Aging and Memory

The Conventional Stereotype

- Memory declines <u>significantly</u> in old age
- All forms of memory decline with age (semantic; episodic; retrospective; procedural)
- Memory loss is inescapable

Factors that strengthen the stereotype

- Age-related pathologies
  (depression; cardiovascular disease; dementia)

- Early scientific studies focused upon <u>institutionalized populations</u>

- Less structured environment post-retirement

- Self-fulfilling prophecy

Golden Age of Gerontology
(1965-1985)

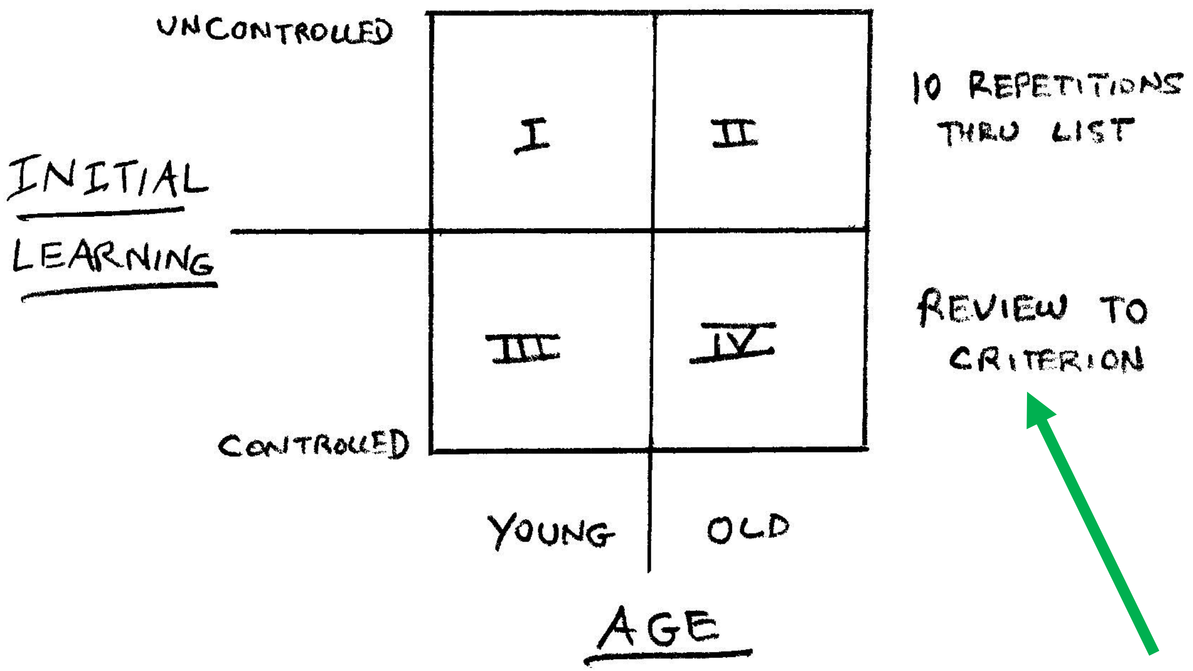
- Numerous scientists began to document significant deviations from the “conventional wisdom” about aging
- **Gerontology** – the study of normative aging – emerged as a distinct field of scientific investigation
- Gerontology departments proliferated across U.S. universities
- NIH established the National Institute on Aging (1971) (Robert Butler, Director)

Let’s look at a seminal study that reflected the new focus upon the study of normative aging

Controlled Studies of Aging and Memory
(Hulicka & Weiss, 1965)

- Existing research regarding memory and aging was seriously flawed
- Studies focused upon <u>institutionalized older participants</u> compared to healthy young college students (health and education confounds)
- None of the studies demonstrating memory decline controlled for group differences in the quality of <u>initial learning</u> of the to-be-remembered stimuli

