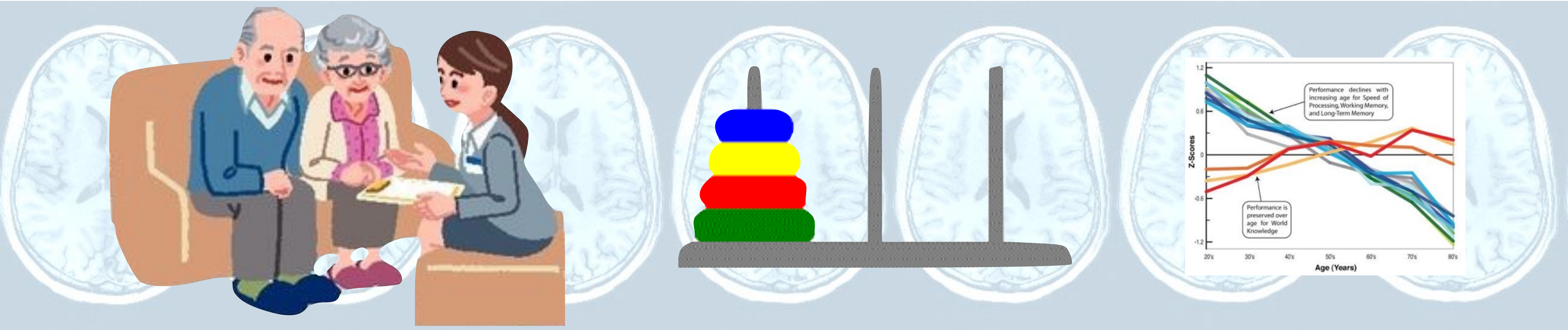


Memory across the lifespan

May 24, 2016
Steph Gagnon

Announcements

- Review session (Q&A format)
  - Thursday 6/2, in 420-040 (9-10:20am)
- Final exam
  - Similar format to midterms
  - Focus on latter third, but with high-level cumulative questions
  - EARLY FINAL: Thurs, 6/2, 12-3pm, 420-040
  - STANDARD FINAL: Mon, 6/6, 8:30-11:30am, 420-040
- Paper grades are available on Canvas
- Please submit evals!

The aging brain

- Brain development continues from birth to early 20s
- Then…
  - Brain volume declines slowly but steadily
  - Cognitive processing speed slows
  - Fluid intelligence declines
  - Episodic memory declines
- It’s not all bad: Well-consolidated knowledge and skills are resistant to age-related decline

Agenda

- Memory in ‘Healthy’ Aging
- Memory in ‘Healthy’ Aging: Evidence for Multiple System Changes
- Mechanisms of Impairment
- Neurobiology of Age-Related Memory Change

Agenda

- **Memory in ‘Healthy’ Aging**
- Memory in ‘Healthy’ Aging: Evidence for Multiple System Changes
- Mechanisms of Impairment
- Neurobiology of Age-Related Memory Change

Episodic memory

Rey Auditory Verbal Learning Test

- 15 concrete nouns
- 5 repeated study/ free recall tests (trials)
- final test following 20 min delay

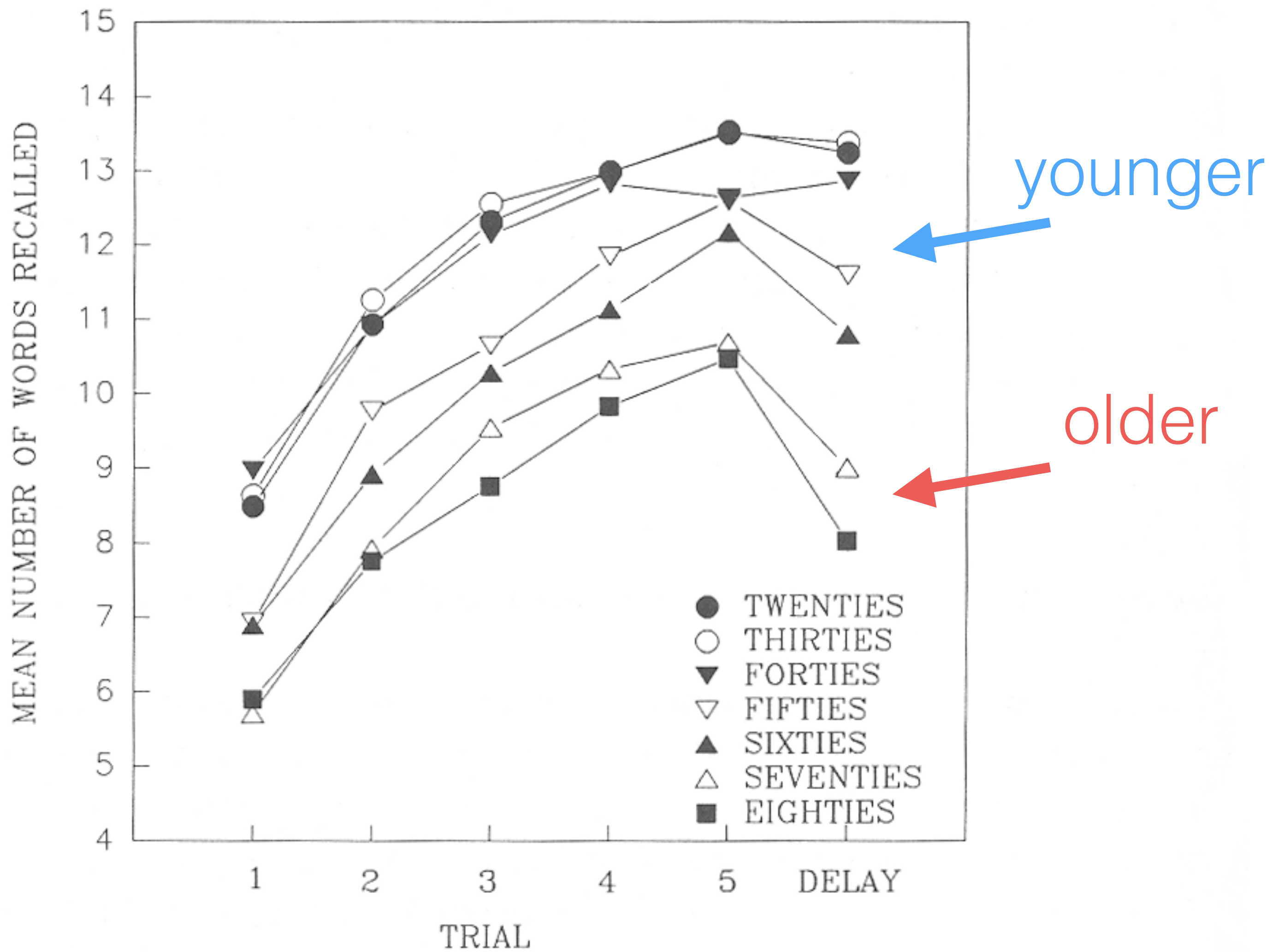


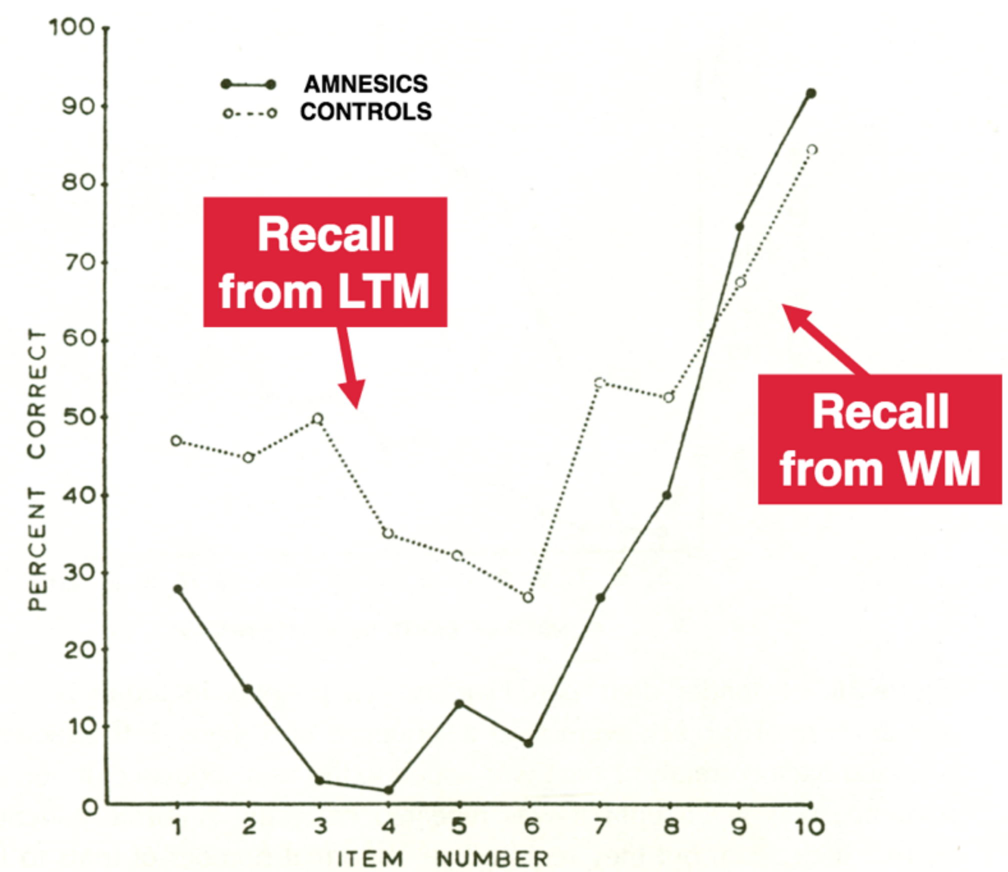
FIGURE 22.2. The mean number of words recalled on the immediate and delayed trials of the Rey AVLT for subjects in their 20s through their 80s. The n per age group ranged from 41 to 130; total $n = 474$.

(Davis et al., 1990)

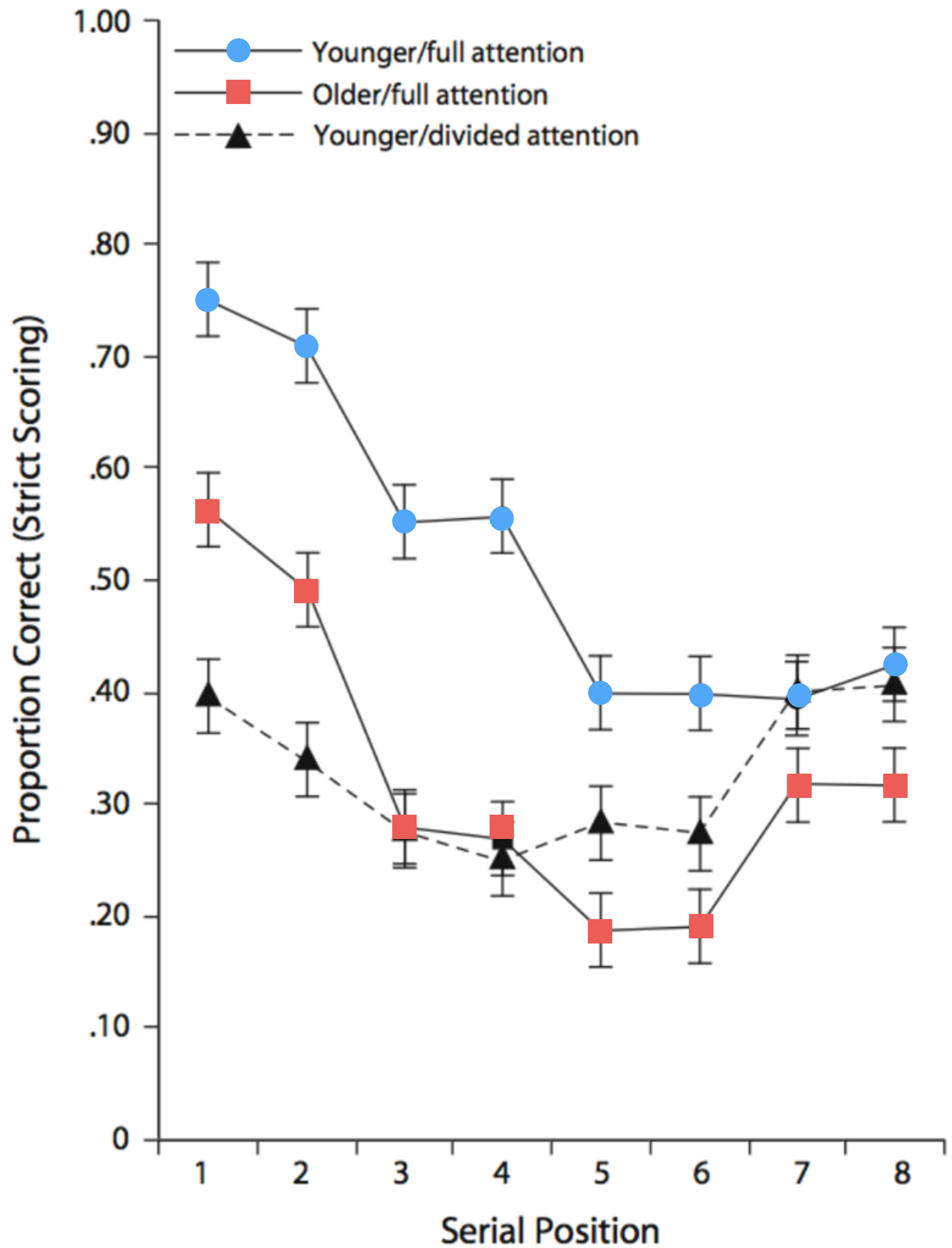
Retrieval practice: Serial position function

What is the typical serial position function in free recall?

How is this function affected by MTL damage?



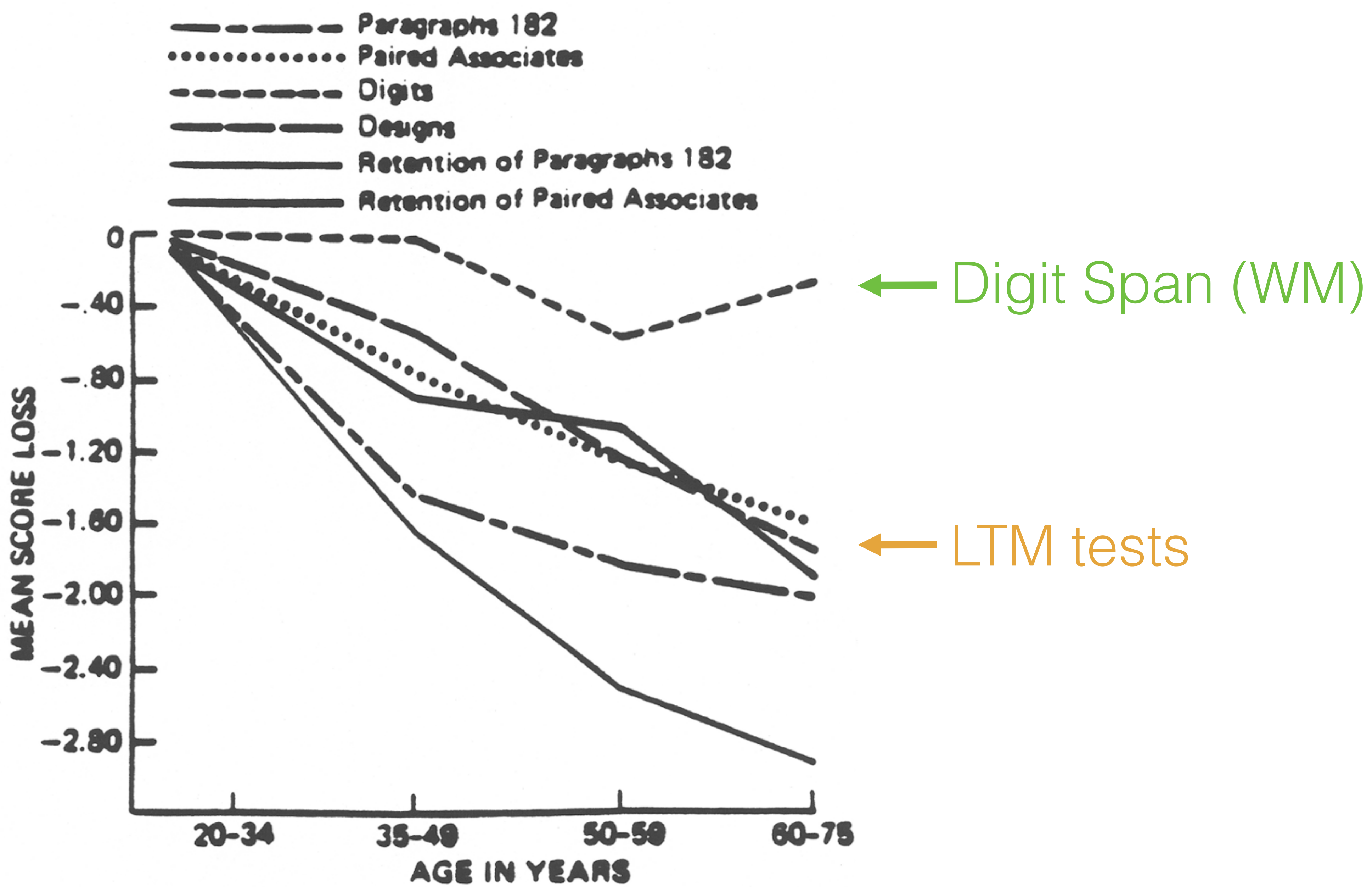
WM vs. LTM



- *Primacy* (LTM) is more affected than recency (WM) as a function of age
- The serial position pattern in older adults is similar to that of younger adults encoding under *divided attention*

(Naveh-Benjamin et al., 2007)

