INTELLIGENCE

John Gabrieli 9.00

Exam 2 – Next Thursday

50 multiple-choice questions

30 from book (Chapters 5-7)

20 from Sacks & lectures

5 short answers (4 pts)

Select 5 from 8-10 choices

70 points

WHY HAVE TESTS?

WHY HAVE TESTS?

- learning
- selection & prediction
  - *achievement*
  - *aptitude (SAT, GRE)*

Standardized tests and graduate students' success
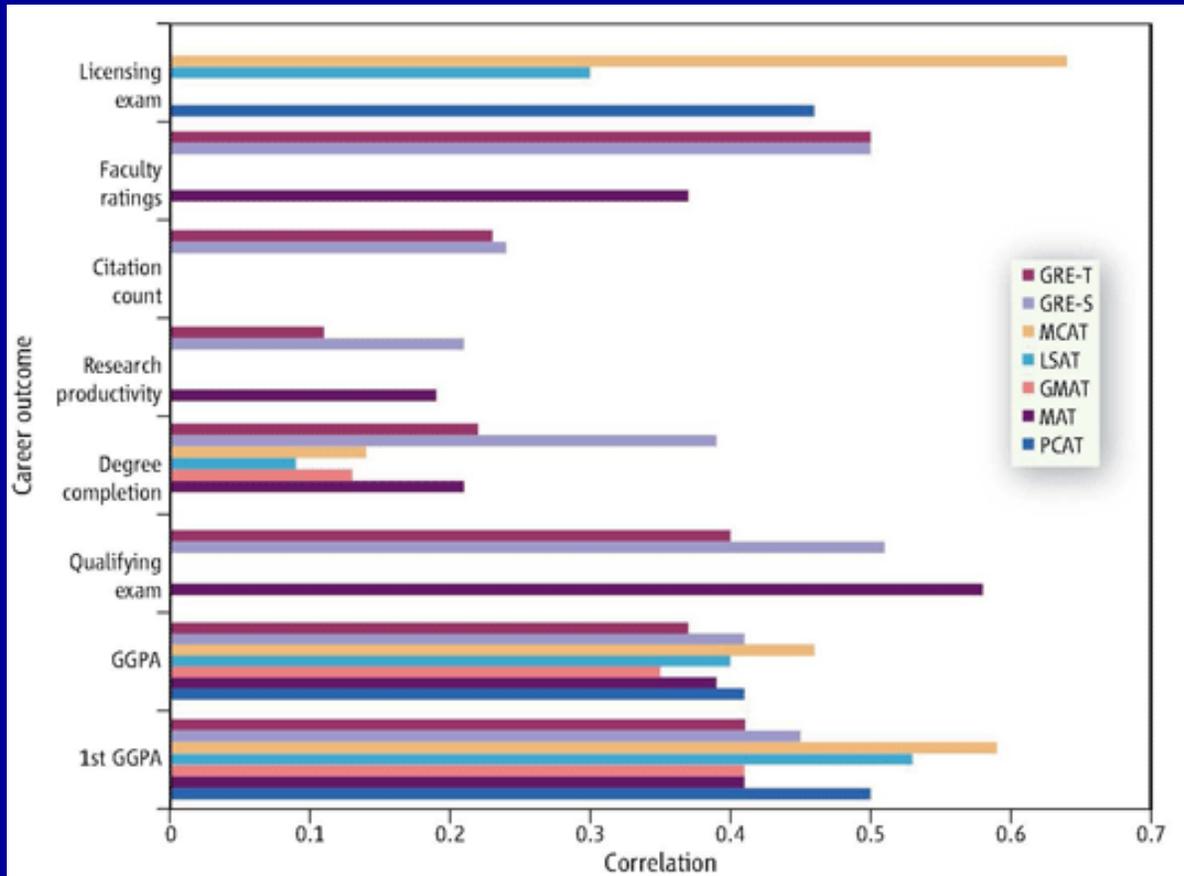
- **tests are good predictors**
- **tests predict success better than grades**
- **combination of tests and grades is best**

Kuncel & Hezlett, *Science*, 2007

(.4 correlation between sex & height)

5

WHAT IS *INTELLIGENCE*?

WHAT IS *INTELLIGENCE*?

- **ability to solve problems**
- **understand and learn complex material**
- **adapt to the environment**
- **mental quickness**

WHAT MAKES SOMETHING AN EXPERIMENT?

dependent variable

   what you measure - the outcome

independent variable

   what you vary

   Studies of intelligence are almost always correlational and rarely experimental

   Studies of intelligence focus on differences among people rather than intelligence per se

Positive Correlation

Weight (pounds) vs. Height (inches)

Image by MIT OpenCourseWare.
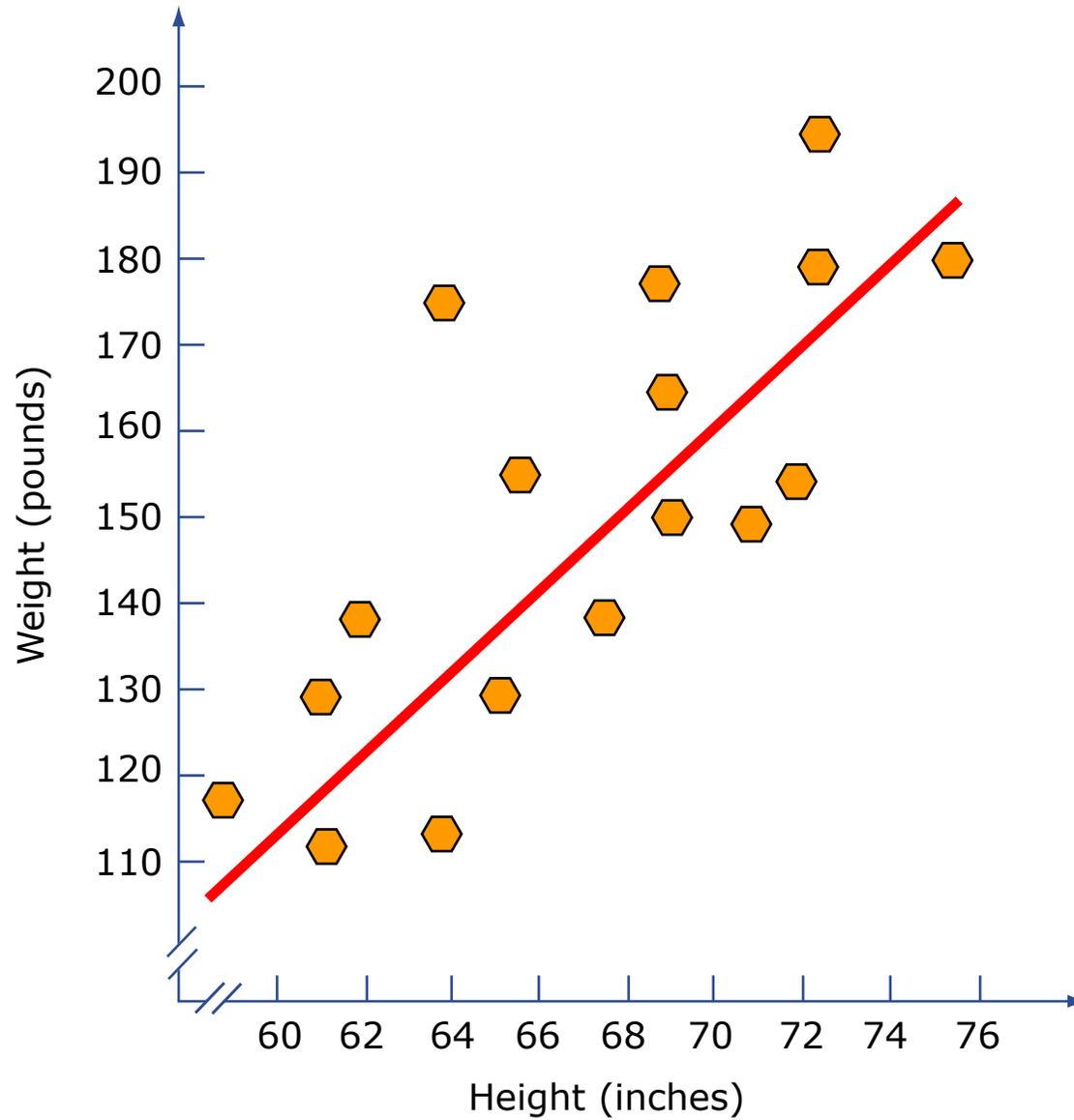
IQ = Intelligence Quotient

- **France, 1904-1911, universal elementary education**
- **Alfred Binet, physician, aimed for an objective way to identify children who needed extra help**
- **many abilities, many tests - copy a drawing, repeat digits, recognize coins, explain why a statement did not make sense**

IQ = Intelligence Quotient

- give test to normal children at multiple ages
- mental age vs. chronological age

IQ = Intelligence Quotient

- **David Wechsler**

Wechsler Adult Intelligence Scale (WAIS)

Wechsler Adult Intelligence Scale for Children (WISC)

Verbal Subtests and Performance Subtests

WAIS - III

- **Verbal Subtests**

  Vocabulary - define words

  Similarities - how are an airplane and a car alike

  Arithmetic - simple operations

  Digit Span - digits in STM capacity

  Information - who was Martin Luther King, Jr.?

  Comprehension - why are there taxes?

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WAIS - III

- **Performance Subtests (nonverbal)**

  Picture Completion **- what is missing?**

  Digit-Symbol Coding

  Block Design

  Matrix Reasoning

 *Picture Arrangement* **- order pictures**

IQ = Intelligence Quotient

- give test to normal children at multiple ages

- mental age (MA) vs. chronological age (CA)

IQ = (MA/CA) X 100

Average = 100

Standardized Test

- standardized sample - random population

- normal distribution

- norming (raw score vs. standardized score)

mean = 100 standard deviation = 15 for WAIS

67% of people are +/- 1sd (85-115); more than 2sd = 4.54%

Age norming - on 6th birthday - move from 120/100 - 40 year-old like undergrad raw score = 230 IQ
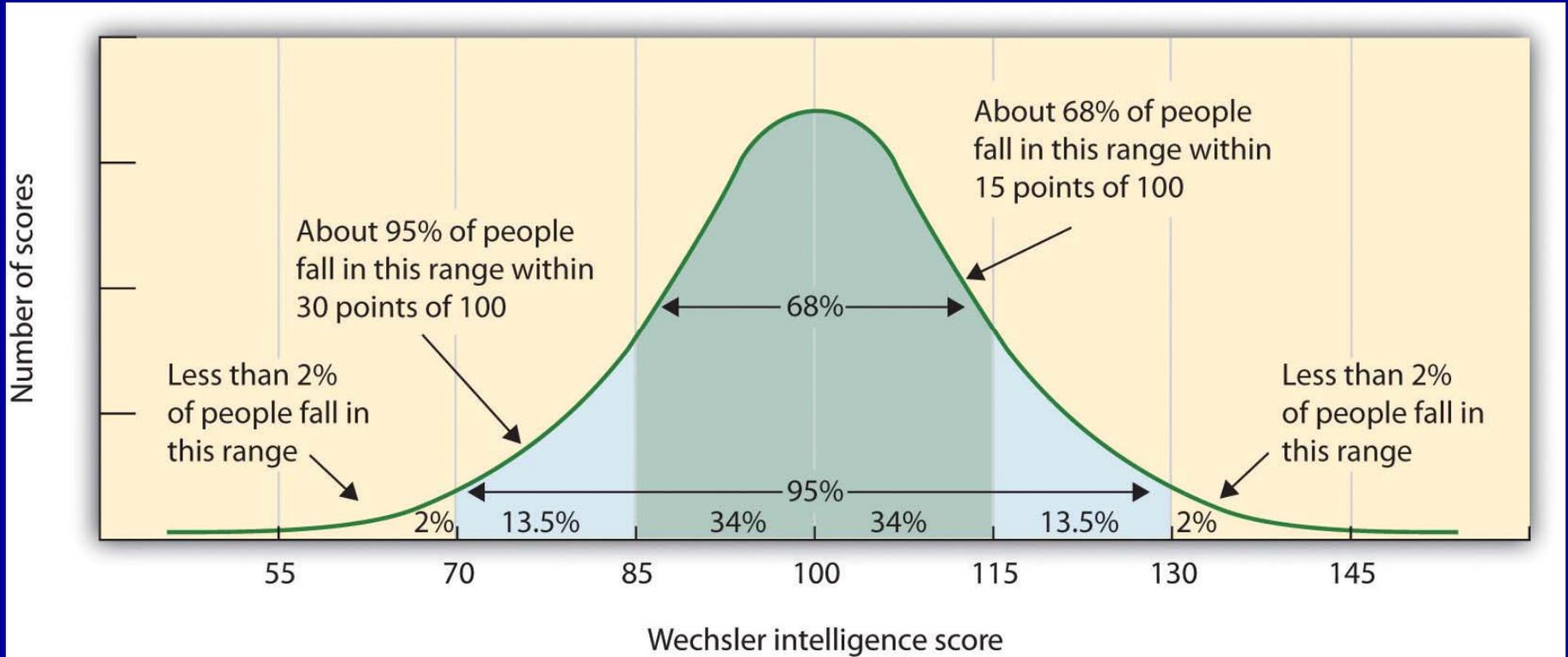
Source: Stangor, C. *Introduction to Psychology*. Flatworld Knowledge, 2010. Courtesy of Flatworld Knowledge.

