ADULT DEVELOPMENT

John Gabrieli

9.00


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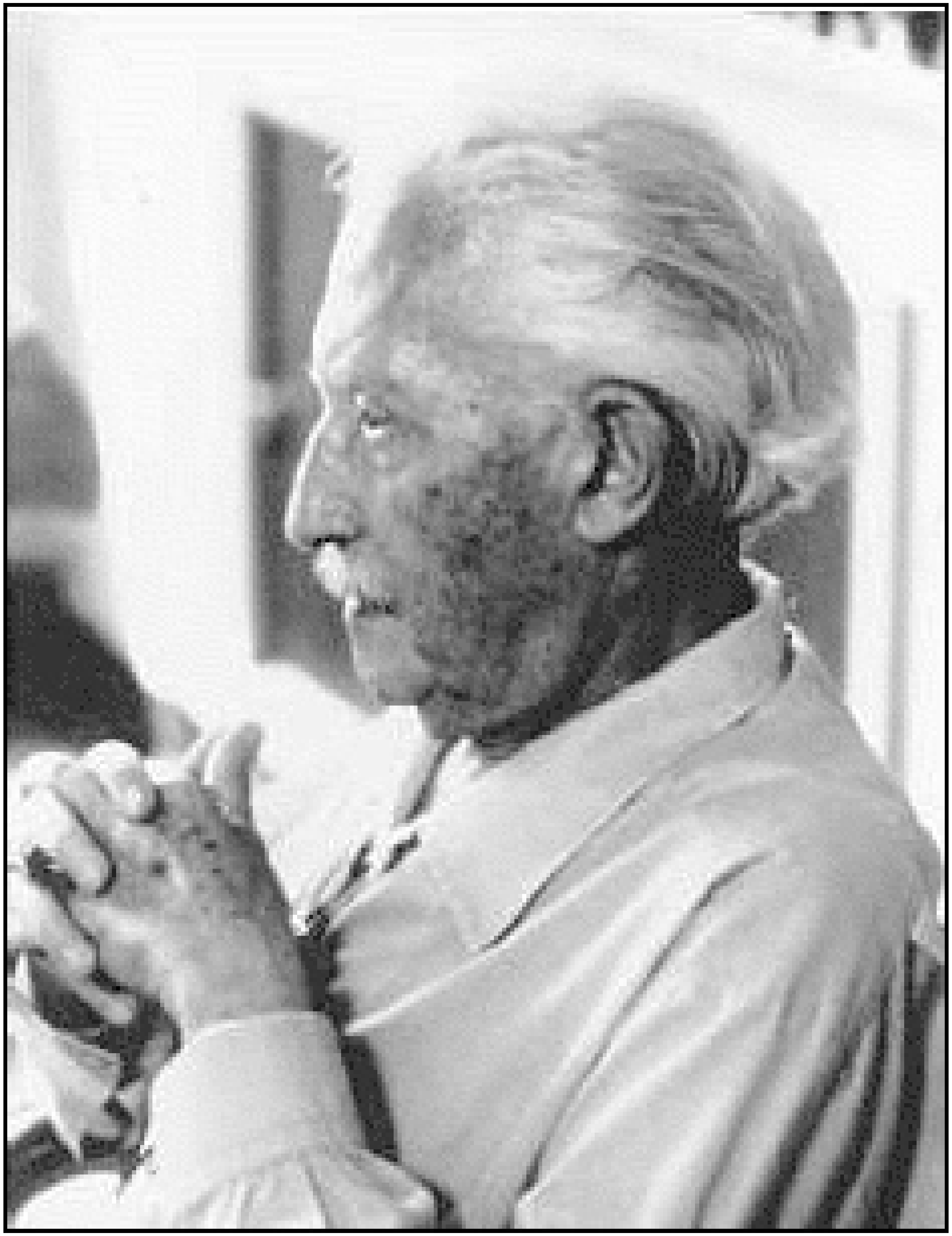
What walks with four legs in the morning, two legs in the afternoon, and three legs in the evening?



Erik Erikson

(1902 -1994)

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Age	Stage of Development	Developmental Task
Infancy	Trust vs Mistrust	Attachment & Bonding
Early Childhood	Autonomy vs Shame & Doubt	Potty training & Self-Maintenance
Early School	Initiative vs Guilt	Academic success, adding, abc’s, making friends
School Age	Industry vs Inferiority	Social competence friendship network
Adolescence	Identity vs Role Confusion	Loyalty & friendship
Young Adulthood	Intimacy vs Isolation	Falling in love, maintaining a relationship
Maturity	Generativity vs Stagnation	Having & Nurturing children
Old Age	Integrity vs Despair	Imparting Wisdom to others

Trust vs Mistrust (Infancy)

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Attachment & bonding

Autonomy vs. Shame & Doubt (Early Childhood)

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Potty training & self-maintenance

Initiative vs Guilt
(Early School)

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Academic success, adding, abc's, making friends

Industry vs Inferiority (School Age)

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Social competence, friendship network

Identity vs Role Confusion (Adolescence)

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Loyalty & friendship

Intimacy vs Isolation (Young Adulthood)

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Falling in love, maintaining a relationship

Generativity vs Stagnation (Maturity)

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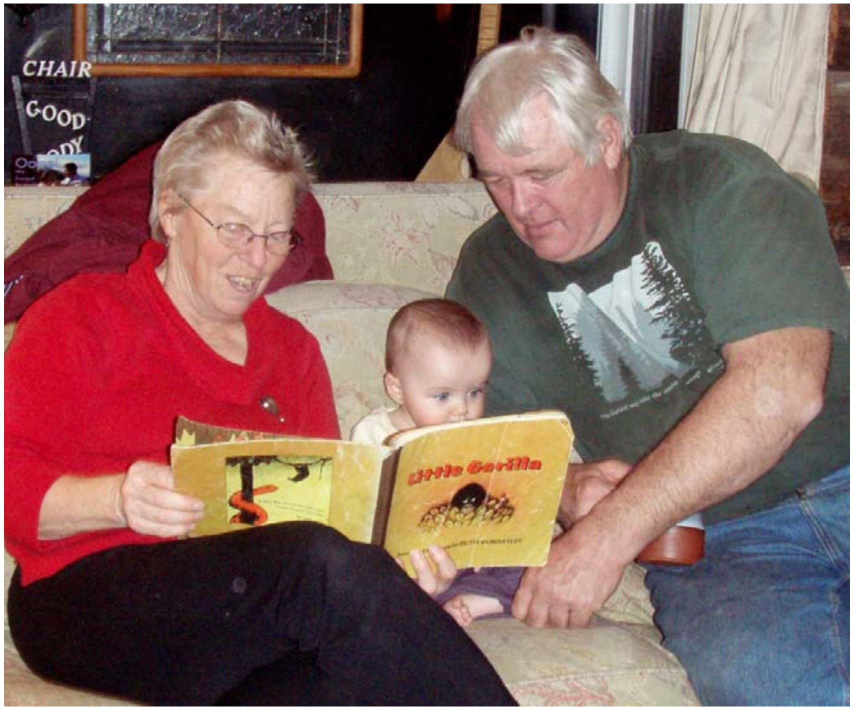
Having & nurturing children

Integrity vs Despair (Old Age)



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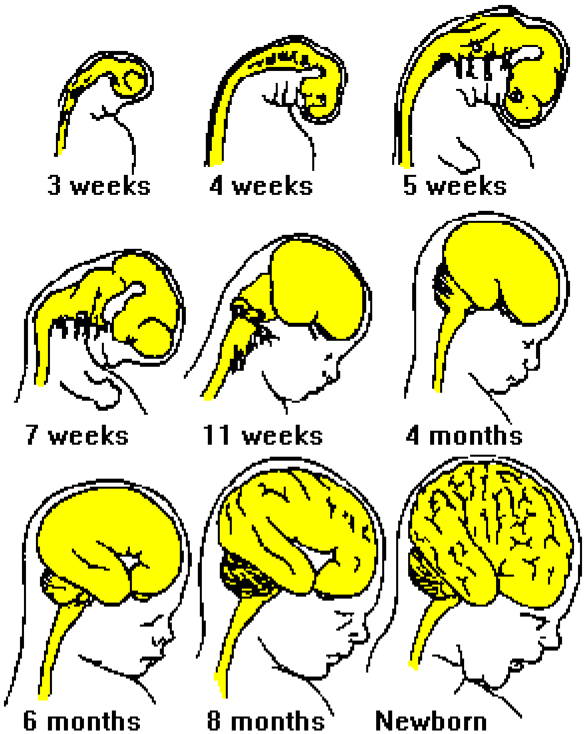
Imparting wisdom to others

ADULT DEVELOPMENT

- brain development from infancy to young adulthood
- cognitive stability & decline in adulthood
- alteration in hemispheric asymmetry with age
- exercise, aging, & the brain
- socioemotional selectivity & amygdala
- reward system of the brain
- gist vs. specificity in decision making

Complexity…



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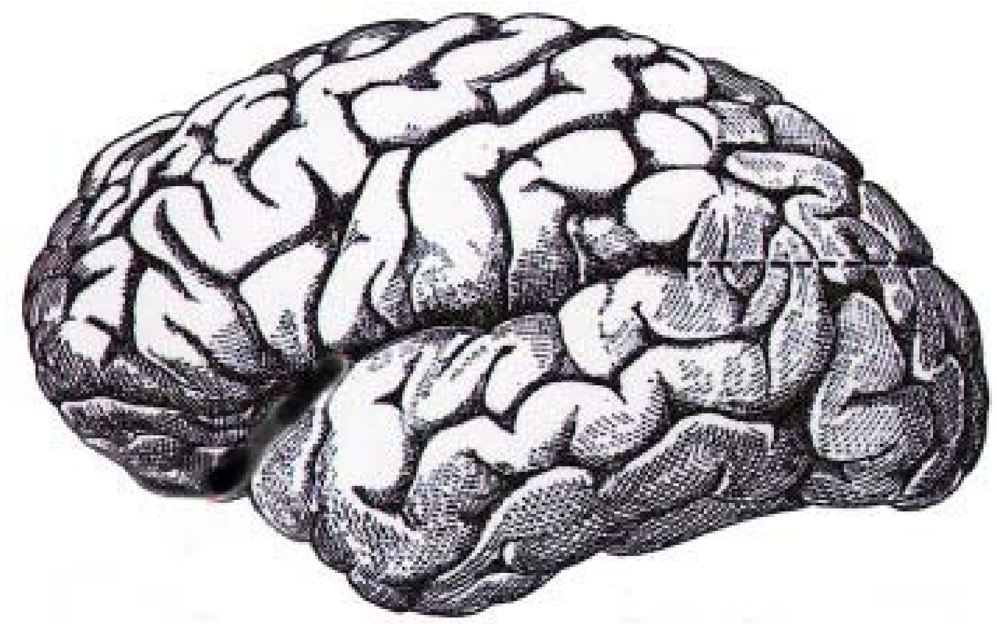

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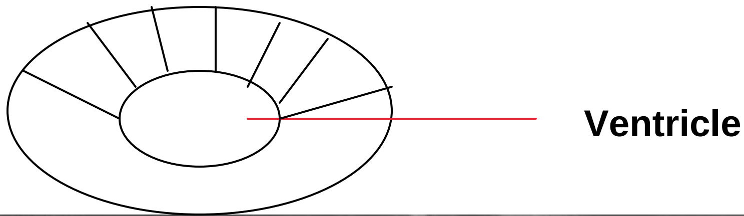
1×10^{9} neurons

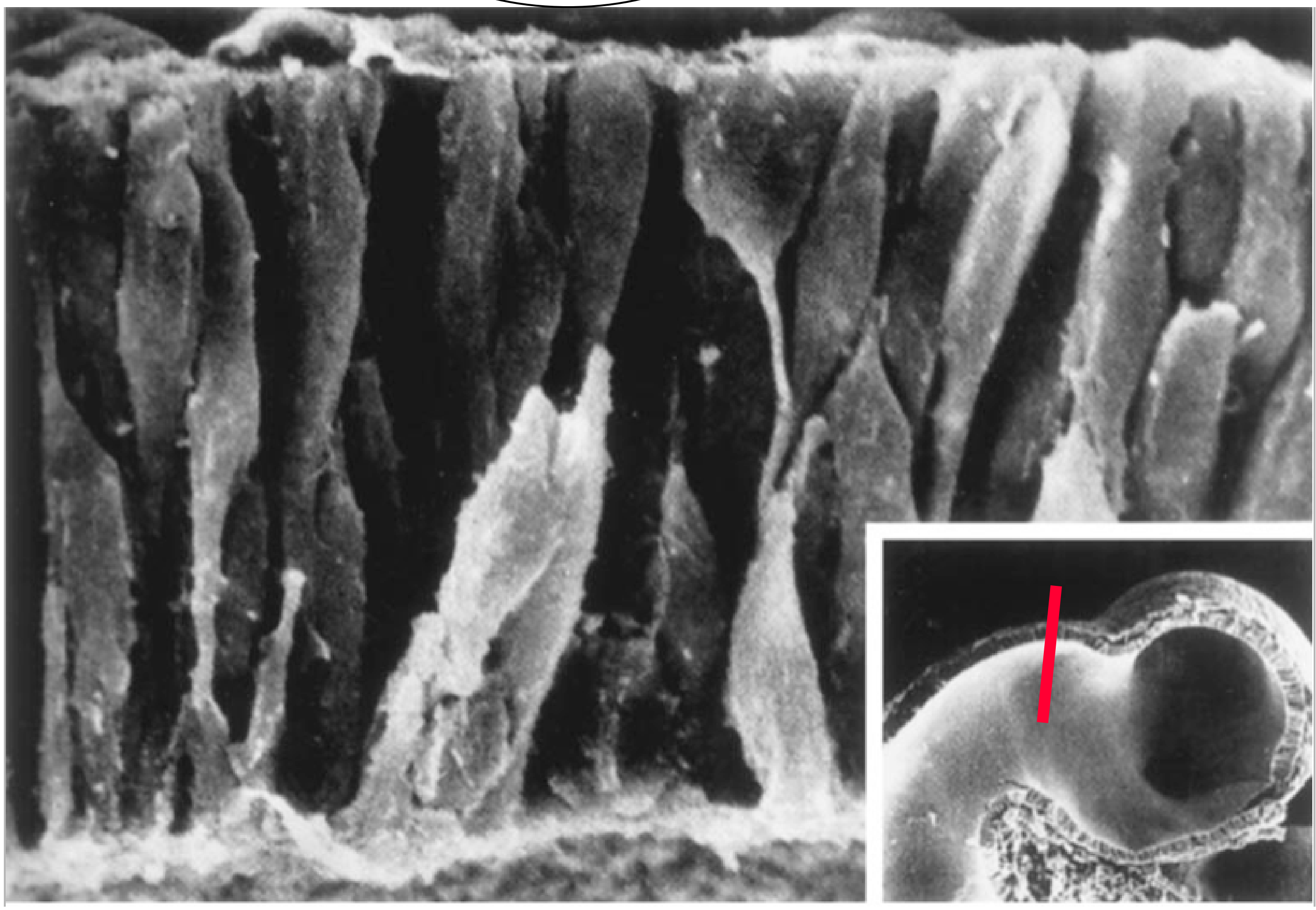
1×10^{12} synapses

i.e., 1000 connections/neuron

…Neurogenesis



Outer surface



Ventricular surface

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Summary of Neurogenesis

- **Cells divide along the ventricular zone**

- **Earliest neurons during the 2rd embryonic week (EW)**

- **Peak production during the 7th EW - 500,000 neurons/minute**

- **Mostly completed by 18th EW, but continues in adults(??)**

- **Excess production followed by programmed cell death**

e.g., Frontal lobe neuron density is:

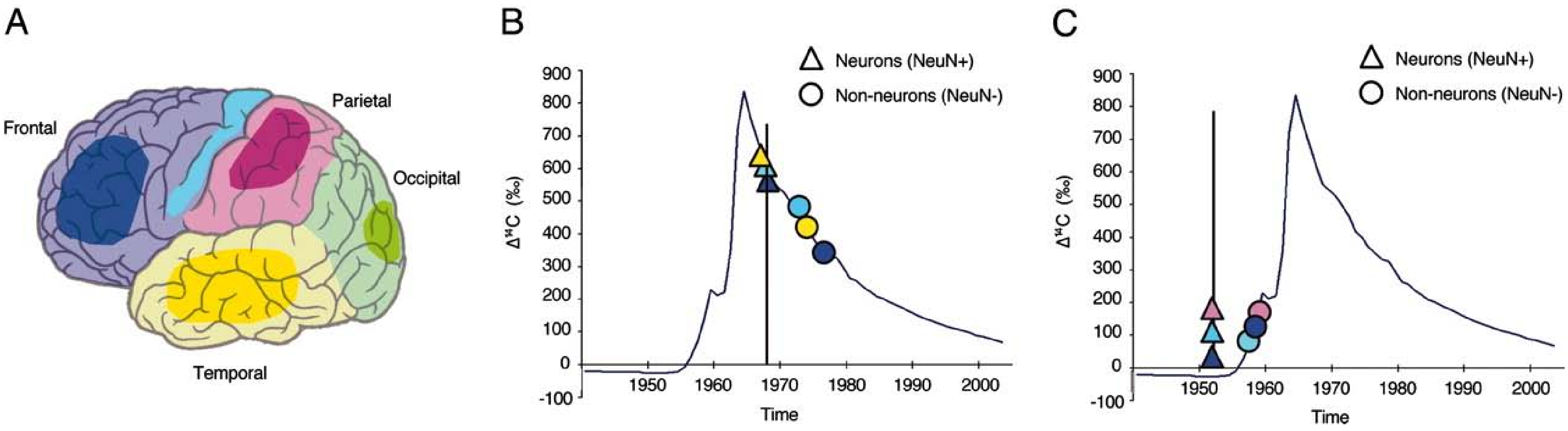
55% above adults at age 2
20% above adults at age 5
10% above adults at age 7

Neurogenesis in Adult Brain?

- for many years, answer was no in mammalian brains
- neurogenesis in granule cells in olfactory bulb & dentate gyrus of hippocampus
- Gould thought she observed new neurons in adult primates
- Rakic argues these were really glia

Neurogenesis in Adult Brain?

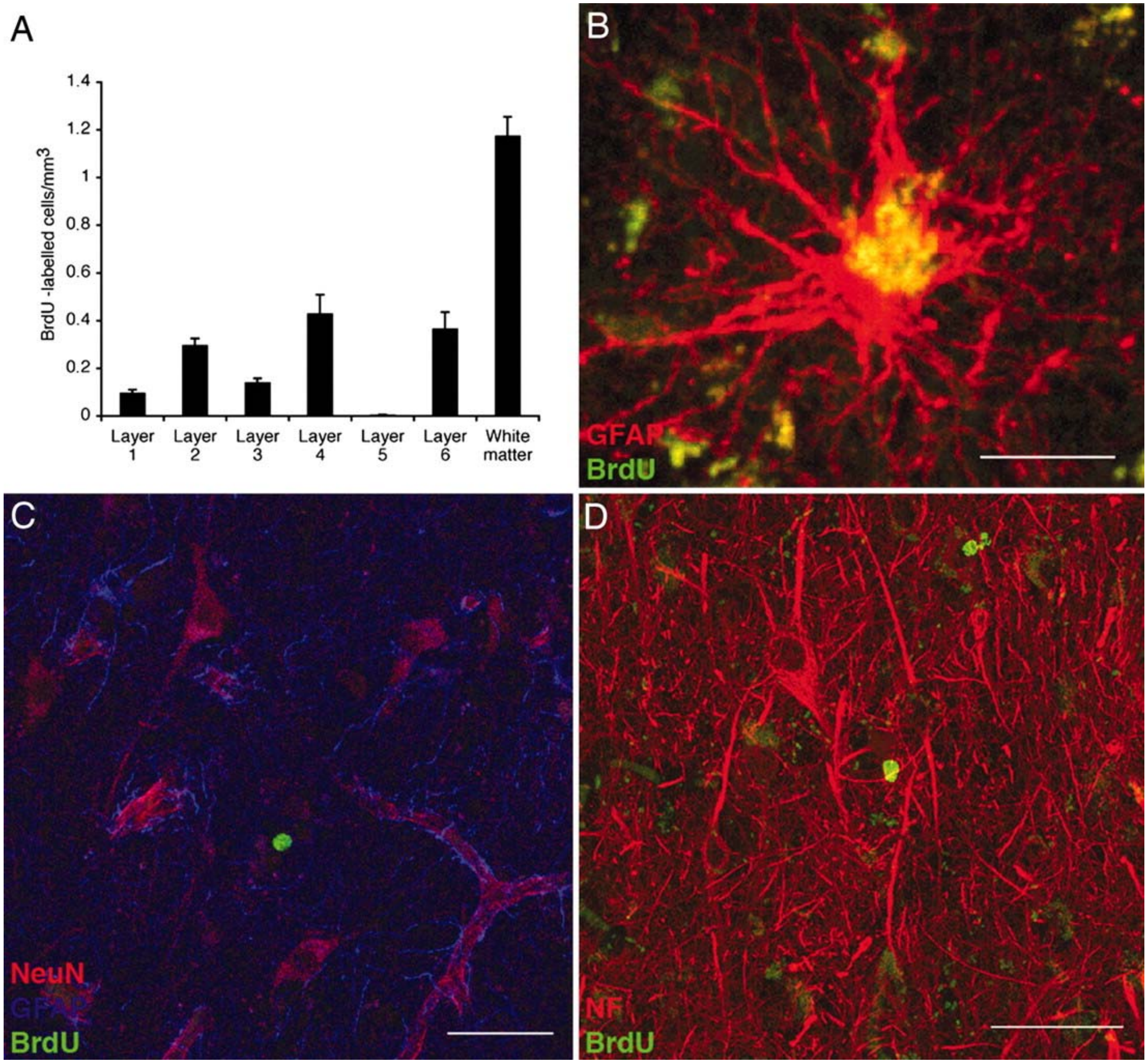
- Bhardwaj, 2006
- nuclear bomb tests during Cold War sent 14C into atmosphere, 1955-1963, Test Ban Treaty, decreased
- integrated with DNA, date mark for cell birth
- non-neuronal cells are generated, but neurons are *not* generated in adult neocortex
- Bromodeoxyuridine (5-bromo-2-deoxyuridine, BrdU) incorporates into newly synthesized DNA



born after 1963 **born before 1963**

Neocortical neurons are as old as the individual. (*A*) The cerebral lobes are outlined (the large colored fields), and the cortical area analyzed within each lobe is color-coded. Both prefrontal (blue) and premotor (light blue) areas were analyzed in the frontal lobe. The analysis of occipital cortex was reported in ref. 23. (*B*) A representative example of values obtained from one individual born after the nuclear weapons tests plotted on to the curve of atmospheric ^{14}C levels indicates that nonneuronal cells turn over, whereas the cortical neurons were generated close to the time of birth. (*C*) A representative example of the analysis of an individual born before the nuclear tests, indicating no measurable cortical neurogenesis. The ^{14}C level in the nonneuronal cells demonstrates there is turnover within this population, but there are several possible interpretations of these data, and the age of this population cannot be concluded from this material alone. The coloring of symbols in *B* and *C* corresponds to the regions in *A*. Vertical bars in *B* and *C* indicate the birth date of the individual.