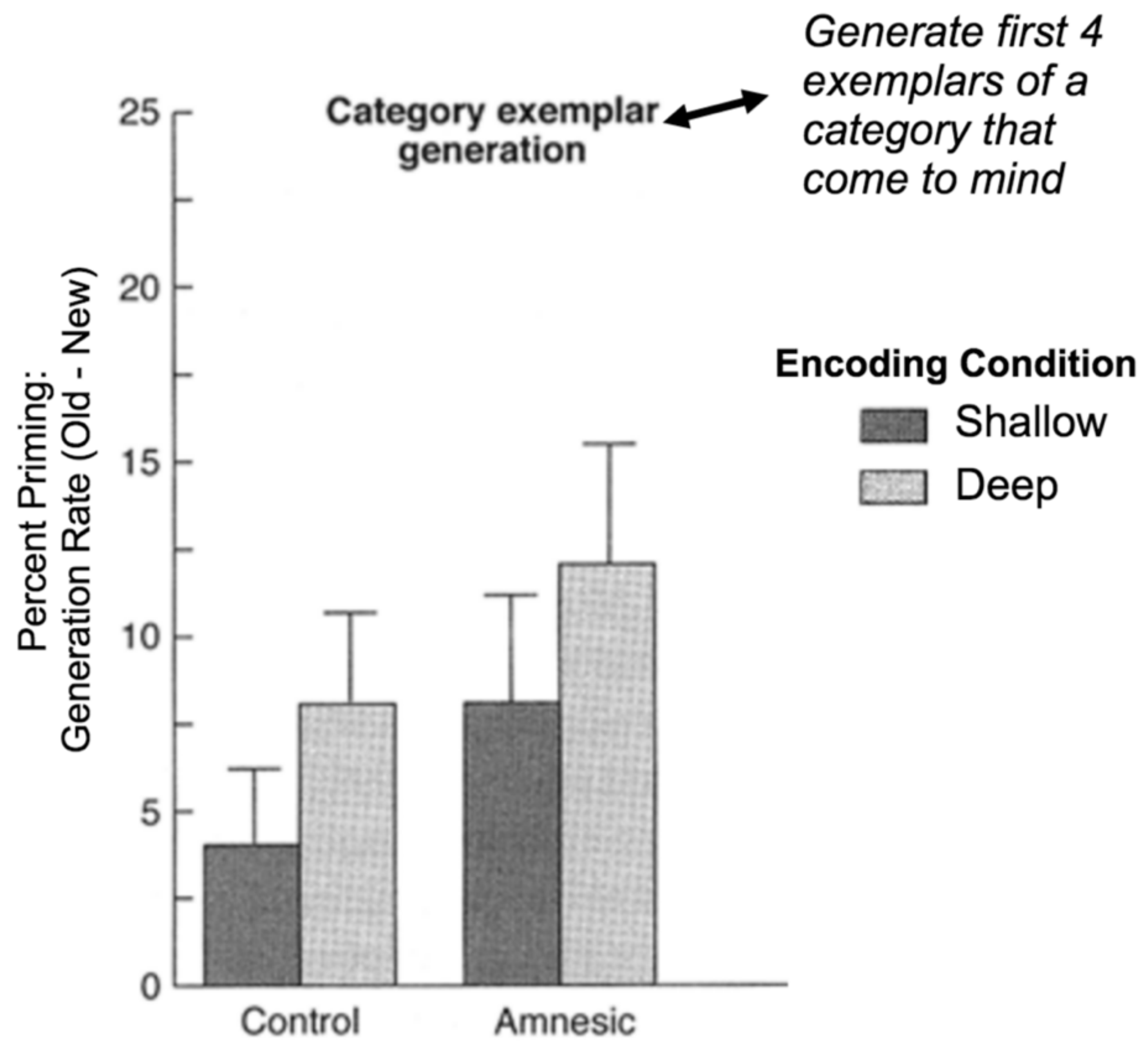
WM vs. LTM



Differential decline on memory tests throughout maturity (Gilbert et al., 1971)

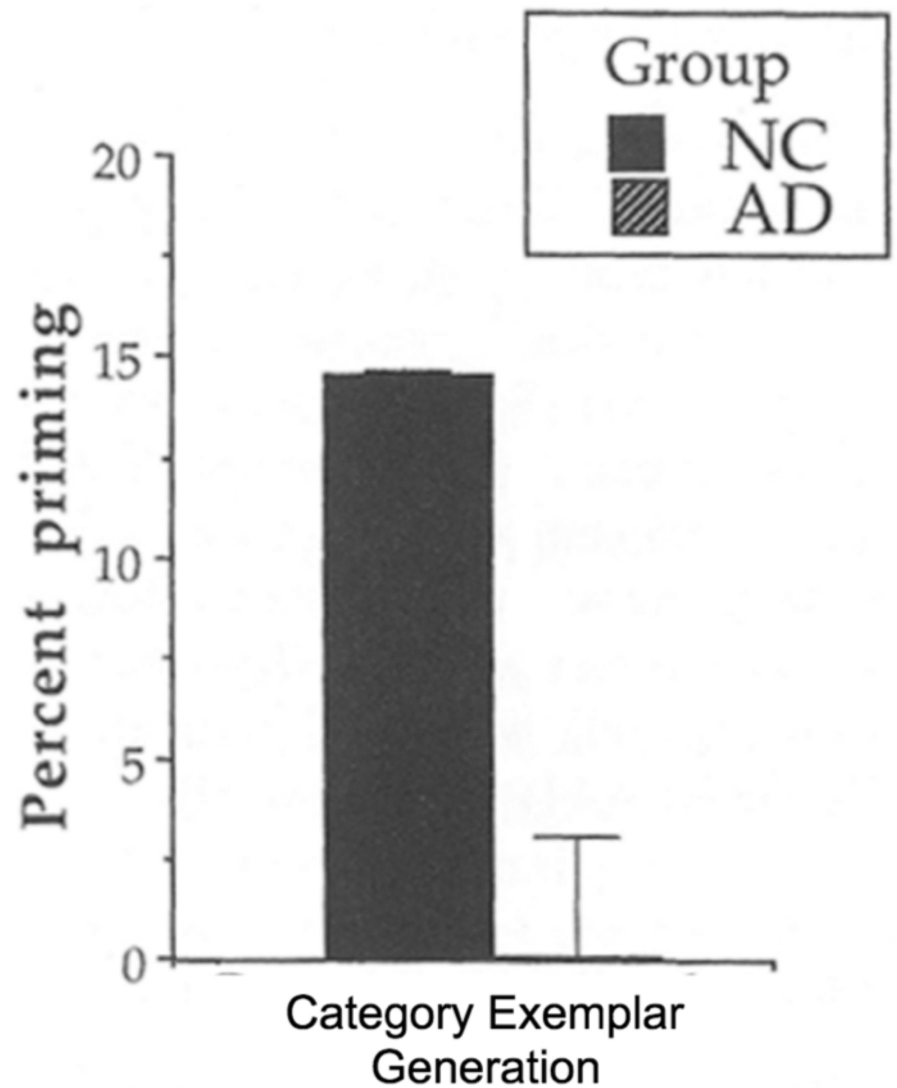
Retrieval practice: conceptual priming

Do amnesics show intact conceptual priming?



Retrieval practice: conceptual priming

Do Alzheimer's Disease patients show intact conceptual priming?



Declarative vs. nondeclarative memory

- Conceptual implicit test: Category exemplar generation
- Explicit test: Category cued recall

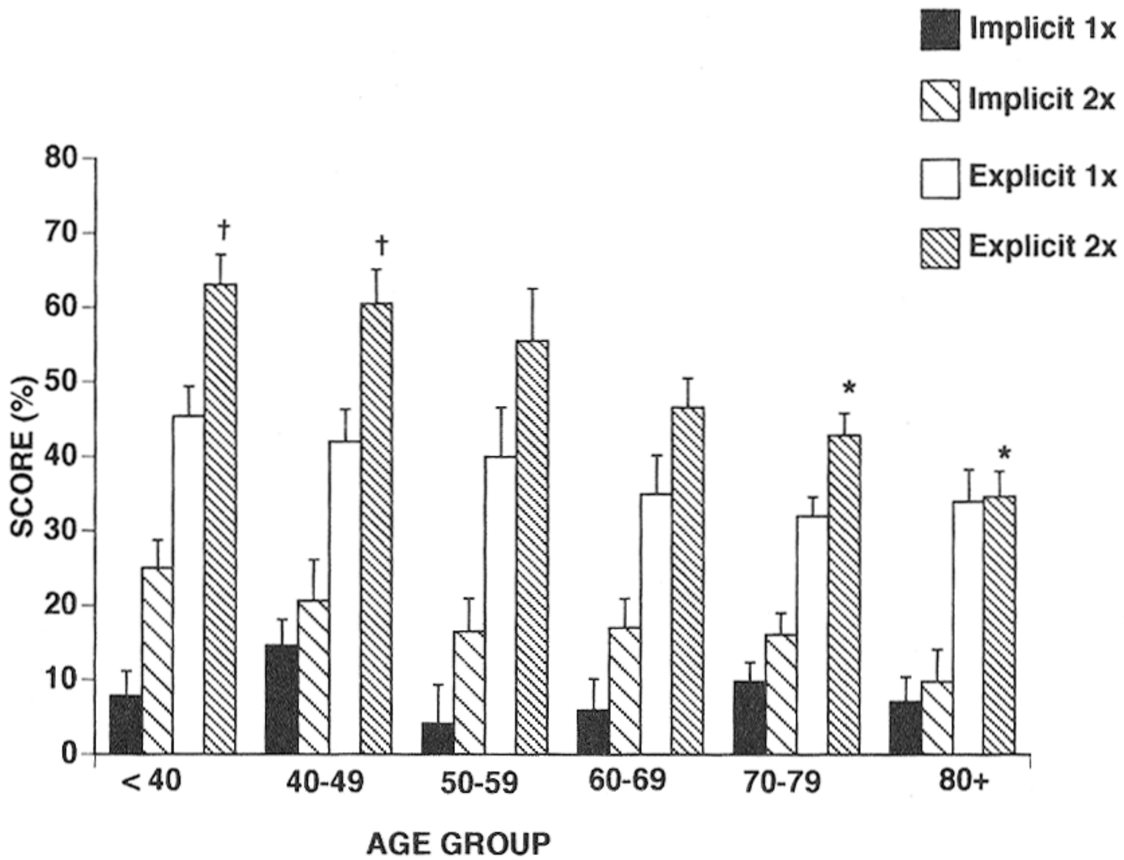
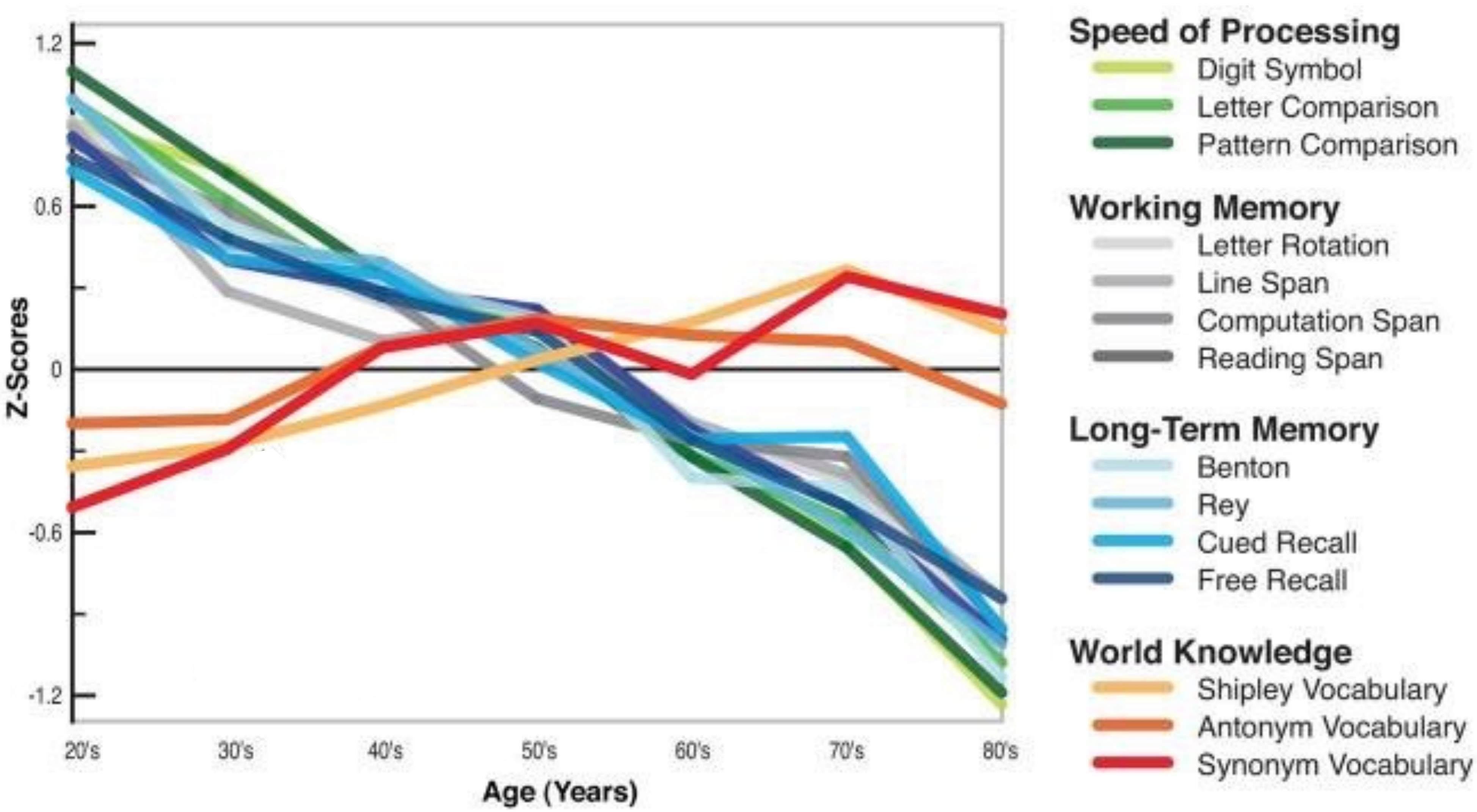


Figure 4. Mean scores and standard errors on the conceptual implicit and explicit memory tests as a function of item frequency and age group. Asterisks indicate significant differences between that group and the under-40 group. Crosses indicate significant differences between that group and the over-80 group.

Healthy aging yields modest or no impairments on perceptual or conceptual implicit tests of memory

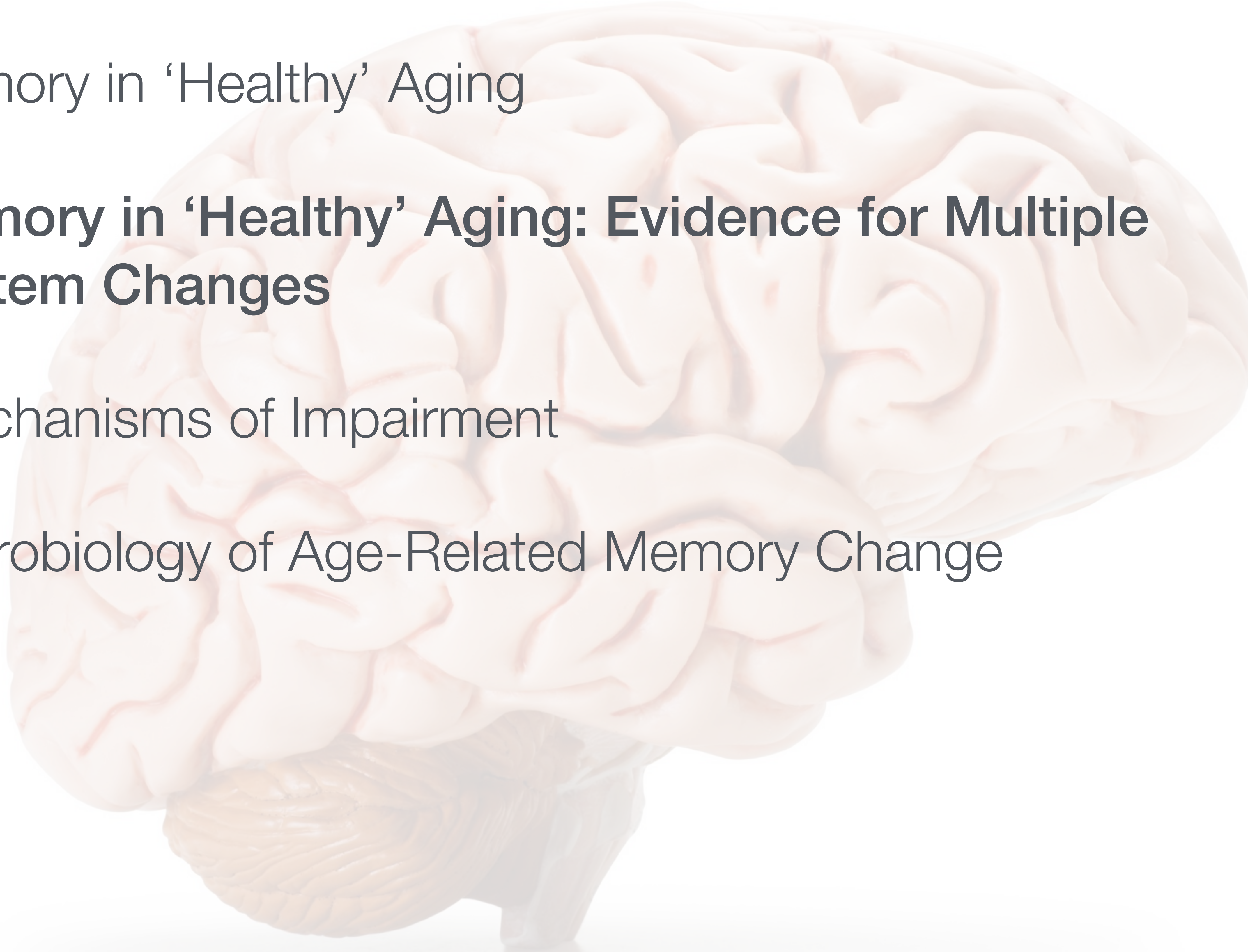
(Maki et al., 1999)

Episodic vs. semantic memory



(Park & Reuter-Lorenz, 2009)

Agenda



- Memory in ‘Healthy’ Aging
- **Memory in ‘Healthy’ Aging: Evidence for Multiple System Changes**
- Mechanisms of Impairment
- Neurobiology of Age-Related Memory Change

MTL dysfunction?

