Sensory and Working Memory

EXP 4404 - Psychology of Learning

In what ways have you used your memory so far today?

How might you use your memory during the rest of today?

Types of Memory

- Semantic Memory
- Episodic Memory
- Procedural Memory
- Autobiographical Memory

Information Processing Metaphor

- Memory functions in many ways like a computer
  - *receives input from the environment*
  - *stores some information in a coded form*
  - *retrieves coded information for current problem solving*
- Memory systems are *not* identical to a computer
  - *computers rely on electronic switches for storage, encoding & retrieval*
  - *memory relies on neurological processes*

Memory Processes

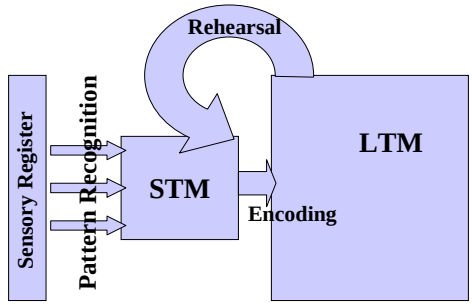
- Encoding
  - *sensory stimuli are recoded in terms of neural activity and changes in neural connectivity*
- Storage
  - *maintenance of coded information for long periods of time*
  - *some memories are stored for very short durations*
  - *other memories might be stored for a lifetime*
- Retrieval
  - *reactivation of coded material from a memory store*
  - *depends on both* availability *and* accessibility

Memory Systems

- Extension of the computer metaphor
- Computers have various storage systems
  - *input buffers*
  - *CPU memory*
  - *Hard drive, floppy disk storage, etc.*
- Human memory also has specialized storage systems
  - *sensory memories*
  - *Short-Term Memory / Working Memory*
  - *Long Term Memory*
- Limitations of the computer metaphor

Atkinson-Shiffrin Model

- Information processing model of memory
- Memory Structures (analogous to computer hardware)
  - *sensory registers / sensory memory stores*
  - *short-term memory / working memory*
  - *long-term memory*
- Control Processes (analogous to computer software)
  - *attention*
  - *pattern recognition*
  - *rehearsal*
  - *retrieval*



Atkinson-Shiffrin Model of Memory

Sensory Memory

- Very short duration memory representations
- Iconic Memory
  - *memory for visual information*
- Echoic Memory
  - *memory for auditory information*
- Other Sensory Memories
  - *model assumes that a sensory memory exists for each sensory receptor system*

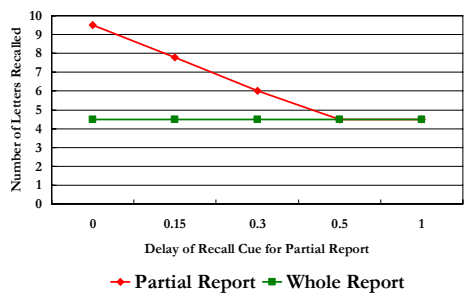
Iconic Memory

- Sperling Whole Report Technique
  - *brief presentation of an array of letters*
    - *usually 50 msec (.5 sec)*
    - *demonstration will show letters for 2 sec*
  - *participants asked to recall all of the letters presented*

Sperling Partial Report Technique

- Array of letters presented (ususally for 50 msec)
- Cue is presented to signal which row of the array to recall
  - Recall top row
  - Recall middle row
  - Recall bottom row
- Cue is presented *after* the array is no longer in view

Performance on Whole and Partial Report Tasks



Iconic Memory

- Perceptually detailed visual memory
- Duration is *very short* (.5 sec - 1 sec)
- Information stored has not been analyzed yet for meaning
  - *precategorical information*

Echoic Memory

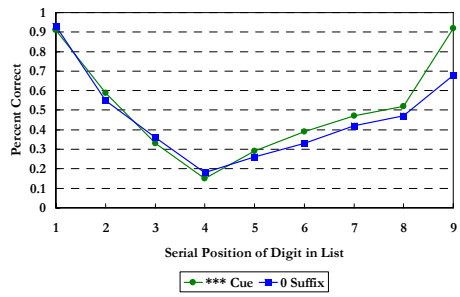
- Auditory analog to iconic memory
- Darwin, Turvey & Crowder (1972)
  - *auditory analog of Sperling's experiments*
  - *found that spatial locations could be cued to improve recall in a partial report procedure*
- Echoic memory contains sensory (precategorical) auditory information
  - *can make use of cues to recall selected items based on sensory qualities but not based on meaning*
- Very short duration (approximately 2 sec)

Suffix Effects

Crowder & colleagues

- Present a list of digits to be recalled
  - *all digits* except *the digit 0 were used as list items*
  - *3 6 9 2 3 7 8 1 5*
  - *end of list signaled in one of two ways:*
    - *recall cue: ****
    - *recall cue: 0*
  - *subjects recalled the list in serial order*
- Recall of final digits in lists ending with the *** recall cue showed a strong recency effect
- Recall of final digits in lists ending with the *0* recall cue showed significantly worse recall

Crowder's Stimulus Suffix Effect



What is Sensory Memory Good For?