Courtesy of National Academy of Sciences, U.S.A. Used with permission. Source: Bhardwaj, Ratan D., et al. "Neocortical Neurogenesis in Humans is Restricted to Development." *PNAS* 103, no. 33 (2006): 12564-8. Copyright © 2006 National Academy of Sciences, U.S.A.



BrdU incorporation in the adult human cerebral cortex. (*A*) Distribution of BrdU-labeled cells in the adult human motor cortex. (*B*) A subset of BrdU-labeled cells are immunoreactive to the astrocyte marker GFAP. (*C* and *D*) None of the BrdU-labeled cells are immunoreactive to the neuronal markers NeuN (*C*) or neurofilament (*D*). [Scale bars, 70 µm (*B*) and 100 µm (*C* and *D*).]

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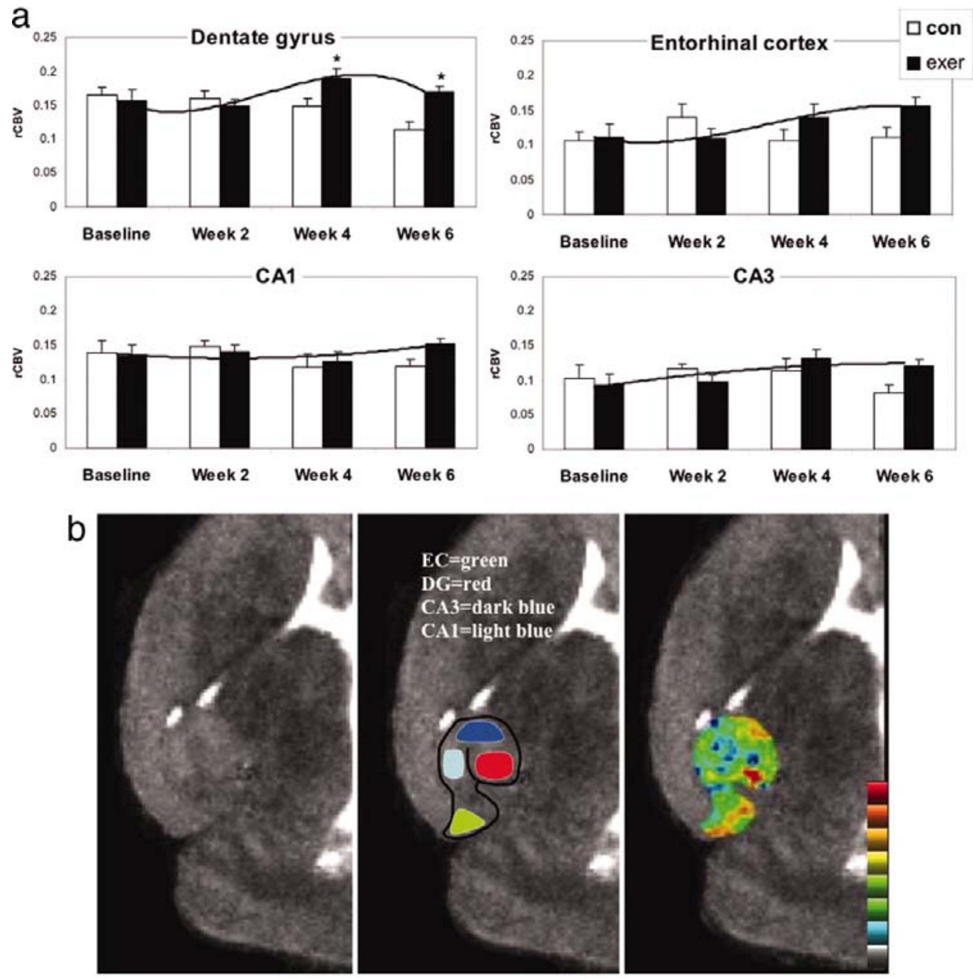
Exercise-Induced Neurogenesis

- measure cerebral blood volume (CBV) in hippocampus, including dentate
- exercise in mice selectively increases CBV in dentate
- exercise-induced increases in dentate CBV correlated with post-mortem measures of neurogenesis
- in humans (12 weeks, 4/wk, 1hr) selective effect on dentate CBV, CBV changes correlate with cognitive functions



Exercise selectively increases dentate gyrus CBV in mice. (*a*) Exercise had a selective effect on dentate gyrus CBV. Bar graphs show the mean relative CBV (rCBV) values for each hippocampal subregion in the exercise group (filled bars) and the nonexercise group (open bars) over the 6-week study. The dentate gyrus was the only hippocampal subregion that showed a significant exercise effect, with CBV peaking at week 4, whereas the entorhinal cortex showed a nonsignificant increase in CBV. (*b*) An individual example. (*Left*) High-resolution MRI slice that visualizes the external morphology and internal architecture of the hippocampal formation. (*Center*) Parcellation of the hippocampal subregions (green, entorhinal cortex; red, dentate gyrus; dark blue, CA3 subfield; light blue, CA1 subfield). (*Right*) Hippocampal CBV map (warmer colors reflect higher CBV).

Courtesy of National Academy of Sciences, U.S.A. Used with permission. Source: Pereira, Ana C., et al. "An In Vivo Correlate of Exercise-Induced Neurogenesis in the Adult Dentate Gyrus." *PNAS* 104, no. 13 (2007): 5638-43. Copyright © 2007 National Academy of Sciences, U.S.A.

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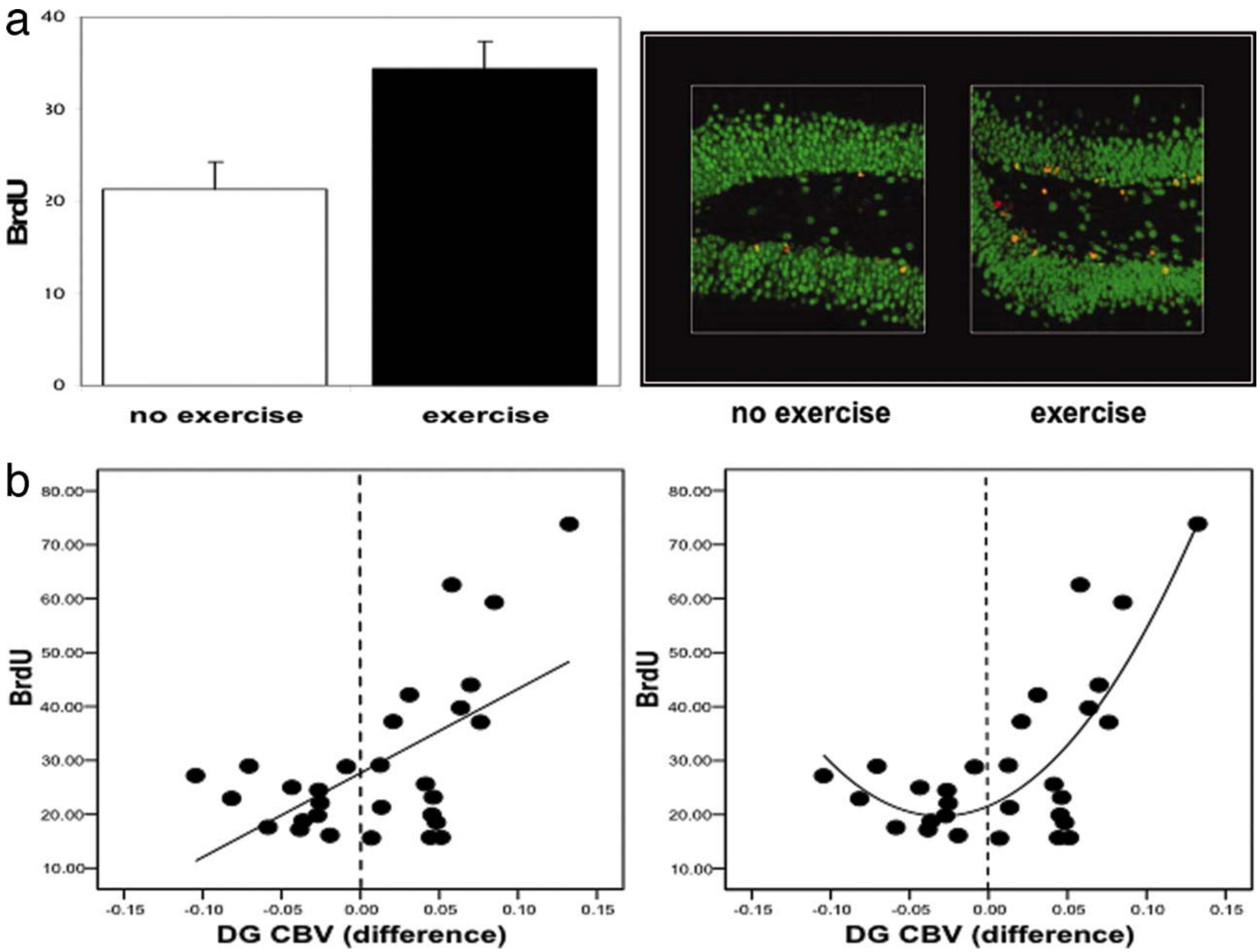

Exercise-induced increases in dentate gyrus CBV correlate with neurogenesis. (*a*) (*Left*) Exercising mice were found to have more BrdU labeling compared with the no-exercise group. (*Right*) As shown by confocal microscopy, the majority of the new cells were colabeled with NeuN (red, BrdU labeling; green, NeuN; yellow, BrdU/NeuN double labeling). (*b*) (*Left*) A significant linear relationship was found between changes in dentate gyrus CBV and BrdU labeling. (*Right*) A quadratic relationship better fits the data. The vertical stippled line in each plot splits the *x* axis into CBV changes that decreased (left of line) versus those that increased (right of line) with exercise.

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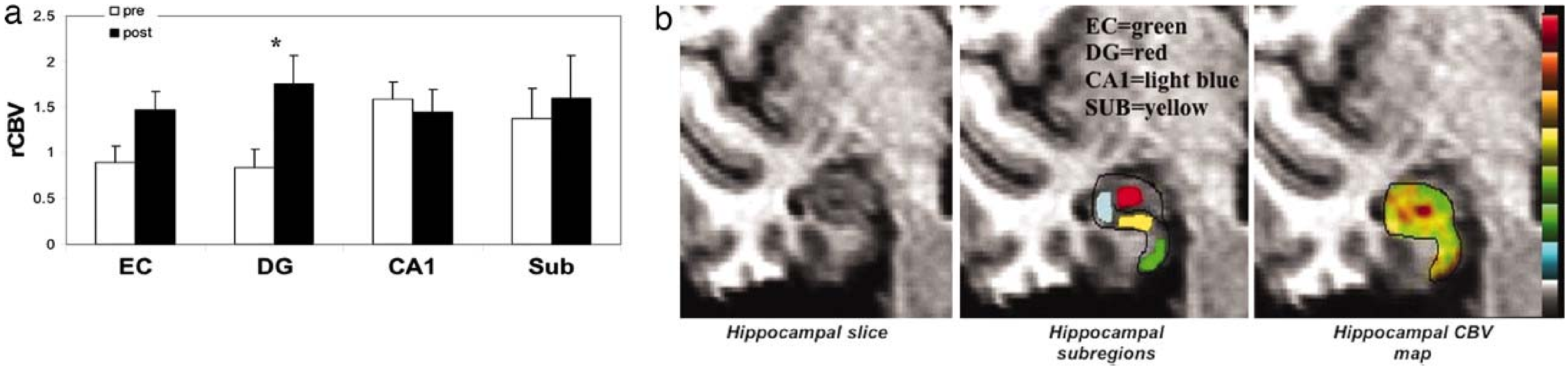

Exercise selectively increases dentate gyrus CBV in humans. (*a*) Exercise had a selective effect on dentate gyrus CBV. Bar graph shows the mean relative CBV (rCBV) values for each hippocampal subregion before exercise (open bars) and after exercise (filled bars). As in mice, the dentate gyrus was the only hippocampal subregion that showed a significant exercise effect, whereas the entorhinal cortex showed a nonsignificant increase in CBV. (*b*) An individual example. (*Left*) High-resolution MRI slice that visualizes the external morphology and internal architecture of the hippocampal formation. (*Center*) Parcellation of the hippocampal subregions (green, entorhinal cortex; red, dentate gyrus; blue, CA1 subfield; yellow, subiculum). (*Right*) Hippocampal CBV map (warmer colors reflect higher CBV).

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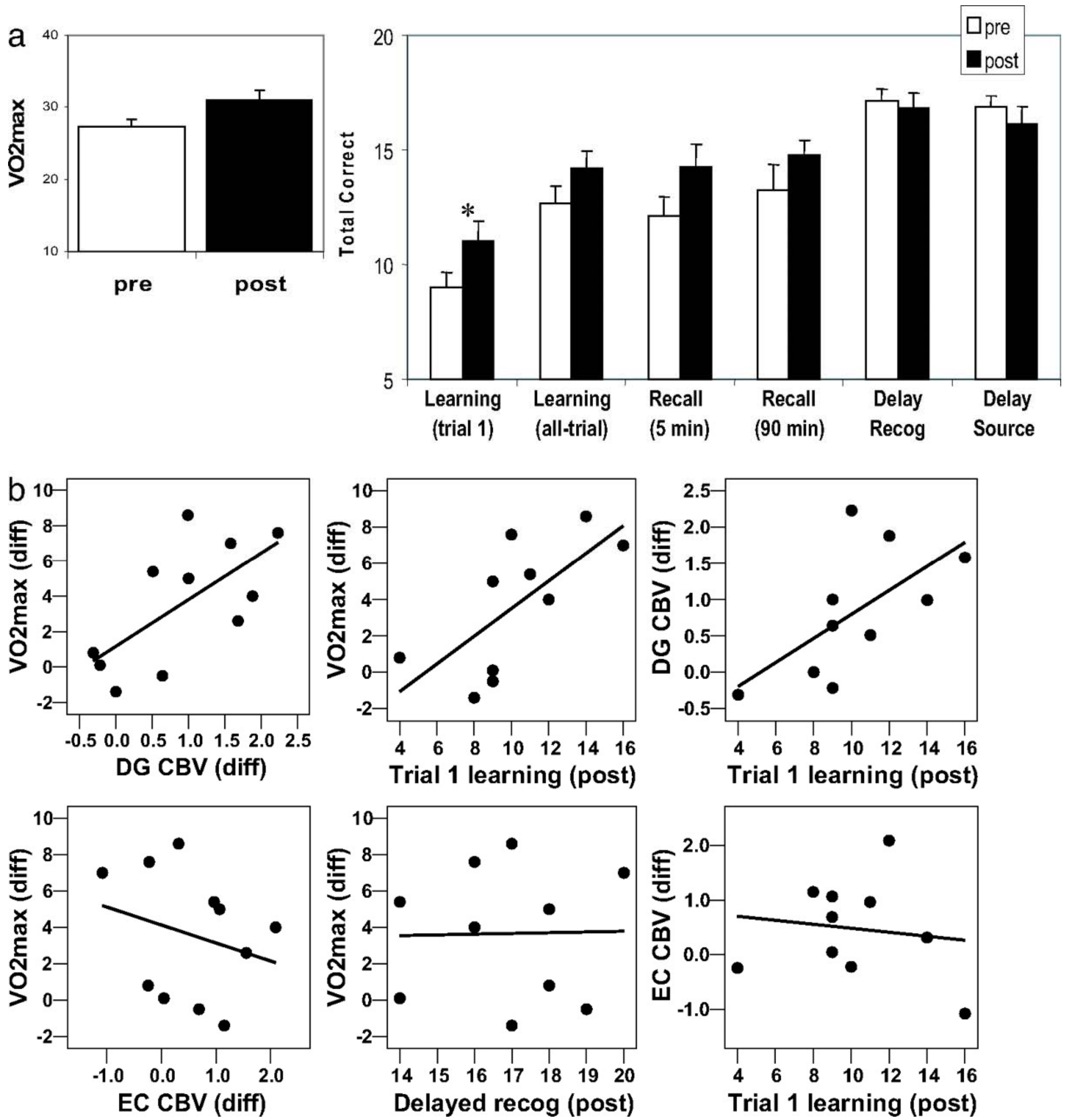

Exercise-induced increases in dentate gyrus CBV correlate with aerobic fitness and cognition. (*a*) (*Left*) VO_2max, the gold-standard measure of exercise-induced aerobic fitness, increased after exercise. (*Right*) Cognitively, exercise has its most reliable effect on first-trial learning of new declarative memories. (*b*) (*Left*) Exercise-induced changes in VO_2max correlated with changes in dentate gyrus (DG) CBV but not with other hippocampal subregions, including the entorhinal cortex (EC), confirming the selectivity of the exercise-induced effect. (*Center*) Exercise-induced changes in VO_2max correlated with postexercise trial 1 learning but not with other cognitive tasks, including delayed recognition. (*Right*) Post-exercise trial 1 learning correlated with exercise-induced changes in dentate gyrus CBV but not with changes in other hippocampal subregions, including the entorhinal cortex.