- Age-related memory declines partially resemble those following MTL insult:
    - LTM is more impaired that WM
    - memory deficit is greater for recent than remote events
    - declarative memory is impaired more than nondeclarative memory

∴ A component of age-related memory decline may derive from progressive deterioration of the MTL memory system

Age-related decline in binding?

Study

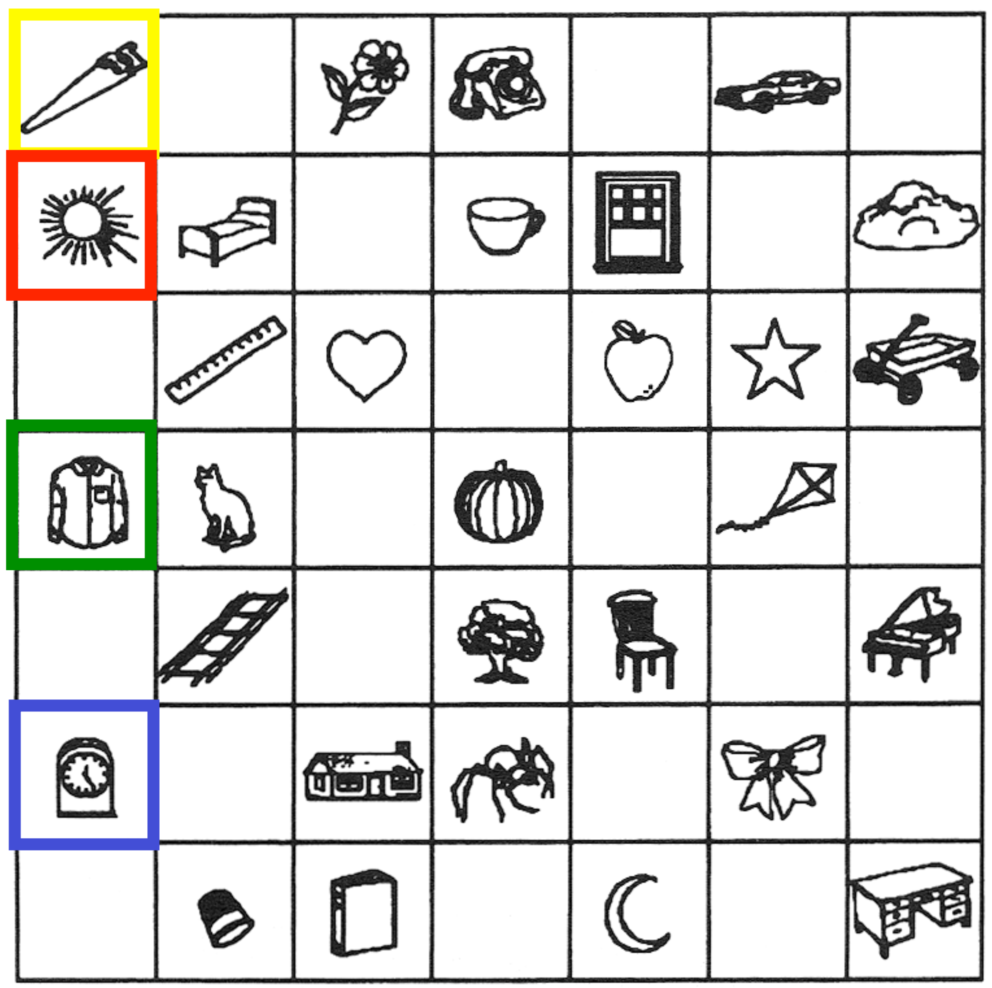


Figure 1. Example study array. **Black lines composing the items seen here were colored in the actual arrays.**

Instructed to remember the *items* (either object, color, or location) or *associations* (object+ location or object+color)

(Chalfonte & Johnson, 1996)

Age-related decline in binding?

Test

Objects?

Locations?

Colors?

Objects & Locations?

Objects & Colors?

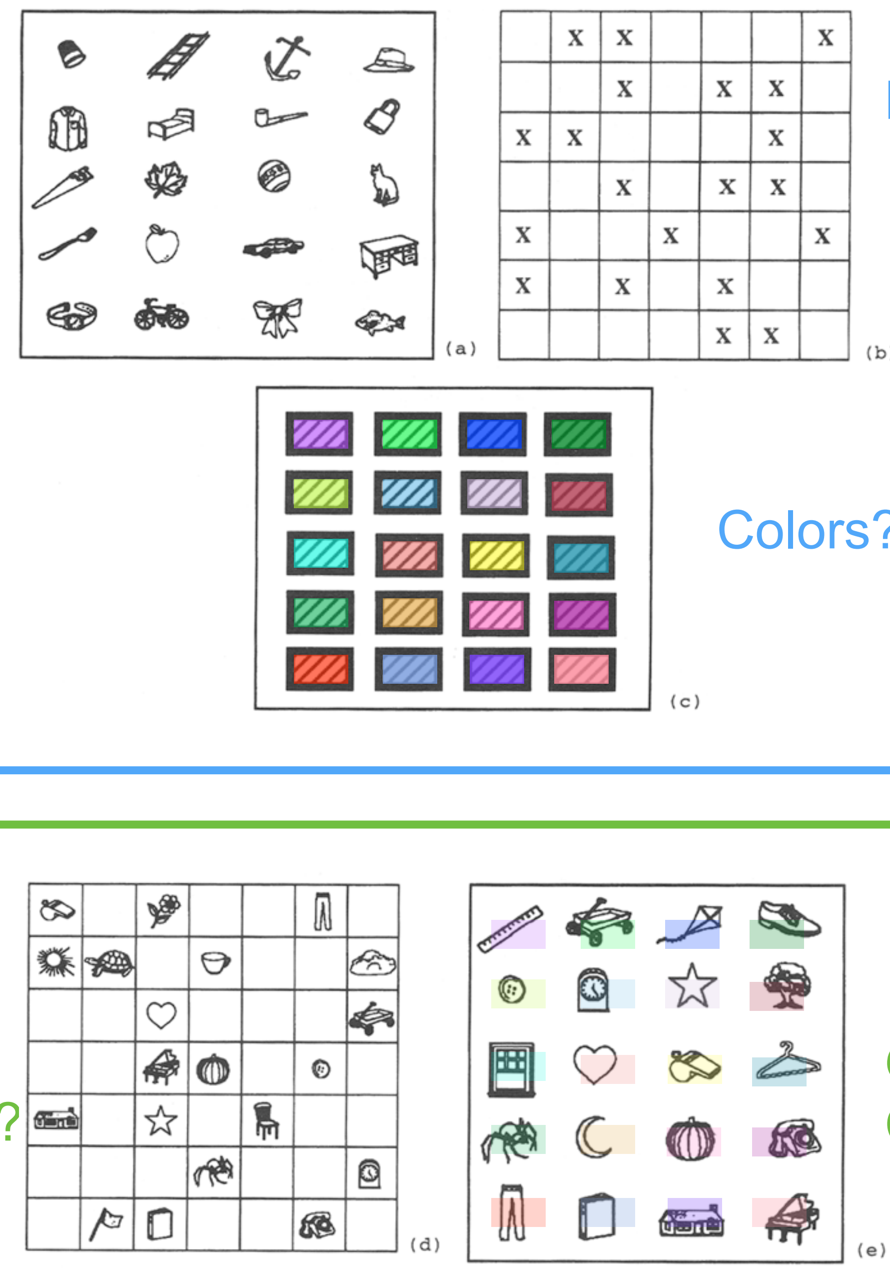
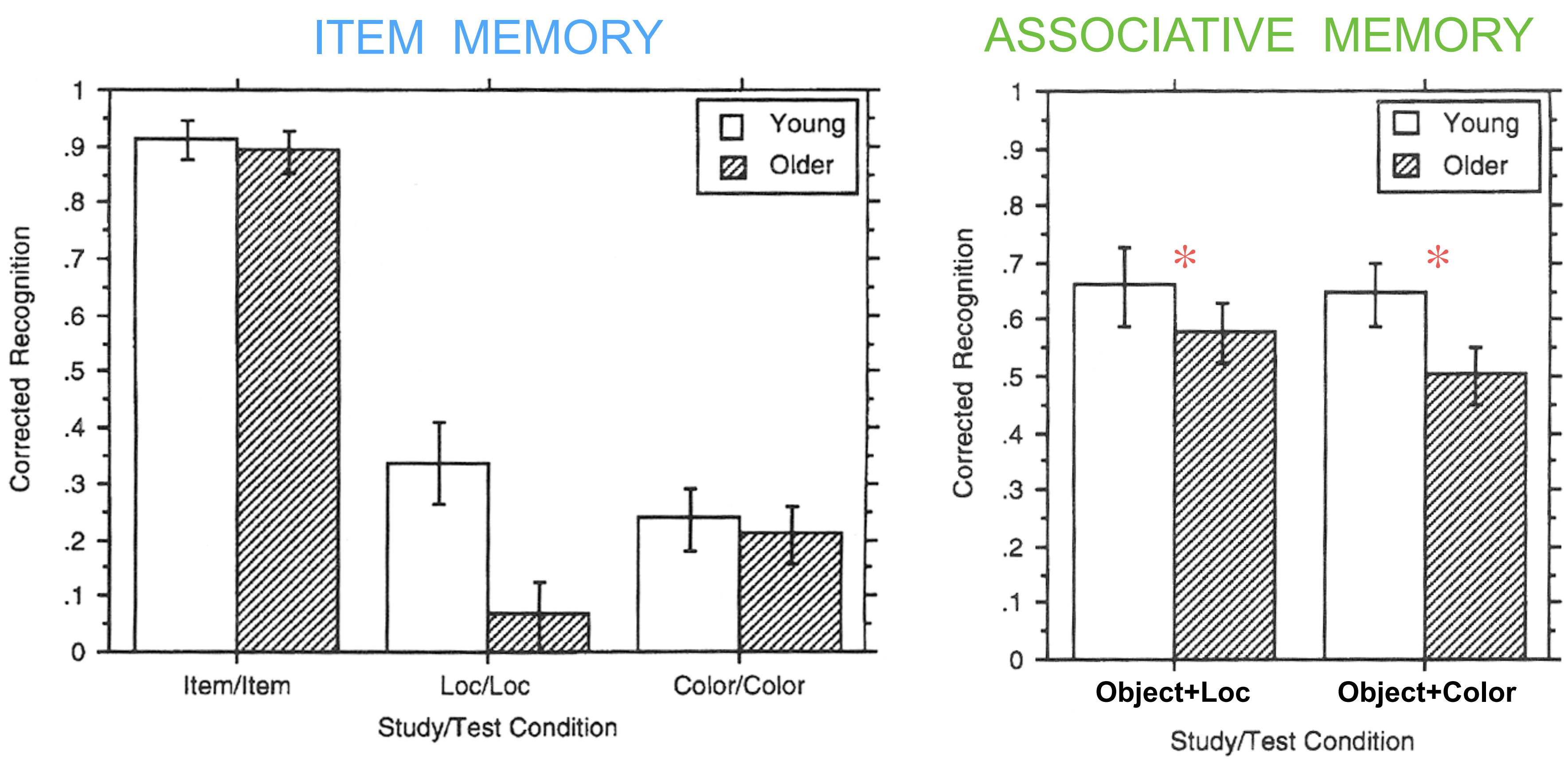


Figure 2. Example recognition tests. (a) Item only. (b) Location only. (c) Color only—black lines composing the color blocks seen here were colored in the actual tests. (d) Item & location. (e) Item & color—black lines composing the items seen here were colored in the actual tests.

(Chalfonte & Johnson, 1996)

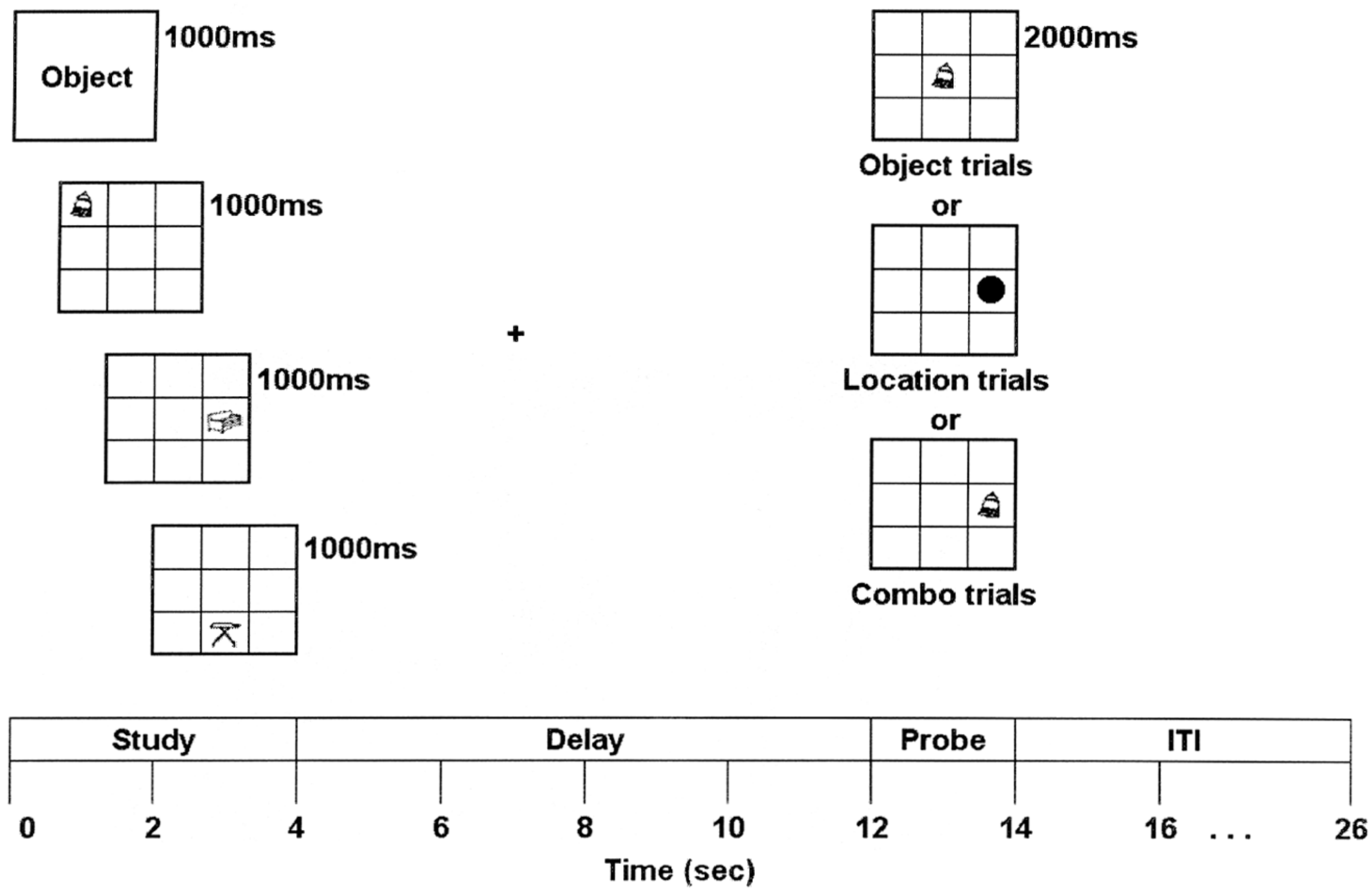
Age-related decline in binding?