< 70 a big problem　　　　　　　**Top 2% = Mensa**

RELIABILITY & VALIDITY

- **Reliable - same score on two occasions**

- **Valid - measures what it is supposed to measure**

VALIDITY

- **IQ - correlates with GPA in high school and college, job success, salary, stable marriages, staying out of jail, longevity**

- **25% of variation**

  (personality, education, culture)

WHAT DO 15 IQ POINTS MEAN?

100 IQ - average in high school, year or two in community college

115 IQ - at least college, white collar

85 IQ - dropping out of high school, skilled labor

Relationship between IQ and income and percentage of women having illegitimate children, for siblings from the same stable, middle-class family who differ in IQ.

IQ Group	Income	Illegitimacy Rate (%)
Very bright siblings (120+)	$70,700	2
Bright siblings (110-119)	$60,500	10
Reference group (90-109)	$52,700	17
Dull siblings (80-89)	$39,400	33
Very dull siblings (<80)	$23,600	44

Examples of Rise in IQ Test Scores ("Flynn effect")

IQ scores relative to reference — Year
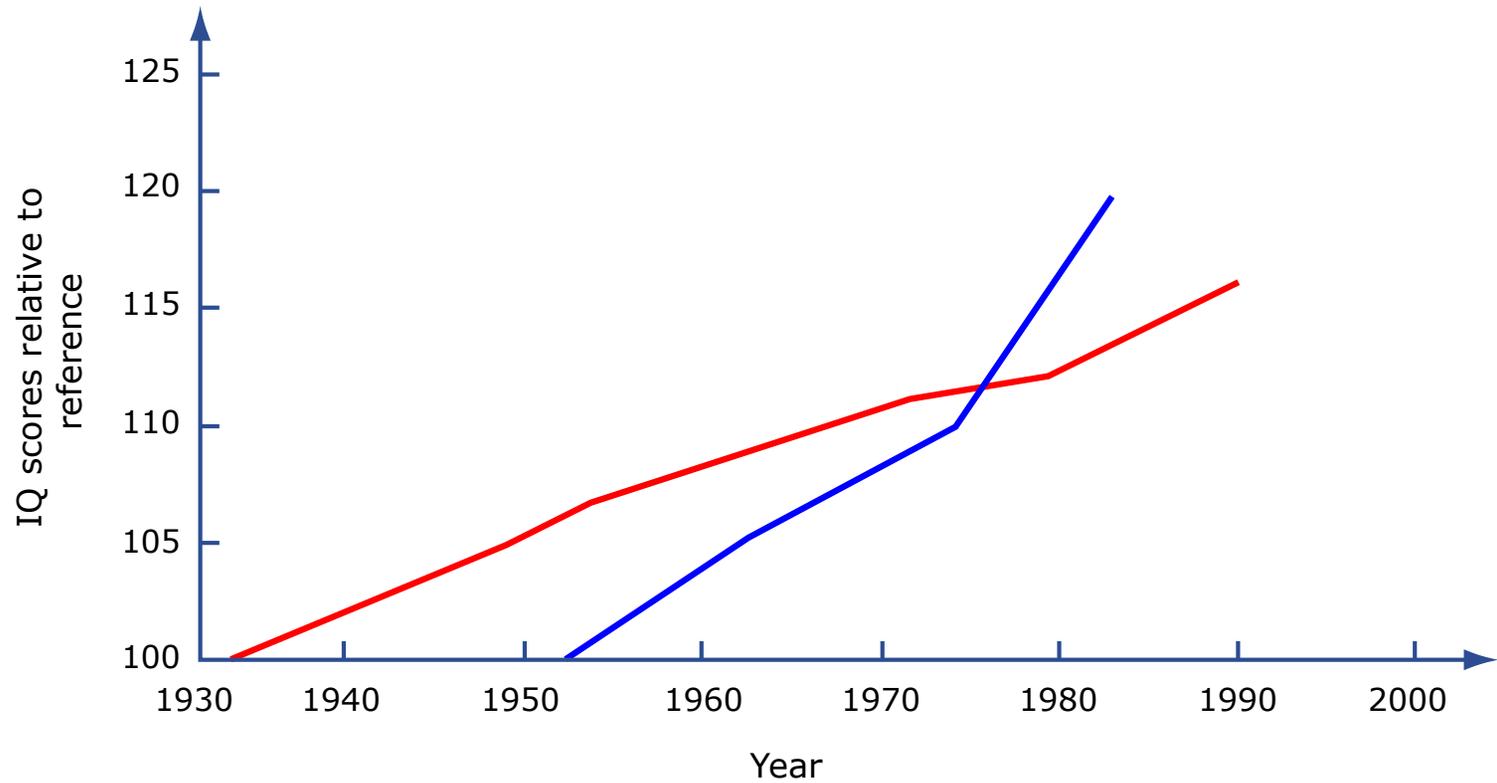
= Mean scores by Americans on Stanford-Binet and Weschler IQ tests

= Mean scores by Dutch males on Raven's Progressive Matrices

Image by MIT OpenCourseWare.

Generational Increases in Intelligence Scores

(James) Flynn effect - Raven's Progressive Matrices - IQ scores going up 3 points every 10 years

> born in 1930 - IQ 100
>
> child - 108
>
> grandchild - IQ 120 (standard deviation higher)
>
> (100 IQ today - grandparent IQ 82)
>
> 1900 mean IQ of 70????
>
> daily life? nutrition? reasoning?

WHERE ARE THE GAINS?

- • WISC 10 subtests

- small gains - vocabulary, general knowledge, arithmetic

- large gains - similarities

"In what way are dogs and rabbits alike?"

"both mammals" (abstract/taxonomic)

"you use dogs to hunt rabbits" (functional)

ABSTRACT THINKING

• **Kpelle Tribe - Liberia
sort basket of food, tools,
containers, clothing**

**functional pairings - potato
and knife**

**how would a fool do it?
taxonomic categories**

INTELLIGENCE TESTS

- value attached to a specific time and a specific test

- constant re-norming to set each subtest to population mean of 100

- 70 as cut-off for mental retardation - WISC-III comes out in 1991, number labeled mentally retarded doubled

MODELS OF INTELLIGENCE

- psychometric analysis of subtests
- positive correlation among subtests
- Spearman - *"g" - general intelligence*
  "s" - specific intelligence
- Thurstone - 56 tests - 7 primary mental abilities (verbal, spatial, etc.)
- Cattell & Horn
  fluid intelligence - novel tasks
  crystallized intelligence - known information

Spearman's Theory of Intelligence

g = general intelligence
s = specific intelligenc
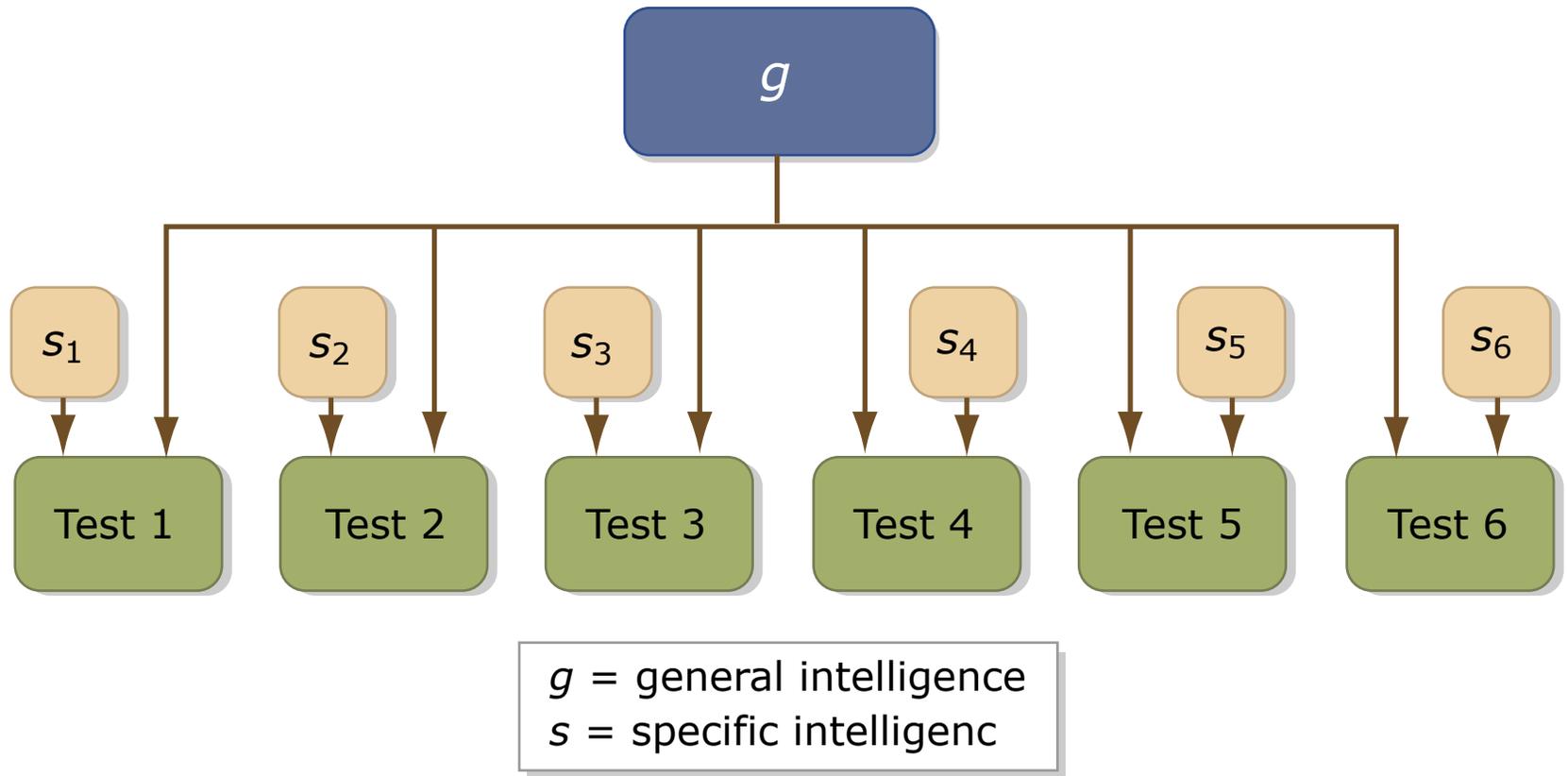
Fluid vs. Crystallized Intelligence

Content removed due to copyright restrictions. See lecture video.