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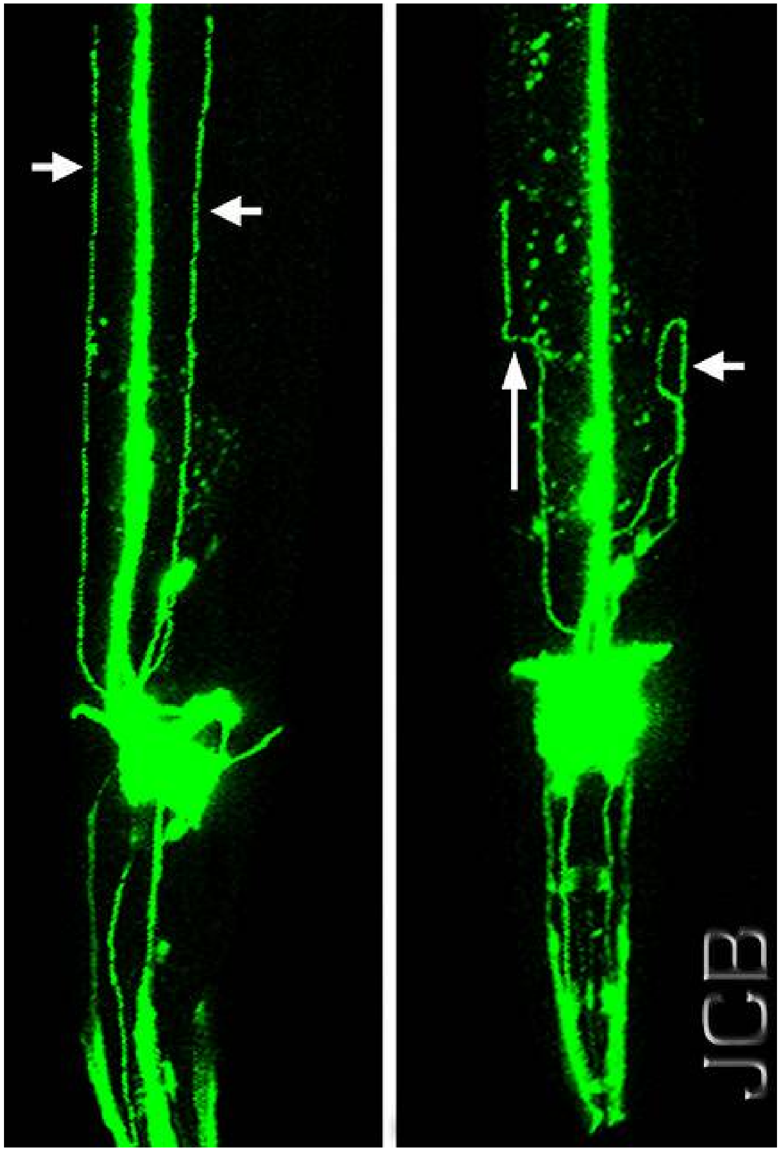
Cell Migration

• neurons must travel to intended locations
• migration occurs over months and perhaps 8 months postnatally
• across radial glial tracks - following molecular cues
• cell's initial destination and function predetermined as it starts migration



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Synaptic Formation

• occurs concurrently in all areas, but at different rates in different areas

• prenatal (from 5 weeks in spinal cord) and postnatal (2 years in cortex)

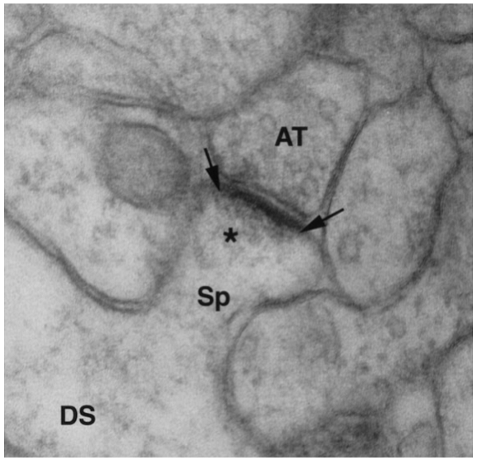
• peak growth - maybe 1.8 million synapses/second

• increase in density until 2 years

50% lost by age 16 (shedding)

• pruning & selection - activity dependent - use it or lose it

neural Darwinism - lose 20 billion synapses per day into adolescence



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Myelination

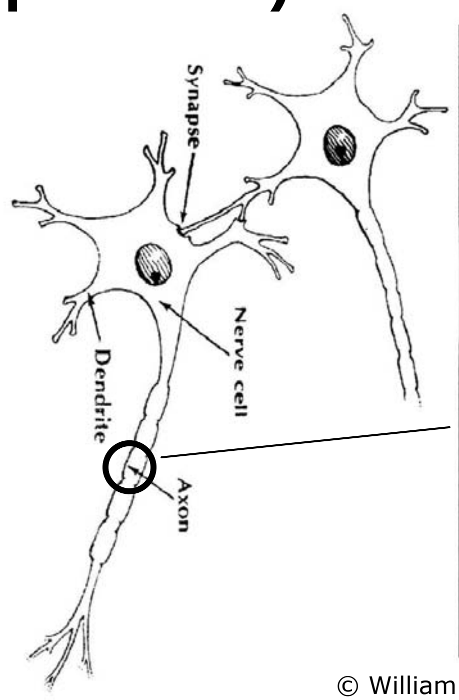
Speeds Signaling along the Axon

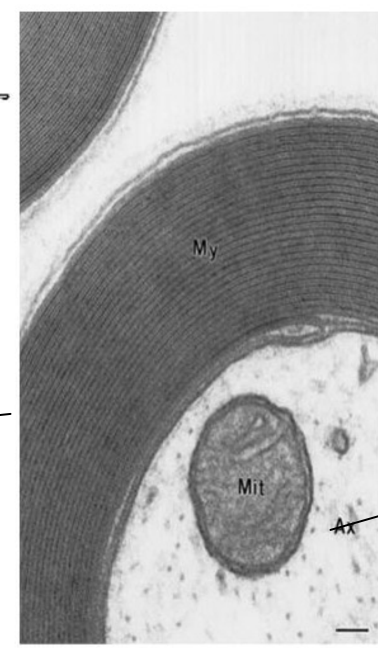
- **Myelin: fatty sheath, multiple layers of compacted oligodendroglia membranes**

- **Insulates segments of the axon bioelectrically**

- **Accelerates signal (action potential) conduction velocity**

- **Myelin: “White Matter”**





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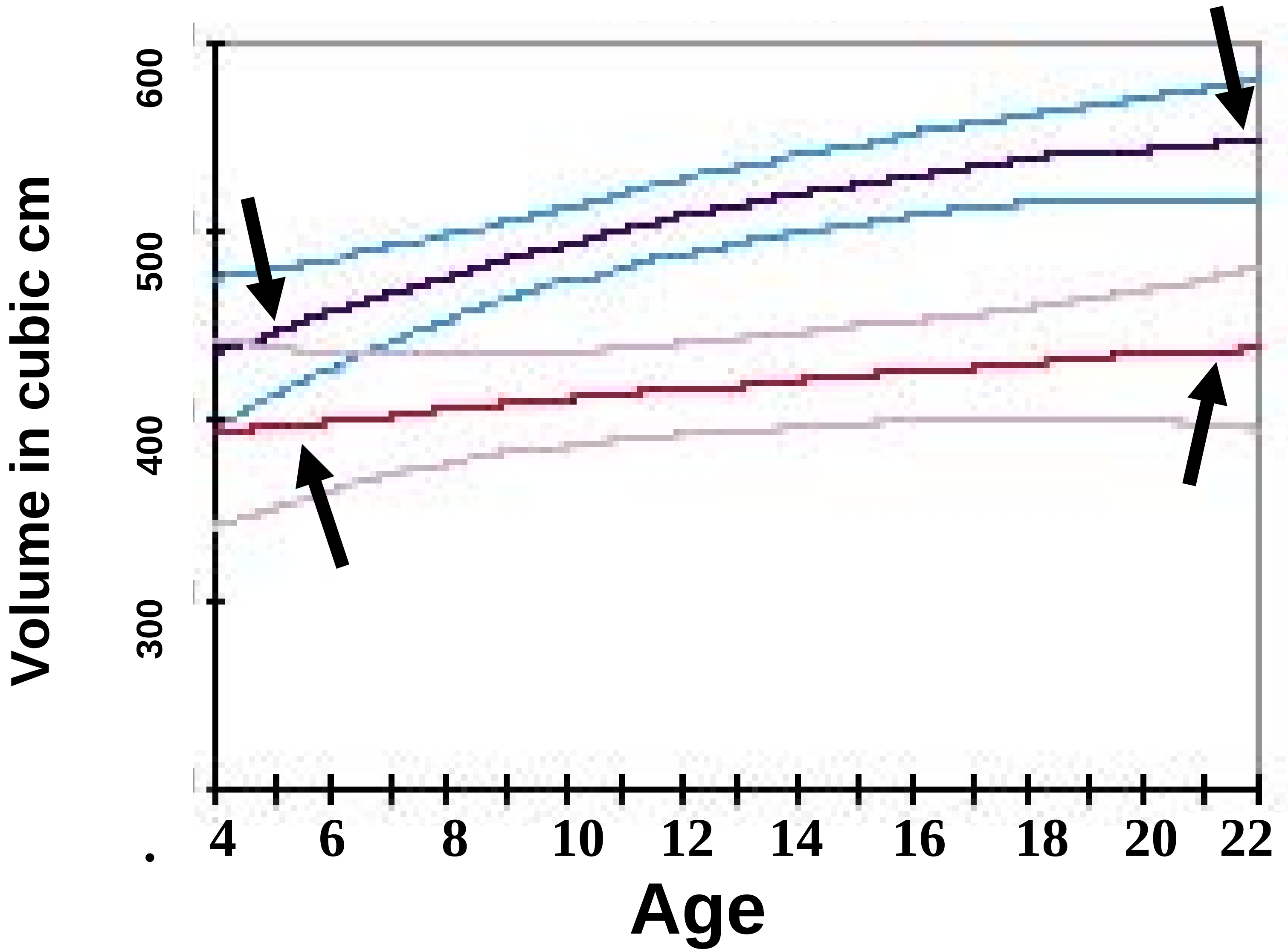
Development of Myelination

Total Volume of White Matter in Brain



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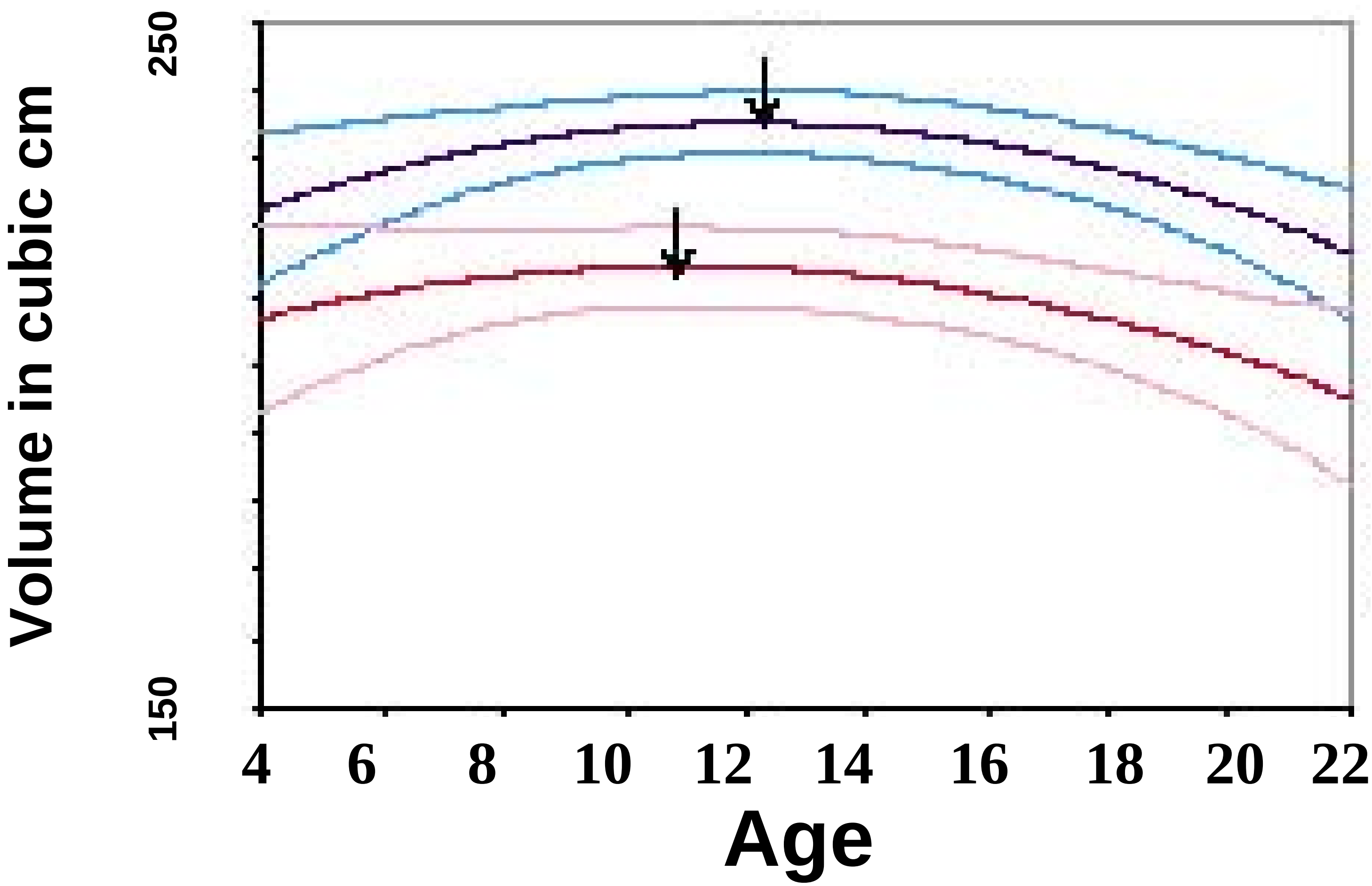
Maturation of Gray Matter

Volume of Gray Matter in Frontal Cortex



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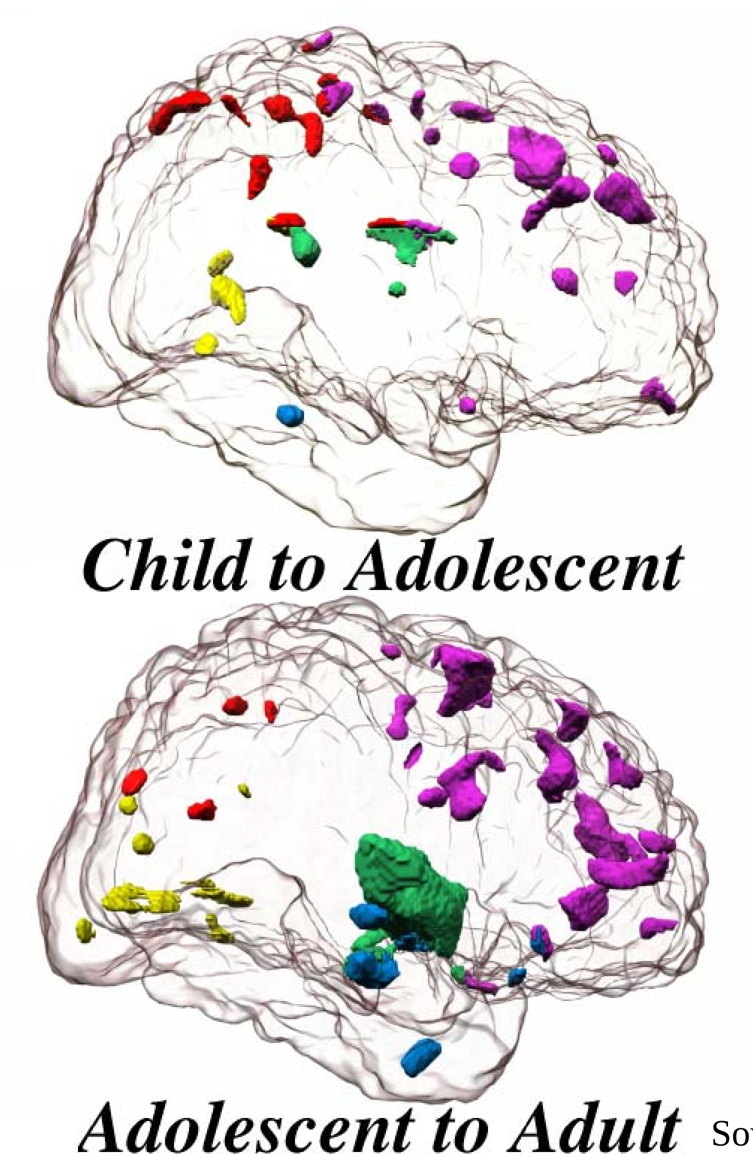
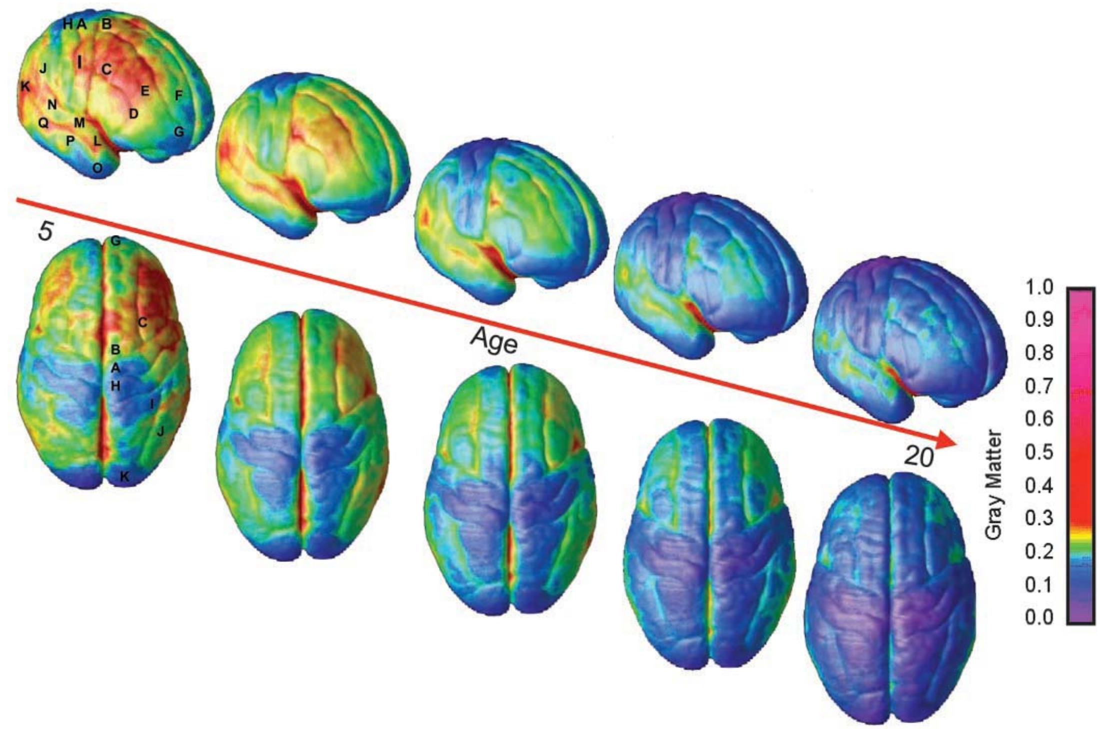
Late Development of Prefrontal Cortex in Adolescence





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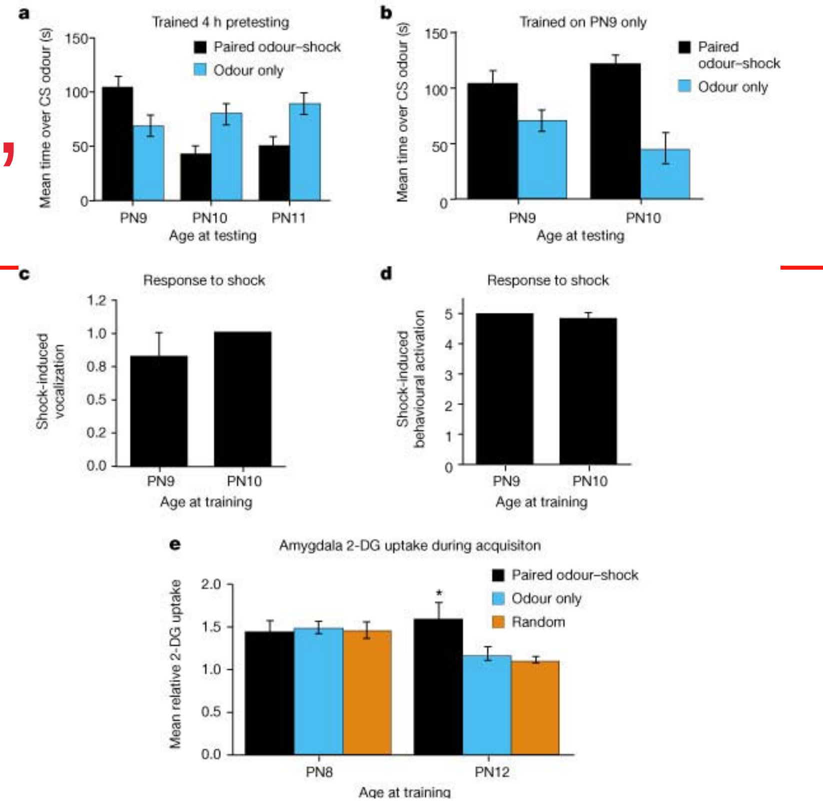
Sowell et al., 1999, *NeuroImage*
Sowell et al., 1999, *Nat Neurosci*

"Good Memories of Bad Events in Infancy"



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- fear important for survival
- amygdala essential for learned fear
- fear conditioning - neutral stimulus (odor) paired with aversive stimulus (shock)
- attachment in rats learned postnatally and through olfaction
- young pups (up to postnatal day 9) exposed to odors & shocks approach odors (produces shock-induced vocalizations & physical responses)
- older pups (after day 10) avoid those odors
- amygdala metabolic activity (measured by 2 do-oxyglucose uptake) higher in young pups but did not vary in response to paired presentations of odor-shock vs. odors only or random odors or shocks - selective enhancement of amygdala metabolism for odor-shock pairs in older pups - learning of aversive associations

Interpretation - helpful for newborns? (avoid aversion to caregiver)
early attachment to abusive caregiver?

A Long Future

- for most of human history, life expectancy about 20 years
- 1800s – mid 30s
- 2000 – 77; 2010 – 78
- 50,000 centenarians in US (3x 10 years ago) and expected to be 1 million by 2050; maybe 50% of girls born in 2000 will live for a century
- families may have 4/5 generations alive at once
- giant effects on education, pension, work, financial markets
- old model – manage child, go to college, career, mate, family, retire at 65
- 1/10 over 65 now, in 20 years ¼ over 65

ADULT DEVELOPMENT

- little studied in middle ages
- contrasts of 20/80 year-olds
- are we done developing at 20?