Older adults are generally fine at remembering ***single items*** (objects, colors), but impaired at remembering ***associations*** between items

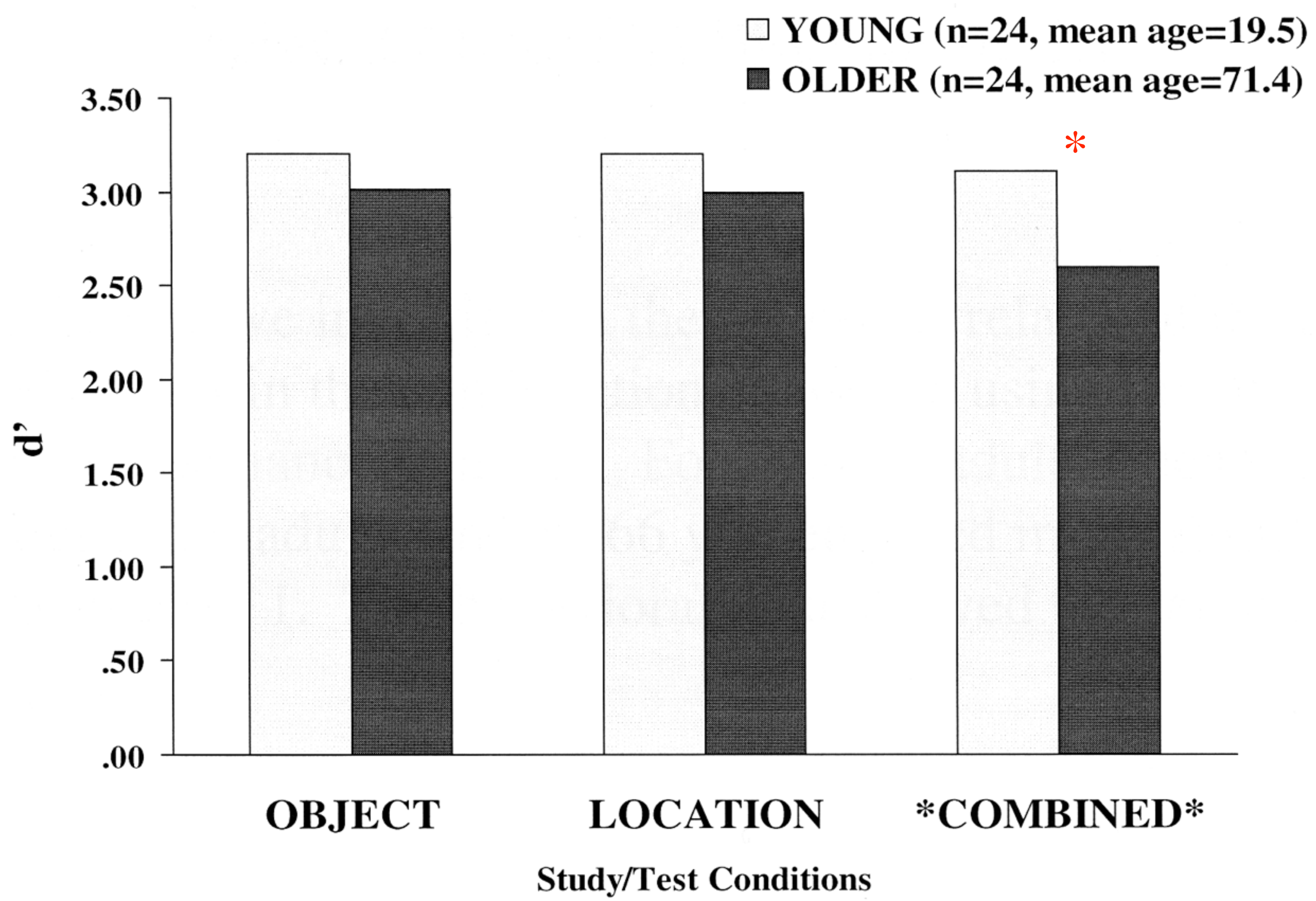
(Chalfonte & Johnson, 1996)

Age-related decline in binding?



(Mitchell et al., 2000)

Age-related decline in binding?



Older adults show a specific impairment in remembering object-locations *associations*

(Mitchell et al., 2000)

Participation prompt #7

- Age-related memory declines also tend to resemble prefrontal deficits. Based on what we’ve learned about prefrontal function, on what types of tasks might older adults show impairments?

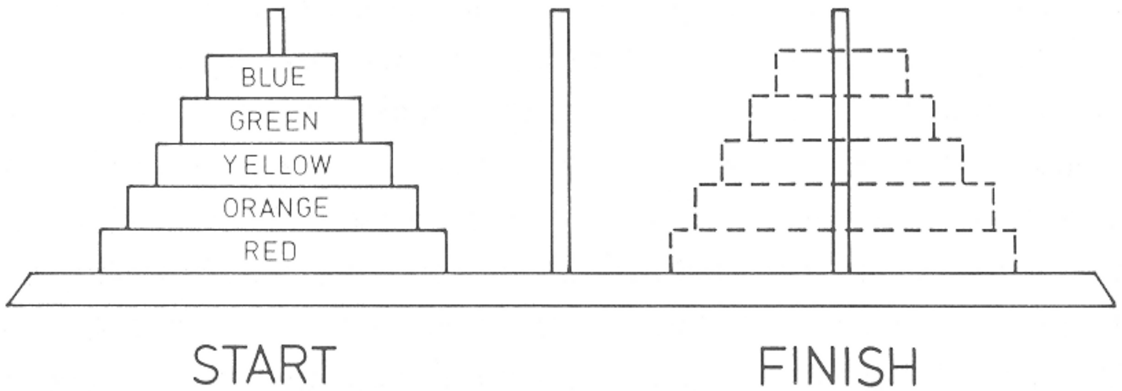
Prefrontal cortical dysfunction?

- Age-related memory declines resemble prefrontal deficits:
  - Wisconsin Card Sort Task and other “executive function” task impairments
  - verbal fluency decreases with age (proactive interference)
  - greater Stroop interference / conflict-related slowing
  - need more “cue support”: recall < cued recall < recognition < younger adults
  - greater source amnesia: source memory < item memory = younger adults
  - increased probability of false memory (similarity-based and source amnesia)

∴ A component of age-related memory decline may derive from progressive deterioration of frontal lobe function

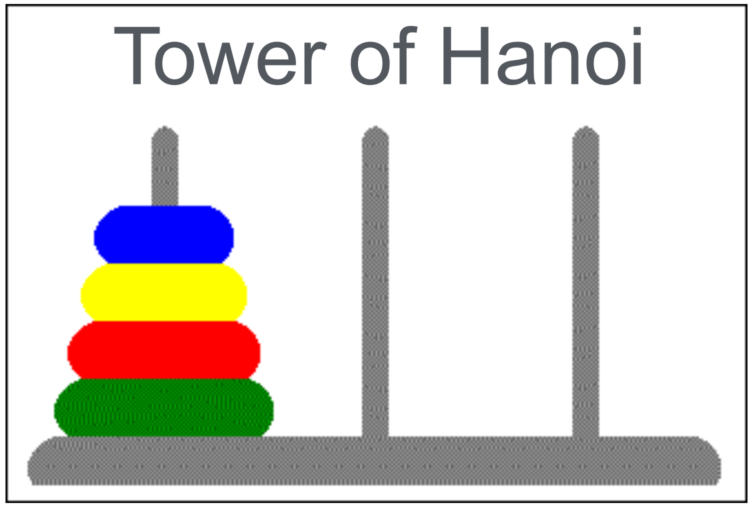
Age-related decline in executive function

Tower of Hanoi



(Davis & Bernstein, 1992)

Age-related decline in executive function



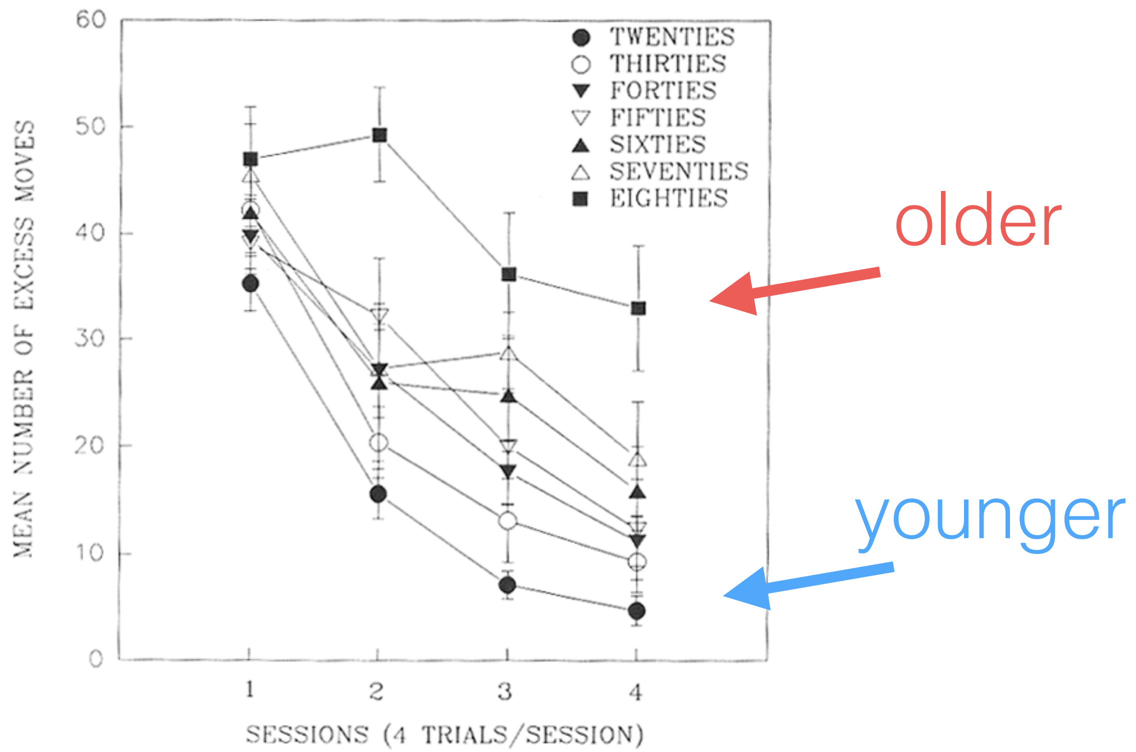


FIGURE 22.6. The mean number of excess moves per solution attempt for the Tower of Hanoi puzzle for subjects in their 20s through their 80s. The *n* per age group ranged from 15 to 37; total *n* = 132.

(Davis & Bernstein, 1992)

Retrieval practice: Source memory

How does damage to the frontal lobes influence source memory?

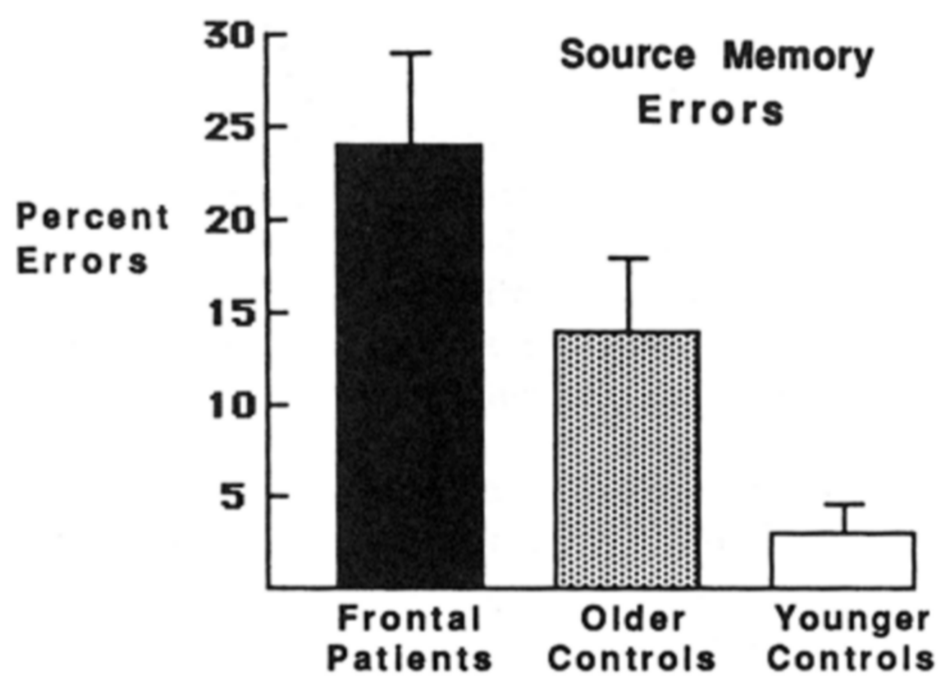
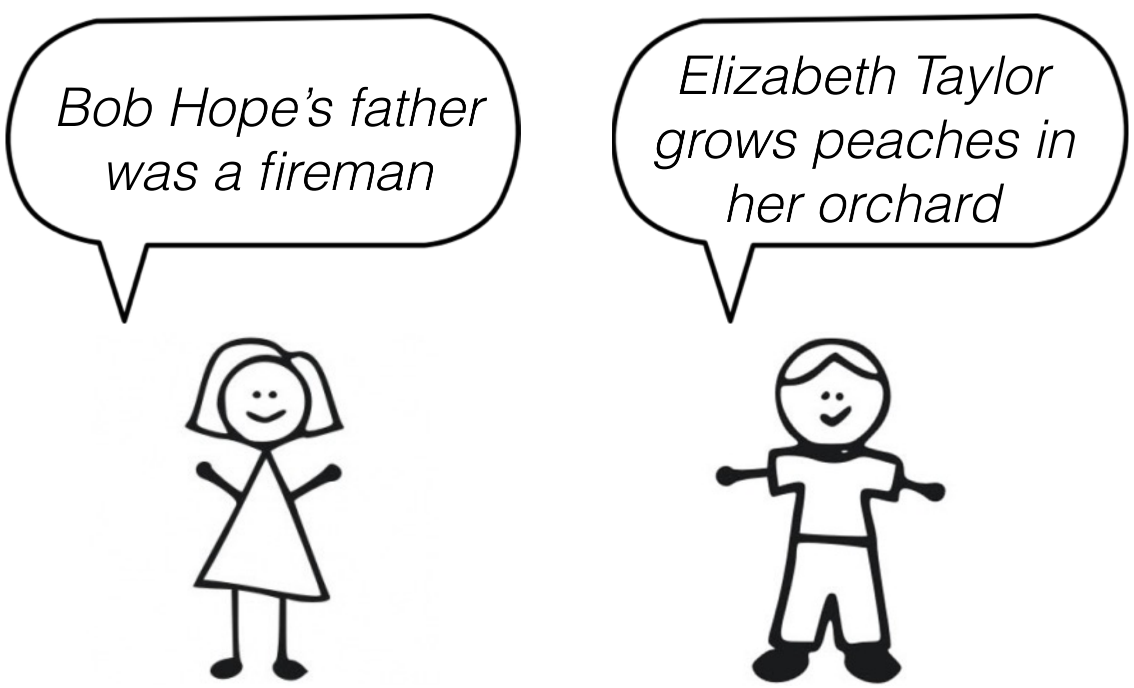


FIGURE 51.6 Source memory performance by patients with frontal lobe lesions (mean age, 64 years), age-matched control subjects (mean age, 62 years), and younger control subjects (mean age, 49 years). Source errors represent instances when a subject failed to recall the time and place a fact was presented. (Data from Janowsky, Shimamura, and Squire, 1989, experiment 2)

Decline in source vs. item memory

Study

40 fictitious sentences
(intentional encoding of facts + sources)



Female or male presenter

2 min or 2 hr

Test

Fact/item recall:

What job did Bob Hope's father have?

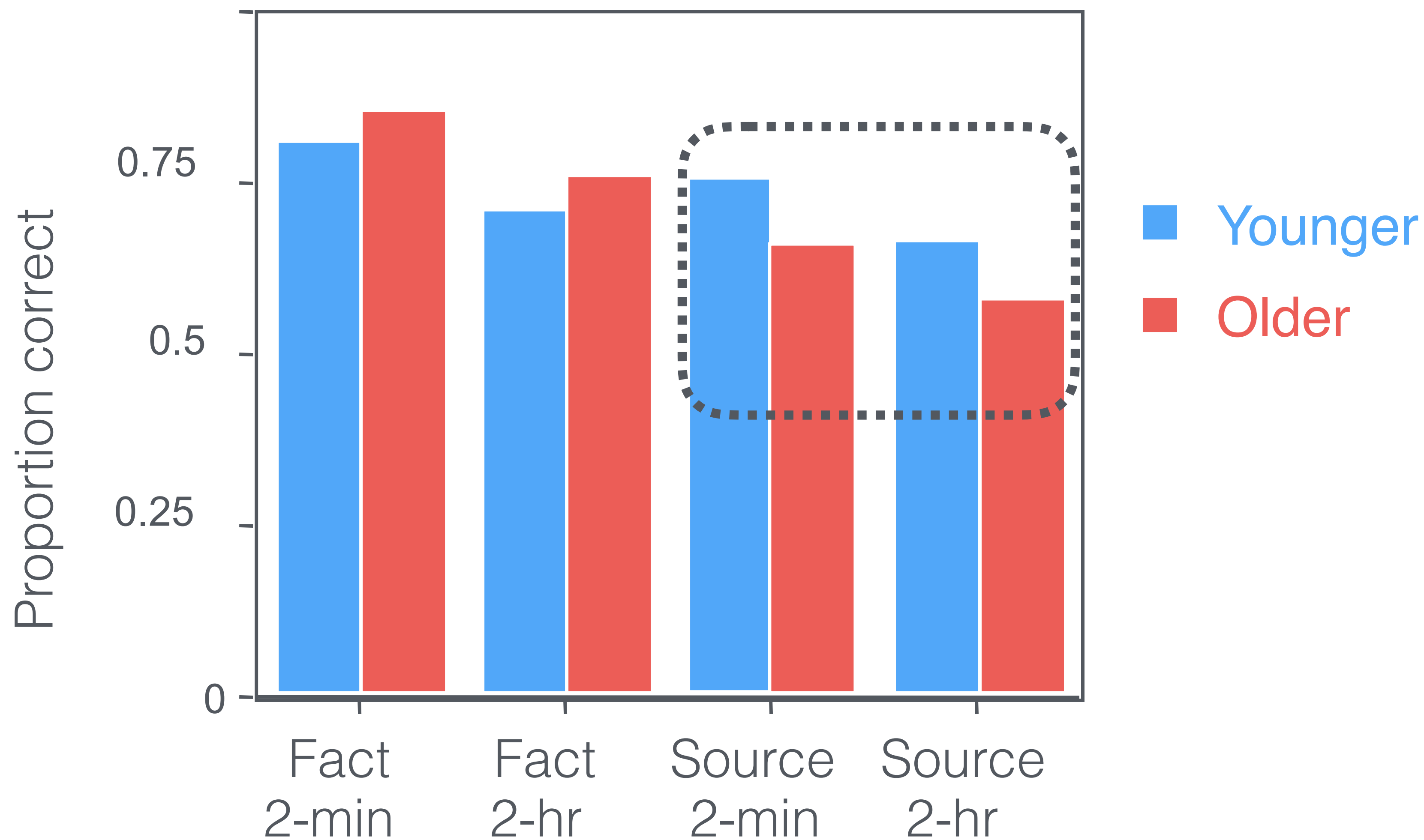
What does Elizabeth Taylor grow in her orchard?

Source recall:

Male, female, or non-study?