Reference: p. 10 in
http://www.wiley.com/college/westen/0471387541/ppt/lecture/ch8.ppt
(Companion content for textbook Western, D. *Psychology* 3/e, Wiley, 2002.)

Average Scores on Mental Tests as Function of Age

Content removed due to copyright restrictions. See lecture video.

Reference: Fig. 10.11 in Gray, P. O. *Psychology* 5/e, Macmillan, 2006.
http://books.google.com/books?id=o6m9AyzSbAkC&lpg=PA369&pg=PA369#v=onepage&q&f=false

MODELS OF INTELLIGENCE

- psychometric analysis of subtests
- positive correlation among subtests
- Carroll - Three-stratum theory (in 1993 from 450 studies)

g, 8 specific factors, more factors

all levels contribute to task performance

but "g" remains best predictor in real life

EMOTIONAL INTELLIGENCE EQ

• **Salovey - perceiving emotion, faciltating though with emotion, understanding emotion, managing emotion**

Theory of Multiple Intelligences

Gardner

- **patients, development, special skills**
- **Linguistic, Spatial, Music, Logical-Mathematical, Bodily-Kinesthetic, Intrapersonal, Interpersonal, Naturalist, Existential**
- **profile of intelligences**
- **? Measurement, skills**

Intelligence: Mental & Neural Mechanisms

- **Mental Speed**

    high correlation between IQ and simple reaction time speed, speed of simple perception of line lengths

- **Working Memory**

    holding goal-relevant information in mind

Frontal cortex

Parietal lobe

Dorsal-lateral prefrontal

Occipital lobe

Temporal lobe

Visual cortex

Auditory cortex

Cerebellum

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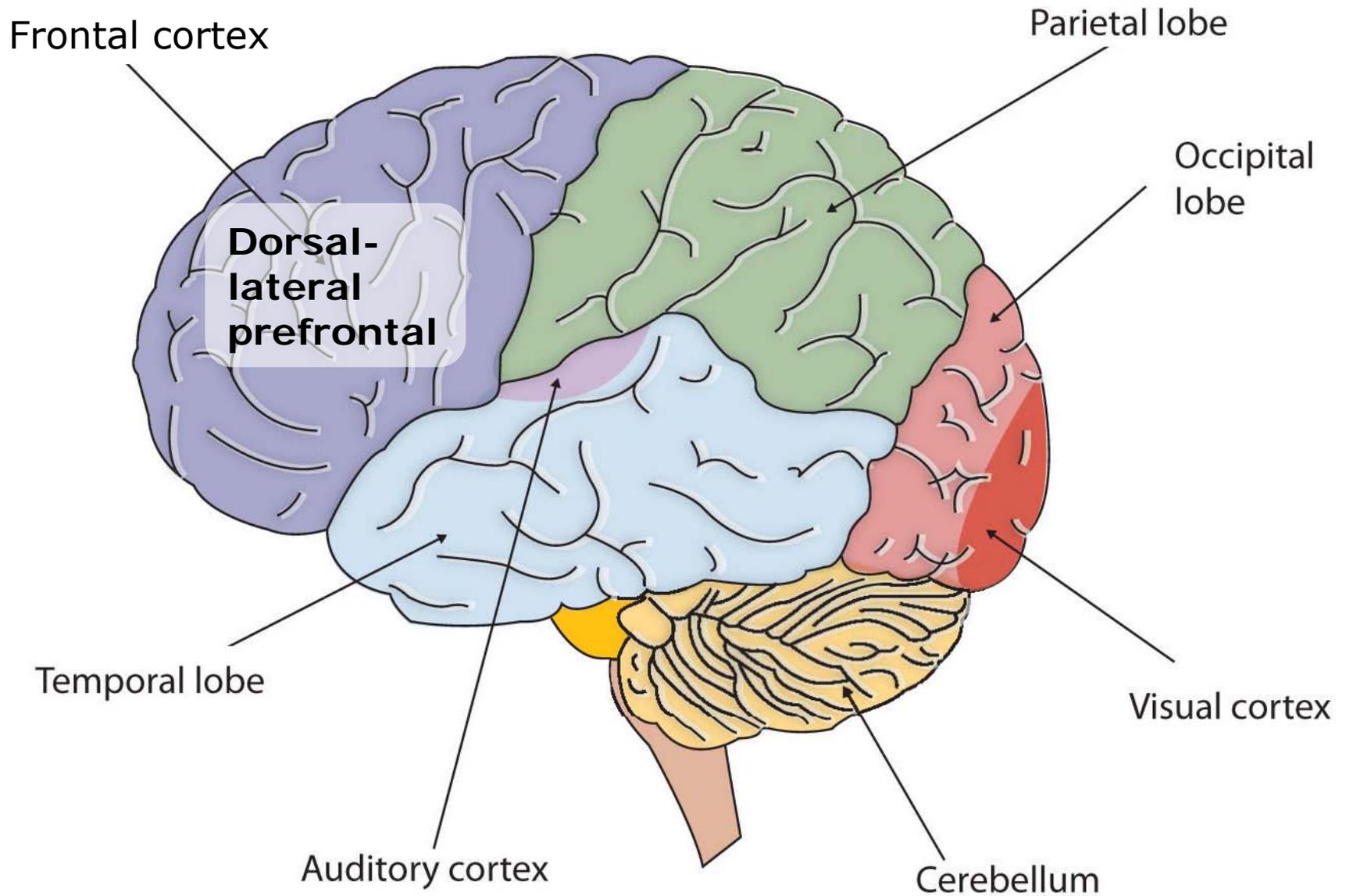
Image removed due to copyright restrictions. See lecture video.

Example of an item on a Culture-Fair Test, from Chapter 7 in Wood, S. E.,
E. G. Wood, and D. Boyd. *Mastering the World of Psychology*, 3/e. Allyn & Bacon, 2007.

Raven's Progressive Matrices
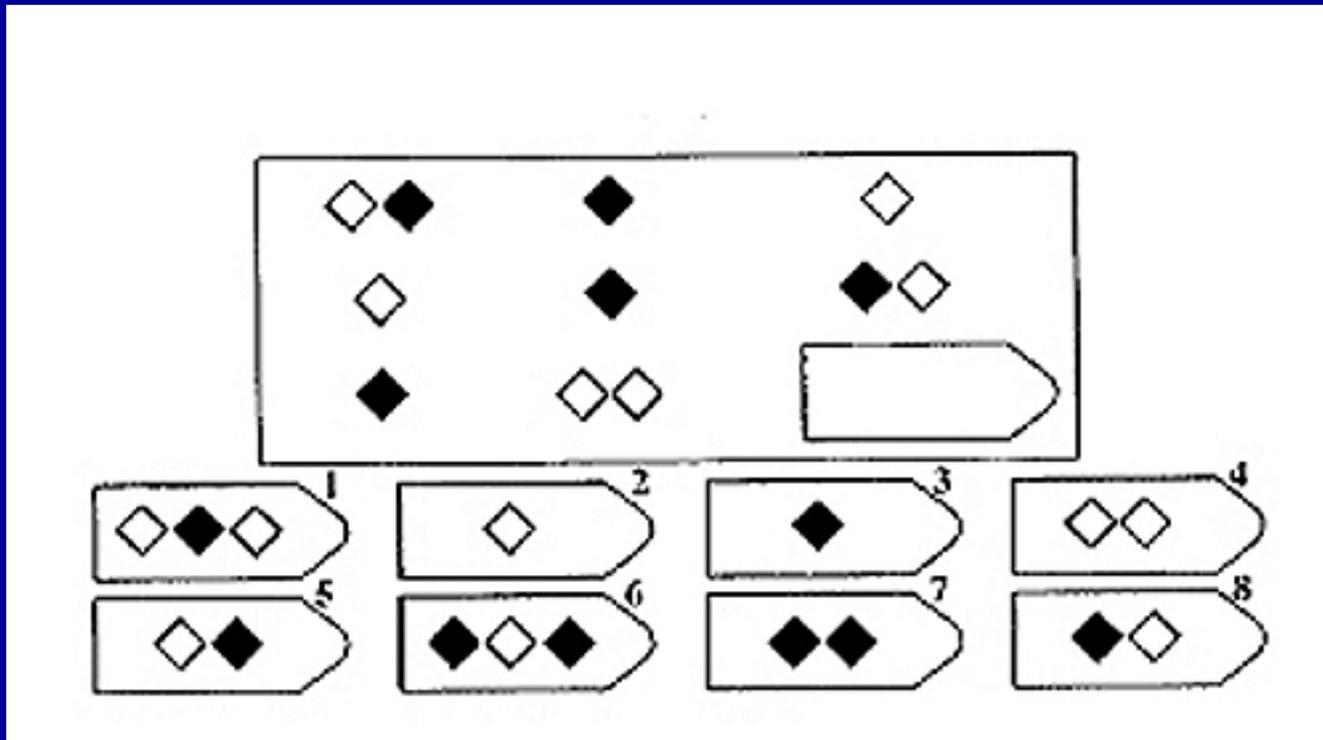
37
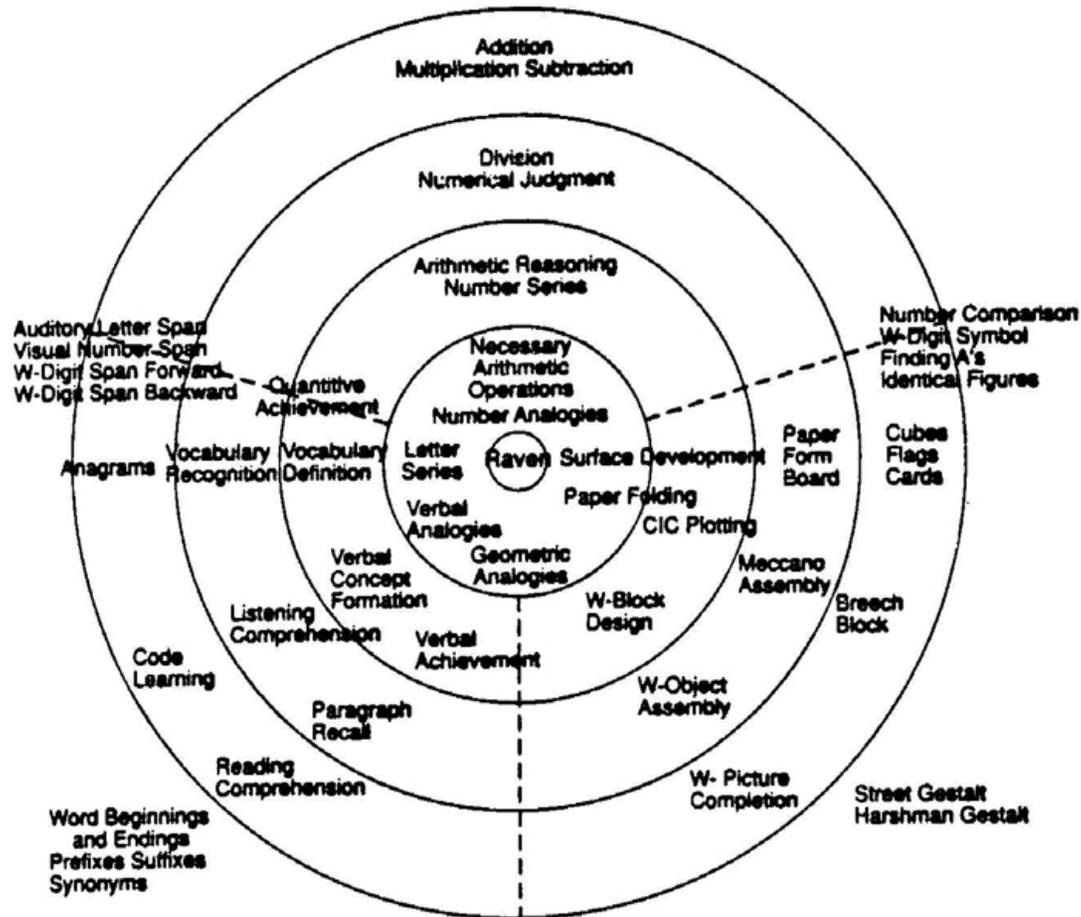
FIG. 1. A multidimensional scaling solution illustrating the intercorrelations among various ability tasks is shown in this idealized model. The Raven's task occupies the center of the model. Complex tasks such as Necessary Arithmetic operations and Verbal Analogies are shown to be near the Raven's task, indicating that performance on these tasks are highly correlated despite their differences in content. The subsequent contours contain tasks that show less correlation to the tasks near the center of the model and cluster more as a function of content area with separate clusters for figural, numerical, and verbal tasks. Tasks involving different content are separated
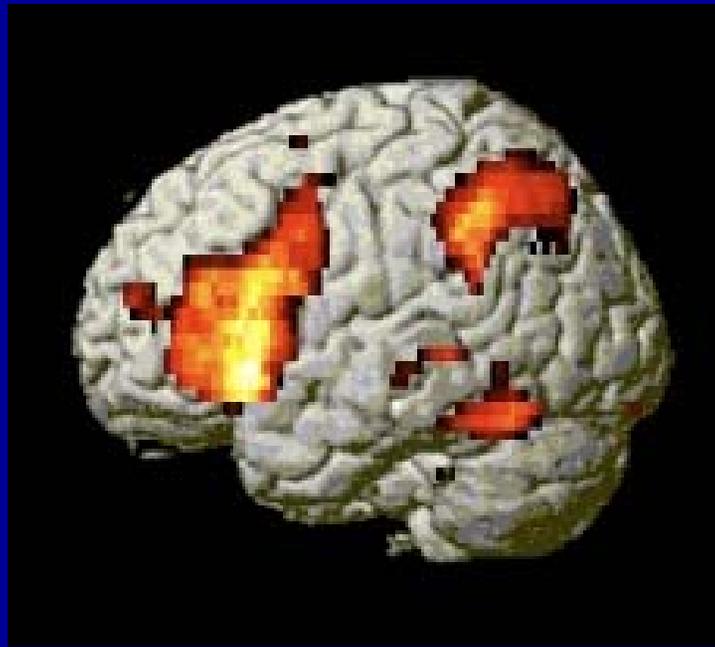
Raven's Progressive Matrices