ADULT DEVELOPMENT

- **cross-sectional vs. longitudinal designs**

Strengths? Limitations?

Cognition and Aging:
Decline and Preservation across the Life Span

Image removed due to copyright restrictions.
See: Figure one in Park, Denise C., and Patricia Reuter-Lorenz. "The Adaptive Brain: Aging and Neurocognitive Scaffolding." *Annual Review of Psychology* 60 (2009): 173-96.

ADULT DEVELOPMENT

- **cross-sectional vs. longitudinal designs**

Cross-sectional

fast

cohort effects

Longitudinal

slow

more accurate

practice effects

Age-related changes in cognition: Cross-sectional vs. Longitudinal data

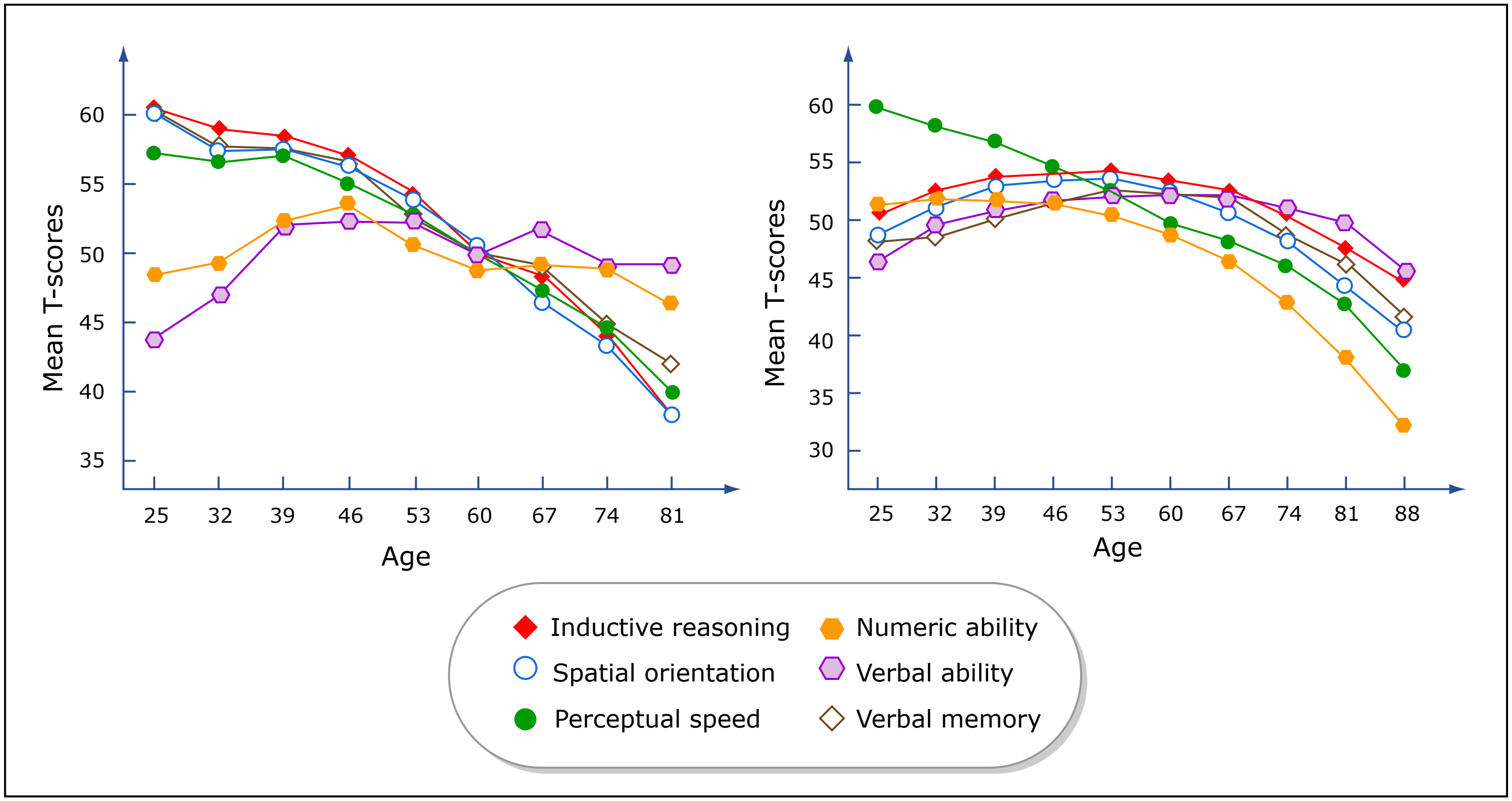


Image by MIT OpenCourseWare.

In cross-sectional data, aging leads to increased knowledge and experience, but decreased processing capacity (WM, memory, speed). Developmental changes in cognition measured (a) cross-sectionally and (b) longitudinally (7-year interval).

Figure based on the Seattle Longitudinal Study at the University of Washington (http://www.uwpsychiatry.org/sls/).

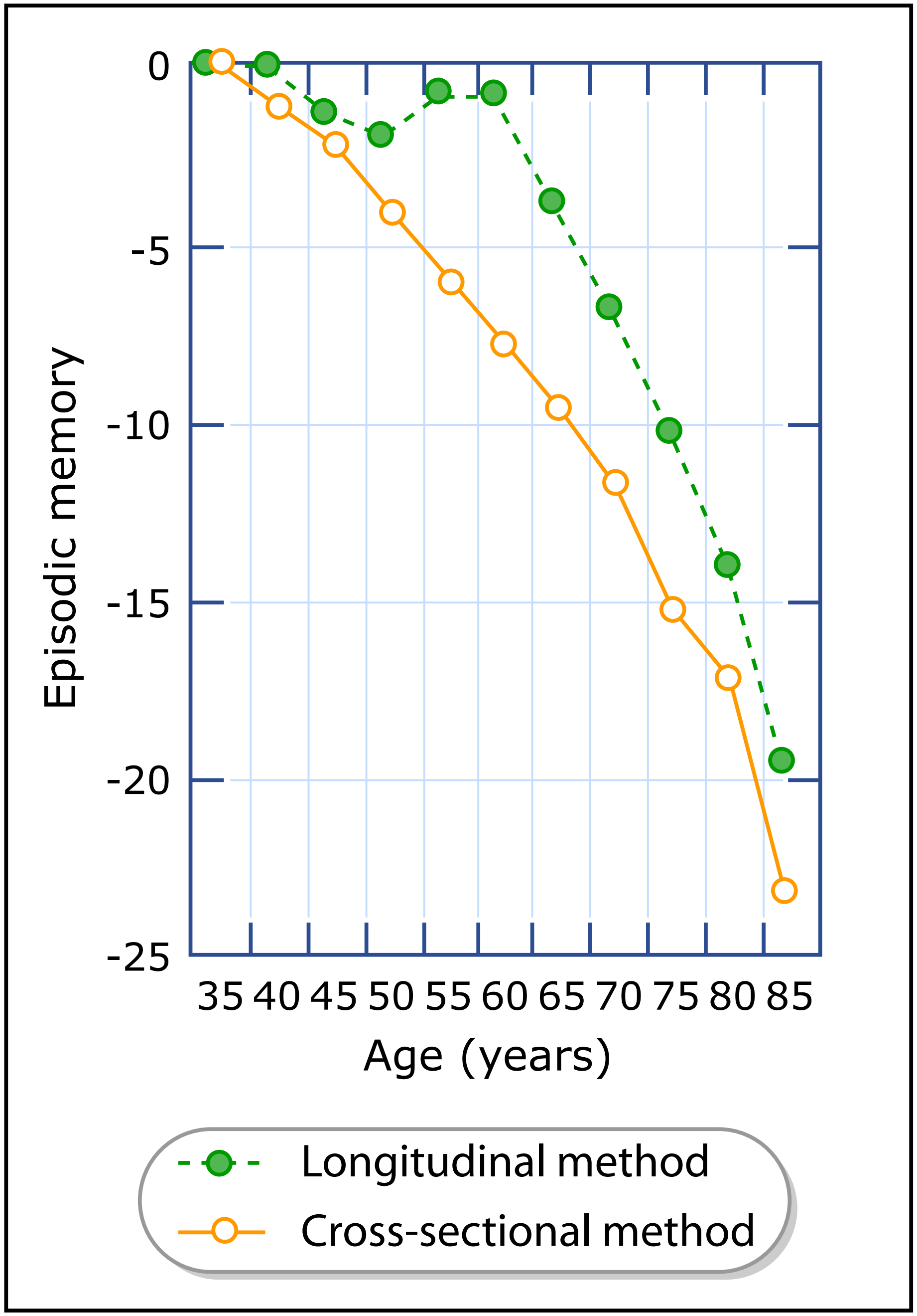
Aging: Loss of Speed vs. Gain in Knowledge/Expertise

- air traffic controllers in Canada – US retirement is 55 – Canada is 65 – age influenced simple processing speed, but not task performance
- 118 pilots – 40-69 years of age – flight simulators – tested 3 times across 3 years – older pilots worse in Year 1 – then were better in Years 2/3

DOES MEMORY DECLINE WITH AGE?

- **yes for declarative memory**
  mildly, steadily in healthy aging
  severely in Alzheimer’s disease

- **implicit memory (repetition priming)**
  can be minimally influenced by age
  and even by Alzheimer’s disease



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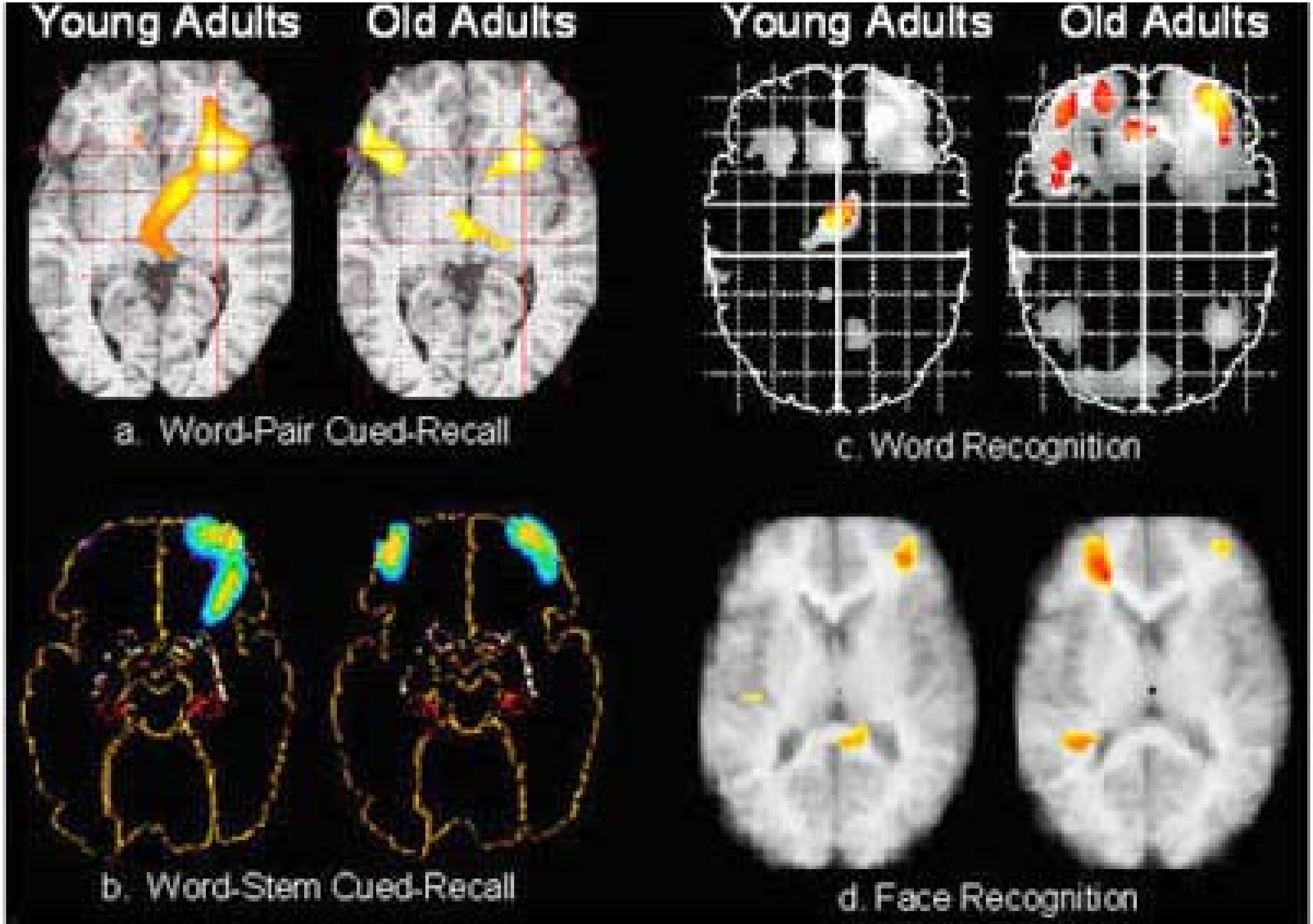
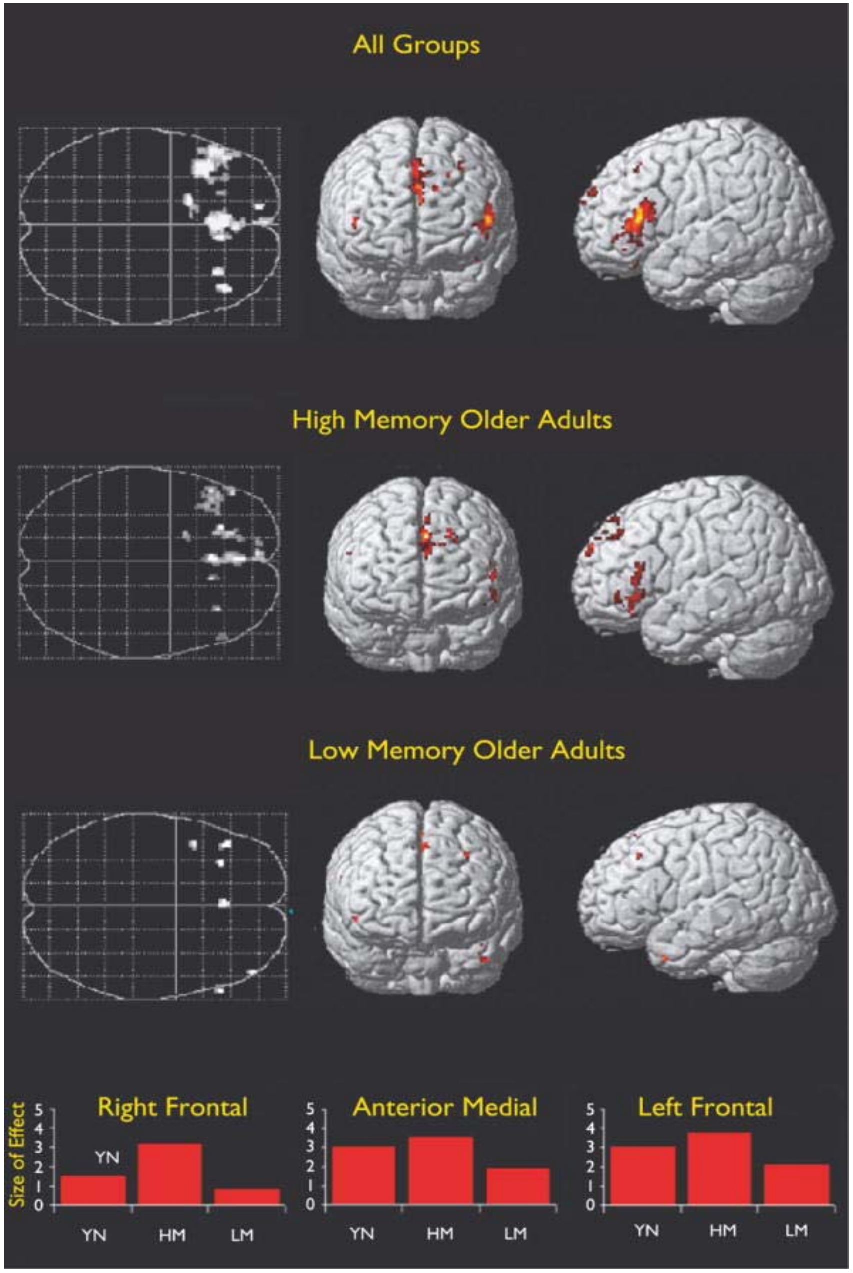
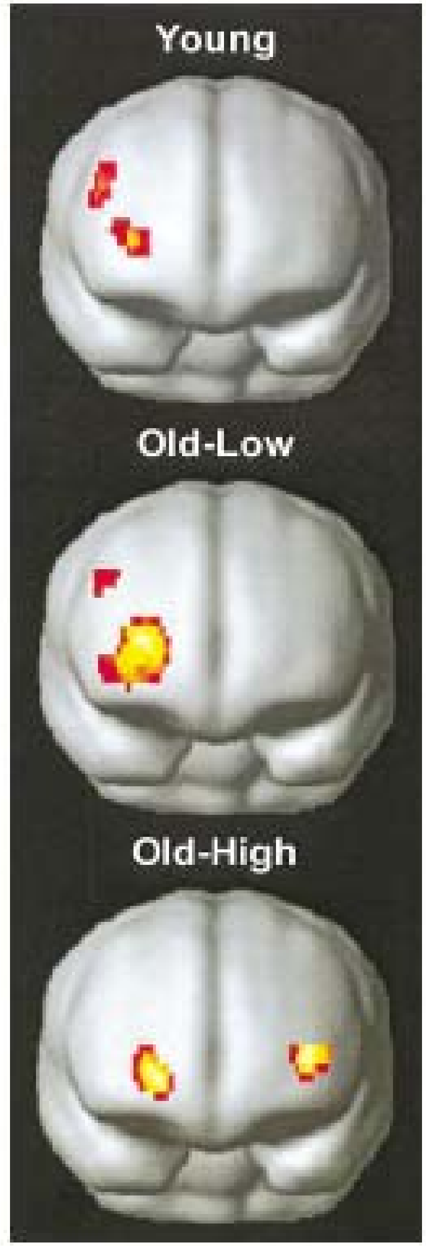


Figures from Cabeza, Roberto. "Hemispheric Asymmetry Reduction In Older Adults: The HAROLD Model." *Psychology and Aging* 17, no. 1 (2002): 85-100. Courtesy of the American Psychological Association. Used with permission.

Reduction of Hemispheric Asymmetry in Aging

- bad? loss of specialization; leakage
- good? compensatory mechanism





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Rosen et al., NeuroReport, 2002

Cabeza et al., NeuroImage, 2002

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Reduction of Hemispheric Asymmetry in Aging

- bad? loss of specialization; leakage
- good? compensatory mechanism
- good - associated with better aging

Factors that Minimize Cognitive Loss

- education (cognitive reserve, not protection from AD)
- lifelong cognitive activity
- high conscientiousness
- exercise

Exercise, Aging, & Brain

• **relatively sedentary people over 60 randomly assigned to two groups**

- **aerobic training (walking, swimming)**

- **non-aerobic training (toning/stretching)**

-**hour/day, several times/week, for months**

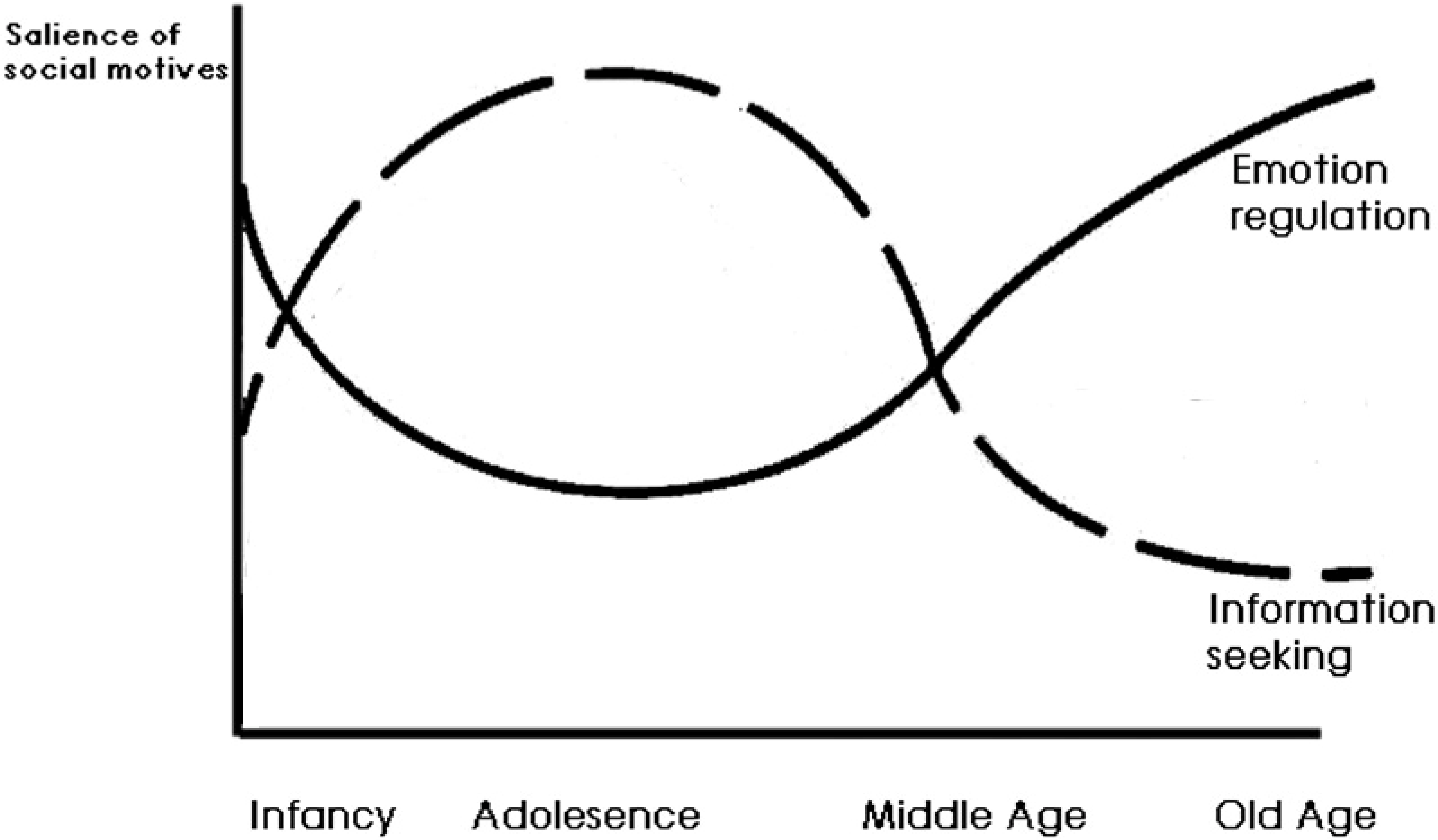
• **cognitive benefits? brain changes?**

CAN ATTITUDES ABOUT AGING INFLUENCE HEALTHY AGING?