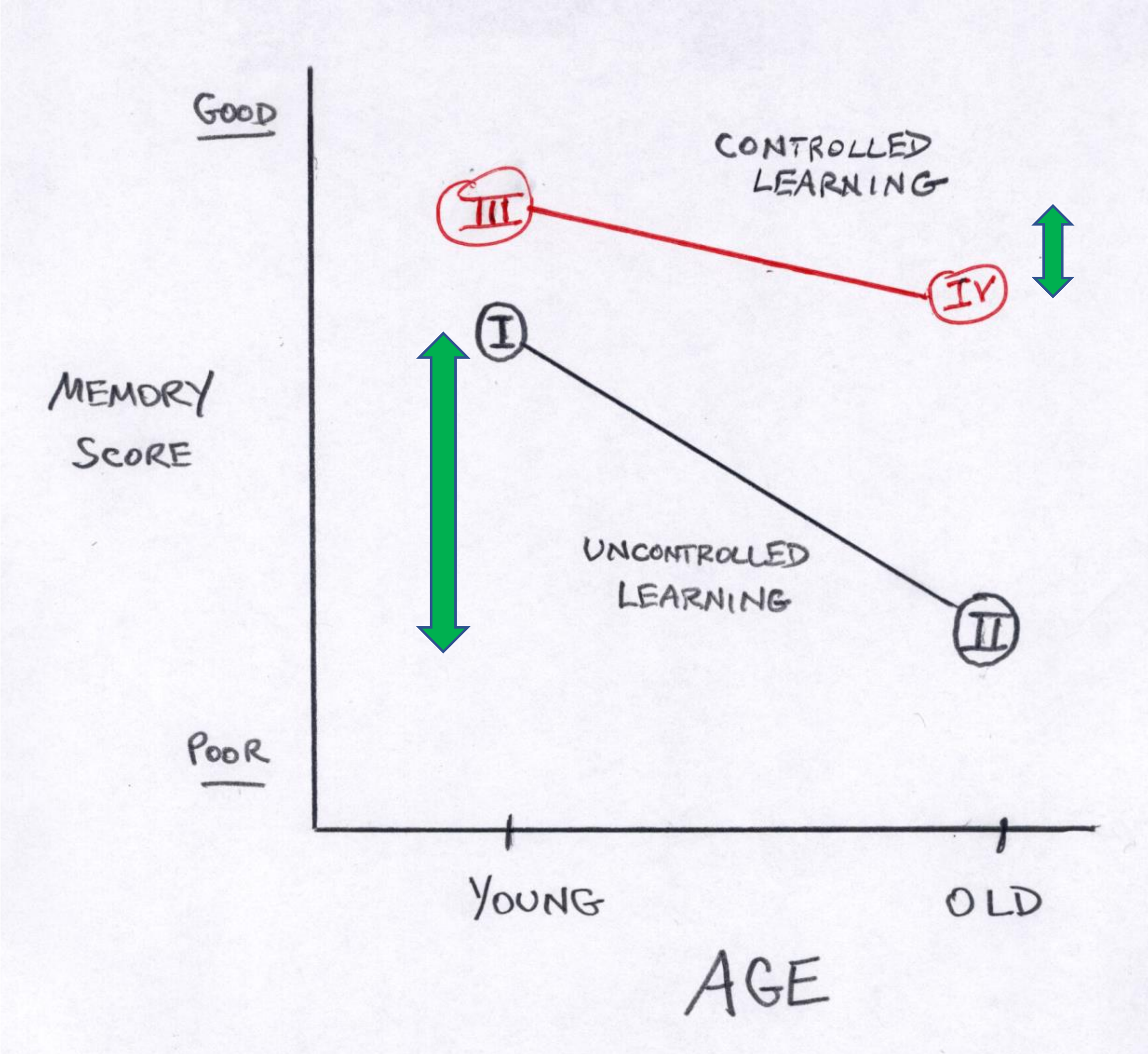
Experimental Design



- Young vs. Old
- Old were healthy, community residents
- Paired-Associates Task
- Memory assessed at 1-week follow-up
- Manipulated quality of "initial learning" across age groups

Study list of word-pairs until no errors occur

Results of Experiment



- Large age-related decrements in memory when initial learning was not controlled (Groups I versus II)
- Only minimal age-related decrements were observed when initial learning was equalized using "study to criterion" approach (Groups III versus IV)
- <u>Conclusion</u>
  Much of the previously demonstrated age-differences in memory probably reflected poor experimental controls

Information Processing Model of Human Memory

- Most of the memory research initiated since the “Golden Age” has been guided by the Information Processing Model

- We will review the structure and function of the model and then examine the age-related changes that occur at each level of the model

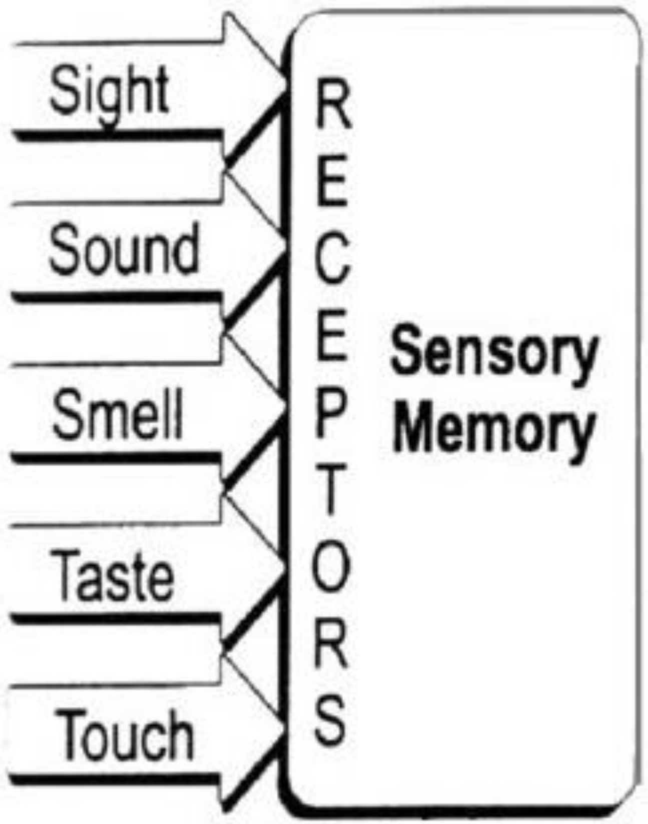
Information Processing Model

(3) Stages

- Sensory Memory
- Short-Term (“Working”) Memory
- Long-Term Memory

(3) Major Processes

- Attentional Selection
- Storage
- Retrieval

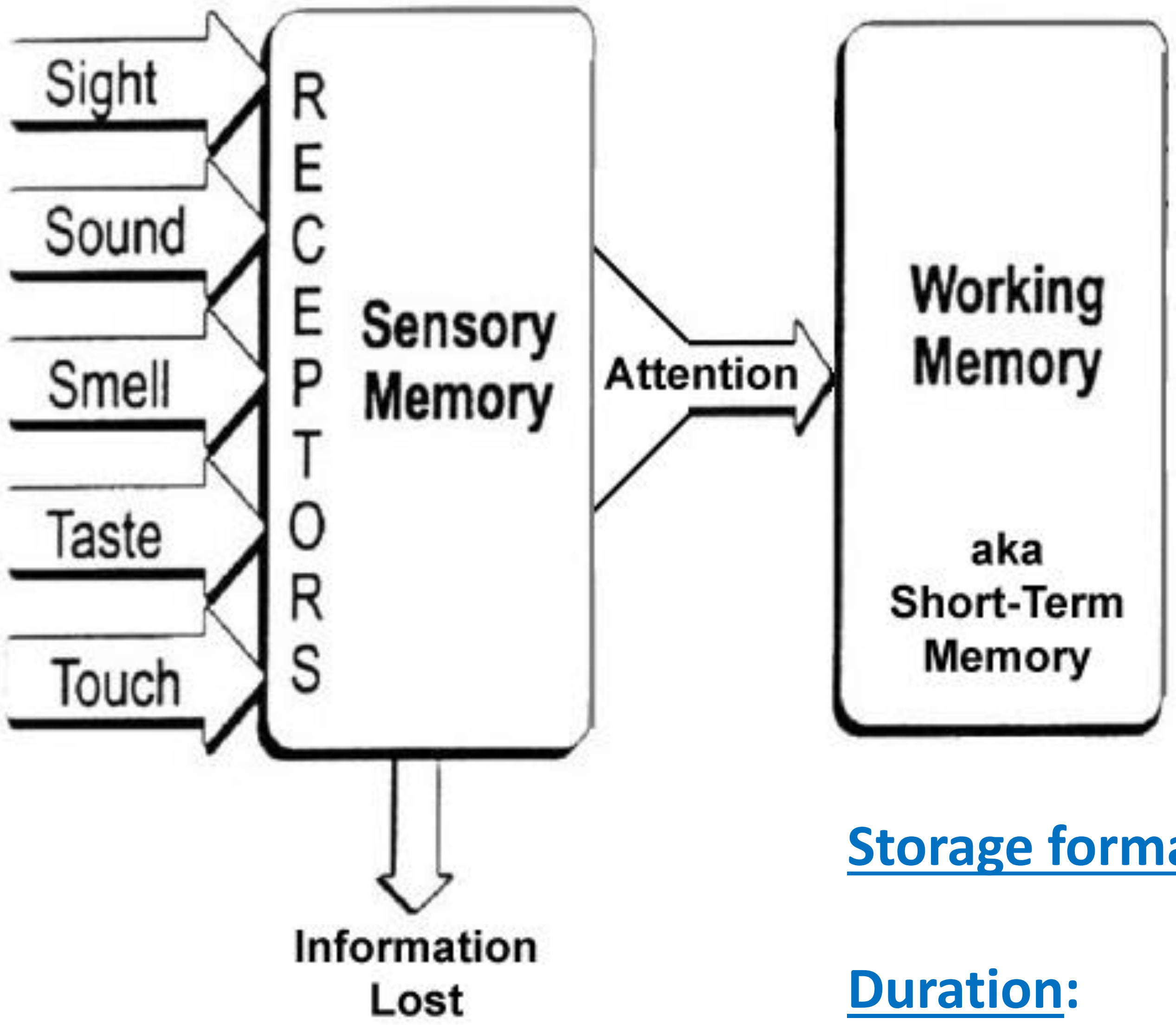


Information from our senses must be selectively filtered and "encoded" into cognitive representations before becoming useful.