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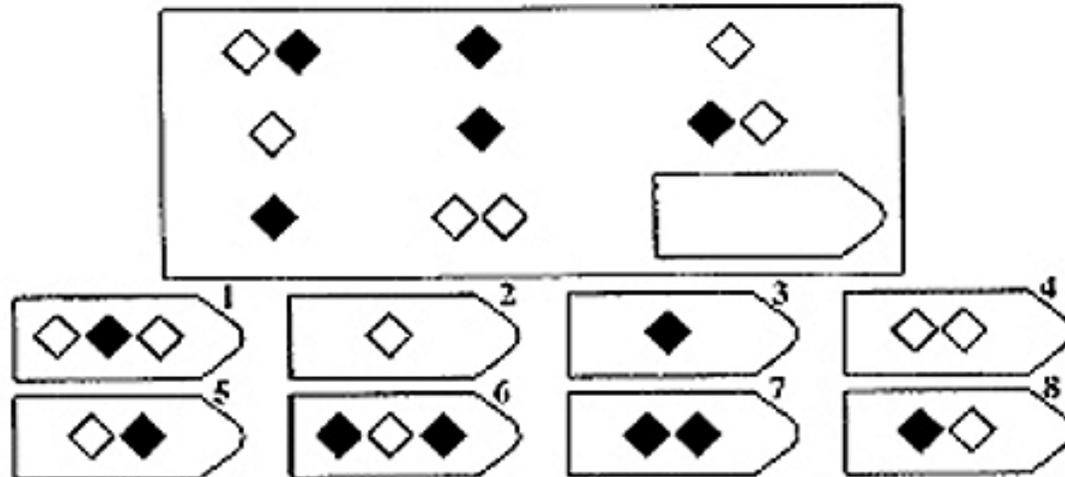
Image removed due to copyright restrictions. See lecture video.

Table 1 in Duncan, J., et al. "A Neural Basis for General Intelligence."
*Science* 289 (2000): 457-60.
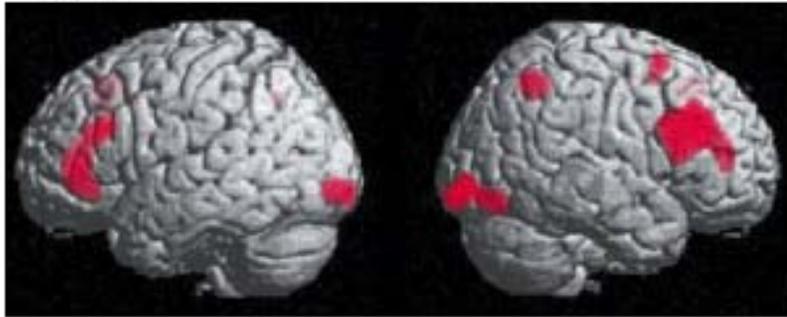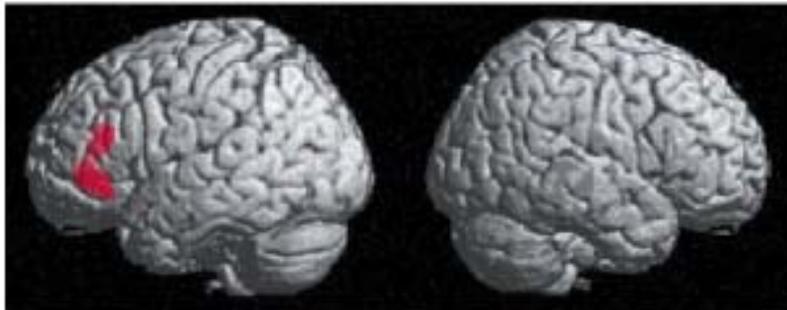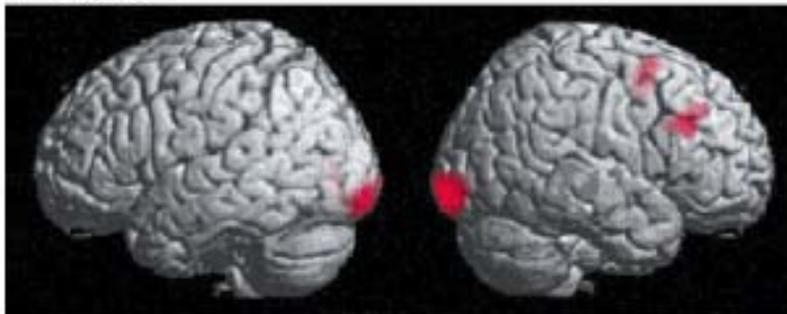
Fig. 2. Significant activations for three contrasts, rendered onto canonical T1-weighted brain image of SPM99. (A) Spatial high-*g* minus spatial low-*g* ($P < 0.05$ corrected for multiple comparisons). (B) Verbal high-*g* minus verbal low-*g* ($P < 0.05$ corrected). (C) Circles minus spatial low-*g* ($P < 0.001$ uncorrected).

N-Back Task

Greater Frontal Activation with Larger N-Back

PREFRONTAL CORTEX AND WORKING MEMORY

0-Back Condition

1-Back Condition

2-Back Condition

3-Back Condition

FIG. 1. A diagram of the four memory conditions of the sequential letter task.

FIG. 3. Plots of the MR signal, expressed as a percentage of difference from the 0-back condition, across the four load conditions. Values are plotted for the MFG region (Talairach coordinates L38,30,22 and R35,22,27) and the IFG region (Talairach coordinates L40,6,26), the only two regions which showed a significant monotonic effect of load. The activity was averaged across the nine subjects; however, each subject showed essentially the same linear relationship to load.

3-Back Task

Time →
Blocks: - Task - Task - Task - Task -

Trials: A B C + A D E F F + D G + ...

3-back match = Target   4-back match = Lure   New item = Nonlure

Fig. 1. Behavioral protocol, three-back task. Single capital letters represent task stimuli, which were either all words or all faces for a given scanning run. Blocks of task trials are separated by blocks of fixation (dash).

Three-back Task Performance (n=58)

Accuracy (% correct) vs gF (Raven's APM score)

gF = General fluid intelligence

○ Non-Lure trial
● Lure trial

Image by MIT OpenCourseWare.