• 440 healthy people under 50 in Baltimore Longitudinal Study of Aging
• questionnaire on attitudes about aging
- are older people more absent-minded or less intelligent
• examine cardio-vascular (CV) events of stroke or heart attack 38 years later

Socioemotional Selectivity Theory

Regardless of chronological age, when time in life is limited, people focus more on social goals related to emotional meaning and emotional satisfaction and less on those related to knowledge acquisition (e.g., Carstensen, Isaacowitz, & Charles, 1999)



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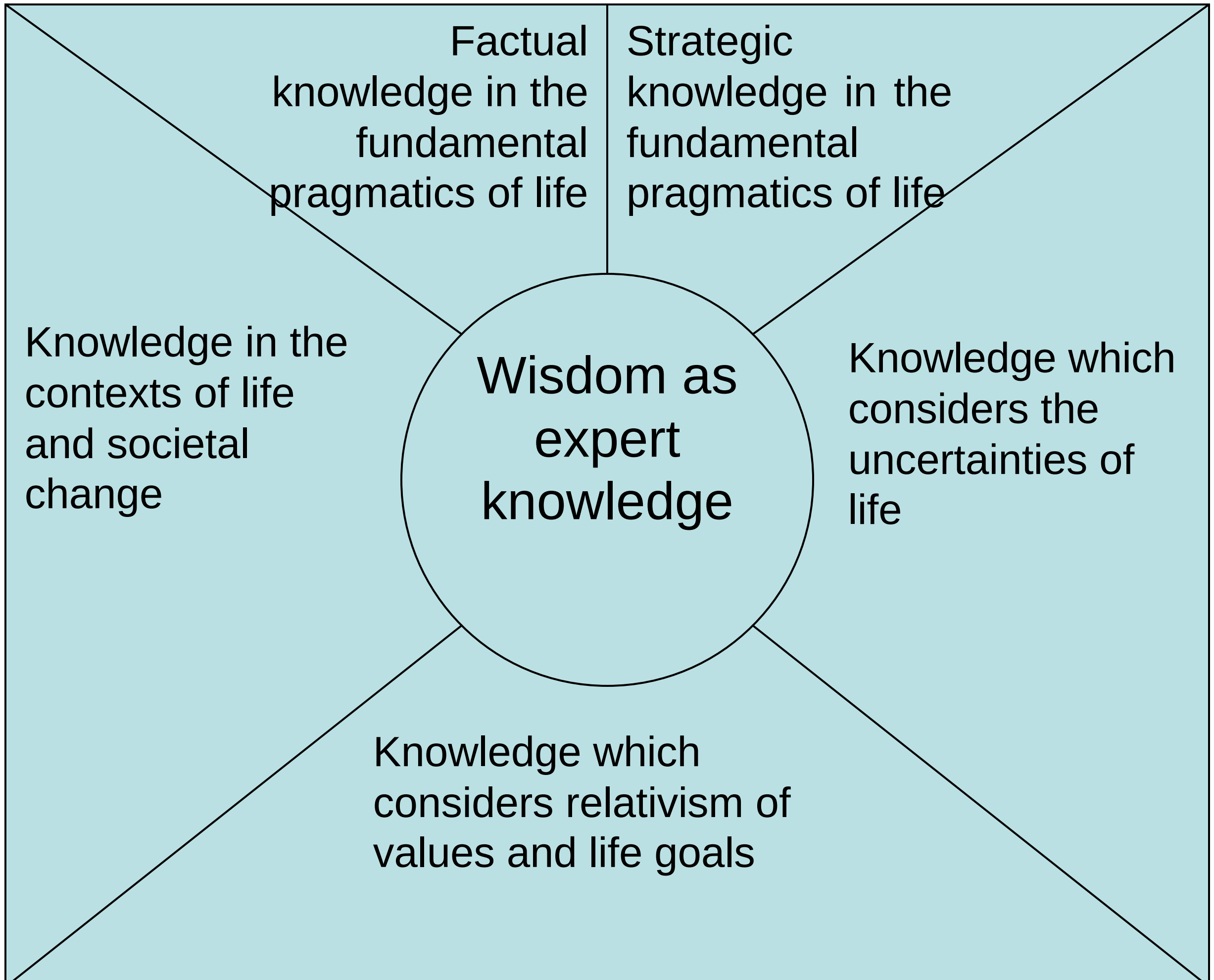
The Berlin model of wisdom as an expertise in the fundamental pragmatics of life



Definition of wisdom: good judgment and advice about important but uncertain matters of life.

Socioemotional Selectivity Theory

- **motivations and goals set by temporal context**
  - **time perceived as limited**

    ↑ **current emotions**

    ↓ **novelty, information acquisition**

    - **emotion > non-emotion**
    - **positive > negative emotions**

    Positivity Bias in older age

Courtesy of Life-span Development Laboratory. Used with permission.

Advertisements used to the way age affects preferences and memories for products. While the photographs are the same, one slogan has emotional appeal and one has adventure appeal.

Carstensen, <u>Science</u>, 2006

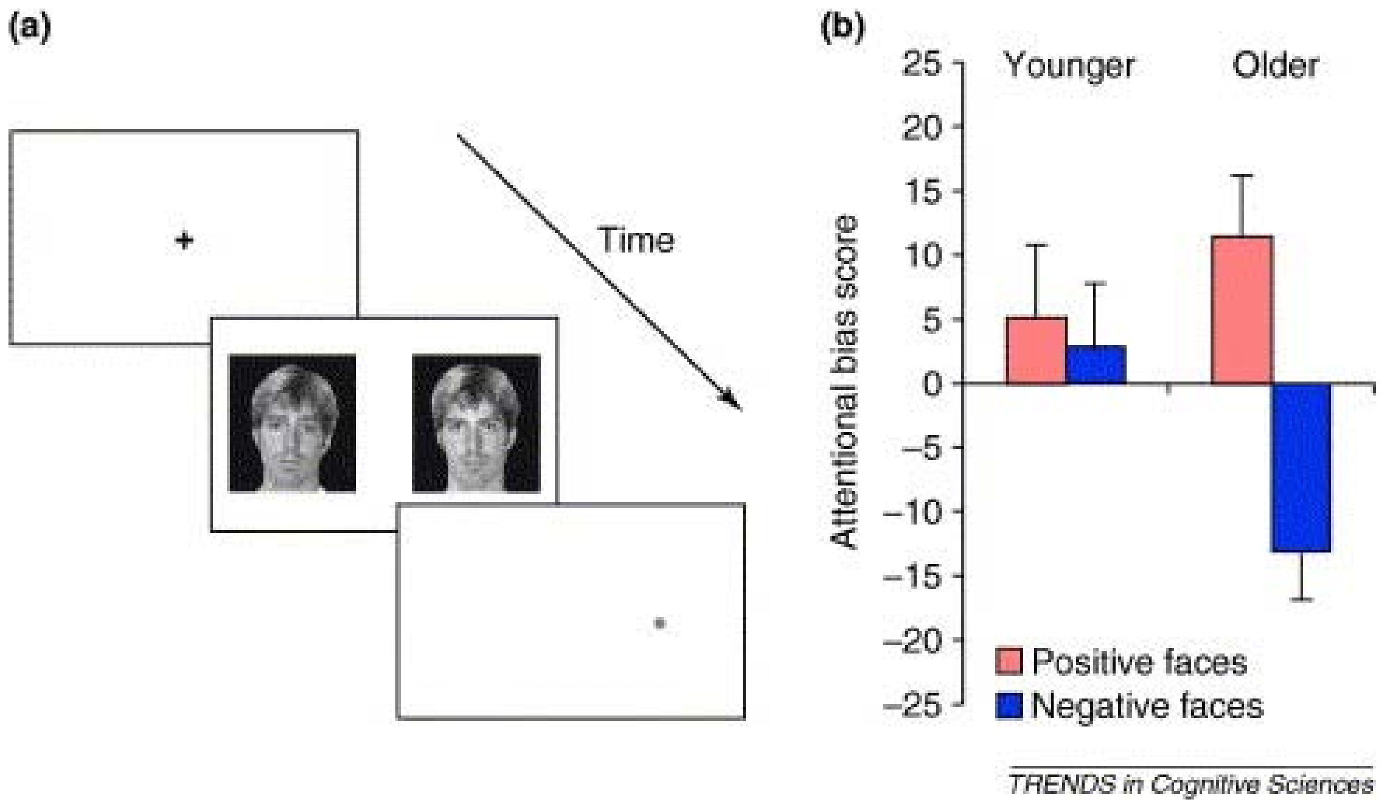


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Figure 1. (a) The display in the dot-probe task. **(b)** Attentional bias scores of younger and older groups of adults. Positive scores indicate faster responses to dot appearing behind emotional faces than behind neutral faces. Older adults showed higher scores to positive faces and lower scores to negative faces than younger adults.

Mather & Carstensen, Trends in Cognitive Sciences, 2005

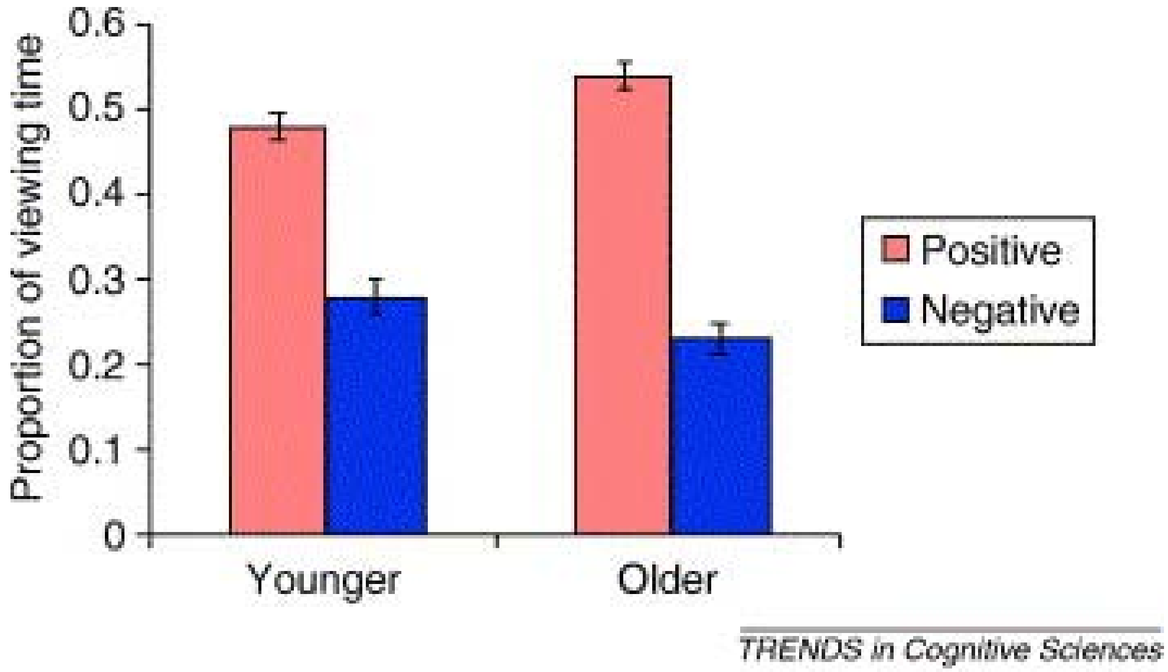

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Figure 2. Total viewing time of older and younger adults for positive and negative car option features, when asked to choose a car.

Mather & Carstensen, <u>Trends in Cognitive Sciences</u>, 2005

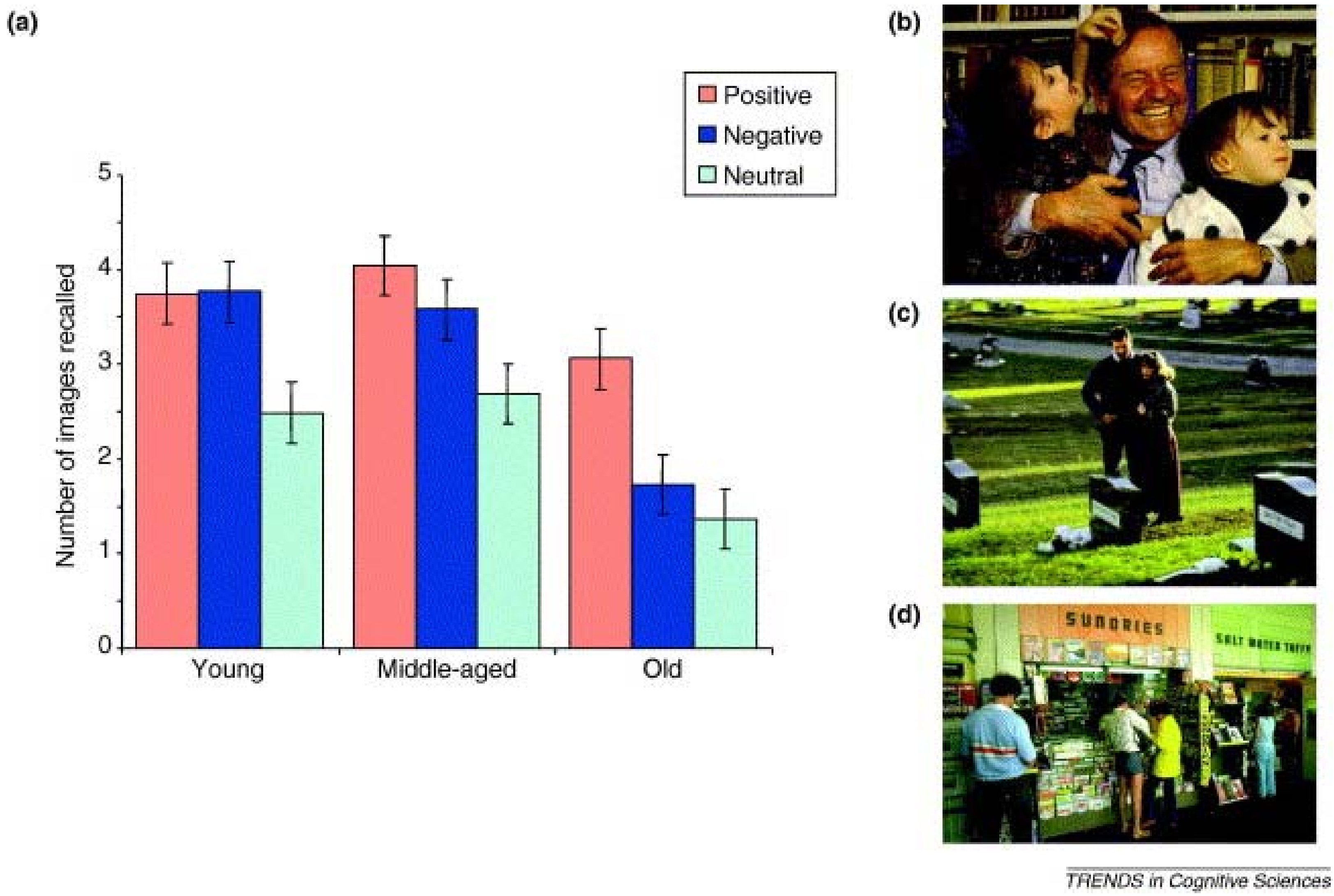

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Figure 3. (a) Total number of pictures recalled by younger (18–29 years old), middle-aged (41–53 years old), and older (65–80 years old) adults; examples of **(b)** positive, **(c)** neutral and **(d)** negative pictures seen in the experiment.

Mather & Carstensen, Trends in Cognitive Sciences, 2005

EMPHASIS ON EMOTION

Age or Time?

- **moving towns**
- **early death**
- **inner city gangs**

temporal horizon

Memory for emotionally positive, negative, and neutral pictures

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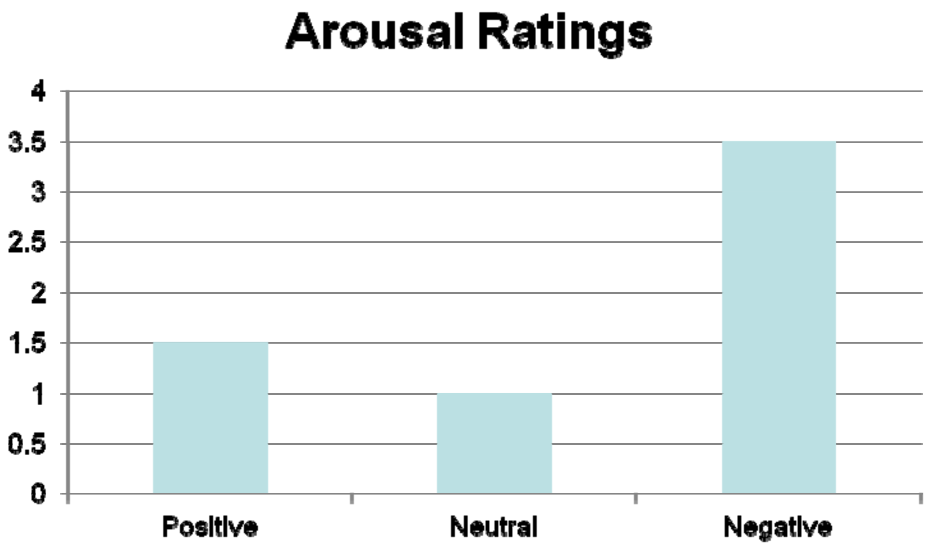
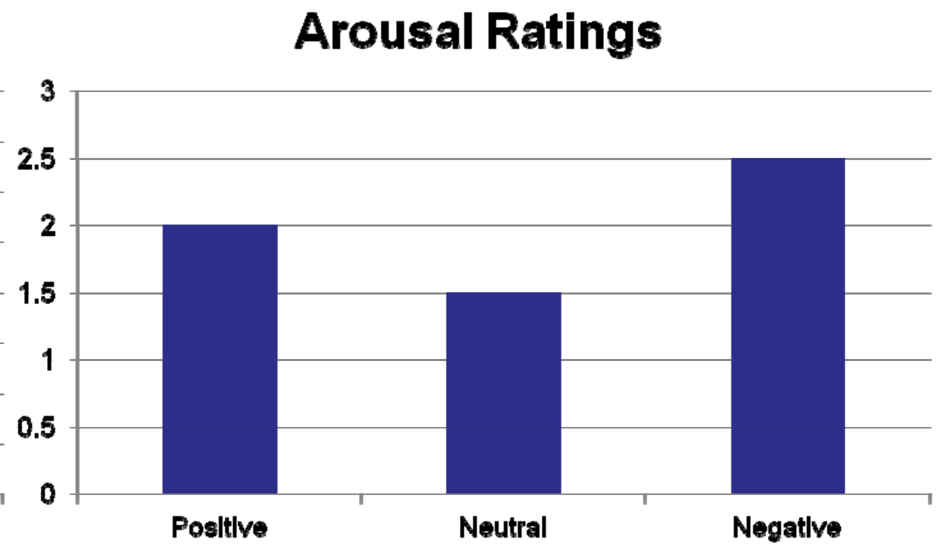
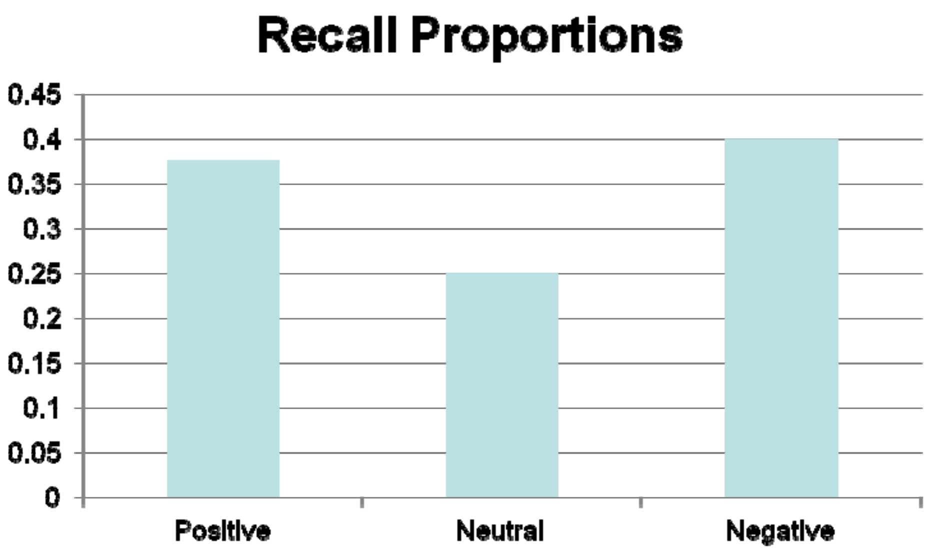