(Schacter et al., 1991)

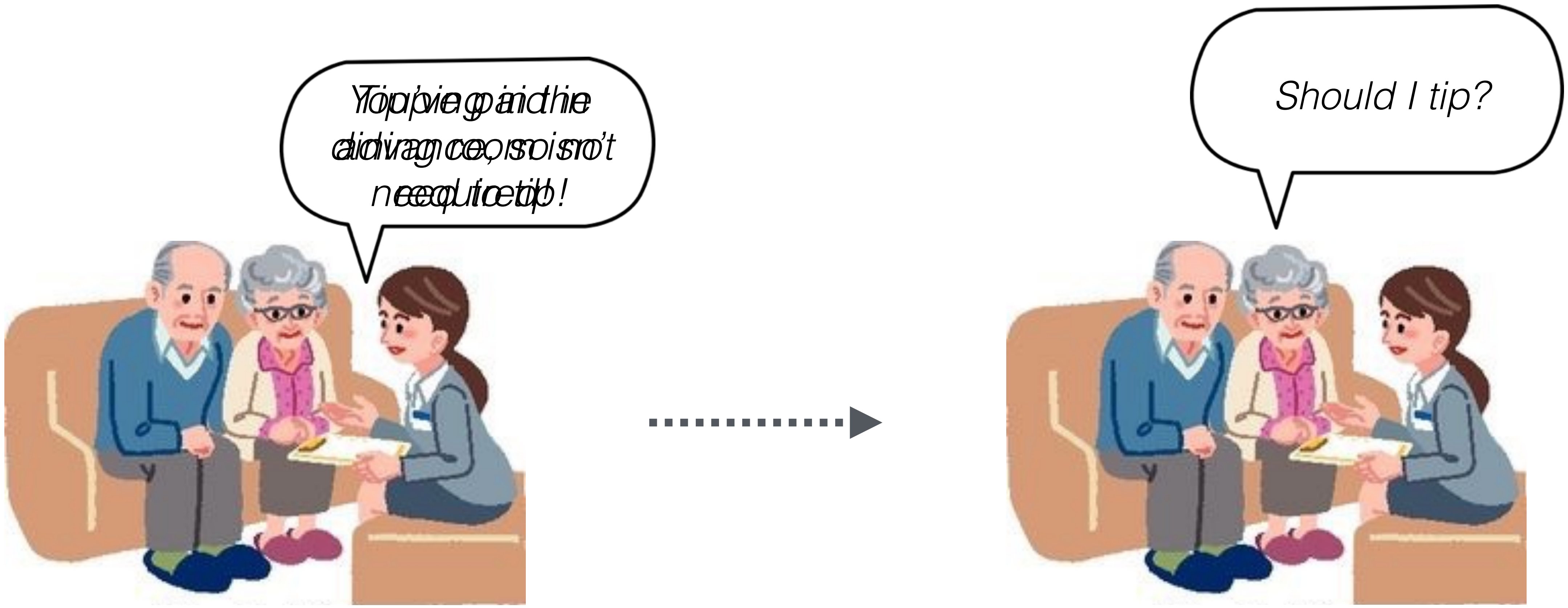
Decline in source vs. item memory



Source (but not item) memory is impaired in older adults

(Schacter et al., 1991)

Decline in recollection vs. familiarity



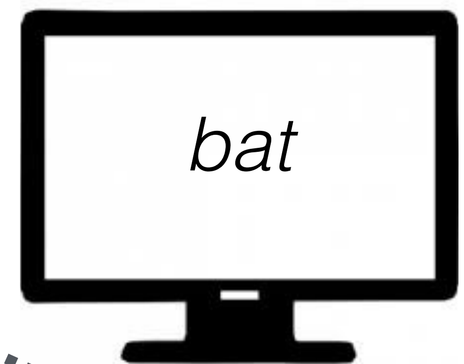
(Jacoby, 1999)

Decline in recollection vs. familiarity

- Exclusion paradigm: recollection and familiarity in *opposition*

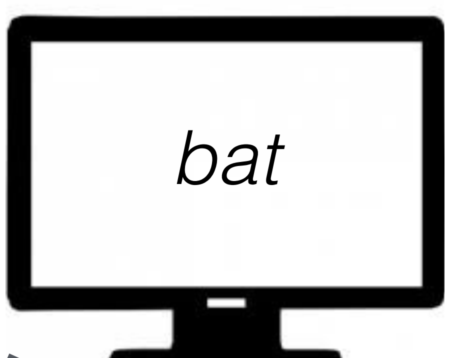
Study (visual)

increase *familiarity*: repeat 1x, 2x, or 3x



Study (auditory)

Test: Respond “yes” *only* to words they *heard* earlier

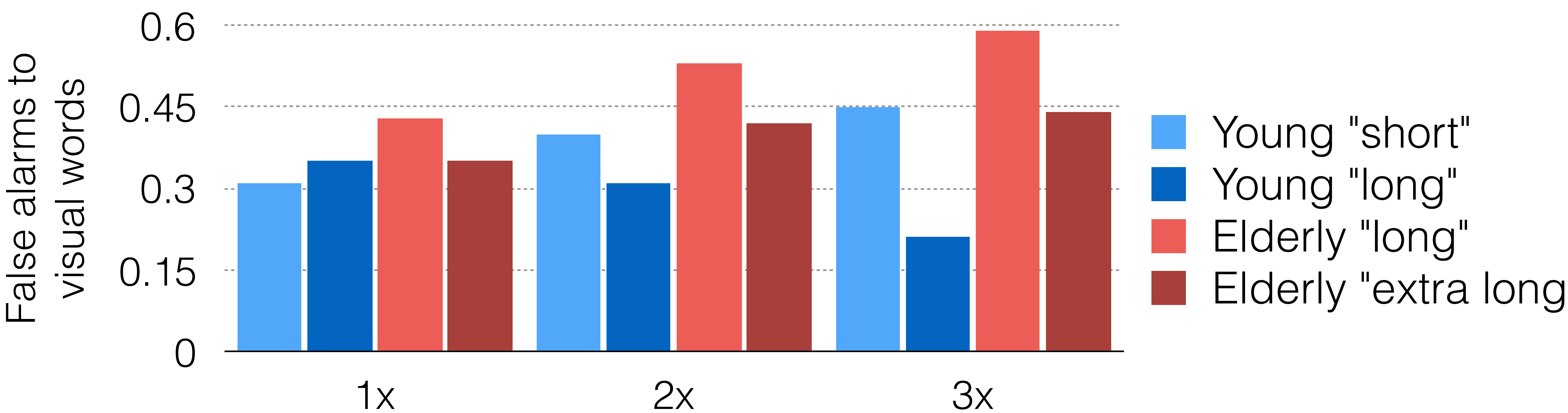


timed deadlines to respond:
young “short”= 750 ms
young/elderly “long”= 2000 ms
elderly “extra-long”= 2750 ms

(Jacoby, 1999)

Decline in recollection vs. familiarity

- “Ironic effects” of repetition



- Elderly have difficulty excluding items with increased repetition (stronger *familiarity* without recollection of the source)

- Young can exclude better with increased repetition
  - increased *recollection* / retrieval of correct source
  - effect of age diminished with speeded responding in young group

(Jacoby, 1999)

Agenda

- Memory in ‘Healthy’ Aging
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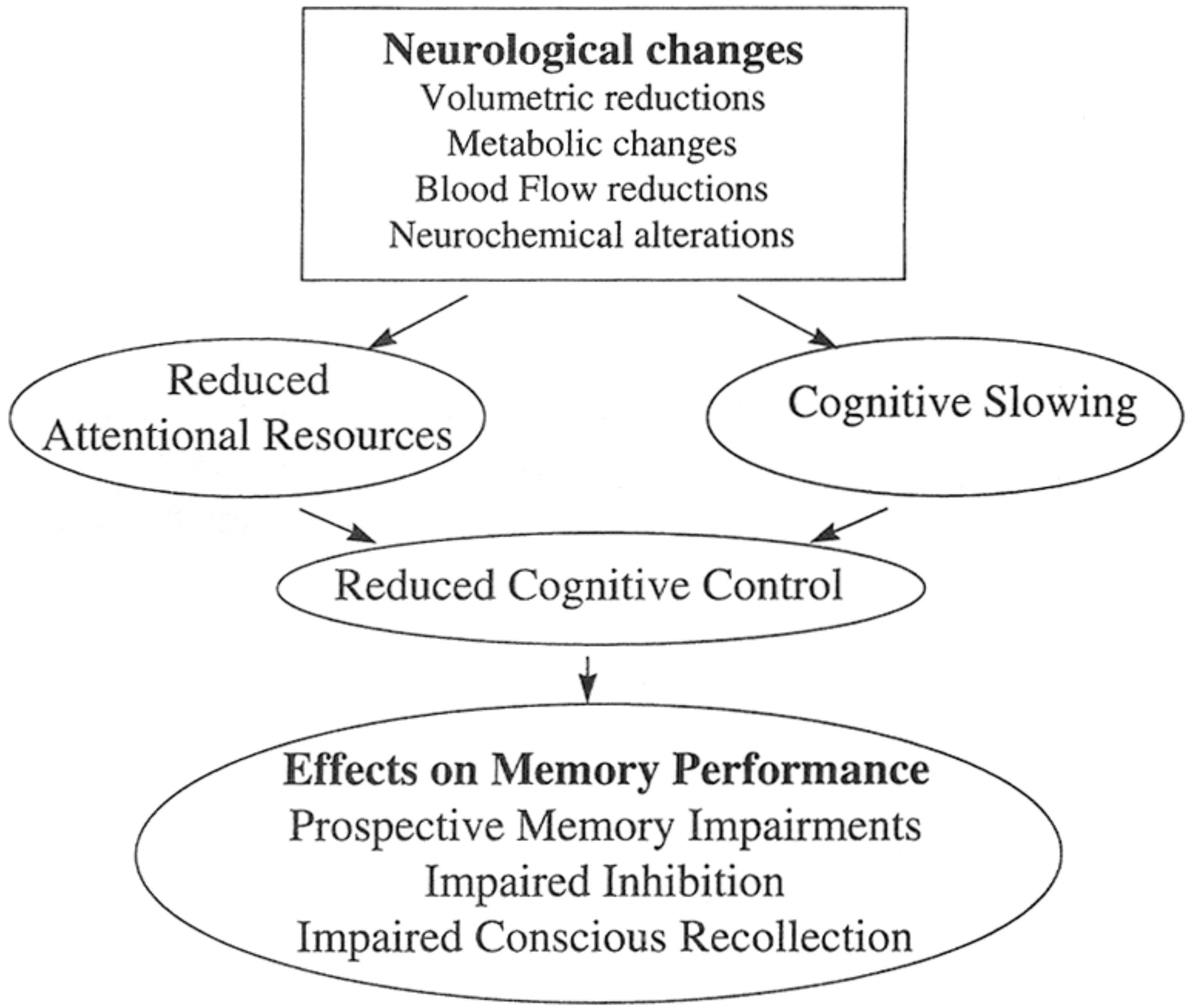
Nature of age-related cognitive decline



(Anderson & Craik, 1999)

Reduced attentional resources?

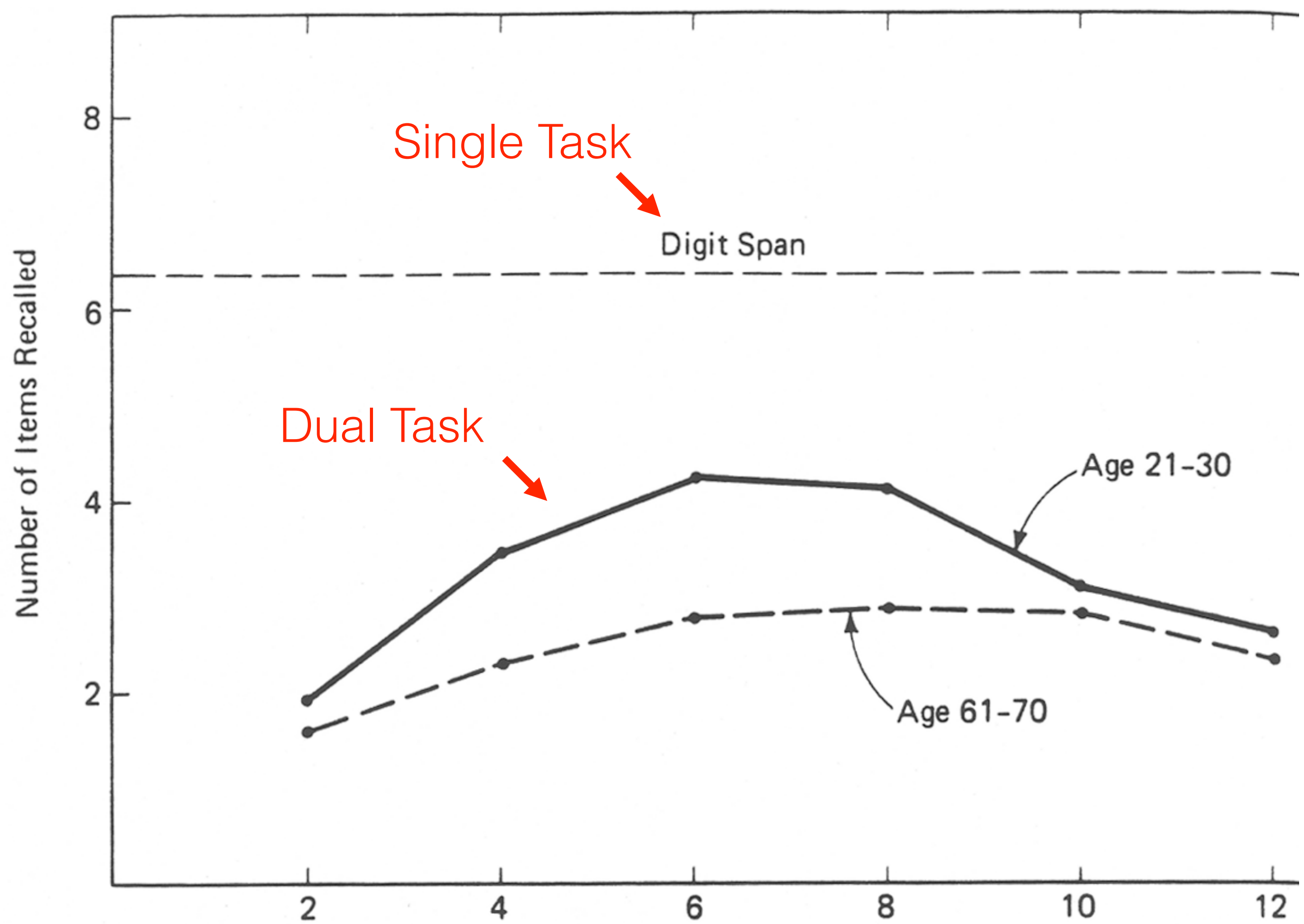
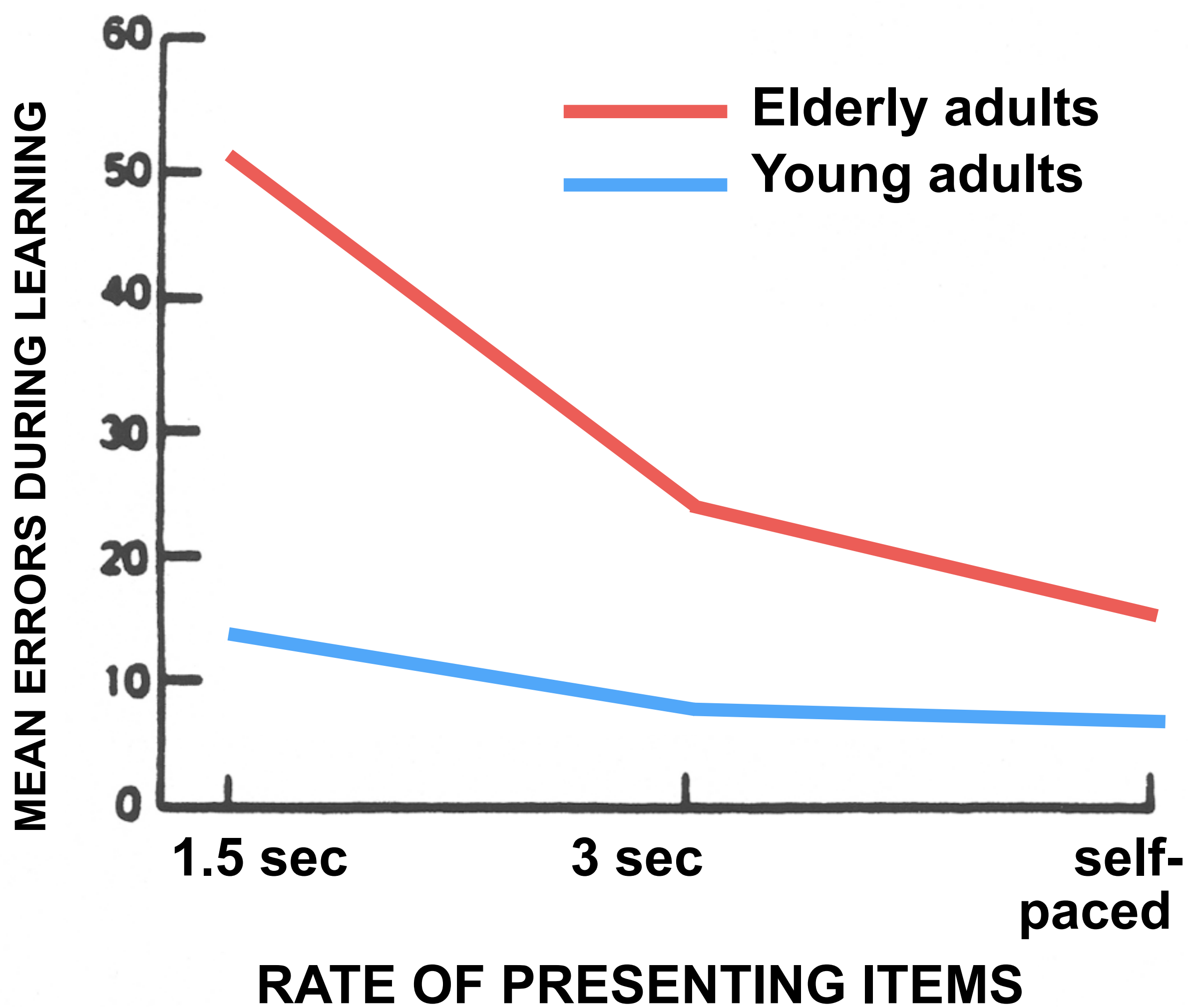


Figure 9.2. Single-task (digit span) and dual-task (dichotic listening) performance as a function of the number of input items. Both age groups had the same digit span but performed in the manner illustrated in the dichotic listening task. Data from Inglis and Caird (1963).