Fig. 3. Regions in which gF predicted lure-trial activity, using *a priori* (red) and whole-brain (yellow) search criteria, shown on the folded surface of a standard brain[48]. From left to right: left lateral, left medial, right medial and right lateral views. The corresponding lateral cerebellar surface is shown below each lateral cortical surface. Voxels meeting the *a priori* threshold outside of the search space are not shown.
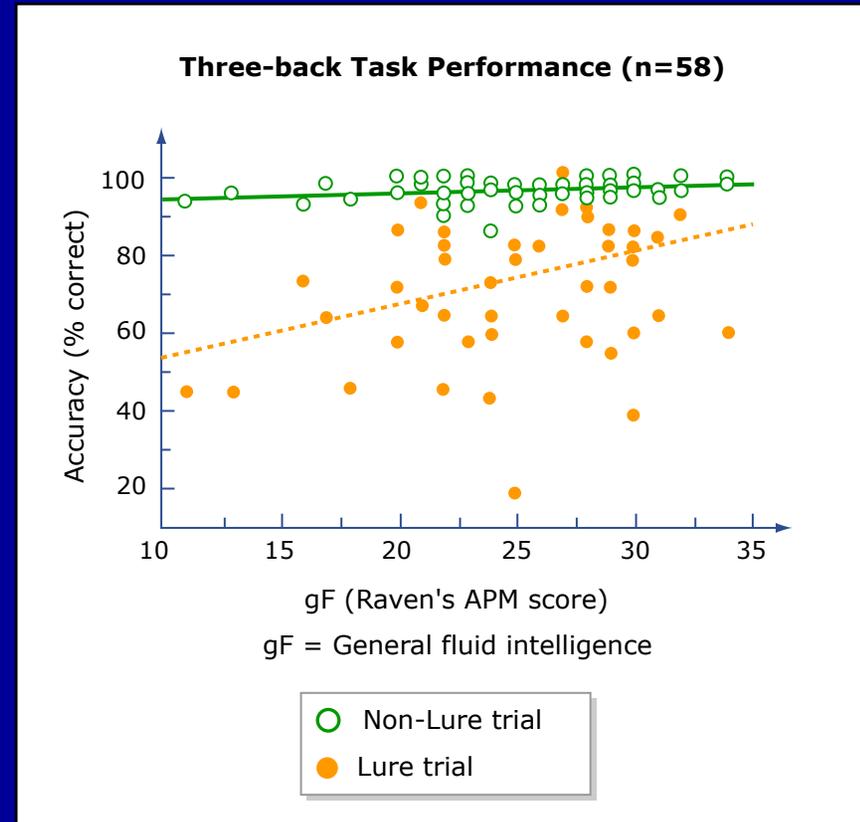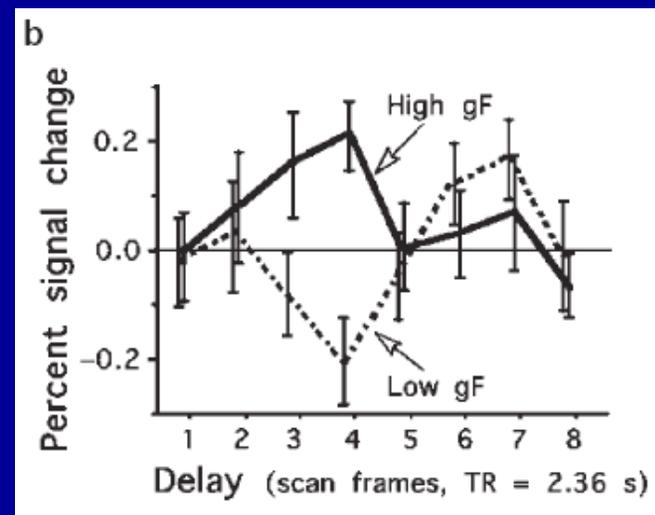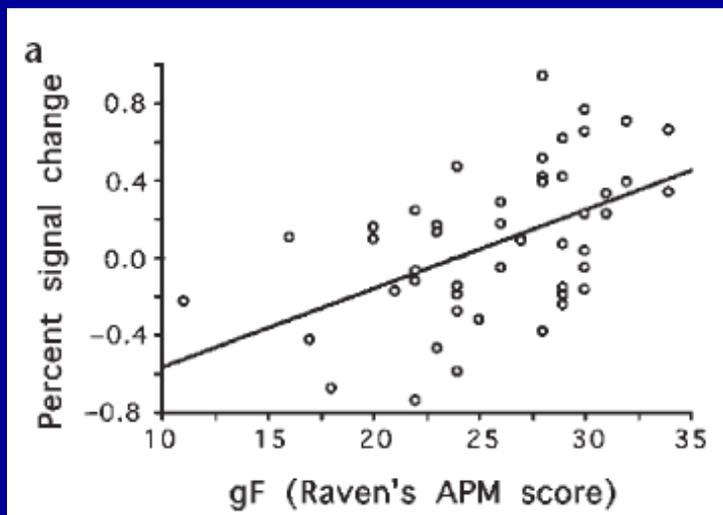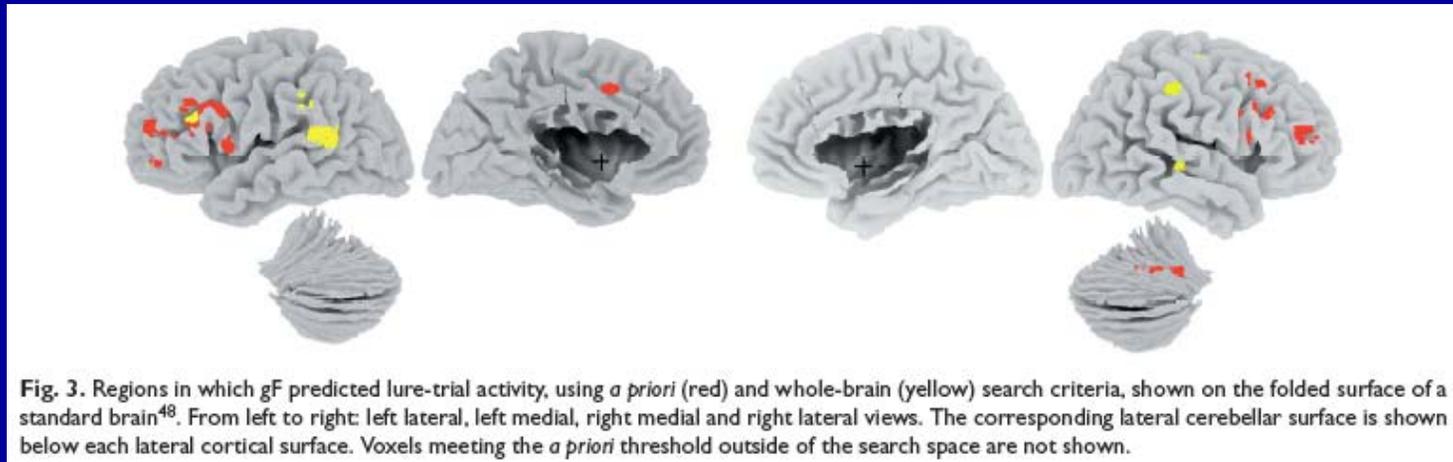
GREATER DEMAND ON BRAN RESOURCES FOR LOWER IQ INDIVIDUALS

LOWER IQ (88-110)
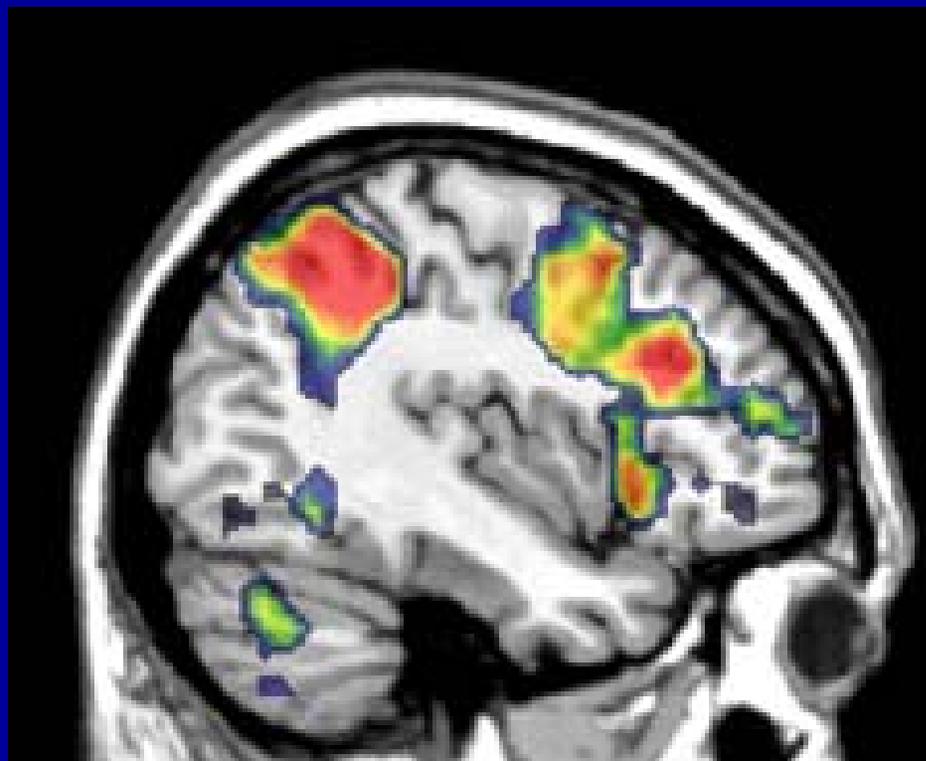
HIGHER IQ (119-126)
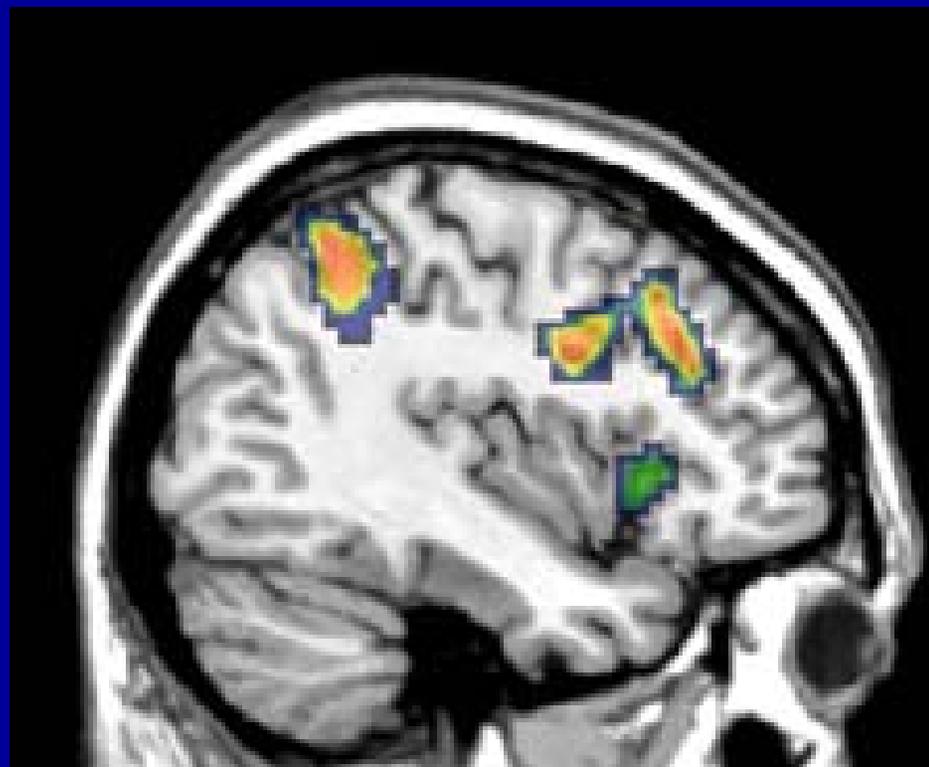
Intelligence: Nature & Nurture

- identify genes
- identify experiential factors
- identify gene x environment interactions
- twin studies (shared genes)

Genetics & fMRI

SNPs - single nucleotide polymorphisms

- DNA sequence variation of a single nucleotide
  adenine (A), thymine (T), cytosine (C), guanine (G)

- at least 1% of the population

- make up 90% of human genetic variation

- constant from generation to generation

Two diagrams explaining Wisconsin Card Sorting Task removed due to copyright restrictions.

See lecture video.
Also refer to http://en.wikipedia.org/wiki/Wisconsin_card_sort

Cartoon illustrating the Wisconsin Card Sorting Task removed due to copyright restrictions.
Fig 12.4 in Gazzaniga, M. S., R. B. Ivry, and G. R. Mangun. *Cognitive Neuroscience*. 2nd edition. WW Norton & Co., 2002.

See lecture video.
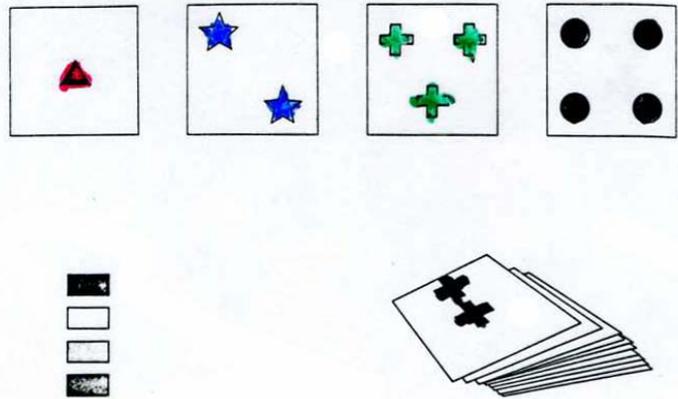
FIGURE 18–4. The Wisconsin card-sorting test, showing test material as presented to the subject (From B. Milner, Some effects of frontal lobectomy in man. In J. M. Warren and K. Akert, eds., *The Frontal Granula Cortex and Behavior*, p. 315. Copyright © by McGraw-Hill, Inc. Used with the permission of McGraw-Hill Book Co.)

Catechol-O-Methyltransferase (COMT)
(Egan et al., PNAS, 2001)

- risk factor for schizophrenia

- COMT metabolizes released dopamine (DA)

- single polymorphism – valine to methionine at codon 108/158 (val/val vs. val/met)

- Wisconsin Card Sorting Task (WCST)

- fMRI – N-back: 0-back & 2-back
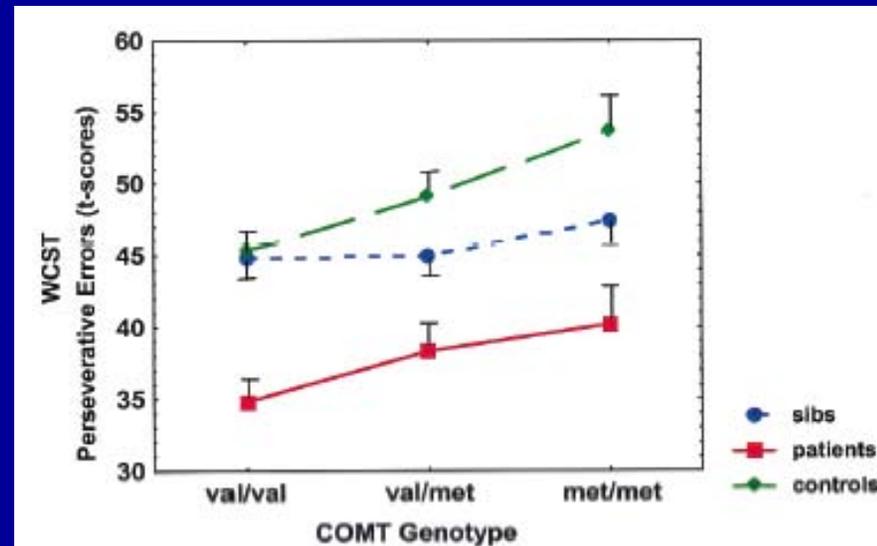
Fig. 1. WCST perseverative error t scores ($\pm$ SE) by genotype for each group (population mean = 50, SD = 10, lower scores indicate worse performance). Main effect of genotype: $F = 4.93$, df = 2,224, $P = 0.008$.