- Adaptive value of Sensory Memories
- Brief buffer to hold information for processing after the physical stimulus is gone
  - *integration of information from a series of eye fixations*
  - *acquisition of language - sensory memory allows comparison of different pronunciations of words*

Characteristics of Short-Term Memory in the Atkinson-Shiffrin Model

- Limited Capacity System
  - *Miller (1956) estimated capacity at 7 ± 2 chunks*
  - *What is a chunk?*
    - *Group of items that form a meaningful unit*
    - *Trade-off between size of a chunk and number of chunks that can be held in STM*
- Limited Duration (< 30 sec)
- Type of code used for representation
  - *Verbal codes versus multiple types of codes*
  - *Confusion errors as indicators of type of code used*

Control Processes in STM

- Early studies focused on rehearsal
- Rehearsal served two purposes:
  - *kept items active in STM for longer than 15-20 sec*
  - *transferred information from the Short-Term Memory system to the Long-Term Memory system*
- Evidence for Different Types of Rehearsal
  - *directed forgetting studies*
  - *Maintenance Rehearsal*
  - *Elaborative Rehearsal*
- Depth of Processing
- Breadth of Processing

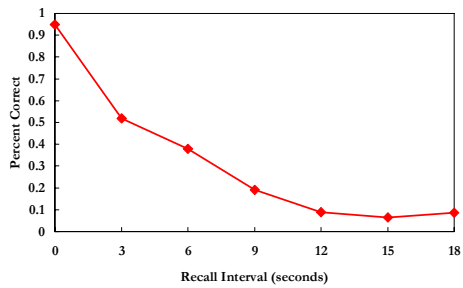
Explaining Forgetting from Short-Term Memory

- Decay Theory
  - *passive loss of information*
  - *gradual deterioration of information over time*
- Interference Theory
  - *active loss of information*
  - *one memory representation is displaced, disrupted, or distorted by another memory representation*

Brown-Peterson Task

- Present a small amount of information to remember: e.g., a consonant trigram
  - *X J Q*
- Present a 3-digit number and ask subject to count backwards by 3s during the retention interval
  - *987 . . . 984 . . . 981 . . . 978 . . . 975 . . . 972 . . . 969*
- Recall the consonant trigram

Recall in the Brown-Peterson Task



Comparing Decay vs. Interference Explanations of Forgetting

- Probe-Digit Paradigm (Waugh & Norman, 1965)
- Presented a long list of digits
- Tested memory for digits by presenting a probe digit
  - *subject's task was to recall the digit that followed the probe digit in the list*
- Digit lists were presented at a fast rate (4 digits per sec) or a slow rate (1 digit per sec)
  - *at the fast presentation rate, many digits occur between presentation and test of a digit*
  - *at the slow presentation rat, fewer digits occur between presentation and test of a digit*
- Number of intervening digits predicted performance rather than the passage of time

Interference in the Brown-Peterson Task

- Reitman (1971, 1974)
- Does the backwards-counting task in Brown-Peterson studies create interference as well as preventing rehearsal?
- Developed alternative tasks to prevent rehearsal that would be less likely to create interference (signal detection tasks)
- Problem: Difficult to find a task that prevents rehearsal without creating interference

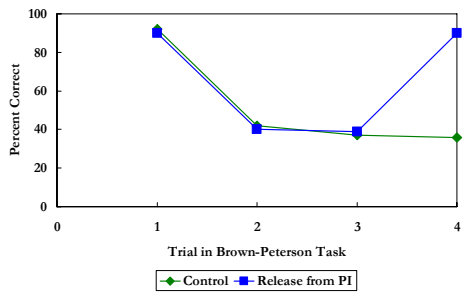
Types of Interference

- Retroactive Interference (RI)
  - *RI Group: Study List A* *Control Group: Study List A*
  - *Study List B* *Rest*
  - *Recall List A* *Recall List A*
    - *Learning List B interferes with ability to recall List A*
- Proactive Interference (PI)
  - *PI Group: Study List A* *Control Group: Rest*
  - *Study List B* *Study List B*
  - *Recall List B* *Recall List B*
    - *Prior Learning of List A interferes with ability to recall List B*