- Older adults are less able to perform two tasks at one time
- Suggesting that aging results in an *attentional decline*

Reduced processing speed?



Age differences in paired-associate learning proficiency as affected by rate of presenting items. (Canestrari, 1963; Kausler, 1982)

- Older adults can partially overcome their memory deficits if they are provided *more time* to learn stimuli.
- Suggests that their *slower processing* results in reduced stimulus processing and, consequently, memory problems.

Reduced processing speed?

- Measures of processing speed
  - Digit symbol substitution test

    1 = §
    2 = œ
    3 = ø
    4 = Δ
    5 = !

2	5	4	1	...

    Performance = # correct in 90 s

  - Letter comparison — perceptual speed test

    Z ____ G
    N ____ N
    Y ____ U

    Write "S" or "D" on line

    Performance = # correct in 30 s

Reduced processing speed?

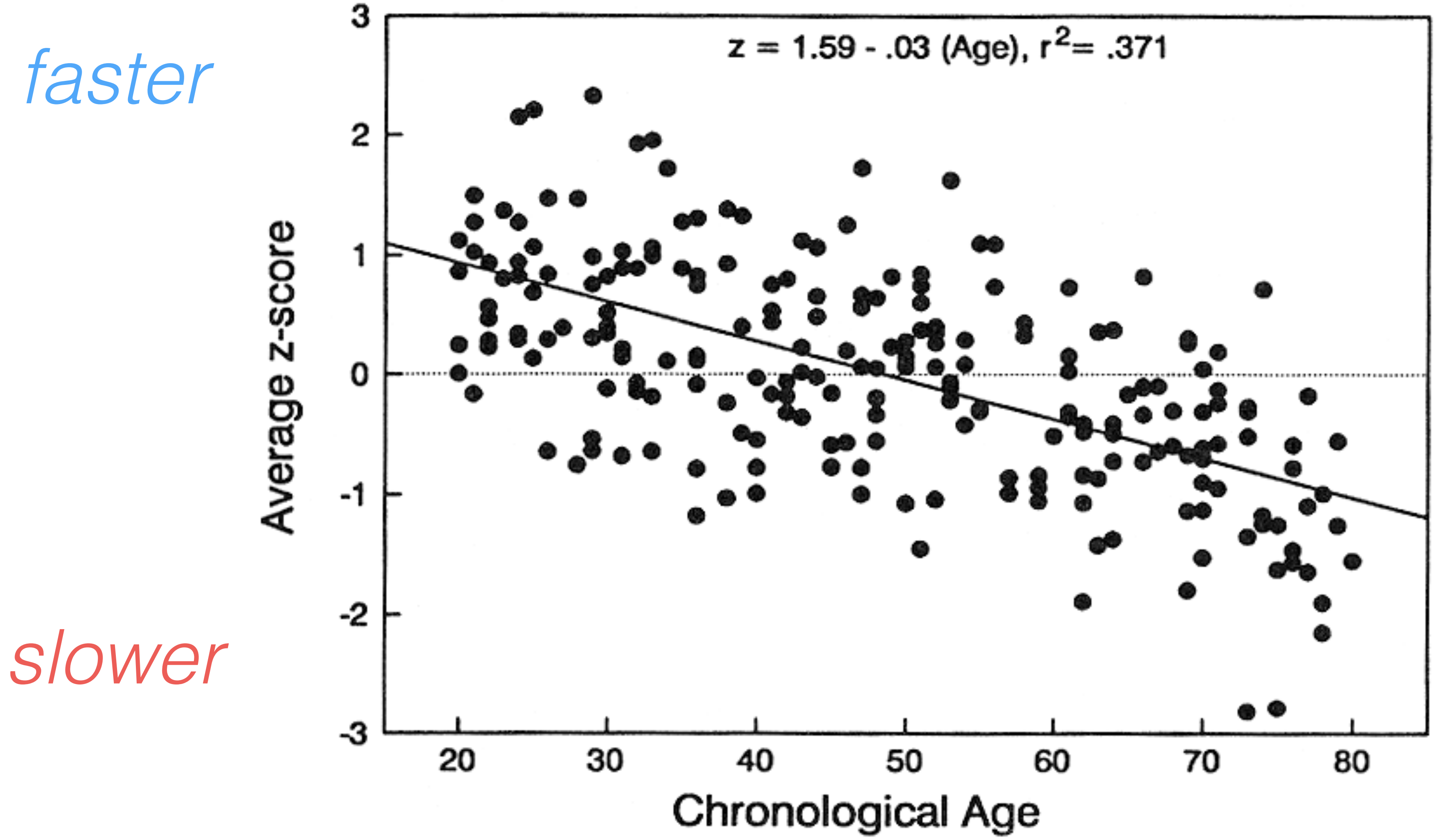
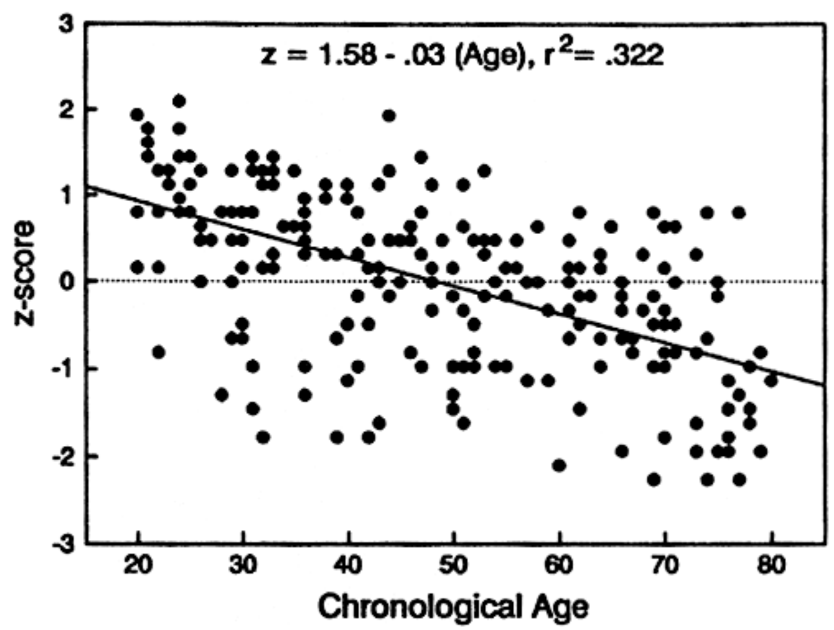


Figure 1. Relation between age and a composite measure of processing speed (data from Salthouse, 1993b, Study 1).

Processing speed declines with age

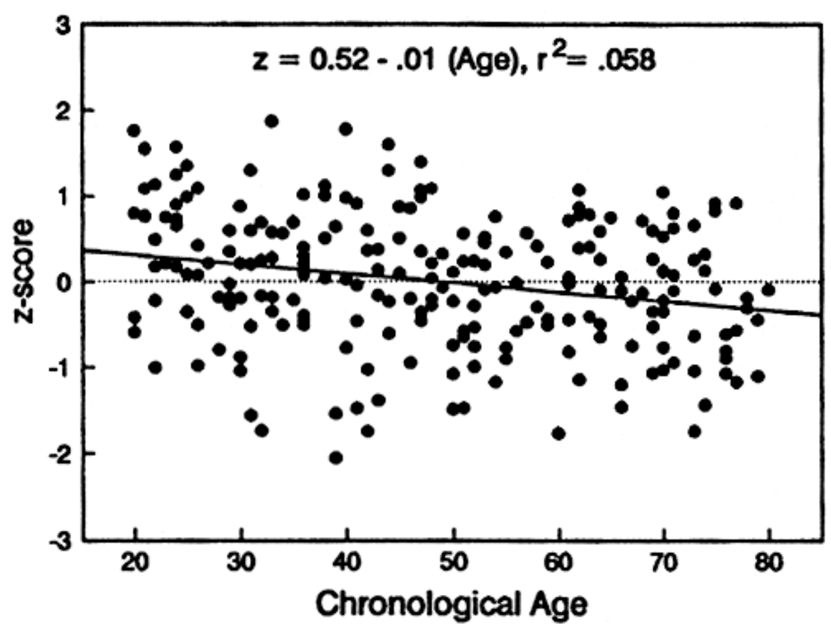
Reduced processing speed?

Reasoning x Age



Reasoning x Age

(factoring out speed)



Processing speed mediates age-related cognitive decline

Impact of processing speed on cognition

- Limited time mechanism
  - the time to perform later operations is greatly restricted when a large proportion of the available time is occupied for executing earlier operations

    can account for the "complexity effect": greater task complexity leads to larger age-related differences in speed

- Simultaneity mechanism
  - the products of early processing may be lost by the time that later processing is performed and completed, thus relevant information *may no longer be available* when needed

    the dynamic capacity of processing systems (e.g., working memory) will be affected b/c *not all relevant information is available* in a usable form when it is needed

(Salthouse, 1996)

Agenda

- Memory in ‘Healthy’ Aging
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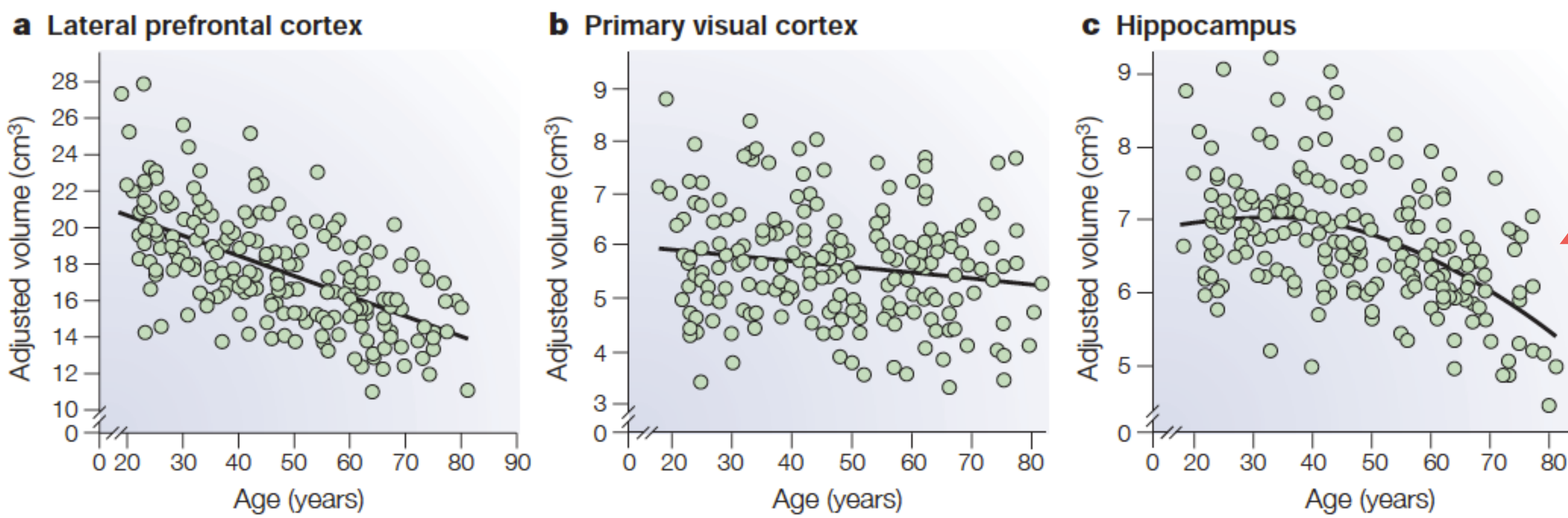
- Mechanisms of Impairment
- **Neurobiology of Age-Related Memory Change**

Neuroanatomic changes

- Anterior-posterior gradient
  - Volumetric reductions:
    - frontal > temporal > parietal & occipital
    - position correlation between hippocampal volume and episodic memory



MCI/
Alzheimer's
Disease?

Figure 2 | **Cross-sectional estimates of age-related volumetric change in lateral prefrontal cortex, visual cortex and hippocampus measured with magnetic resonance imaging.** Points on each scatterplot indicate volumetric estimates from individuals, and the line of best fit is shown. Lateral prefrontal cortex volume declines steadily across the adult lifespan, while hippocampal volume has a curvilinear slope, with its largest declines occurring after age 60. Other areas, such as primary visual cortex, have only slight age-related volume declines. Data from REF. 25; figure courtesy of N. Raz.

Neuroanatomic changes

- Anterior-posterior gradient
    - Volumetric reductions:
        - frontal > temporal > parietal & occipital
        - position correlation between hippocampal volume and episodic memory
    - Metabolic declines
        - frontal > temporal & parietal > occipital
    - Neurochemical changes
        - cholinergic & dopaminergic declines in striatum and frontal regions
    - Functional neuroanatomic changes
        - task-based differences in functional activation

White matter changes

- *Decreased* white matter integrity in non-demented older adults, as measured by diffusion tensor imaging (DTI)

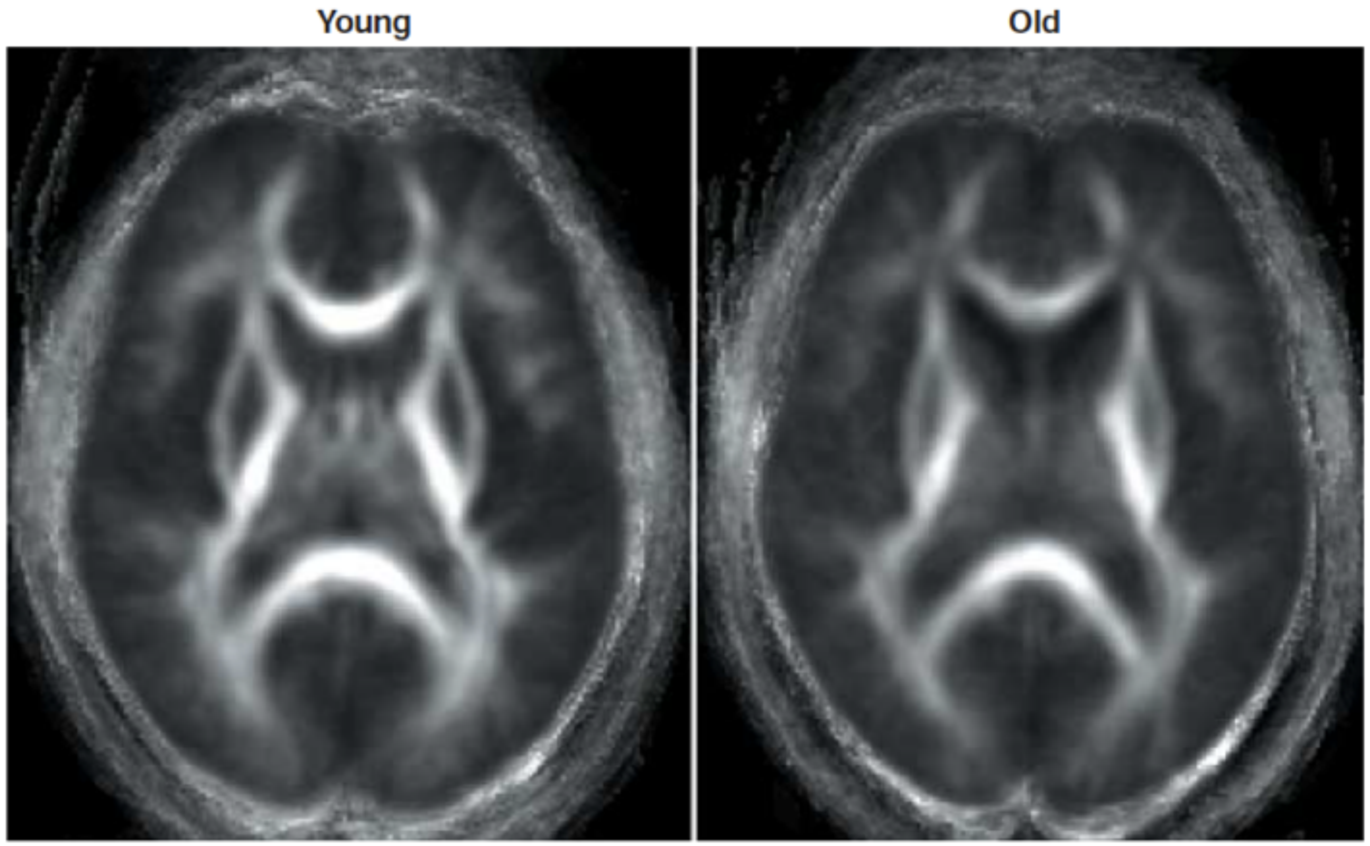


Figure 3 | **Diffusion tensor images of anisotropy of white matter in young and normal elderly subjects.** Group-averaged diffusion tensor images of anisotropy of white matter in young and normal elderly. Parallel movement of water molecules through white matter results in anisotropic diffusion, with greater anisotropy (and so greater white matter density) indicated by brighter areas. Older adults tend to show decreased white matter integrity compared with younger adults, with the greatest age-related declines occurring in anterior cortex. Data from REF. 30; figure courtesy of R. Buckner.