N-Back Task

Increasing Prefrontal Activation for Increasing N-Back

PREFRONTAL CORTEX AND WORKING MEMORY

0-Back Condition

2500 ms delay
500 ms duration
Target

1-Back Condition

Target

2-Back Condition

Target

3-Back Condition

Target

FIG. 1. A diagram of the four memory conditions of the sequential letter task.

DLPFC (BA 46/9)   Broca's Area (BA 44/45)

% Increase

Memory Load (n-back condition)

FIG. 3. Plots of the MR signal, expressed as a percentage of difference from the 0-back condition, across the four load conditions. Values are plotted for the MFG region (Talairach coordinates L38,30,22 and R35,22,27) and the IFG region (Talairach coordinates L40,6,26), the only two regions which showed a significant monotonic effect of load. The activity was averaged across the nine subjects; however, each subject showed essentially the same linear relationship to load.

Val/Val > Val/Met > Met/Met:
## More activation = working harder to achieve same performance
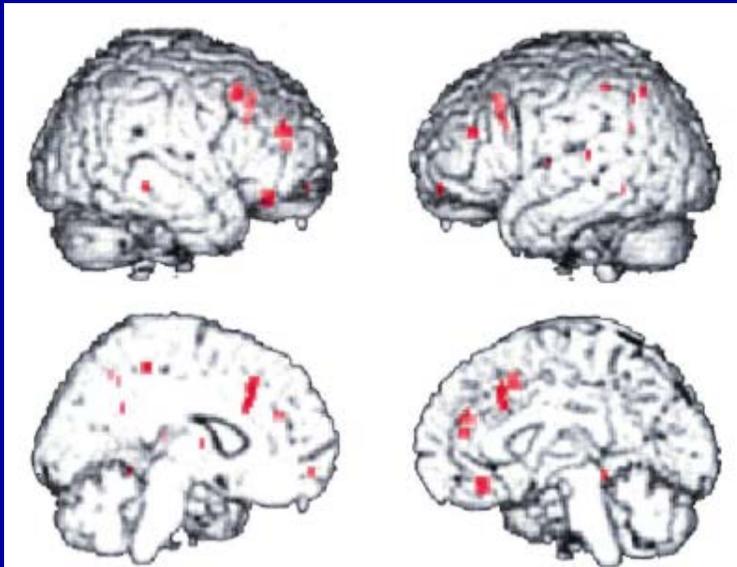
Fig. 2. Effect of COMT genotype on fMRI activation during the two-back working memory task. Regions showing a significant effect of genotype on fMRI activation (voxelwise $P < 0.005$) are in red (shown clockwise from upper left in right lateral, left lateral, right medial, and left medial views, respectively). In dorsolateral prefrontal cortex (e.g., Brodmann area 46; $x = 58$, $y = 32$, $z = 12$; cluster size = 47; $Z = 2.55$) and anterior cingulate (e.g., Brodmann 32; $x = 6$, $y = 60$, $z = 8$; cluster size = 77; $Z = 2.36$), Val/Val individuals showed a greater fMRI response (and by inference, greater inefficiency, as performance is similar) than Val/Met individuals who have greater activation than Met/Met individuals. Post hoc analysis of genotype group contrasts confirmed these significant relationships in dorsolateral prefrontal and cingulate cortices across all groups.
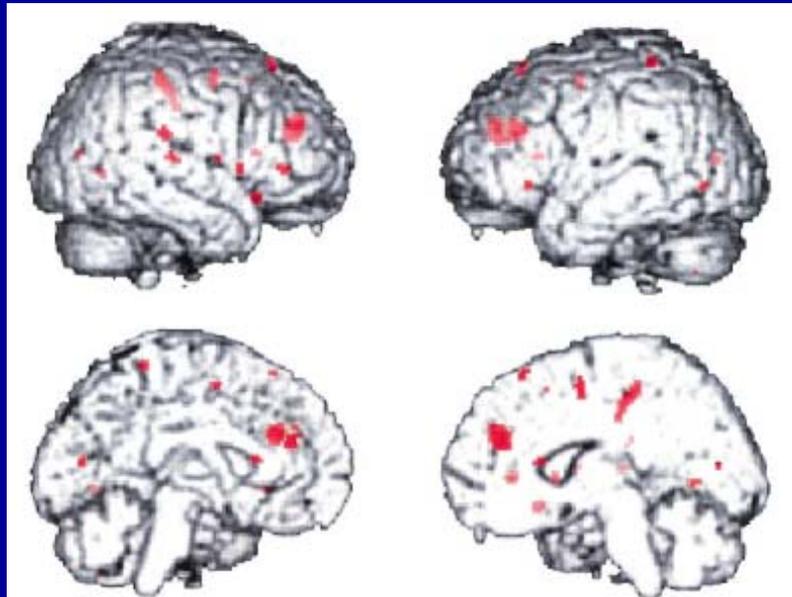
Fig. 3. Effect of COMT genotype on fMRI activation during the two-back working memory task in a second group of subjects. Again, Val/Val individuals showed greater activation (and by inference greater inefficiency) than Val/Met individuals who showed less efficiency than Met/Met individuals in the dorsal prefrontal cortex and several other locales.

Intelligence: Nature & Nurture

?

Intelligence: Nature & Nurture

- twin studies (shared genes)
- behavioral genetics
- heritability
  variability due to genetics
  height may be 90% heritable in US
- twin studies
  monozygotic - same genes
  dizygotic - about half the genes

Fraternal and Identical Twins
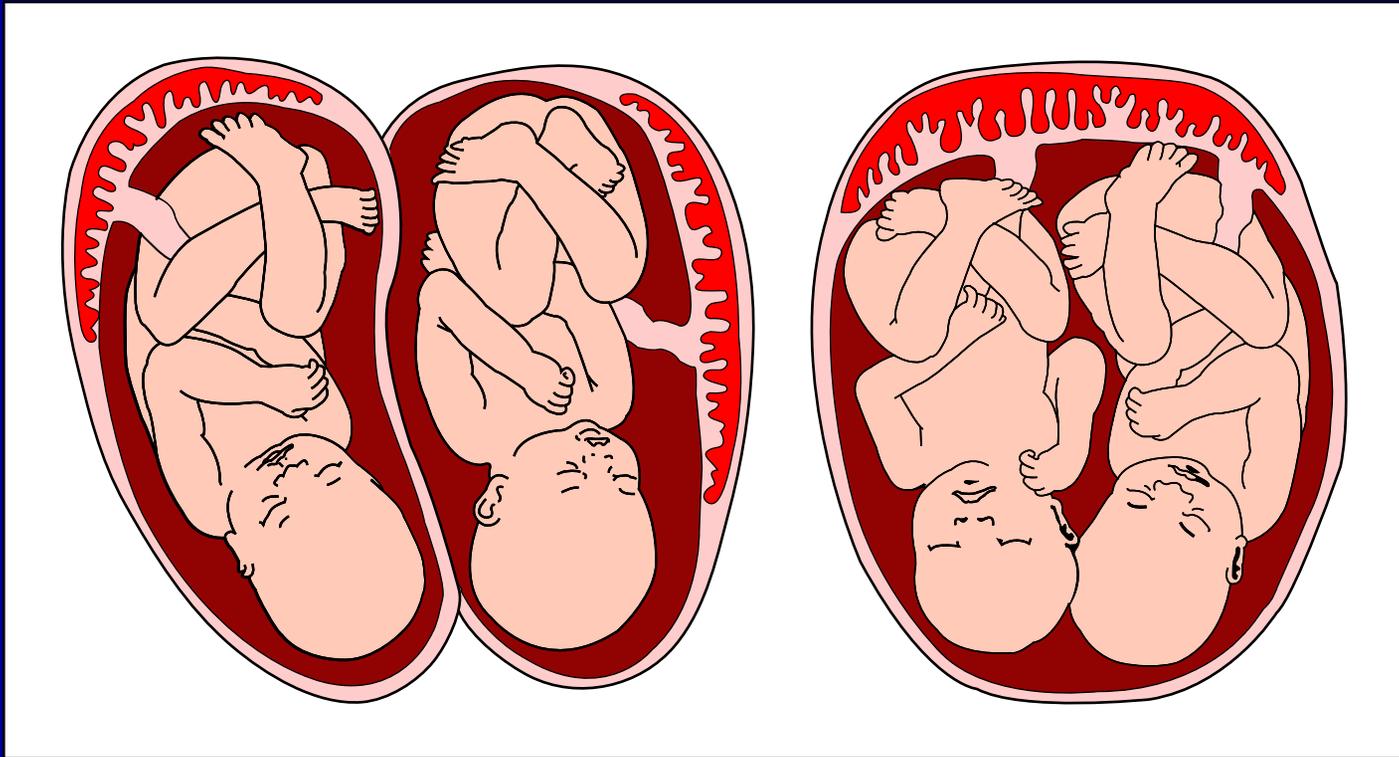
Image by MIT OpenCourseWare.

Correlation Between IQ Scores for People with Various Relationships

Correlation between IQ scores

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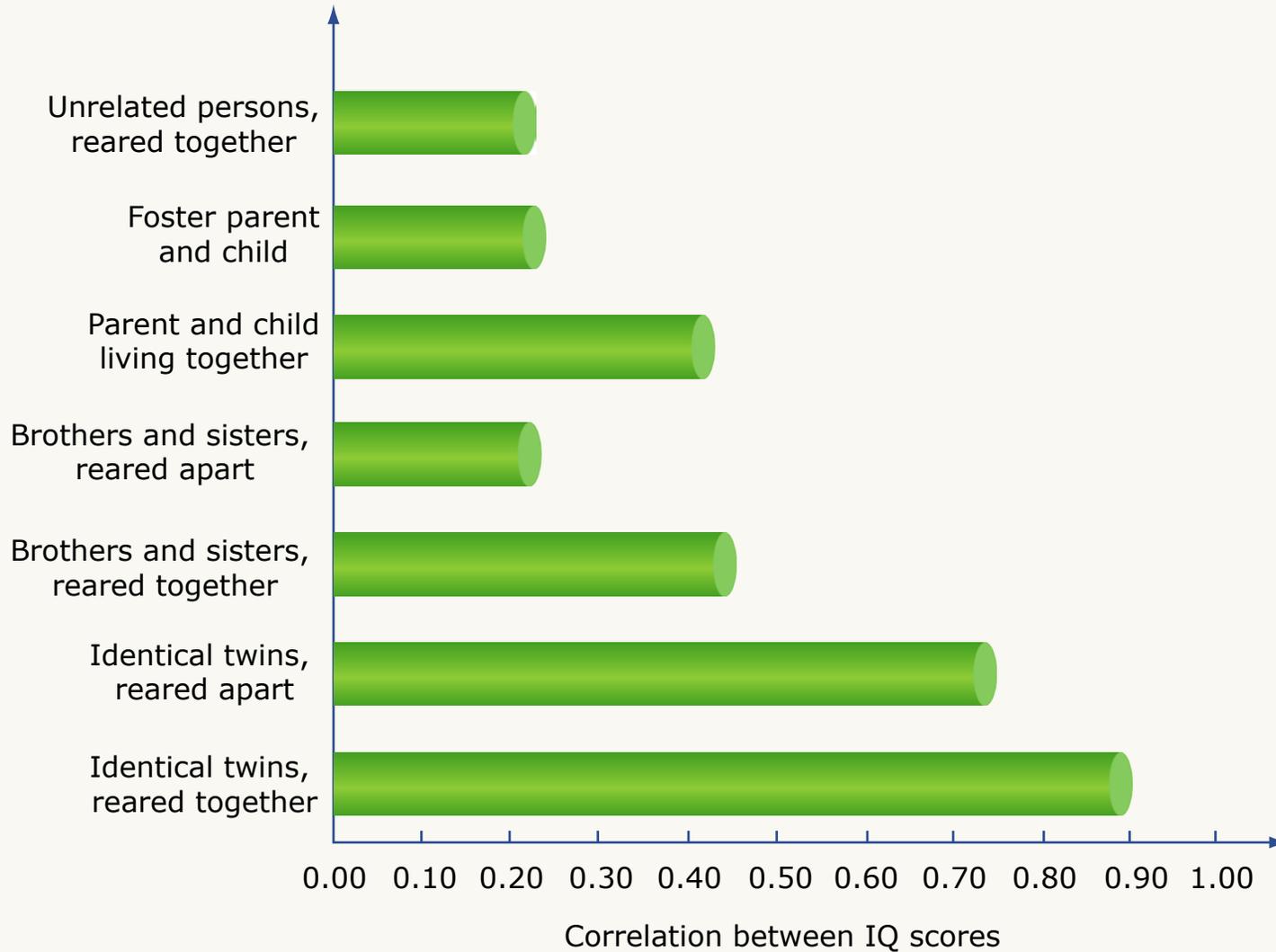
Intelligence: Nature & Nurture