Because selective attention takes time <u>sensory information is temporarily buffered</u> in the primary sensory cortex areas while the selection & encoding processes are completed.

Sensory Memory

<u>Storage format</u>:	raw sensory neural activation
<u>Duration</u>:	500 msec
<u>Capacity</u>:	Very large

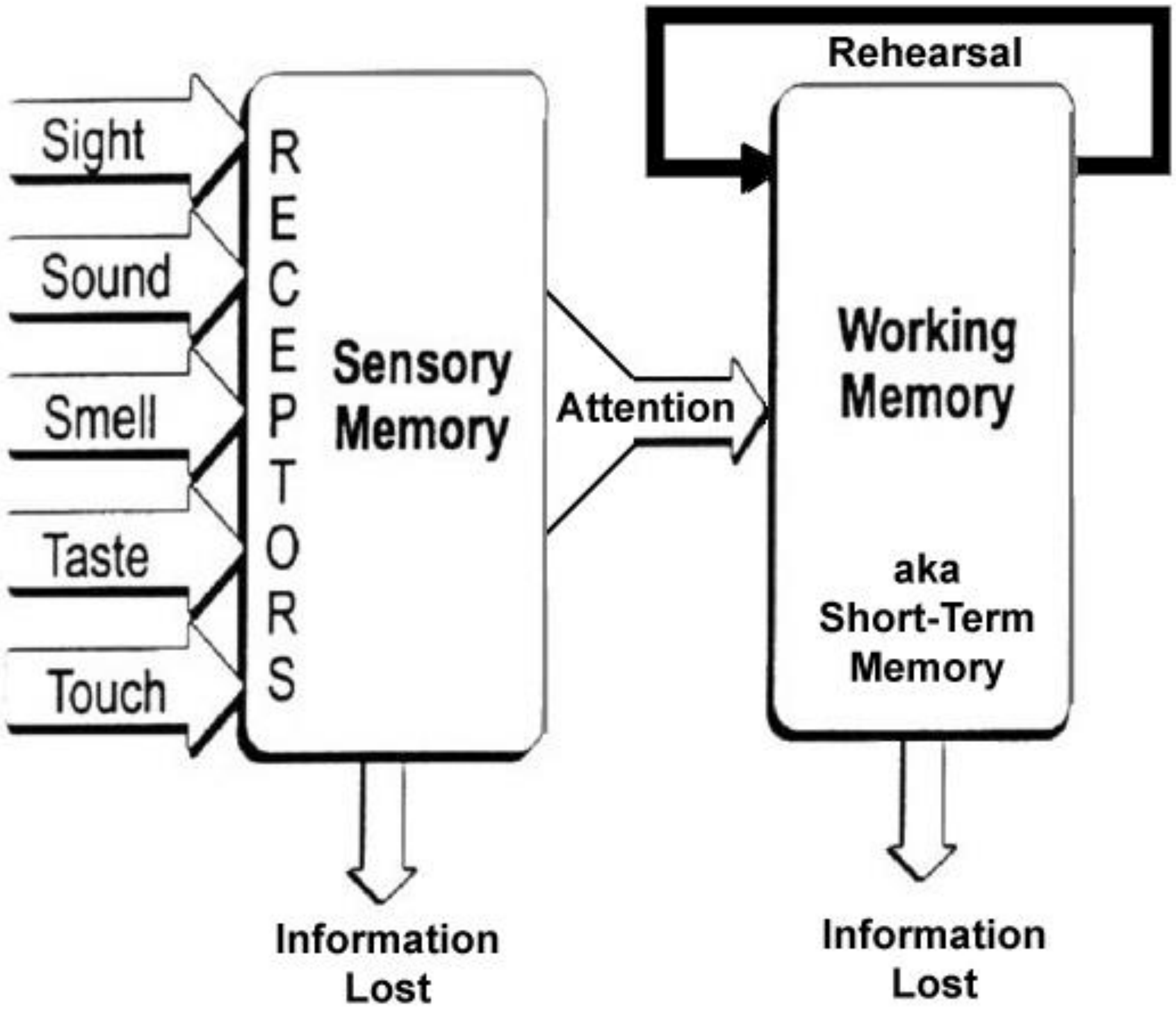


After sensory information is selected and encoded into "cognitive representations", these objects are passed to the Short-Term Memory stage.

Non-selected information in sensory memory quickly decays and is continuously replaced by new incoming signals from the senses