younger

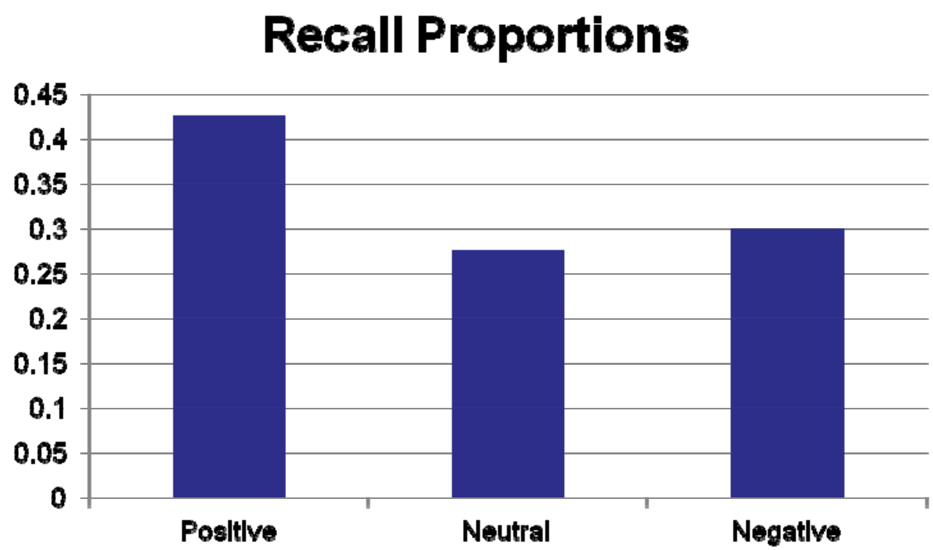


older

Recall Proportions

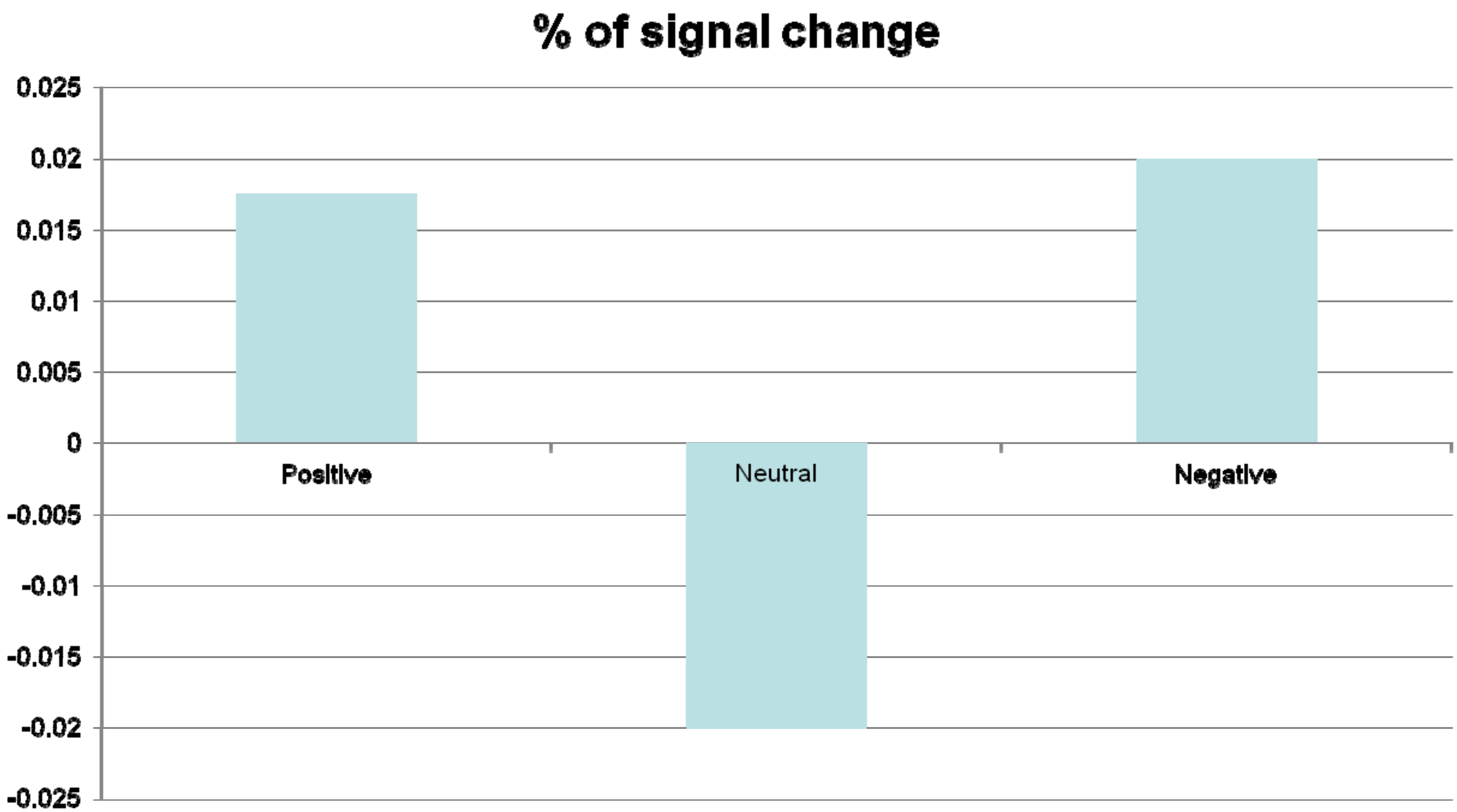


younger

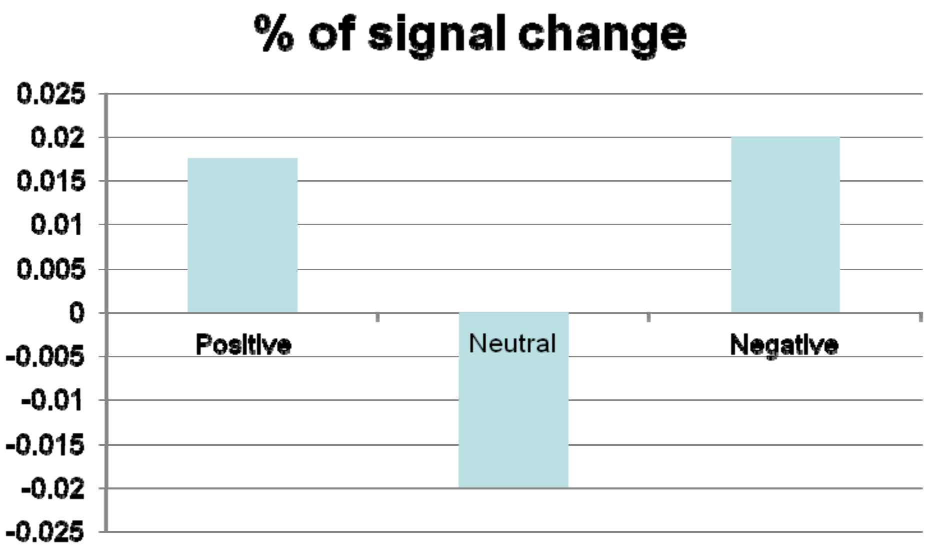


older

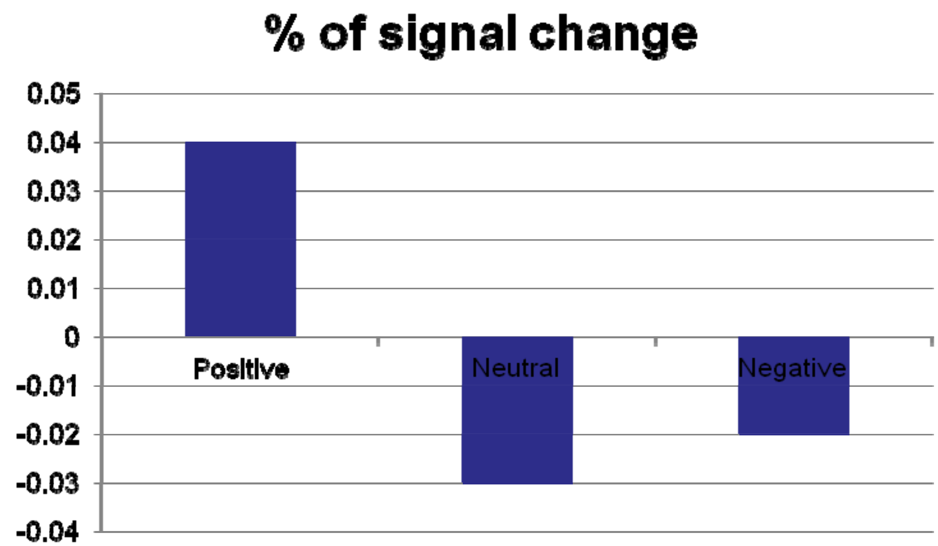
Amygdala Activity



Amygdala Activity

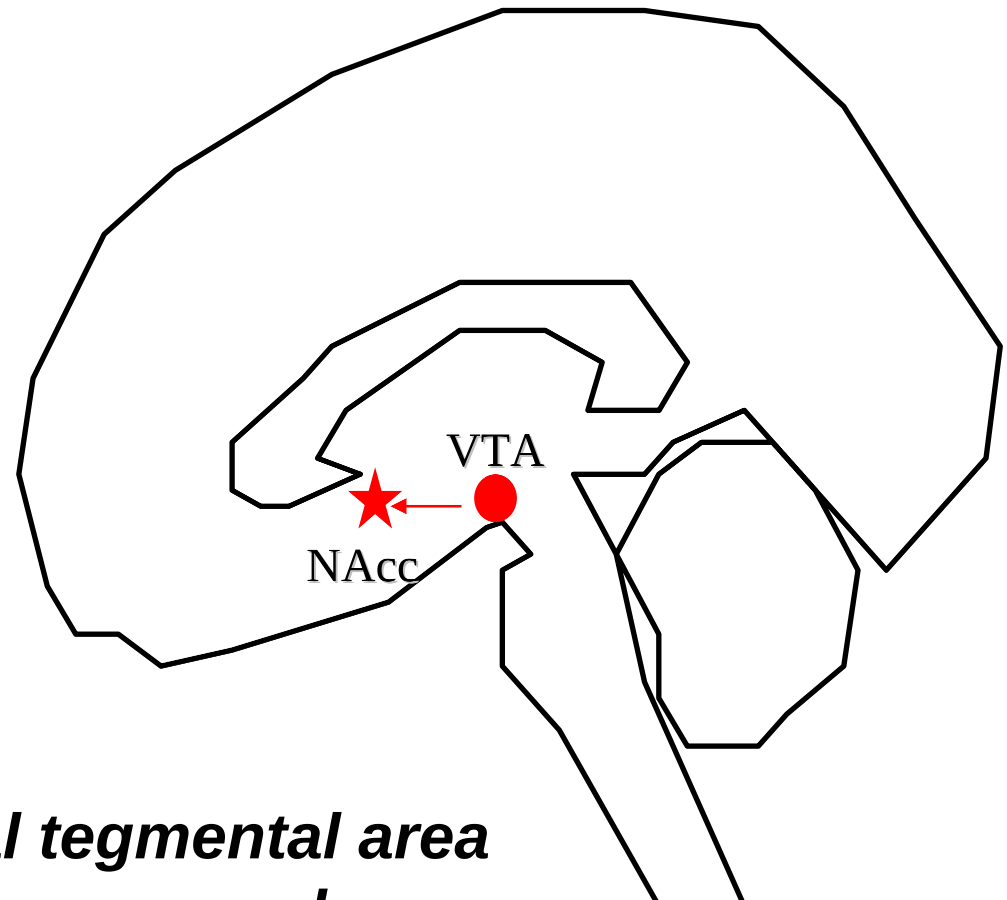


younger



older

Reward System: Dopamine Projection Targets

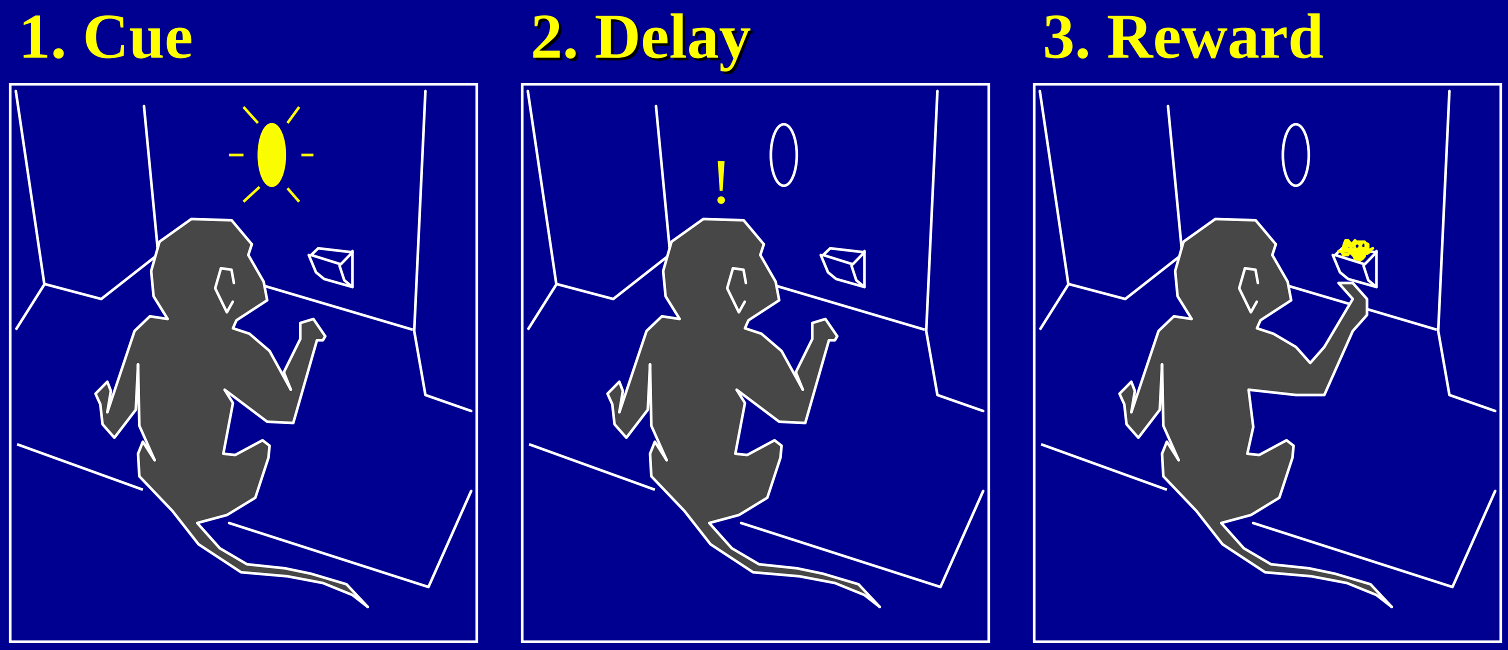


VTA = ventral tegmental area
NAcc = nucleus accumbens

Reward Anticipation

- DA from ventral tegmental area (VTA) to nucleus accumbens (NAcc)
- After learning, VTA cells respond to cue
  - Electrophysiologically (Shultz et al., 2000)
  - NAcc activation (Knutson et al., 2001)

Incentive delay in monkeys



Schultz W et al. (1998) *Neuropharmacology*, 37:421-429.

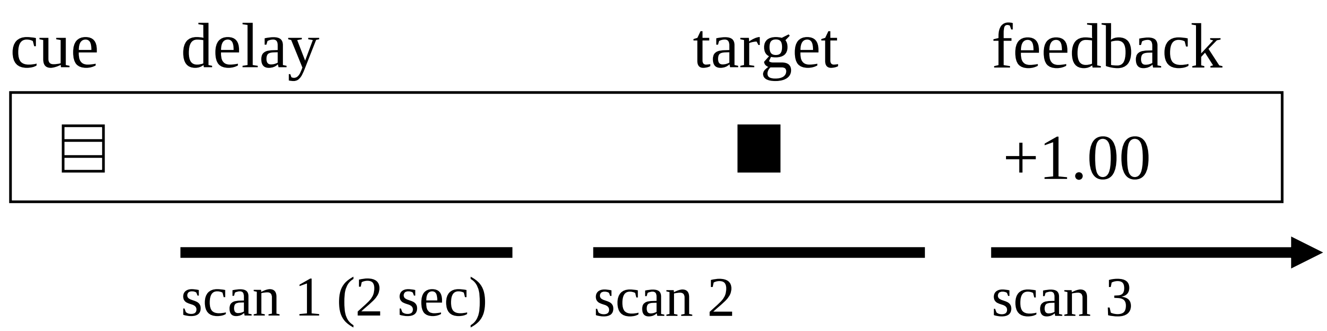
Monetary Incentive Delay Task

(1) See a ***cue*** (500 msec)

(2) Wait a variable ***delay*** (2-2.5 sec)

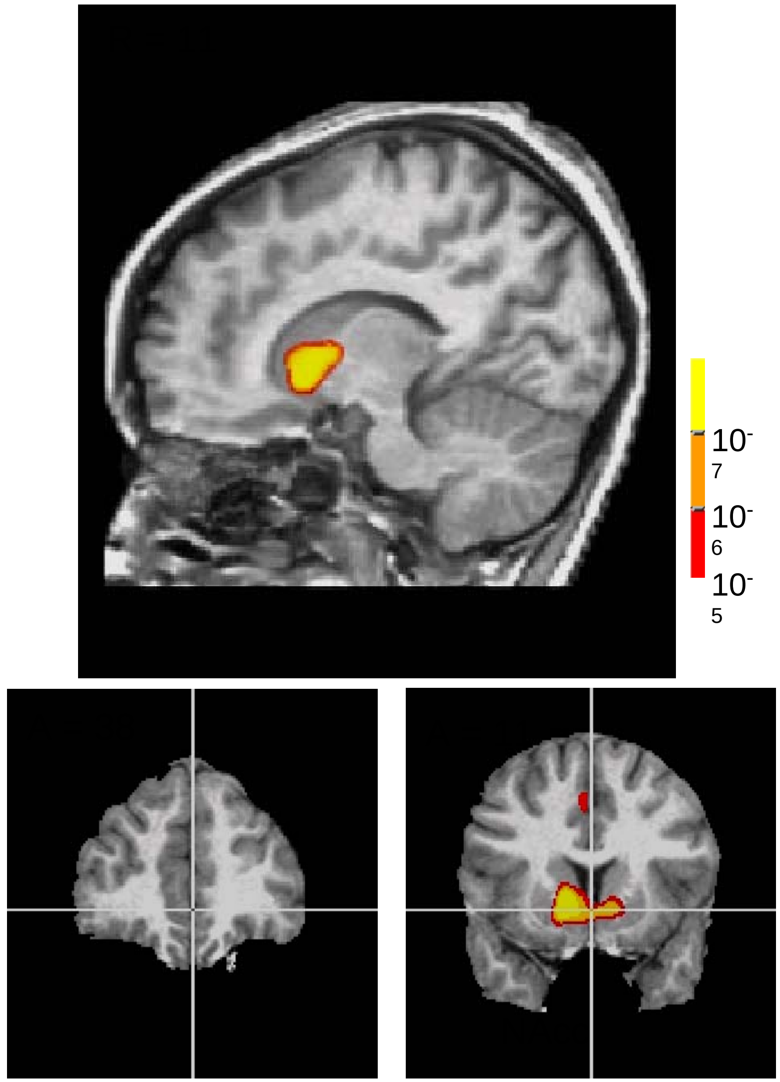
(3) Respond to a ***target*** with a button press (160-260 msec)