- **heritability = about .50**

- **environmental influences**

    breastfeeding
    birth weight
    birth order & family size

Intelligence: Nature & Nurture

• **3000 people followed from birth to young adulthood - breastfeeding for at least 6 months correlated with 5-7 point IQ gain**

IQ vs. Birth Weight
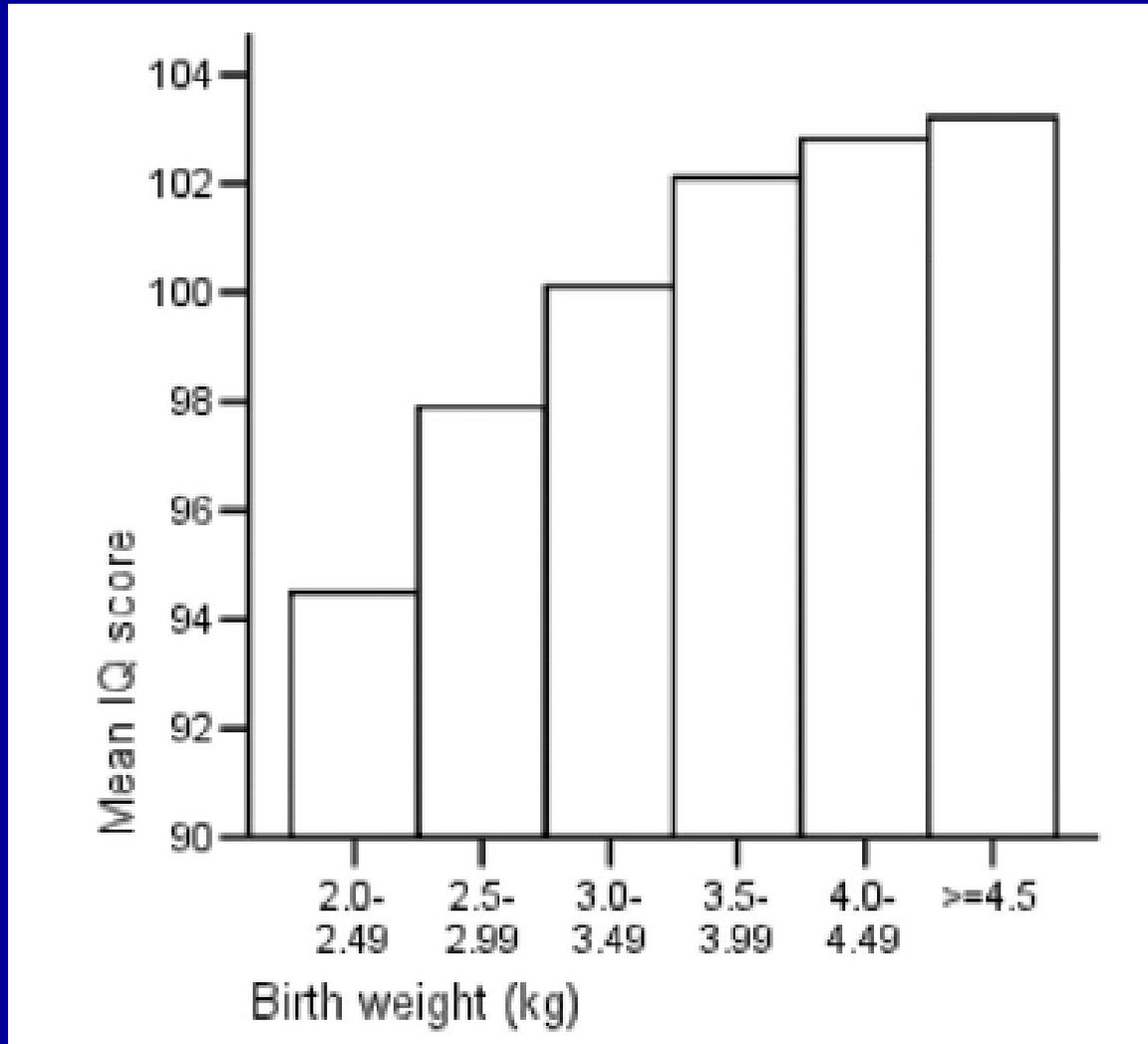
Genetic diversity affects heritability

Height is 90% heritable

Japanese men are 3 inches taller in US than in Japan

Cloned Tomato Plants: Heritability = 0

Poor Soil

Good Soil

Genetically Diverse Tomato Plants: Heritability > 0

Poor Soil

Good Soil
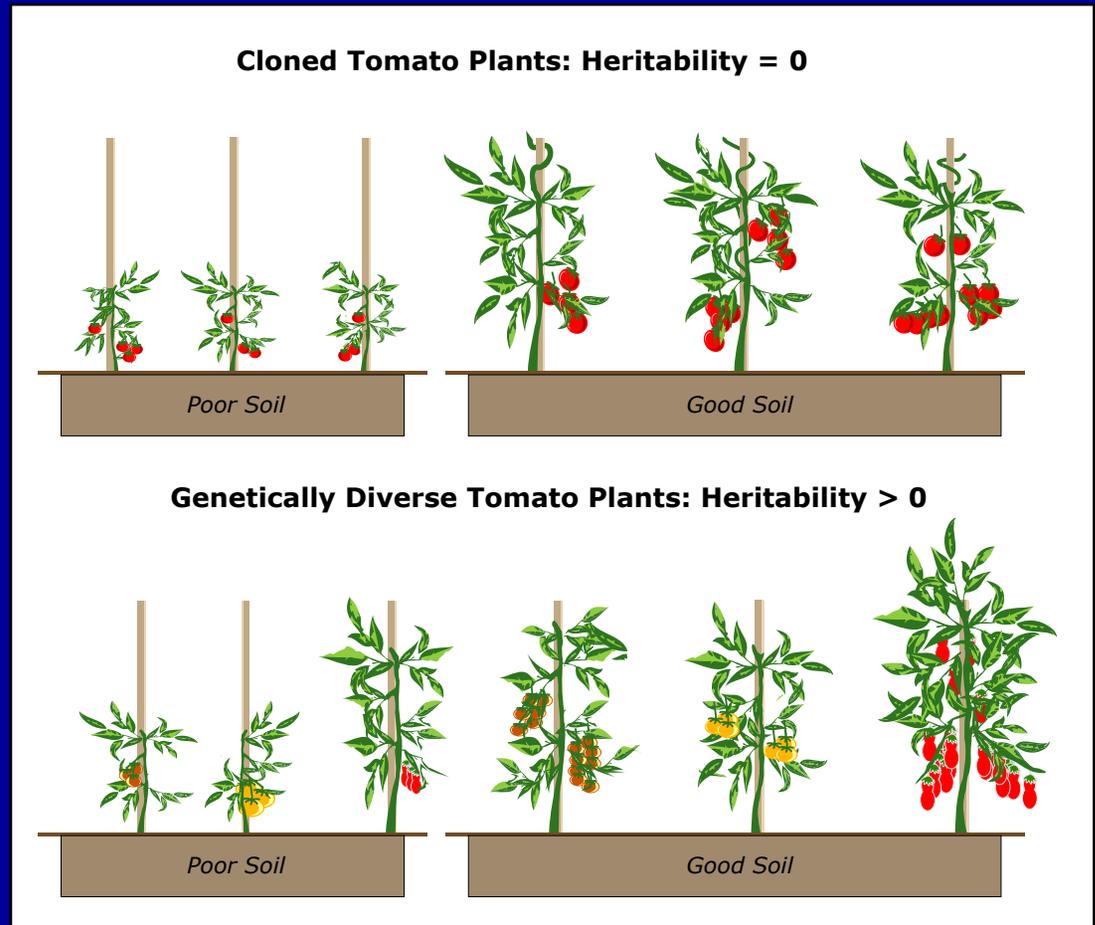
Image by MIT OpenCourseWare.

Relation between birth order and IQ score. Mean IQ scores for male conscripts, first-, second-, and thirdborn in Norway to mothers with single births only and first birth from 1967 through 1976, according to birth order and number of elder siblings who died in infancy (age < 1 year). Scores are adjusted for parental education level, maternal age at birth, sibship size, birth weight, and year of conscription. Error bars show 95% confidence intervals (CIs). Reference: birth order one.

Birth Order Family Size & Raven scores
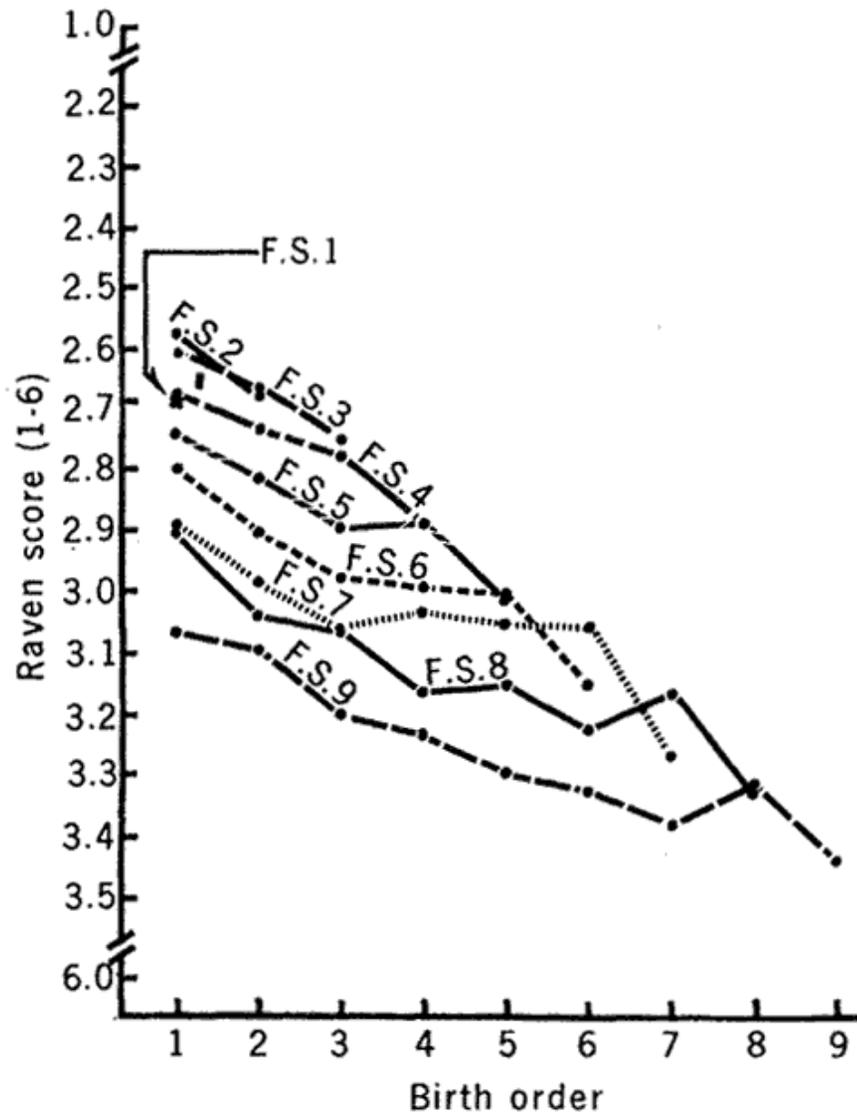

Fig. 1. Mean Raven class score by birth order within family size (F.S.) across the population (N = 386,114).