(Head et al., 2005)

White matter changes

- White matter hyperintensities (“bright signal”), likely caused by subclinical ischemia, axonal degeneration, demyelination, high-blood pressure

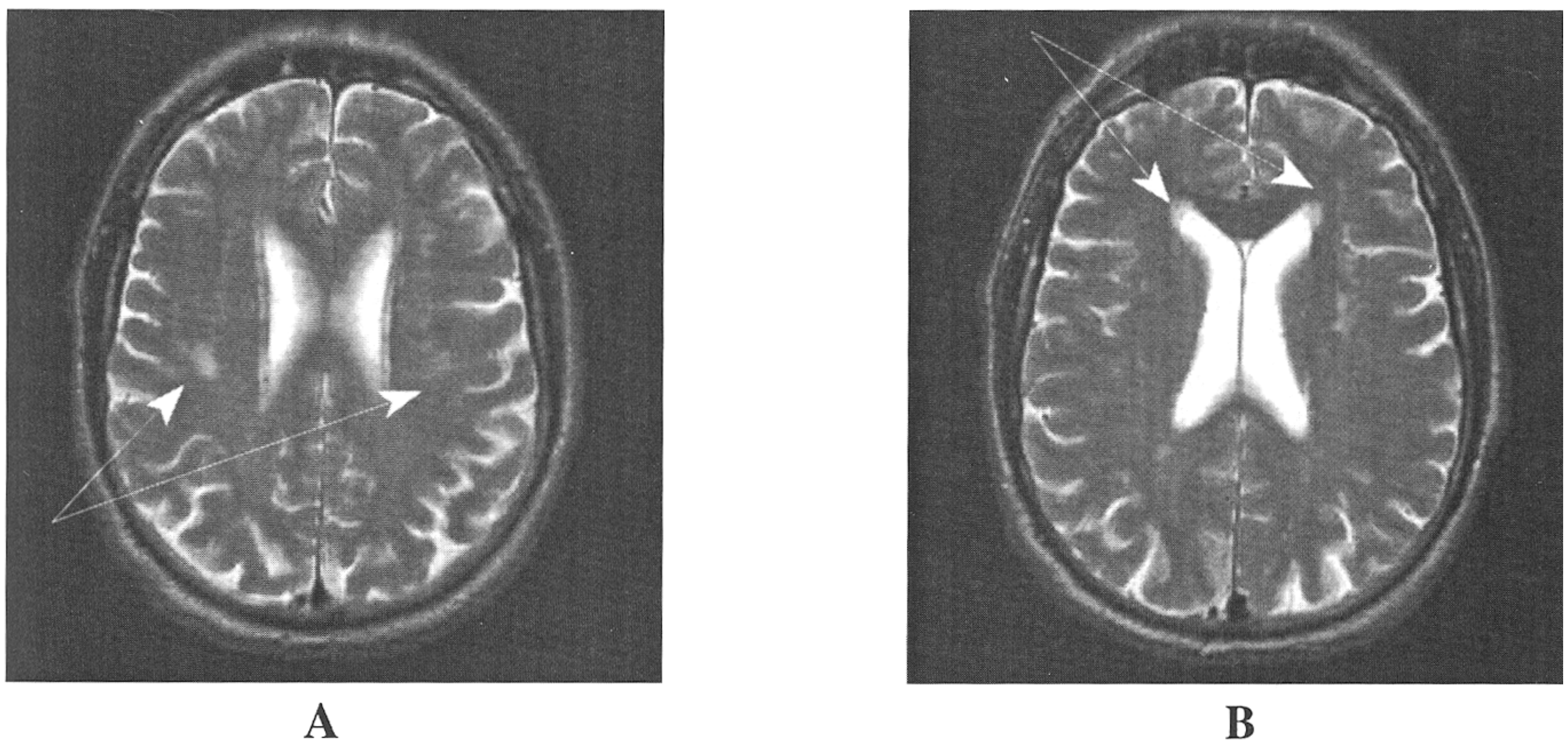


Figure 1. Examples of deep white matter hyperintensity (A) and periventricular hyperintensity (B) as they appear on axial T2-weighted magnetic resonance images. The acquisition sequence was as follows: Fast spin echo, interleaved T2- and proton-density weighted images with repetition and echo times (TR/TE) of 3300/90ef or 18ef, slice thickness 5 mm, and interslice gap 1.5 mm.

(Gunning-Dixon & Raz, 2000)

White matter changes

- Higher white matter hyperintensity scores predicts poorer performance on *speed* (e.g., simple RT), *executive function* (e.g., Stroop interference), *immediate* (e.g., 5 min retention interval for digit span)*/delayed memory tasks* (30-60 min retention interval)

White Matter Hyperintensities and Cognitive Performance

Cognitive domain	No. of studies	Fisher's z ($M \pm SD$)	Mean Pearson's r
Global functioning	16	$.22 \pm .19$***	.22
Speed	16	$.22 \pm .13$***	.22
Immediate–recent memory	11	$.12 \pm .16$*	.12
Delayed memory	6	$.20 \pm .10$**	.20
Fluid intelligence	7	$.09 \pm .26$	.09
Crystal intelligence	4	$.09 \pm .09$	.09
Executive	9	$.31 \pm .26$**	.30
Motor	7	$.09 \pm .13$	.09

Note. Positive correlations indicate poorer cognitive performance associated with higher white matter hyperintensity scores.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Speed > Immediate memory

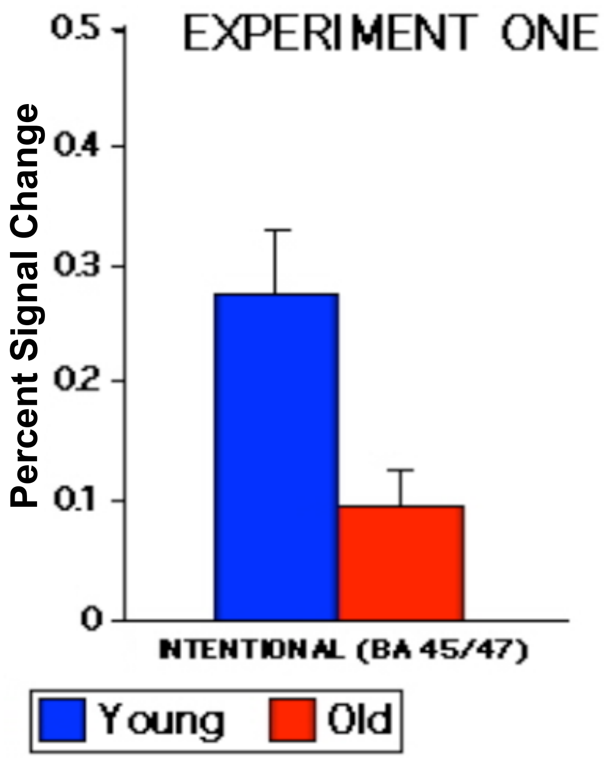
Executive > Immediate memory

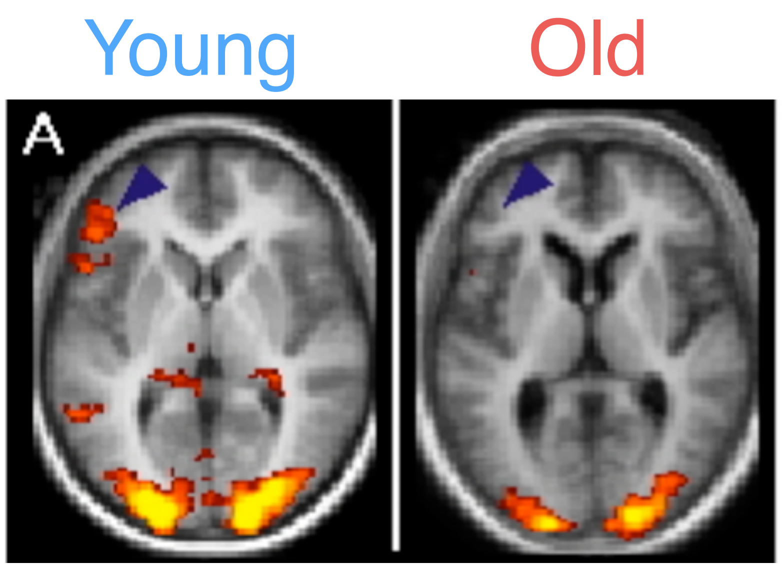
Executive > Delayed memory

(Gunning-Dixon & Raz, 2000)

Under-recruitment of PFC

Would older adults recruit a PFC region (typically recruited for semantic elaboration/word encoding) under intentional encoding conditions when they must *self-initiate* their own strategies?





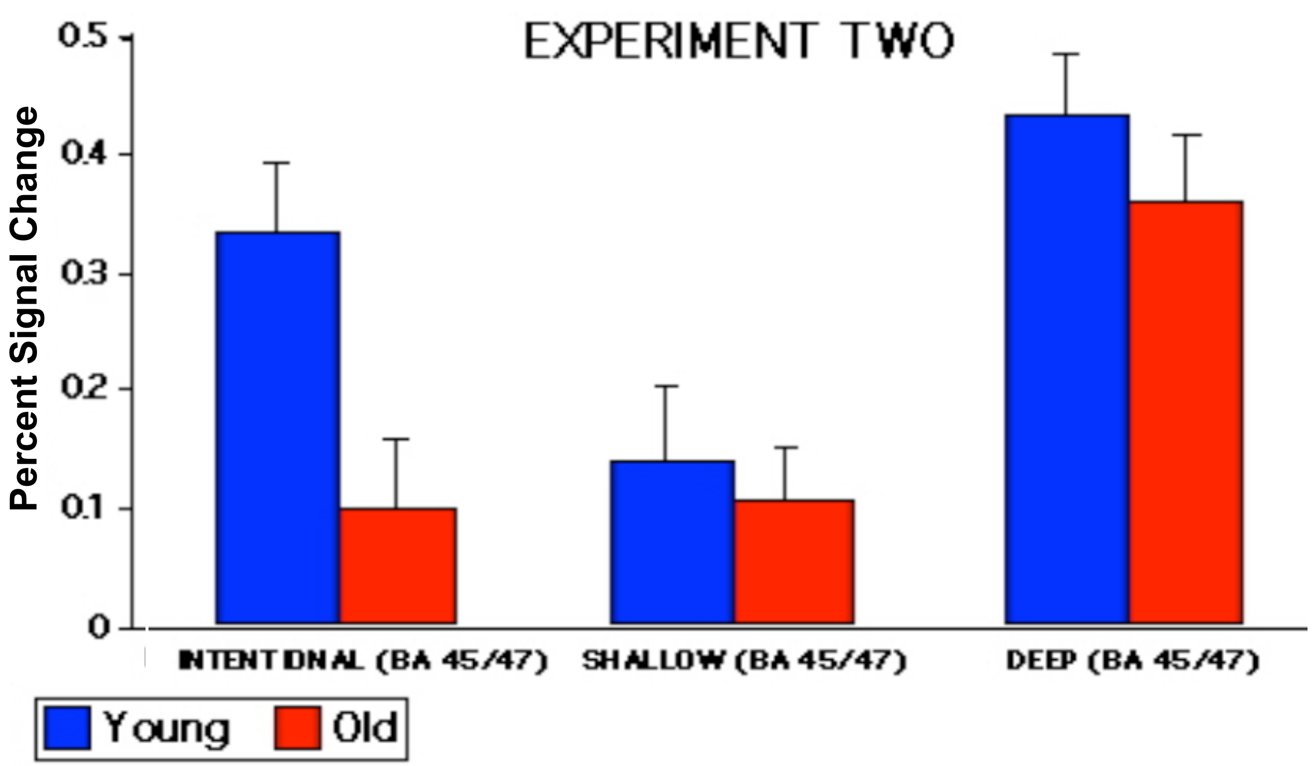
Intentional > Fixation

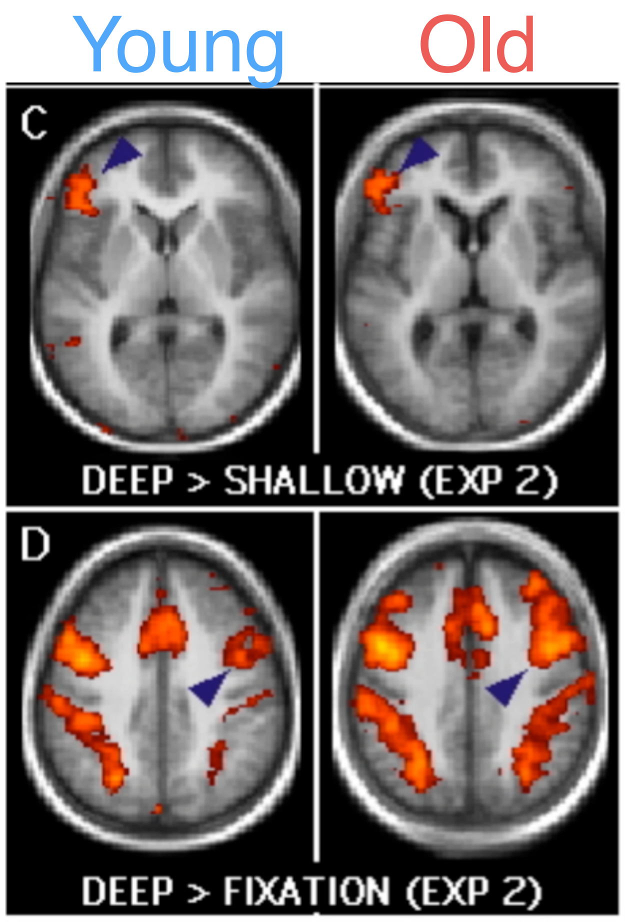
Older adults *under-recruited* this PFC region during intentional encoding

(Logan et al., 2002)

Functional deficit or strategy deficit?

Are the observed decreased in PFC function due to *loss of frontal resources*, or *ineffective recruitment*?



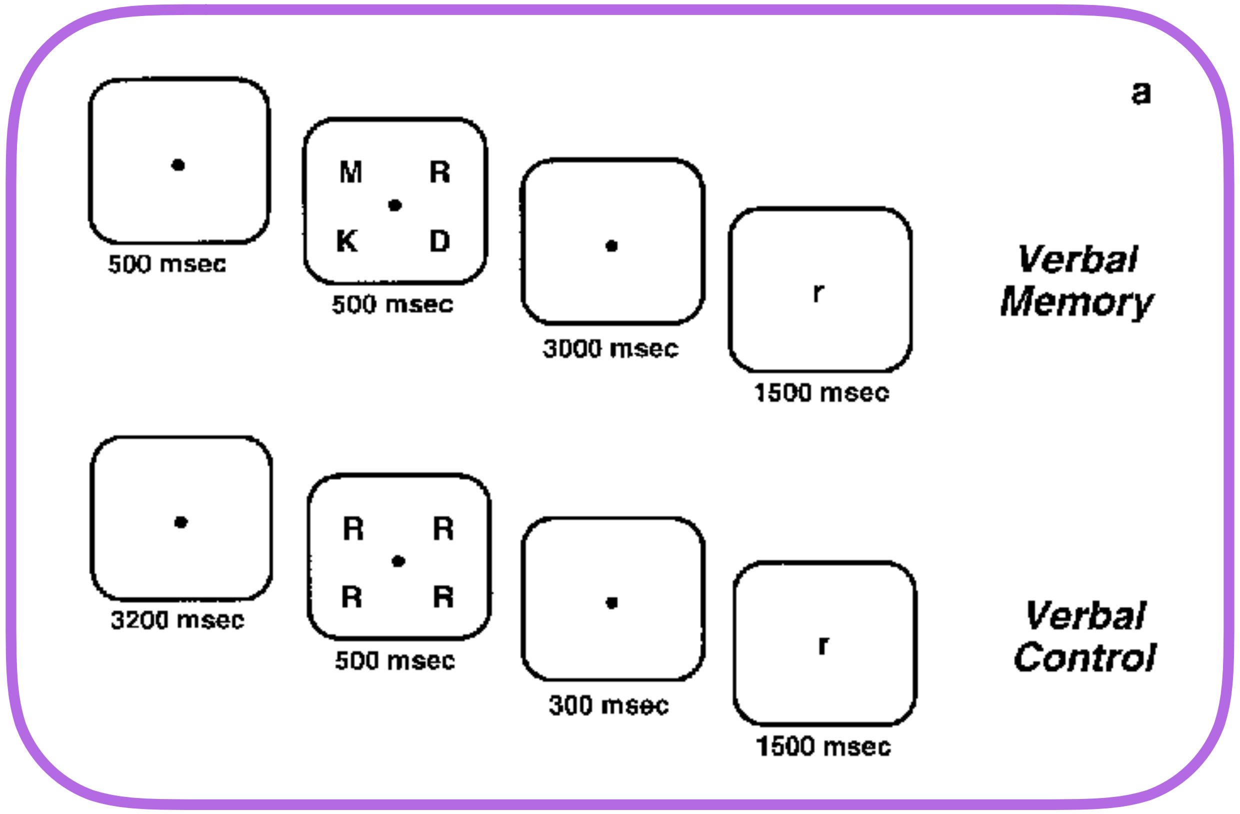


Under deep encoding conditions, adults recruited PFC to *similar levels* as younger adults

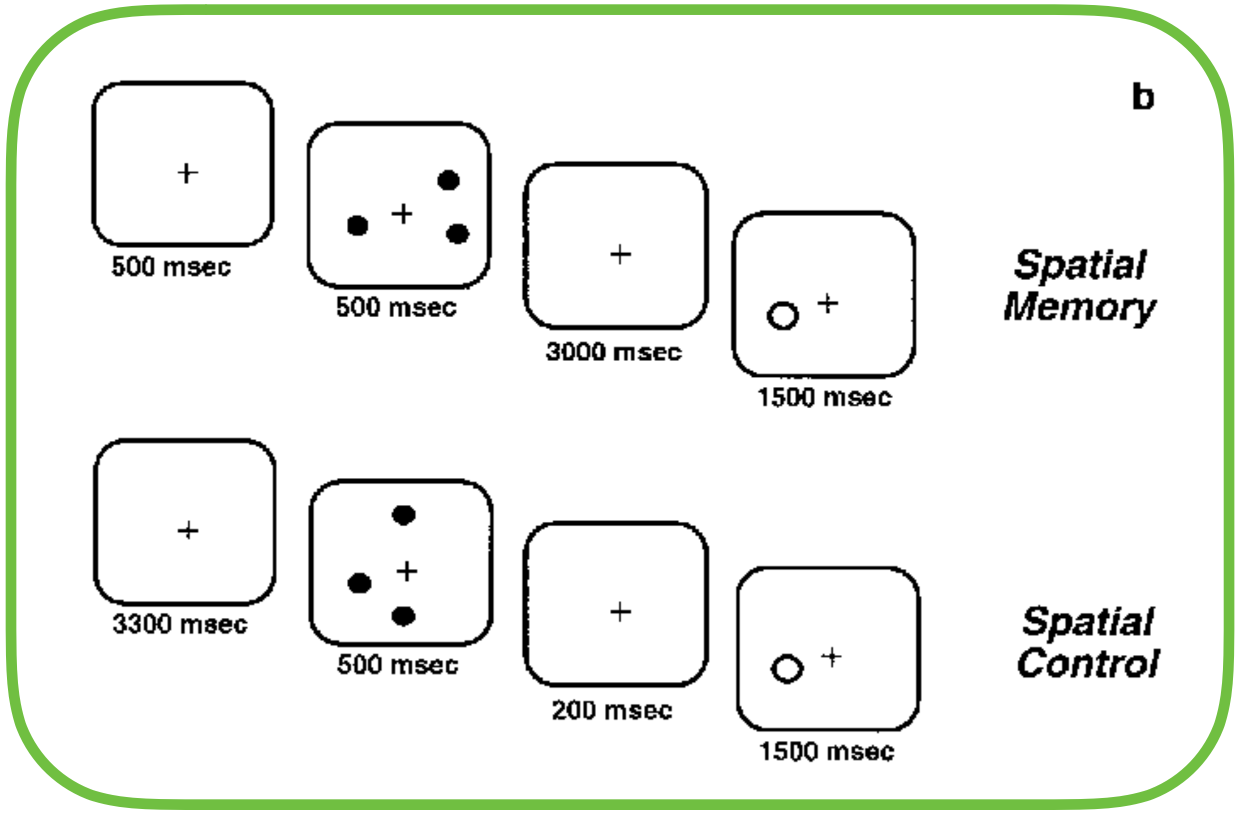
(Logan et al., 2002)

Functional compensation?

