls
- lint
- mv
- pr
- lpr
- awk
- perl

- catenate - rare English word - types file on screen
- global regular expression and print
- list - as in "list files" or "list directories"
- analogy: shreds of fiber from clothing = debugging
- move - refers to computer concept
- print (2/3 letter abbrev.) formats but does not print
- lpr - line printer (anachronism)
- A, W, K - acronym for authors of program
- PERL - practical extraction and report language

Distributed Cognition (Hutchins, 1995)

- Cognitive activities are embodied and situated within the work context in which they occur
- Functional system -
  - individuals
  - setting
  - social context, organizational structure
  - compter systems and technology
- Suchman (1987) - Plans and Situated Actions
  - ethnomethodolgical analysis of novice user and Xerox machine
  - "situated" cognition, cognition is in a social context