Working Memory

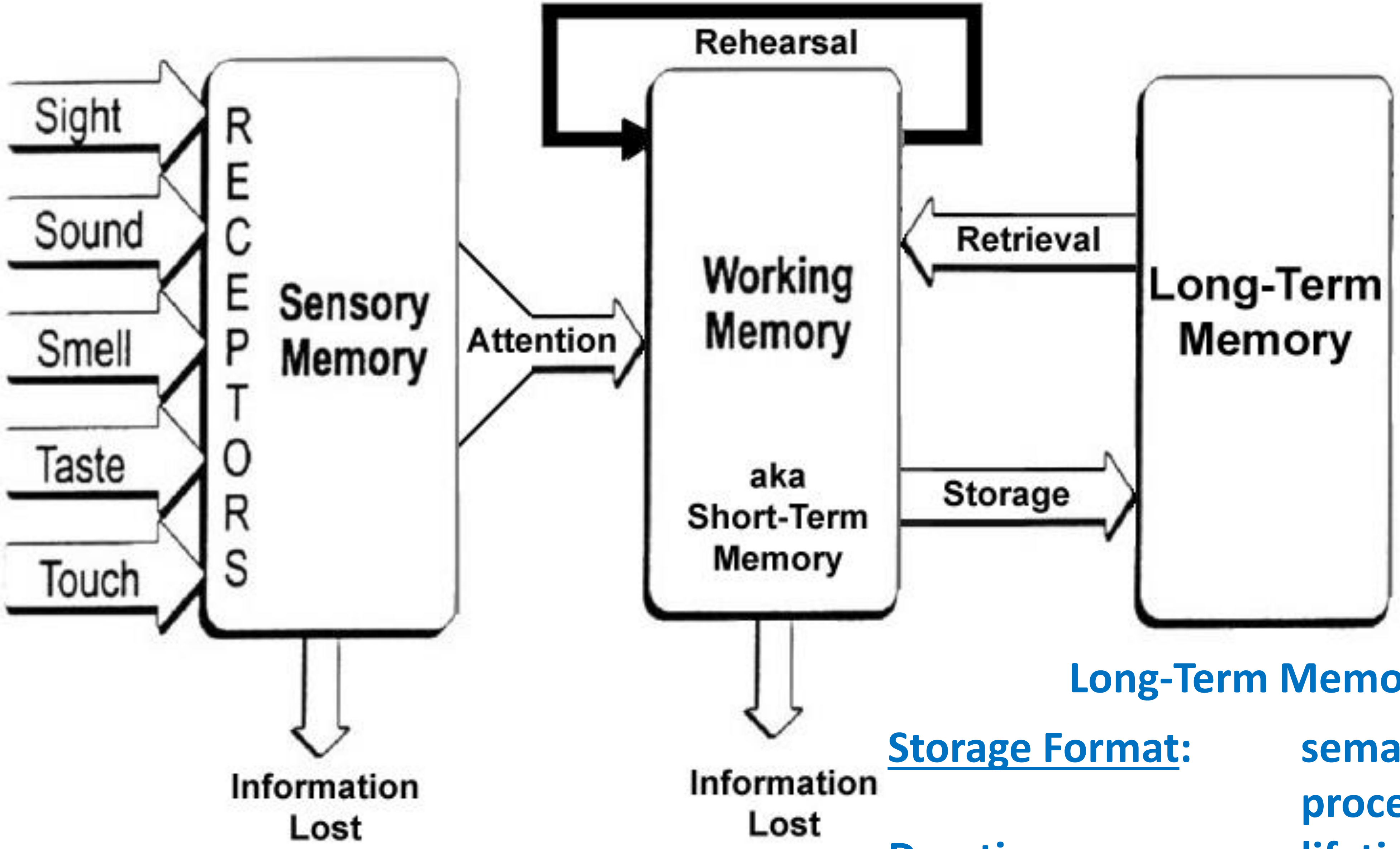
Storage format:	perceptual/semantic codes (words; events; melodies)
Duration:	30 seconds
Capacity:	7 ± 2



The representations (codes) stored in Working Memory are available to consciousness.

They are the psychological "now"

These codes will decay completely within 30 seconds unless they are periodically refreshed via a process termed "rehearsal"



Long-Term Memory

<u>Storage Format</u>: semantic; episodic; procedural encodings

<u>Duration</u>: lifetime*

<u>Capacity</u>: limitless

Age-Differences in Sensory Memory

- Method of Partial Report
- Sequential Integration of Form

Sperling's Method of Partial Report

- Briefly present 4x3 array of stimuli (e.g., 25 msec)
- Wait for 0-1000 msec following stimulus offset
- Cue observer to report top, middle or bottom row of stimuli (Sperling used tones of different pitch)
- Observer reports as many stimuli as possible

N.B. The "cue" is not provided until after the stimulus array has disappeared

Method of Partial Report

(George Sperling)

FULL REPORT PROTOCOL

You are about to be shown a group of random letters.

They will be presented VERY BRIEFLY.

Please report as many of the letters as you can.

E	R	V	F
X	L	D	B
Z	P	W	G

Report the stimulus letters now…….

PARTIAL REPORT PROTOCOL

Let’s try that again….

However, this time only report the letters on the BOTTOM ROW.

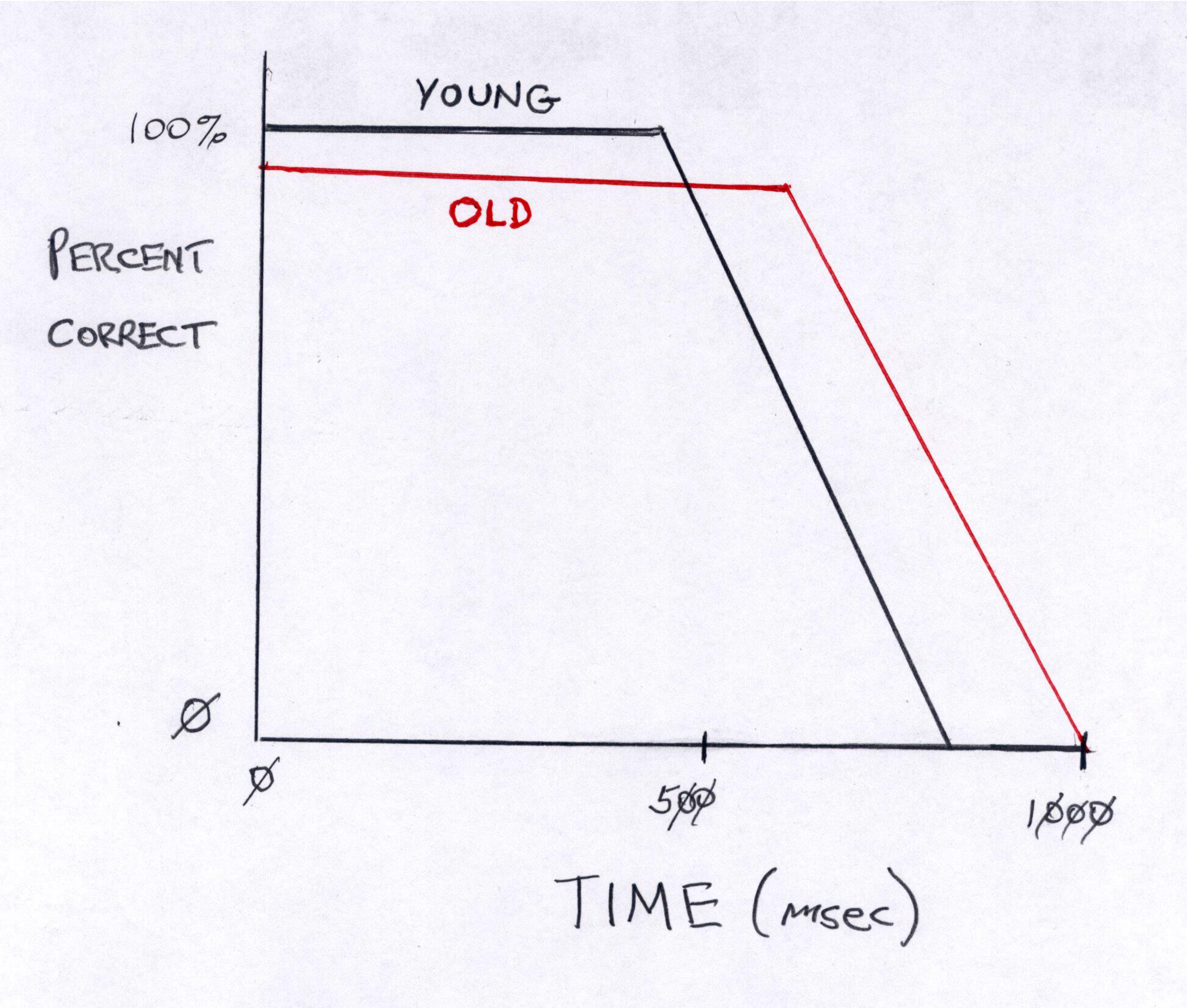
E	R	V	F
X	L	D	B
Z	P	W	G

Report the stimulus letters now…….