(4) View performance ***feedback*** (500 msec)



Knutson B et al. (2000) *NeuroImage*

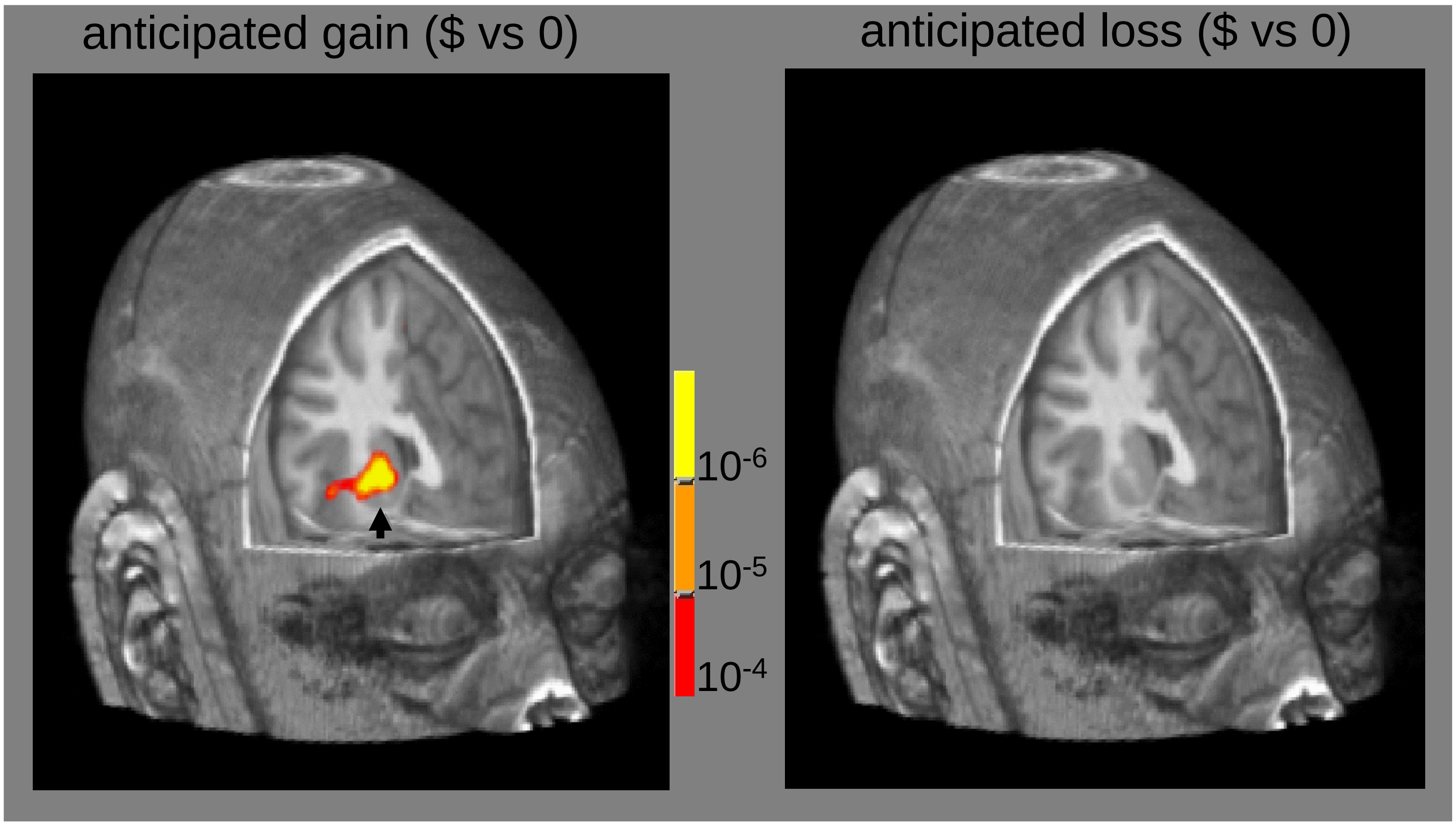
NAcc recruited by anticipation of responding for a reward versus nonreward



Courtesy of Brian Knutson. Used with permission.

Knutson B et al. (2001) *J Neuroscience*

Gain anticipation activates NAcc



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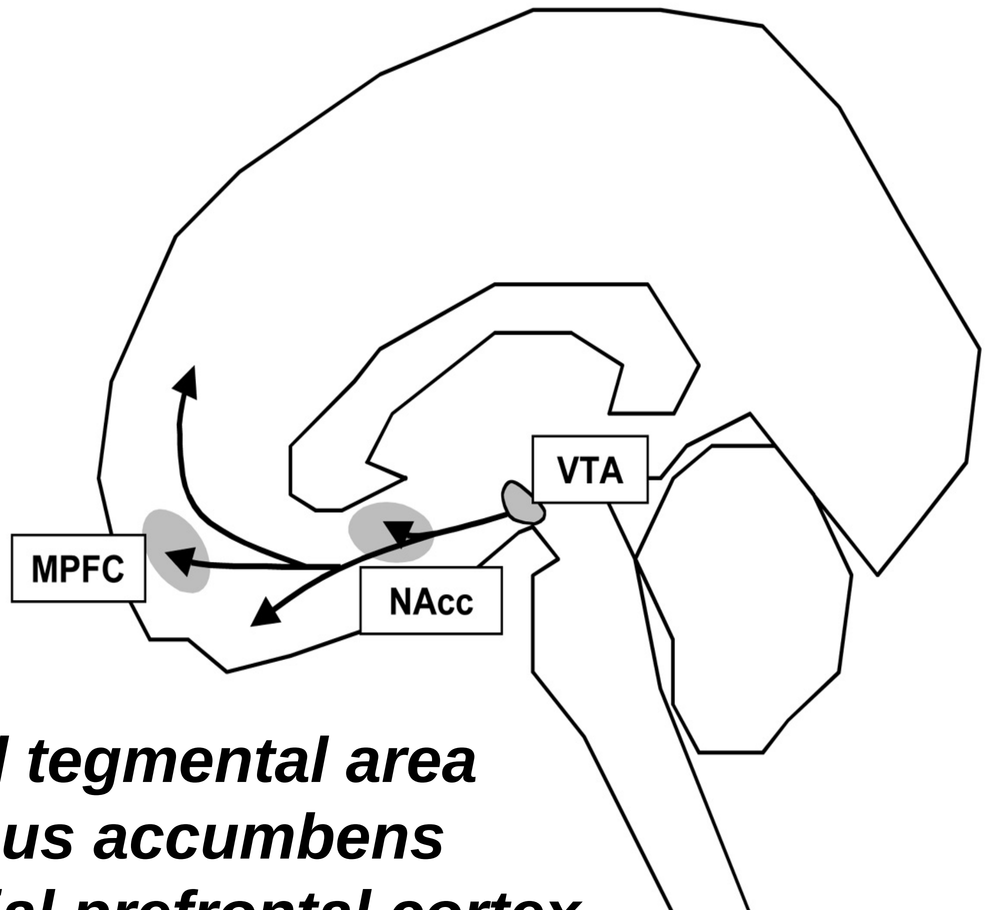
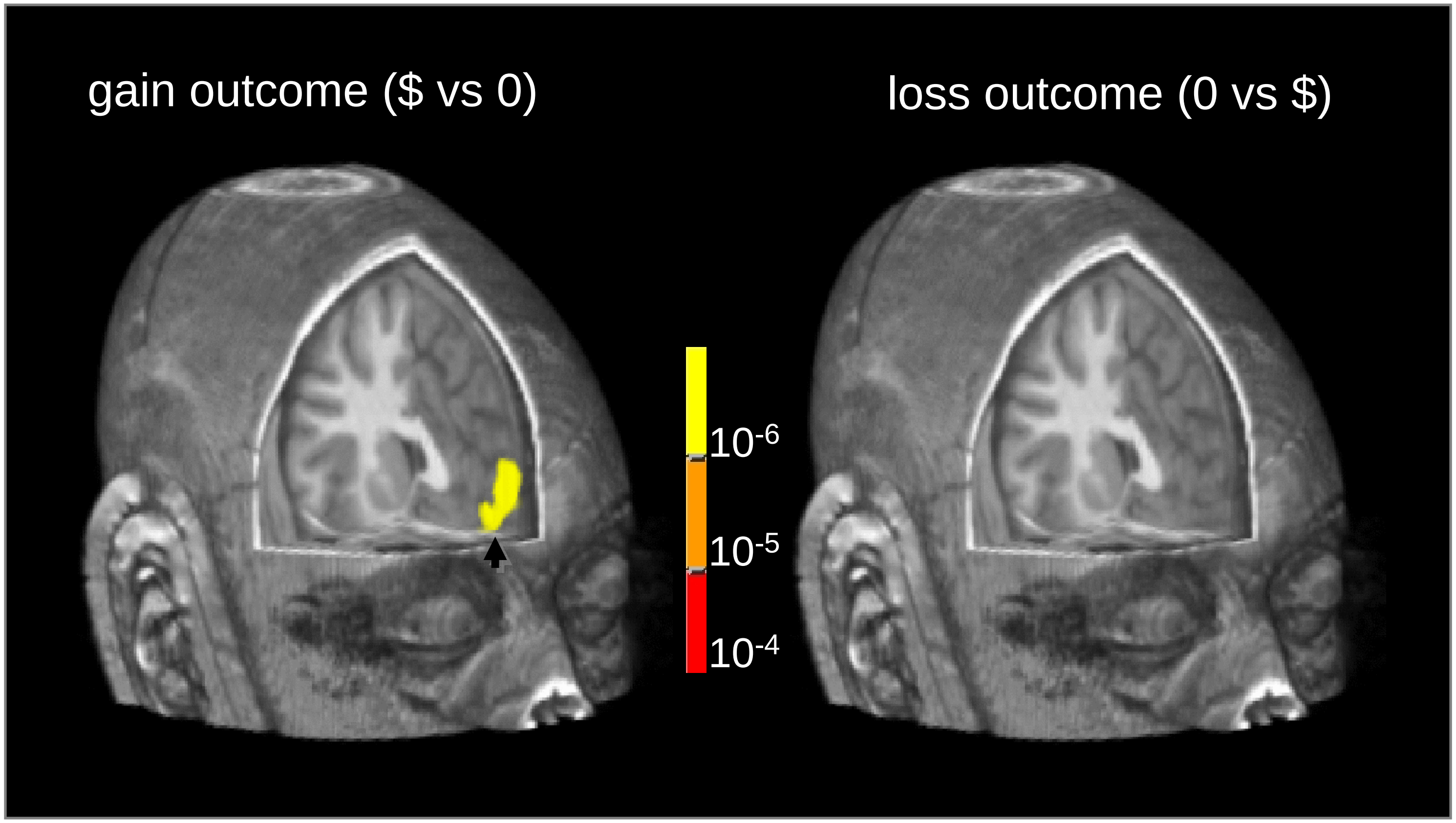
Mesolimbic Dopamine Projections



VTA = ventral tegmental area
NAcc = nucleus accumbens
MPFC = medial prefrontal cortex

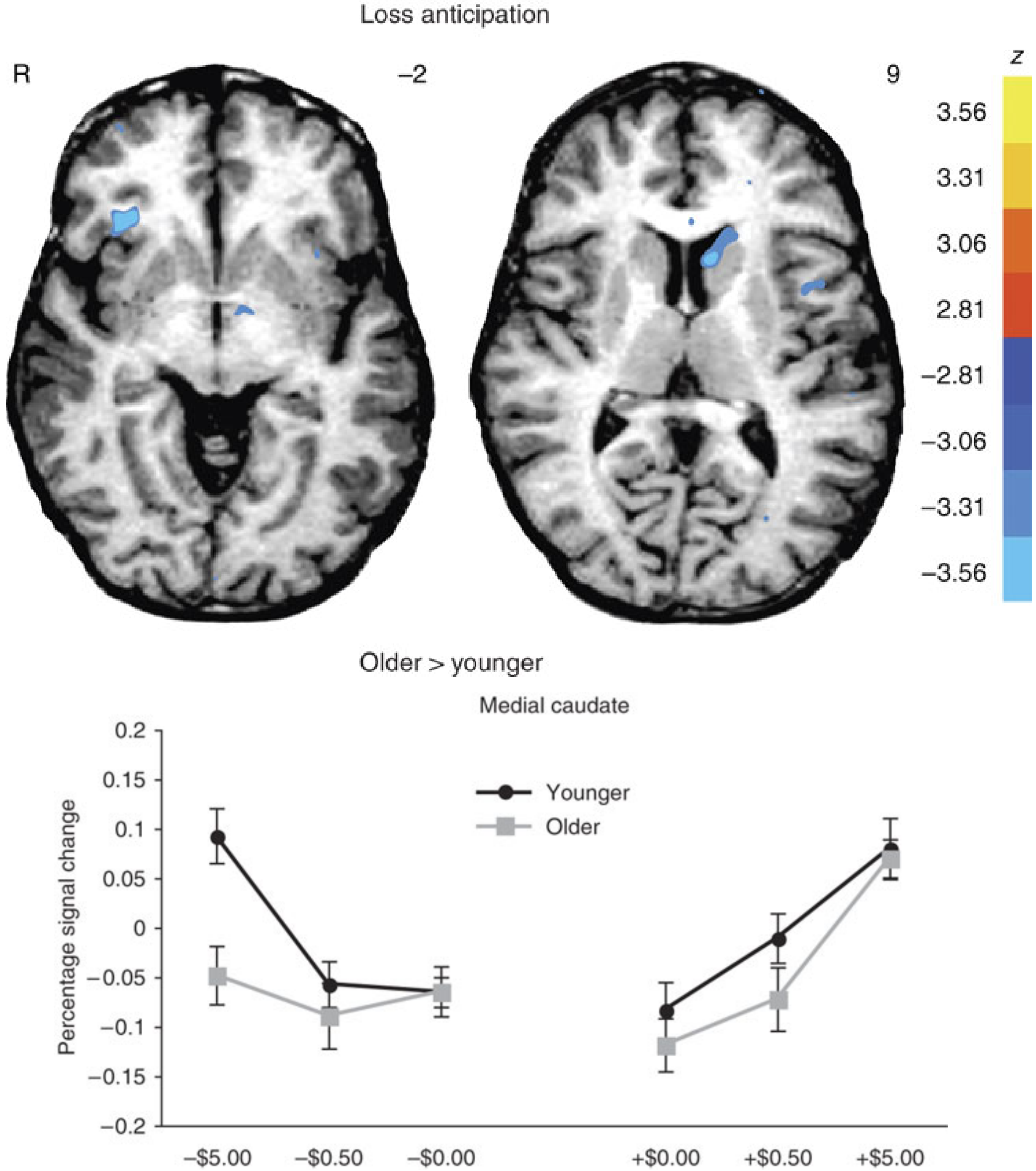
Gain outcomes activate MPFC



Courtesy of Brian Knutson. Used with permission.

Knutson B et al. (2003) *NeuroImage*

OLDER PEOPLE LESS RESPONSIVE TO POTENTIAL LOSS BUT EQUALLY RESPONSIVE TO POTENTIAL GAIN



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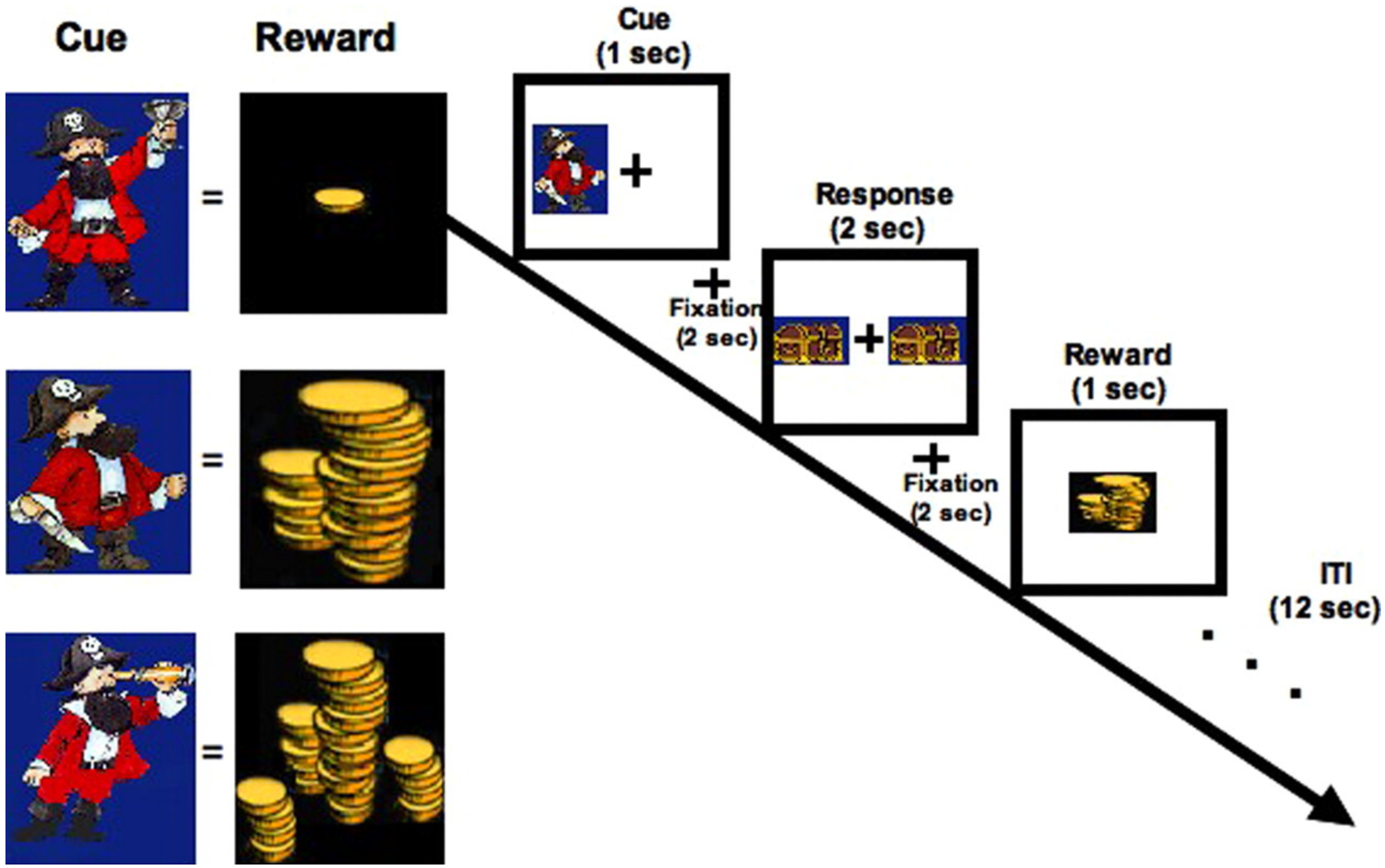
Reward Behavioral Paradigm



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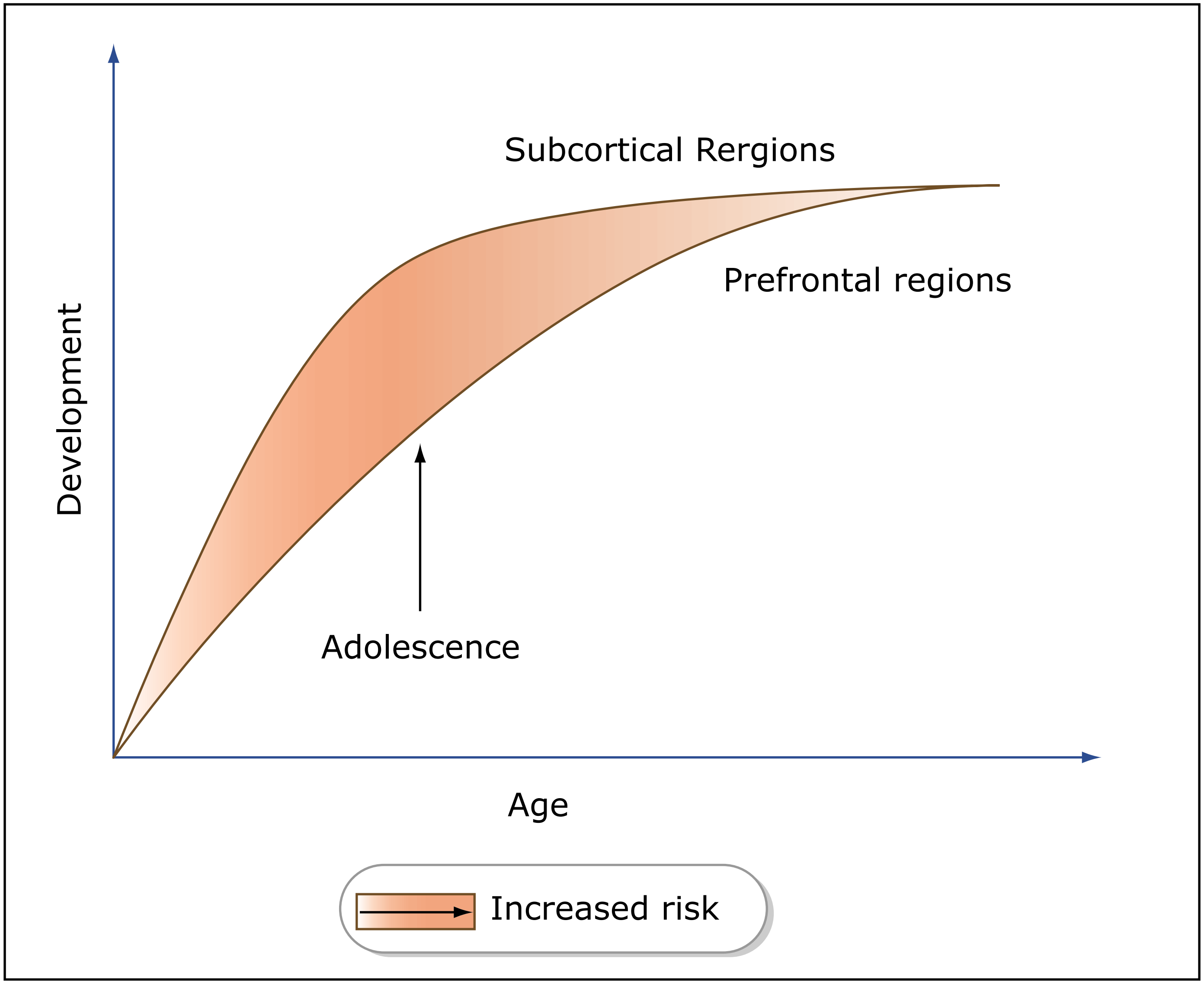