Release From PI

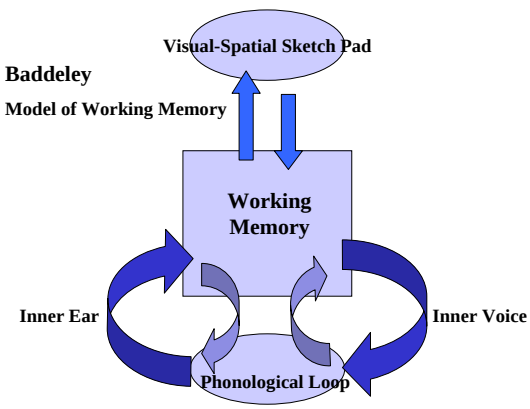
- Proactive Interference (PI) builds up over successive trials in the Brown-Peterson Task
  - *little forgetting of the trigram on trial 1*
  - *more forgetting on later trials*
  - *PI accumulates because of the similarity between trigrams on successive trials*
- Release from PI will occur if the material to be remembered changes
  - *4 trials of remembering names of 3 fruits*
  - *3 trials of remembering names of fruits followed by a release-from-PI trial: remember names of 3 animals*

Release from PI



Working Memory (Baddeley)

- The Working Memory model was developed to account for many of the problems with the Short-Term Memory model proposed by Atkinson & Shiffrin
  - *estimates of the capacity of STM were related to how long it took to pronounce an item*
  - *evidence that a variety of codes are used for representing information in immediate memory*
  - *evidence that verbal rehearsal was not the only way that permanent representations (in LTM) are created*



Working Memory Model

- The term "working memory" reflects the fact that STM/immediate memory is where cognitive processing (work) takes place
- Components of the Working Memory Model
- Central Executive
- Specialized Subsystems
  - *Phonological Loop*
  - *Visuo-Spatial Sketch Pad*
- Different immediate memory tasks might make use of different components - leading to differences in task performance

Central Executive

- Controls the flow of information among the various subsystems
- Attention
- Planning
- Problem-solving
- Coordinates all the subsystems
  - *delegates storage of some information to specialized systems*
  - *controls retrieval of information from LTM*

Evidence for the Phonological Loop

- Phonological loop is a speech-based storage system
  - *holds about 2 sec worth of spoken speech*
  - *items stored in loop both by hearing and by speaking*
- Word-length effect
  - *can hold fewer long words in WM than short words*
- Effects of articulation time
  - *cultures with languages that have long pronunciation times for digits also have shorter digit spans*
- Effects of articulatory suppression
  - *requiring subjects to repeat an irrelevant word while studying a list reduces the digit span*

Applications

- Children who experience difficulty learning to read frequently have difficulty accessing phonological information quickly
  - *Torgesen has developed a test of phonological awareness that predicts reading skill*
  - *Inefficient use of the phonological loop for speech codes during reading means:*
    - *more resources in the Central Executive must be used for storage*
    - *fewer resources in the Central Executive are available for comprehension*

Evidence for Visuo-Spatial Sketch Pad

- Visuo-Spatial Sketch Pad has not been studied as extensively as the Phonological Loop
- Viewing visual patterns or color patches can interfere with ability to generate images or use imagery to remember a list

Other Specialized Systems?

- Reisberg suggests that the specialized systems are created by skill at a cognitive task
- Developed a new skill-based memory subsystem based on a finger-tapping task
  - *each finger represents a digit*
  - *tap fingers in sequence to code a small string of digits*
- Subjects who learned and used the finger-tapping system could remember longer strings of digits
- Drumming the fingers while studying the list reduced the digit span

Neuropsychology of STM & WM

- Case Studies:
  - *Henry M. (HM) (amnesia following surgery for epilepsy)*
  - *KF (brain injury received in a motorcycle accident)*
  - *Korsakoff's Patients (amnesia related to chronic alcoholism and malnutrition)*
- Variations in quality of STM ability (depending on severity of the brain injury)
- All cases show deficits in transfer of information from a short- to a long-term form of representation
- Evidence based on brain imaging studies