Remember:
In a real Partial Report experiment, the "cue" would not be presented until AFTER the matrix of stimulus letters disappeared.

Let's look at some experimental results ….

Partial Report Results



Young participants demonstrate 100% correct performance when the "gap" between stimulus onset and the "cue" is less than 500 msec.

Accuracy quickly collapses beyond 500 msec as sensory memory traces decay.

Older adults demonstrate intact (visual) sensory memory.

In fact, the duration of the sensory memory trace appears to persist longer in older observers.

Speculation:
Could increased persistence of sensory memory help "compensate" for slower selective attention?

Sequential Integration of Form

- Stimuli that are presented sequentially and very rapidly can be <u>integrated over time and space</u> into unified perceptual objects

- Such integration occurs <u>only within a very narrow window of time</u> and appears to reflect the persistence of sensory memory

- Let’s examine this paradigm in more detail…

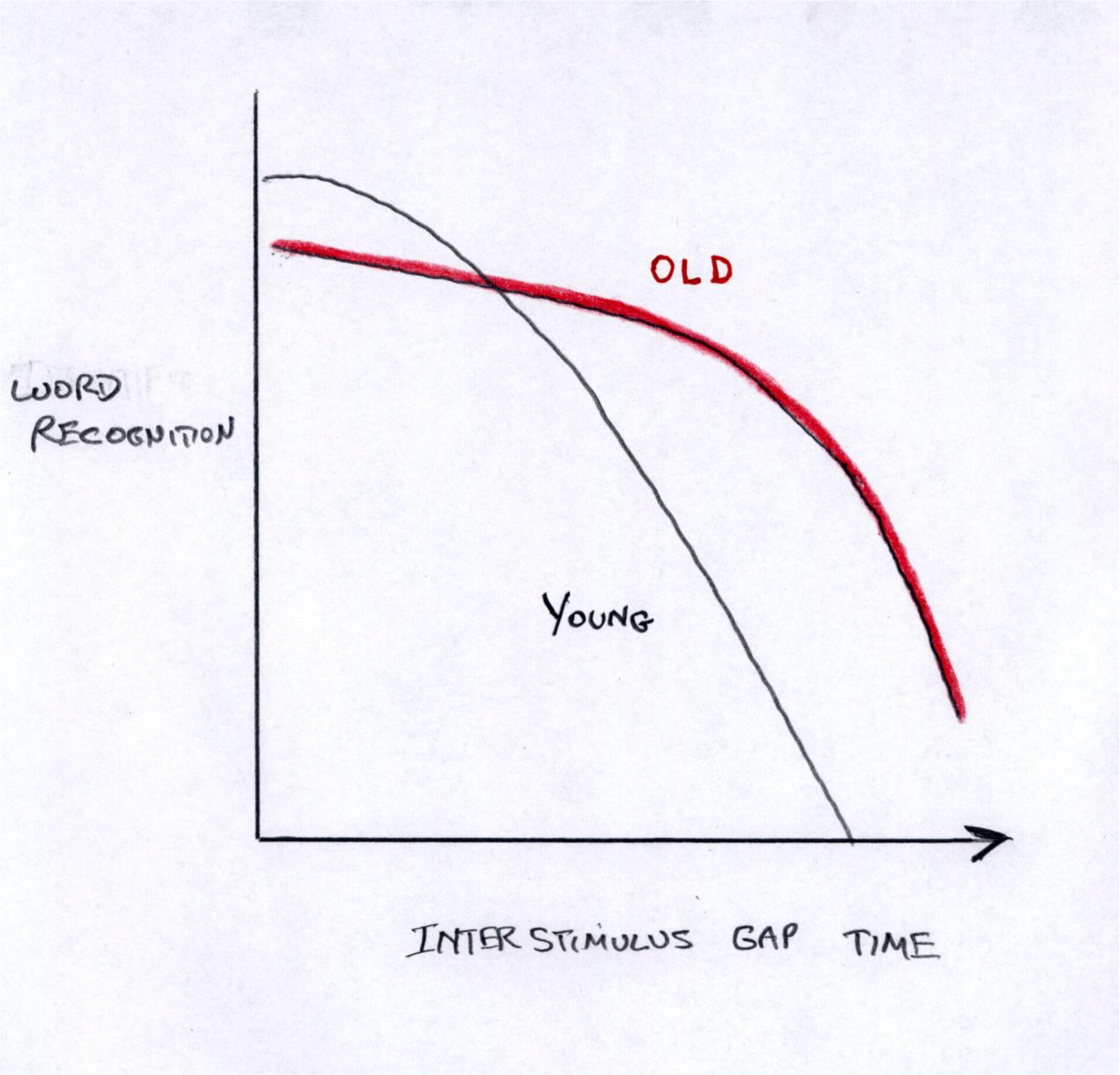
Sequential Integration of Form
(Split 3-letter word into arbitrary stimulus halves)

Briefly present one stimulus-half

…Quickly followed by the second stimulus-half…

When the time “gap” between stimulus-halves is short enough,
the stimulus-halves are integrated together and appear as a whole word

Somewhat paradoxical but predicted results…



Because of increased persistence of visual sensory memory…

Old observers begin to perform better as the time gap between the to-be-integrated stimulus halves increases

<u>Conclusion</u>:
Sensory memory is not impaired by normal adult aging

Age-Differences in Short-Term/Working Memory

Capacity

- Digit Span (forward vs. backward)
- Word Span (static vs. dynamic)

Duration

- Brown-Peterson Task

Speed

- Sternberg Memory Span

Short-Term Memory Capacity
(Digit Span)

- Serially present a string of digits (1 per second)
- Participant recalls digits in the same order as presented
- Length of digit string increases until errors begin to occur

  5 – 8 – 2
  6 – 1 – 3 – 8
  6 – 2 – 9 – 4 – 7

- Forward digit span = longest error-free string
- Backward digit span = longest error-free string recalled in reverse order

“The magical number 7 ± 2”

G.A. Miller

Forward Digit Span

Young adults: 7
Older adults: half digit loss @ age 70

Backward Digit Span

1 digit loss @ age 70

Static STM capacity is relatively intact.
Decrements emerge only when contents of working memory need to be manipulated.