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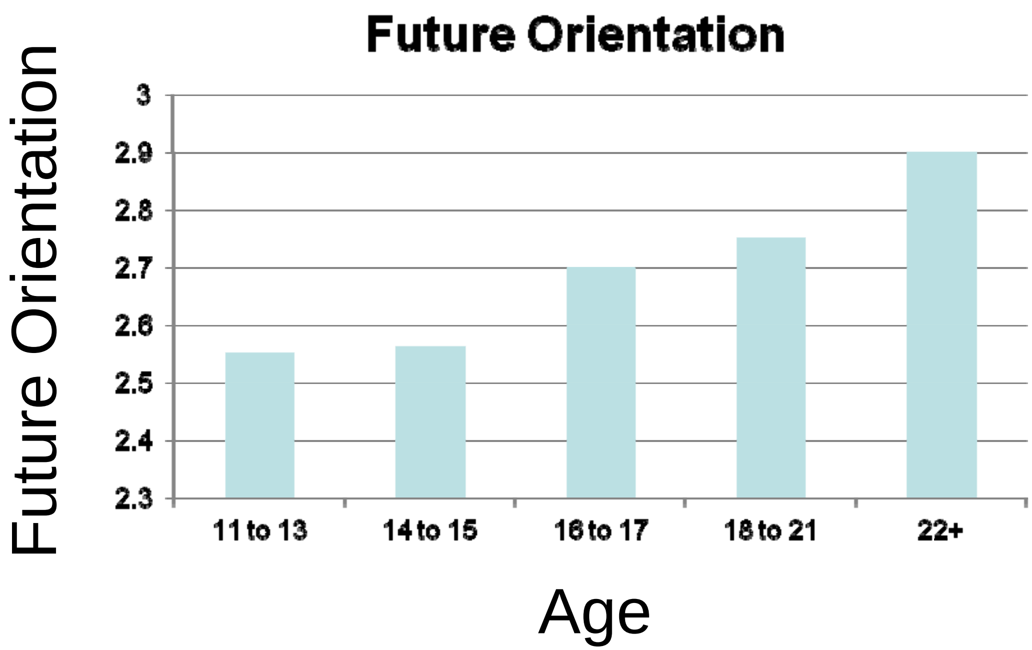
TABLE 2

Adolescent Exposure to Risks and Early Onset of Risk-Taking Behavior

Risk/behavior	Data
Alcohol	40% of adult alcoholics report having initial alcoholism symptoms between the ages of 15 and 19.
Car accidents	Between the ages of 16 and 20, both sexes are at least twice as likely to be in accidents than are drivers between the ages of 20 and 50. These accidents are the leading cause of adolescent death.
Gambling	Pathological or problem gambling is found in 10% to 14% of adolescents, and gambling typically begins by age 12.
Sexual activity	Adolescents are more likely than adults to engage in impulsive sexual behavior, to have multiple partners, and to not use contraception. Younger teens (12–14 years) are more likely to engage in risky sexual behavior than are older teens (16–19 years).
STDs	Annually, 3 million adolescents contract a sexually transmitted disease. HIV infection is the seventh leading cause of death among 13- to 24-year-olds.

Note. Data sources include Bachanas et al. (2002); Chambers & Potenza (2003); Chambers, Taylor, & Potenza (2003); and Turner & McClure (2003).

Courtesy of Association for Psychological Science. Used with permission.


Future Orientation
Future Orientation
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
11 to 13
14 to 15
16 to 17
18 to 21
22+
Age

Creating False/Illusory Memories

***(sweet)* - associates**

sour
candy
sugar
bitter
good
taste
tooth
nice
honey
soda
chocolate
heart
cake
tart
pie

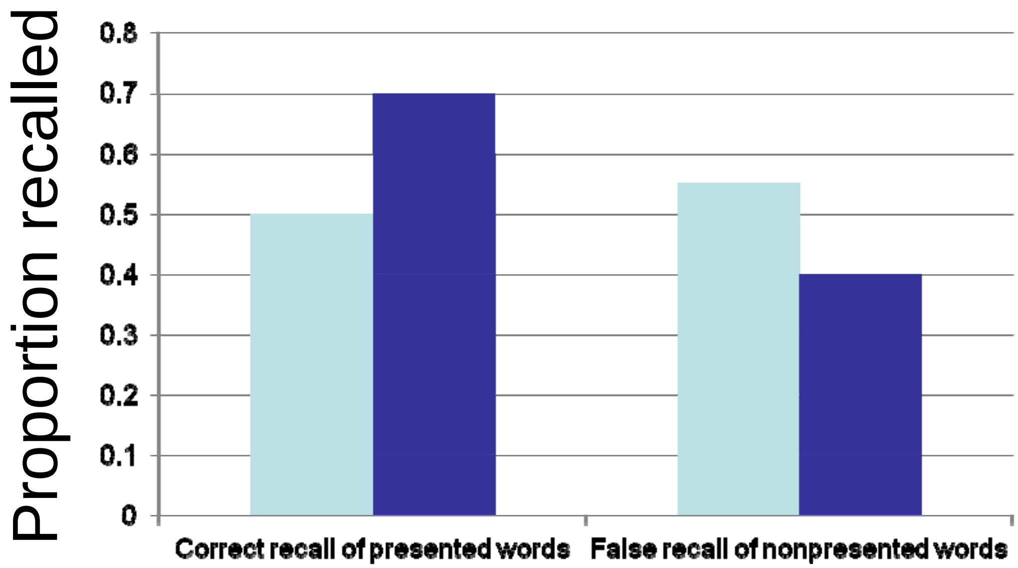
recall/recognition

false lure

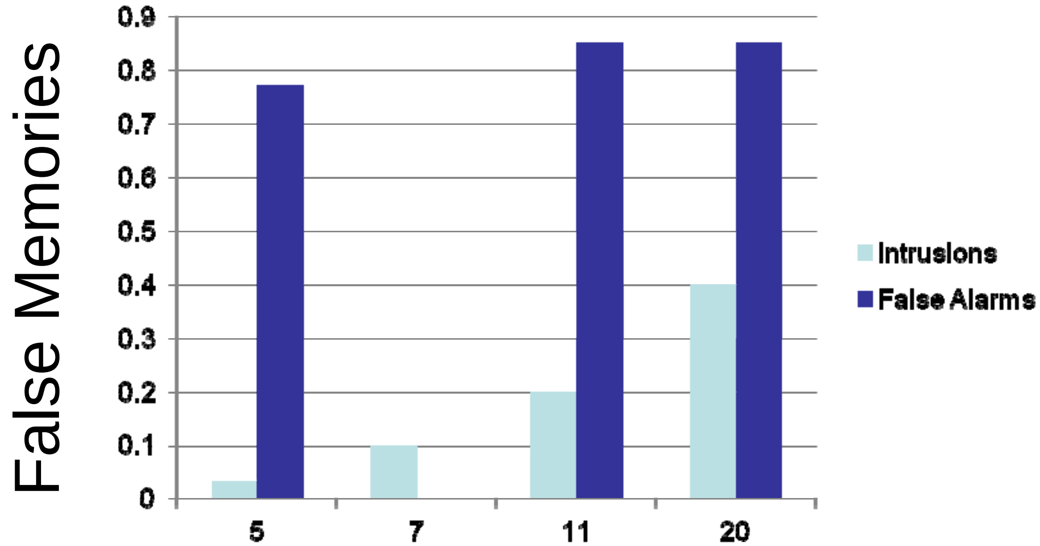
sweet

veridical details
vs.
essential gist

Older Adults Have More False Memories

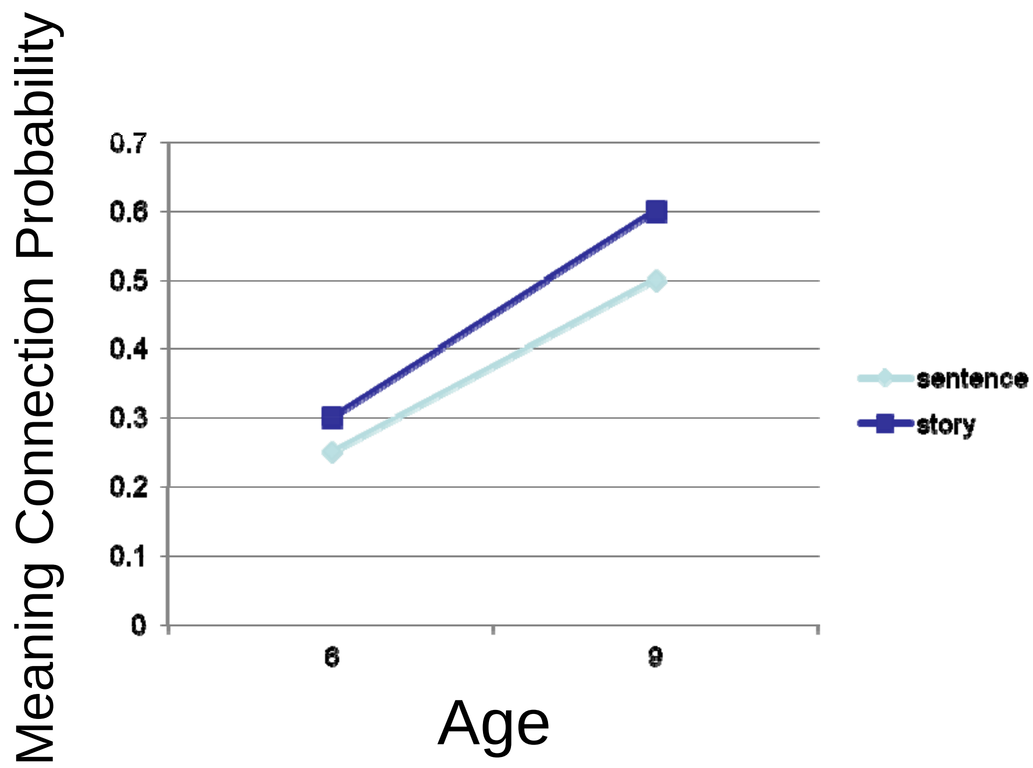


Children Have Fewer False Memories Than Adults

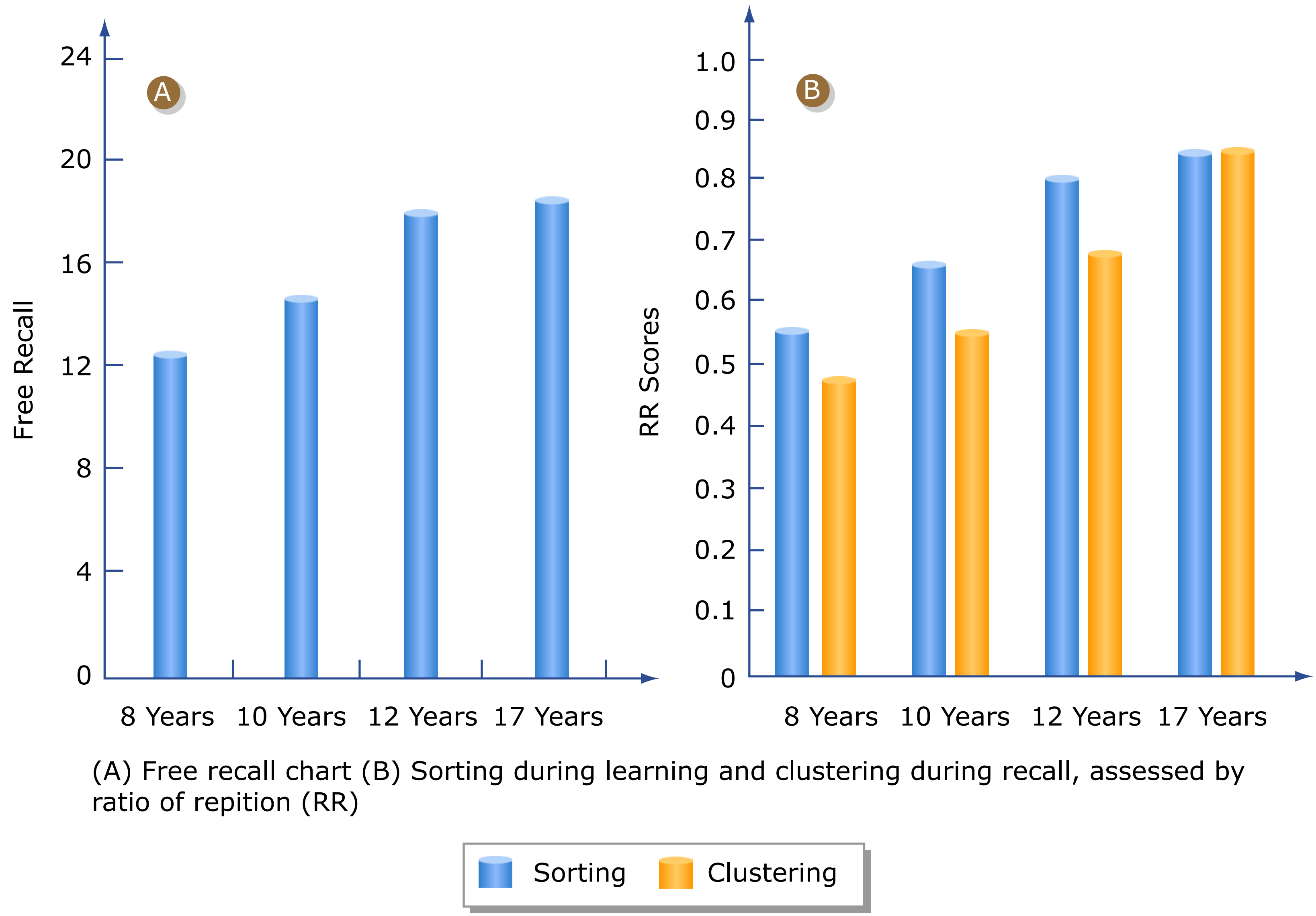


Intrusion = False Memory

Developmental Increase in Connecting Ideas Across Words in a Sentence or Sentences in a Story



Greater Conceptual Organization of Memory in Development



(A) Free recall chart (B) Sorting during learning and clustering during recall, assessed by ratio of repition (RR)

Image by MIT OpenCourseWare.

Physical and Social Transitivity

- ***physical transitivity***

  line A longer than line B

  line B longer than line C

  is line A longer than line C?

- ***social transitivity***

  person A is a friend with person B

  person B is a friend with person C

  is person A a friend with person C?

Physical and Social Transitivity

Grade	*physical transitivity*	*social transitivity*
1	.70	.33
2	.75	.50
3	.82	.58
4	.95	.71

Logic vs. Experience (gist)

Framing Heuristic –
Risk Averse for Gains, Risk Taking for Losses

If Program A is adopted, 200 people will be saved.

(72%) - Lives saved

If Program B is adopted, there is a one-third probability that 600 people will be saved, and a two-thirds probability that no people will be saved.

Which Program do you favor?

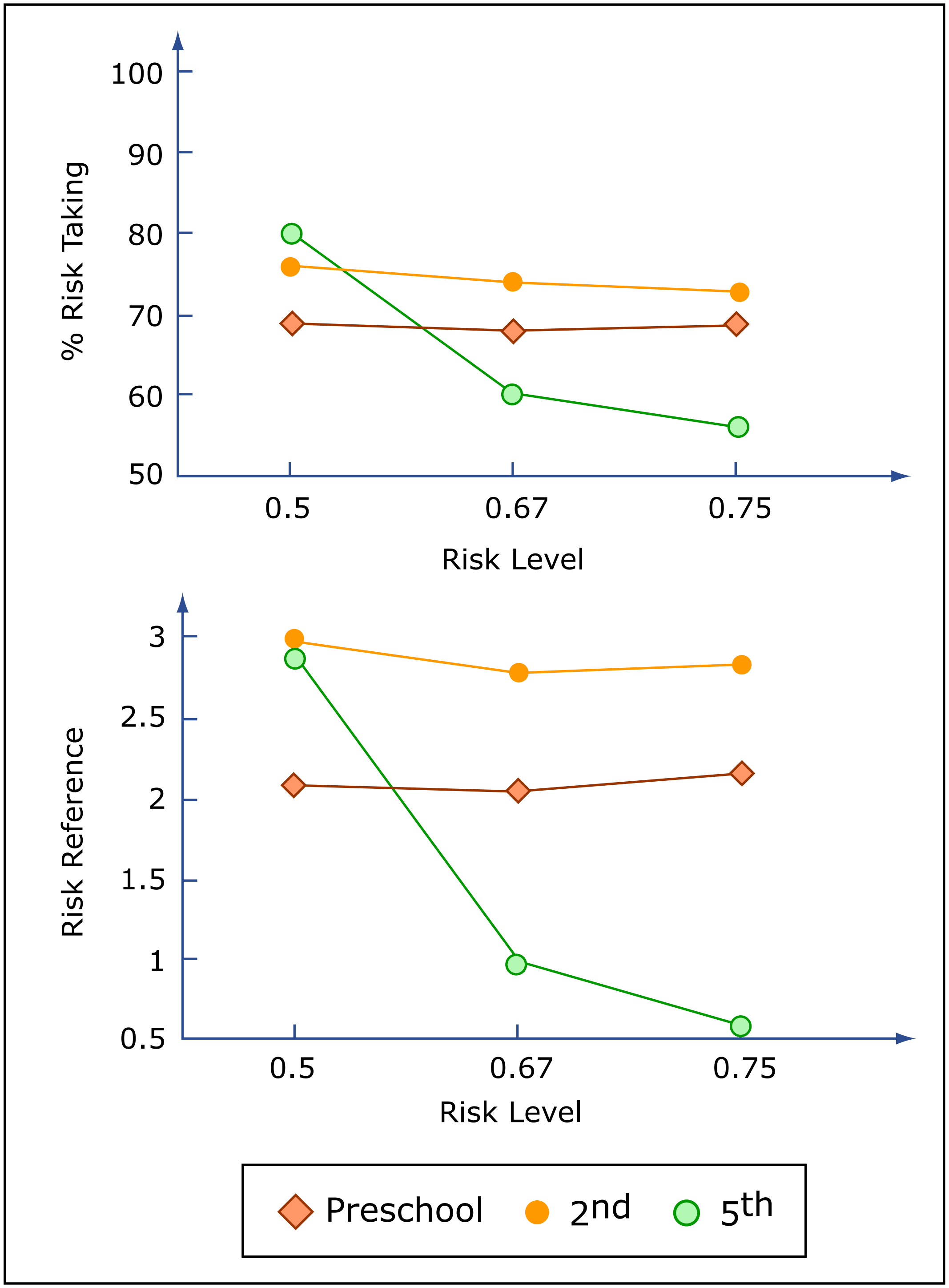
If Program A is adopted, 400 people will die.

(22%) - Lives lost

If Program B is adopted, there is a one-third probability that nobody will die, and a two-thirds probability that 600 people will die.

Which Program do you favor?

Younger Children Have Less Loss Aversion Than Older Children & Adults



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Adolescence

Do adolescents have the same cognitive abilities as adults?

Death penalty for teenage criminals?

Choices

Swim with Sharks?

adult – gist – bad idea, you could die

adolescent – weigh the factors of gain and loss

Have Unprotected Sex?

adult – gist – bad idea, STD, HIV, you could die

adolescent – weigh the factors of gain (sex is fun, a sure thing) and loss (what are the odds I will get infected or die from a single sex act?)

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