Verbal WM

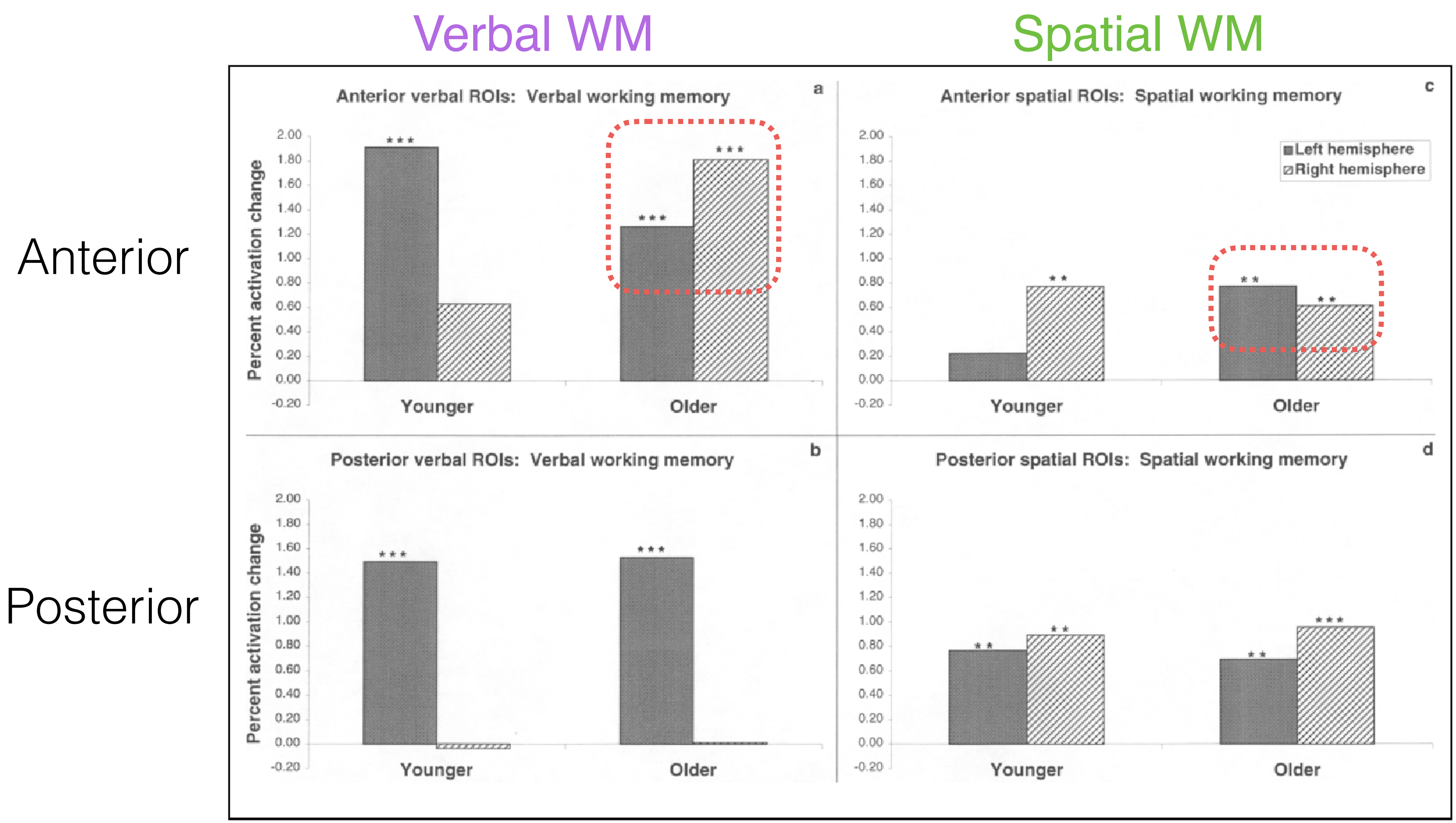


Spatial WM



(Reuter-Lorenz et al., 2000)

Functional compensation?



(Reuter-Lorenz et al., 2000)

Functional compensation?

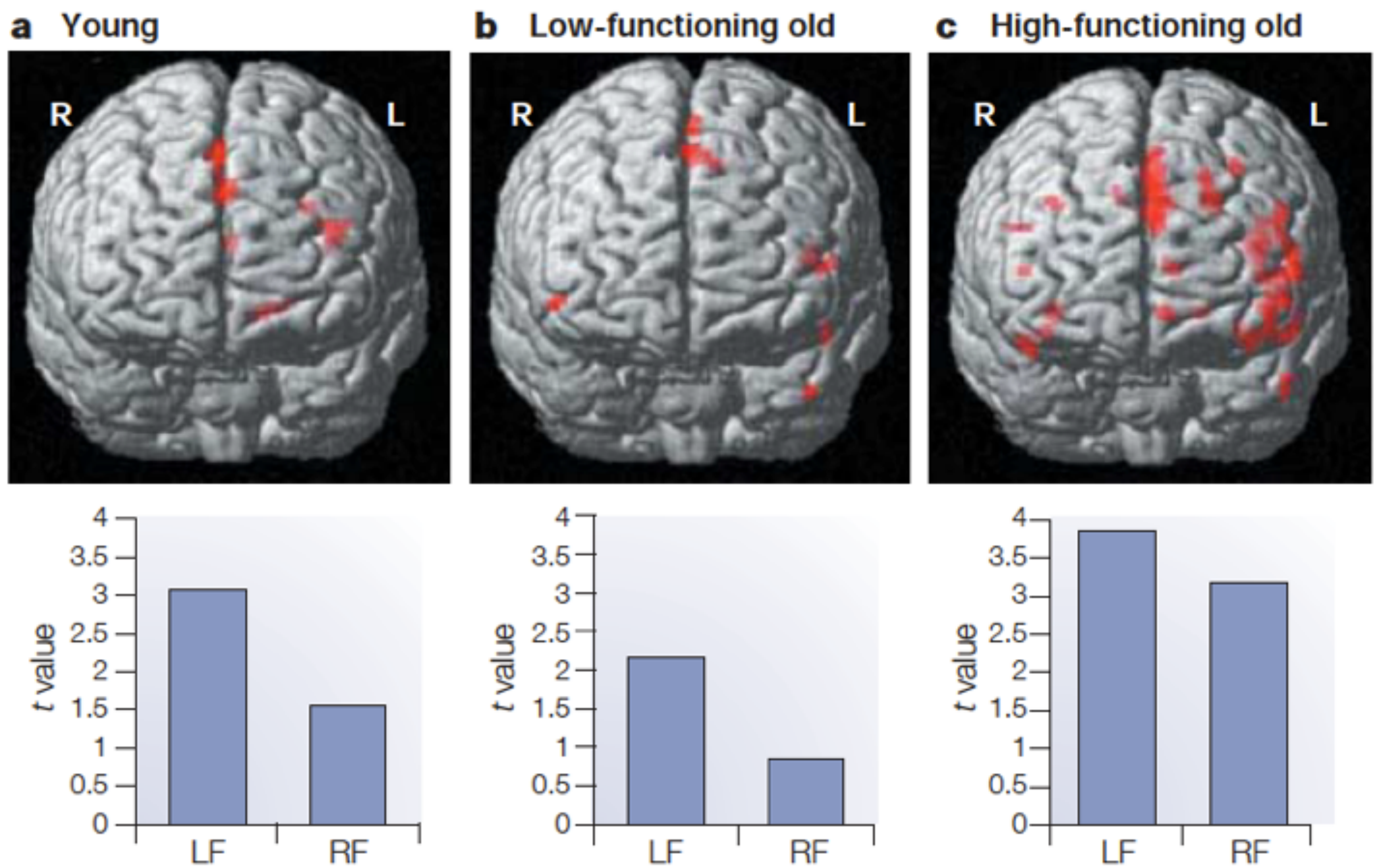
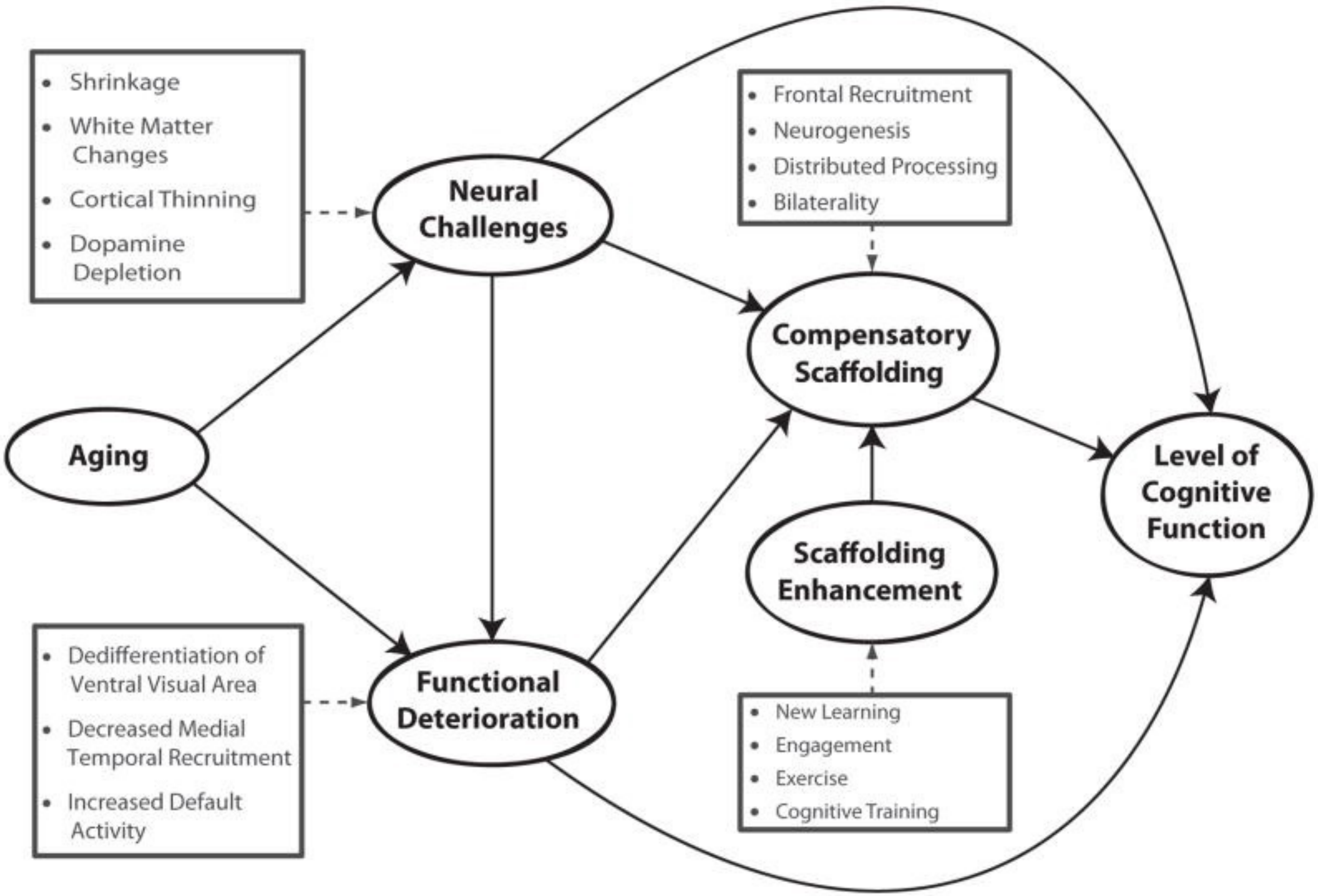


Figure 5 | **Neural activations in prefrontal cortex during a memory encoding task.** Activations are shown for young adults, low-performing older adults and high-performing older adults. Low-performing older adults exhibit a similar pattern as do young adults, with lower overall levels of activation. High-performing older adults exhibit greater bilateral activation. RF, right frontal; LF, left frontal. Data from REF. 93.

(Cabeza et al., 2002)

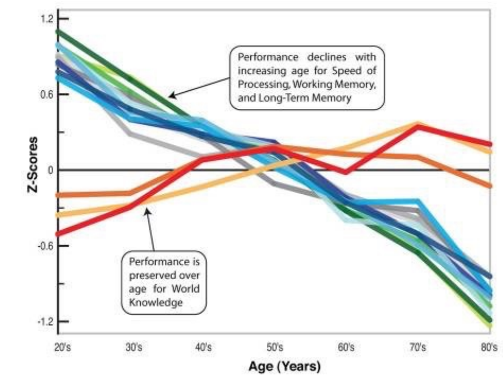
An integrative model of aging & cognition



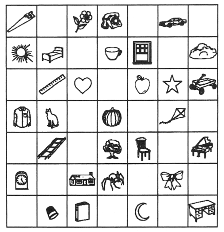
(Park & Reuter-Lorenz, 2009)

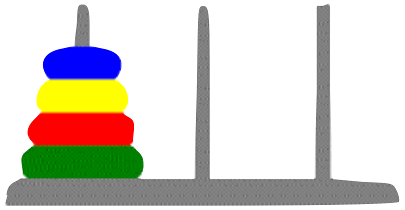
Agenda

- Memory in ‘Healthy’ Aging
  - Episodic Memory vs. Semantic Memory vs. Working Memory
  - Declarative vs. Nondeclarative Memory

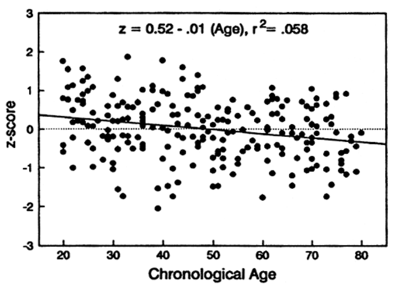


- Memory in ‘Healthy’ Aging: Evidence for Multiple System Changes
  - MTL Dysfunction
  - PFC Dysfunction

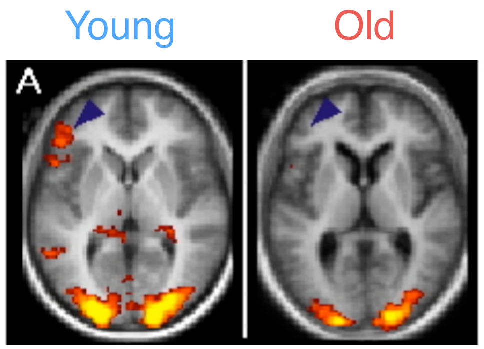




- Mechanisms of Impairment
  - Attention
  - Speed of Processing



- Neurobiology of Age-Related Memory Change
  - Anatomical Changes
  - Functional Changes



Announcements

- Review session (Q&A format)
  - Thursday 6/2, in 420-040 (9-10:20am)
- Final exam
  - Similar format to midterms
  - Focus on latter third, but with high-level cumulative questions
  - EARLY FINAL: Thurs, 6/2, 12-3pm, 420-040
  - STANDARD FINAL: Mon, 6/6, 8:30-11:30am, 420-040
- Paper grades are available on Canvas
- Please submit evals!

“If any one faculty of our nature may be called more wonderful than the rest, I do think it is memory. There seems something more speakingly incomprehensible in the powers, the failures, the inequalities of memory, than in any other of our intelligences. The memory is sometimes so retentive, so serviceable, so obedient; at others, so bewildered and so weak; and at others again, so tyrannic, so beyond control! We are, to be sure, a miracle every way; but our powers of recollecting and of forgetting do seem peculiarly past finding out.”

– Jane Austin, Mansfield Park

Thank you!

Congratulations to the seniors!