Short-Term Memory Capacity
(Word Span)

- Immediate recall of sequentially presented lists of words
- Very small age-difference for immediate free recall (6 vs 7 words)
- **Dynamic demands** (such as <u>recall in alphabetical order</u>) result in significantly larger age-related declines

Moose – Apple – Candor – Serpent

- Especially sensitive to Mild Cognitive Impairment (MCI)

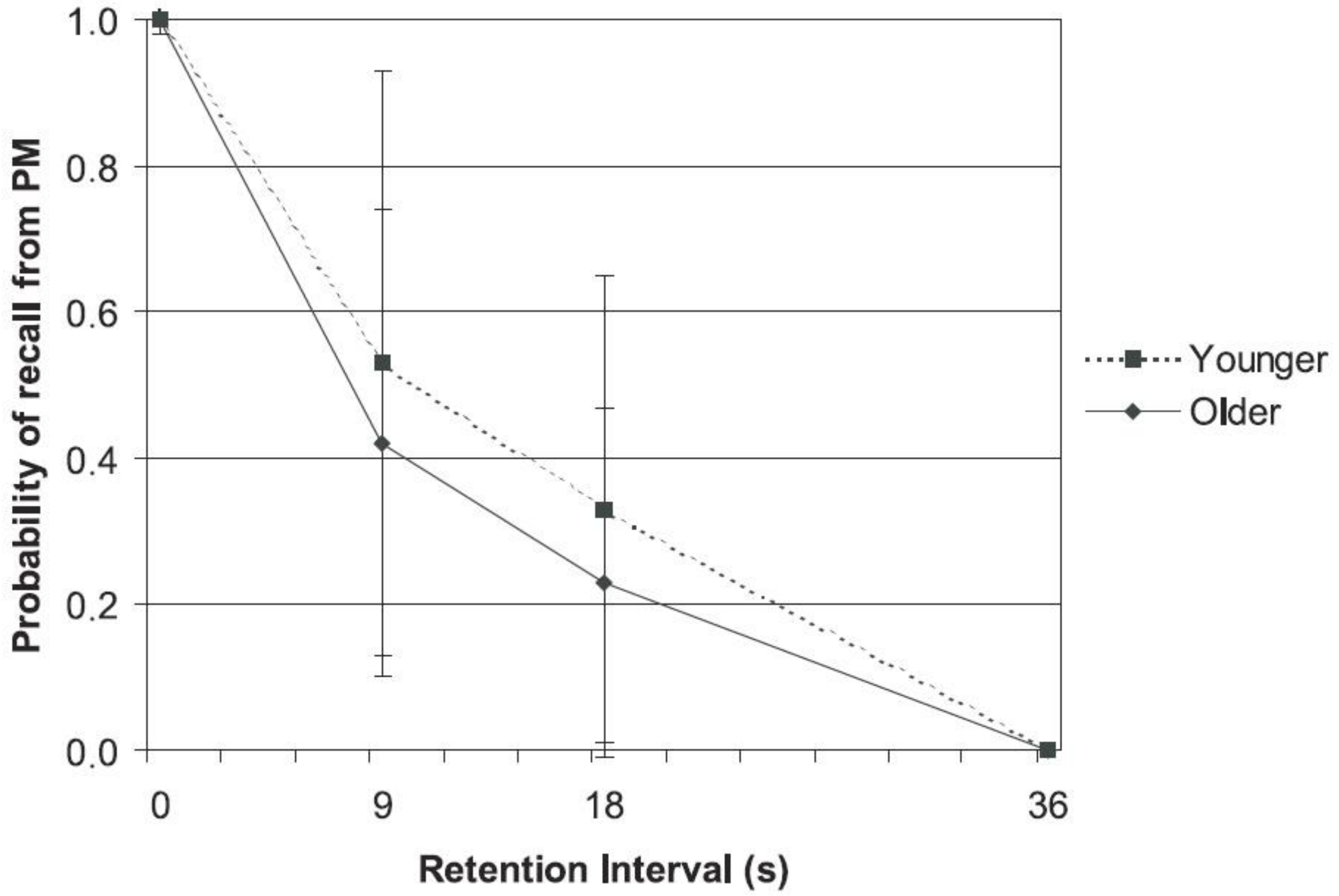
Conclusion:

Static STM capacity is relatively intact in old age <u>but rapidly declines as cognitively demanding manipulations of memory contents are increased</u> (i.e., Diminished Working Memory capacity)

Short-Term Memory Duration
(Brown-Peterson Paradigm)

- Subjects are presented with a list of words to maintain in STM
- In order to assess the rate of decay,
  rehearsal must be prevented
- <u>Rehearsal is prevented using a distraction task</u>
  (e.g., count backwards by 7's; sing a song; etc.)
- Participants are asked to recall the stimulus list after varying intervals of time have elapsed (e.g., 0, 10, 20, 30 sec)
- Recall as a function of time reveals the rate of decay in STM

Short-Term Memory Duration
(Brown-Peterson Paradigm)



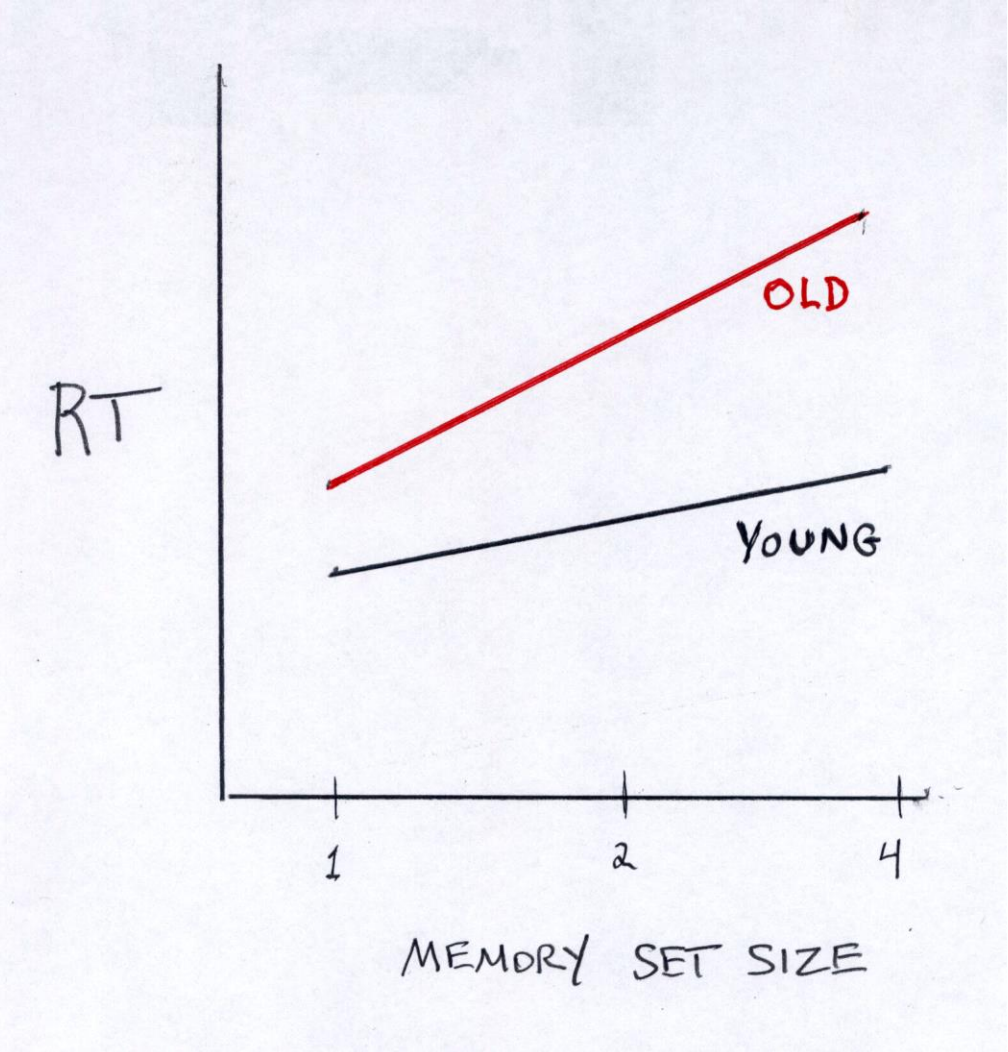
Very modest increases in the rate of STM memory decay are observed among older adults.

Speed of STM Processes
(Sternberg Memory Span)

- How fast can we search through the contents of working memory?
- Require subject to hold a <u>small set of random digits </u>in STM
- Present subjects with single digits and ask them whether or not the digit is a member of the set being held in memory
(i.e., “yes” or “no” reaction time response)
- Plot average reaction times as a function of the memory set size to reveal the speed of the memory search process

Typical findings shown on next slide…

Speed of STM Processes
(Sternberg Memory Span)



The increased slope of the STM search function in older adults reveals a 30% slowing in the rate of working memory operations.

This most probably contributes to the decreasing capacity of working memory in older adults when cognitive demands are intensified.

Again, we see evidence for the universal slowing of behavior with increasing adult age.

Age-Differences in Long-Term Memory

- Recall vs Recognition Memory
  (The Storage vs. Retrieval Problem)

- Craik & Tulving's Depth-of-Processing Paradigm
  (Diminished Level-of-Processing Effects)

- Meta-Memory
  (On-Line Recognition of Memory Failures)

Age-Differences in Long-Term Memory
(The Storage vs. Retrieval Problem)

- Even among healthy older adults, reliable decrements in LTM performance are routinely observed

- Any obvious question is:

  Are these decrements due to storage problems or retrieval problems?

  or…Both?

Let’s explore some classic studies that have addressed this issue…

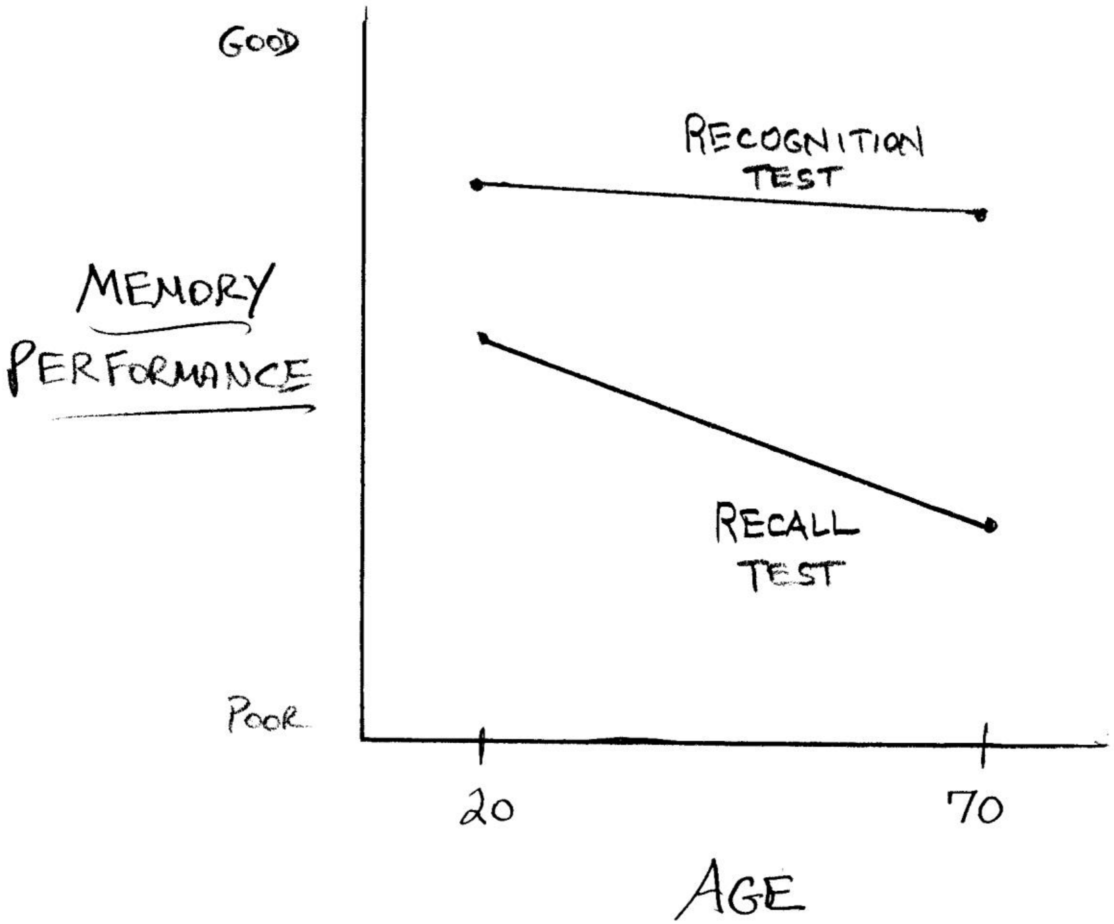
Age-Differences in Long-Term Memory
(Free Recall vs. Recognition Memory)

- Schonfield & Robertson proposed that the limits of LTM performance among older adults are due to a **retrieval deficit** rather than a problem with storage mechanisms.
- They designed a simple but eloquent experiment to test this hypothesis
- Experimental Design:

--Healthy young and healthy old groups
--LTM assessed using traditional "free recall" versus a "recognition" memory task

Prediction:
If memory performance decrements are primarily due to problems with retrieval processes, then age-differences in performance should be much smaller on the recognition memory test than the free recall test.

Age-Differences in Long-Term Memory
(Free Recall vs. Recognition Memory)



Moderate but significant age-related declines in LTM were observed when memory was assessed using free recall.

However, age-differences in LTM almost disappeared when the recognition memory test was used.

This suggests that the memories are "there" but that accessing those memories with contextual cues is more difficult (i.e., a retrieval deficit).

But…Could age-related problems with LTM storage mechanisms also exist?

Age-Differences in Long-Term Memory
(Depth of Processing; Encoding Anomalies)

- The more mental work (or, cognitive elaboration) one performs on the contents of STM, the more extensively they will be incorporated into LTM's representational network.
- The more extensively represented in LTM, the more accessible a new memory becomes….and, hence, is more likely to be recalled on a subsequent memory test.

  This is analogous to cross-referencing items stored in a physical filing system. The more "links" to the item when filed, the more likely it will be found in a subsequent search.

- **Craik & Tulving** developed the "Depth of Processing" paradigm to study such predictions.

Age-Differences in Long-Term Memory

(A Depth of Processing Experiment)

- Experimental Design:

  Young vs. old groups

  Participants inspected lists of word stimuli under four conditions:
  (Each condition was signed to elicit a different level-of-processing)

  Recognition memory tests administered at end of the experiment

- Levels-of-Processing:

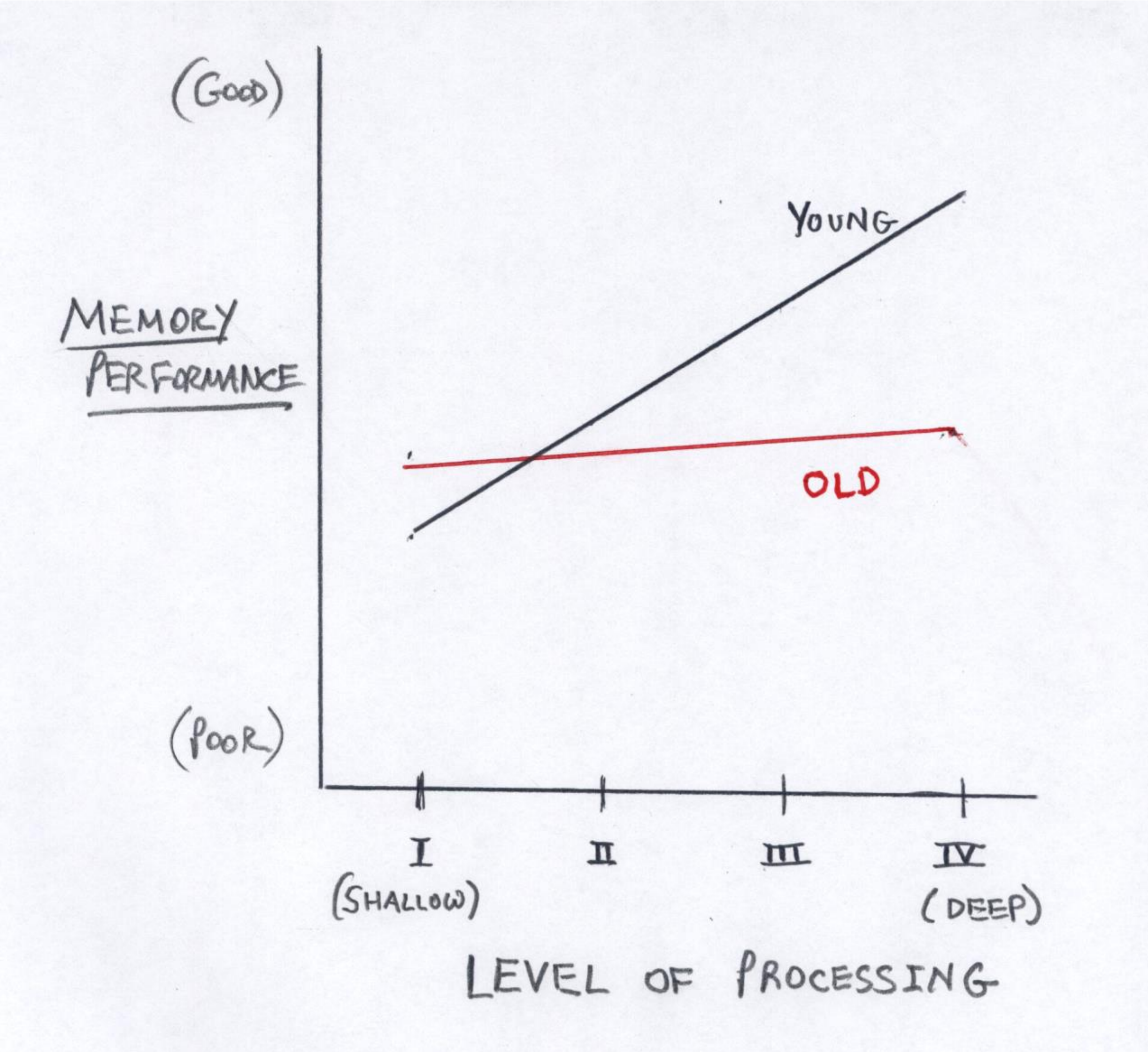
Depth of Processing

Shallow

I. Count the number of letters in each word
II. Generate a rhyme for each word
III. Generate an “appropriate” adjective for each word
IV. Form a vivid visual image for each word

Deep

Age-Differences in Long-Term Memory
(A Depth of Processing Experiment)



As always, the young participants demonstrate a robust depth-of-processing effect.

The more deeply the stimulus words were processed while in working memory. The more likely they are recognized on a subsequent LTM test.

<u>Older participants demonstrated little or no depth-of-processing advantage</u>.

This suggests that newly formed memories are somehow "impoverished" in their connections to the long-term memory network.

Meta-Memory

- **Metamemory** refers to awareness of one's own memory capabilities.

- Many, but not all aspects of memory monitoring are well preserved in old age.

- A major exception:

  Older persons are more prone to have high confidence in affirmative recognition errors.

  That is: When they make the error of recognizing something that they have not encountered previously – They tend to be overly confident in the accuracy of their memory (Frontal lobe executive function)

Hertzog & Curley (2020)