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FAMILY DYNAMICS OF INTELLECTUAL DEVELOPMENT

- birth order, family size (Zajonc)
- confluence model

  first born exposed only to adult
  language

  second born to parents plus first
  born, etc.

  also opportunity to tutor younger
  sibs

FAMILY DYNAMICS OF INTELLECTUAL DEVELOPMENT

- **birth order, family size (Zajonc)**
- **confluence model**

$$\text{1st - } (30 + 30 + 0)/3 = 20$$
$$\text{2nd - } (30 + 30 + 4 + 0)/4 = 16$$
$$\text{3d - } (30 + 30 + 7 + 3 + 0)/5 = 14$$

test at 8

$$\text{1st - } (30 + 30 + 8 + 4)/4 = 18$$
$$\text{2nd - } (30 + 30 + 12 + 8)/4 = 20$$
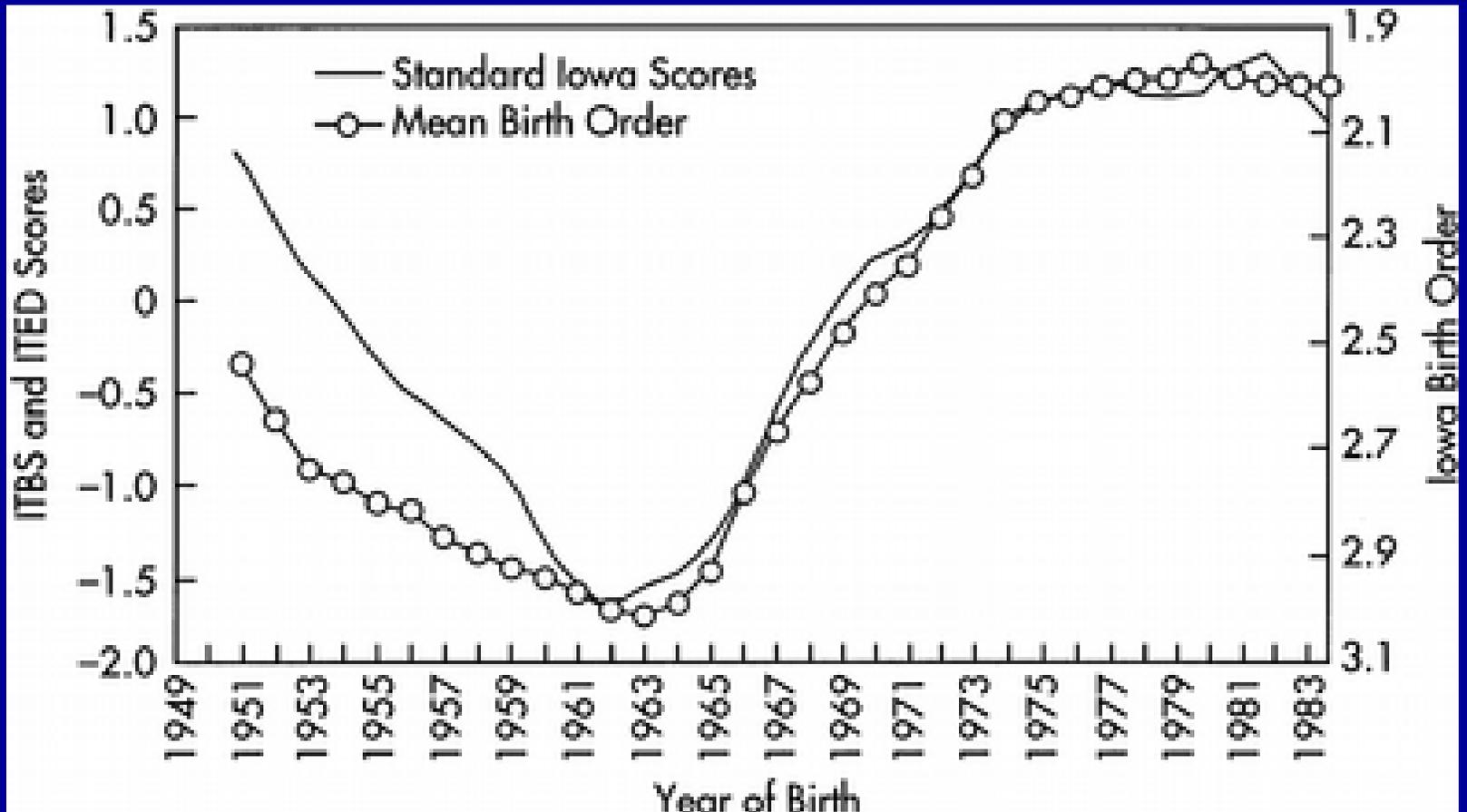
Birth Order and Iowa Basic Skills Scores

The birth order scale is inverted such that higher numerical values represent lower birth ranks. ITBS = Iowa Tests of Basic Skills; ITED = Iowa Test of Educational Development.

EARLY EXPOSURE TO LANGUAGE

• Hart & Risley - record each month for 2.5 years one full hour of every word spoken at home between parent and child in 42 families, categorized as professional, working class, or welfare families (SES) - code and analyze every utterance in 1,318 transcripts - 30,000 pages

Key findings

> • variation in children's IQ and language ability related to amount parents speak to children
>
> • children's academic success at ages 9-10 related to amount of talk heard at ages 0-3

EARLY EXPOSURE TO LANGUAGE

- **by age 3, cumulative vocabulary was 1100 words in professional family, 750 in working class family, 500 in welfare family**

- **welfare family = 616 words/hour; working class family = 750 words/hour; professional family = 2153 words/hour**

- **by age 3, vocabulary used was larger in children of professional parents than welfare parents**

- **300 words more per hour for professional than welfare parents**

- **extrapolated to a year - child in professional family hears 11 million words vs. 3 million in welfare family**

- **strong correlation for children at age 9 in IQ**

Training Up Your IQ
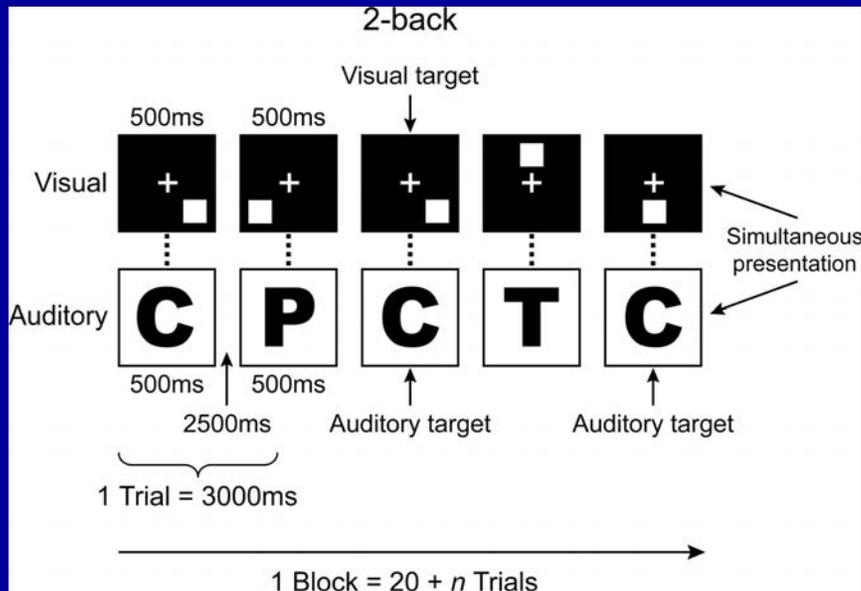
Jaeggi et.al. PNAS 2008

- **34 trained subjects, 35 controls**
- **daily training (between 8 and 19 days), skipping weekends, 25 minutes per day**
- **trained adaptively on dual n-back task;**
- **tested on Raven's Progressive Matrices/BOMAT**

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Training Up Your Working Memory
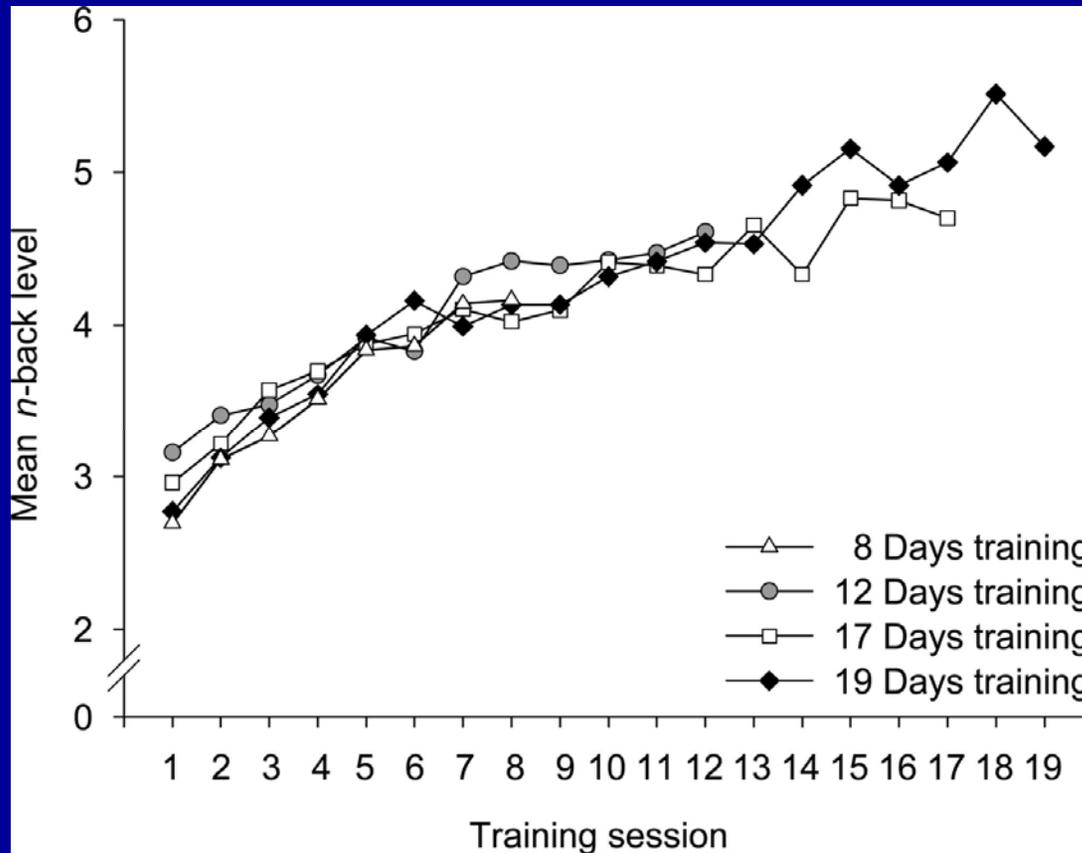
70

Training Up Your IQ
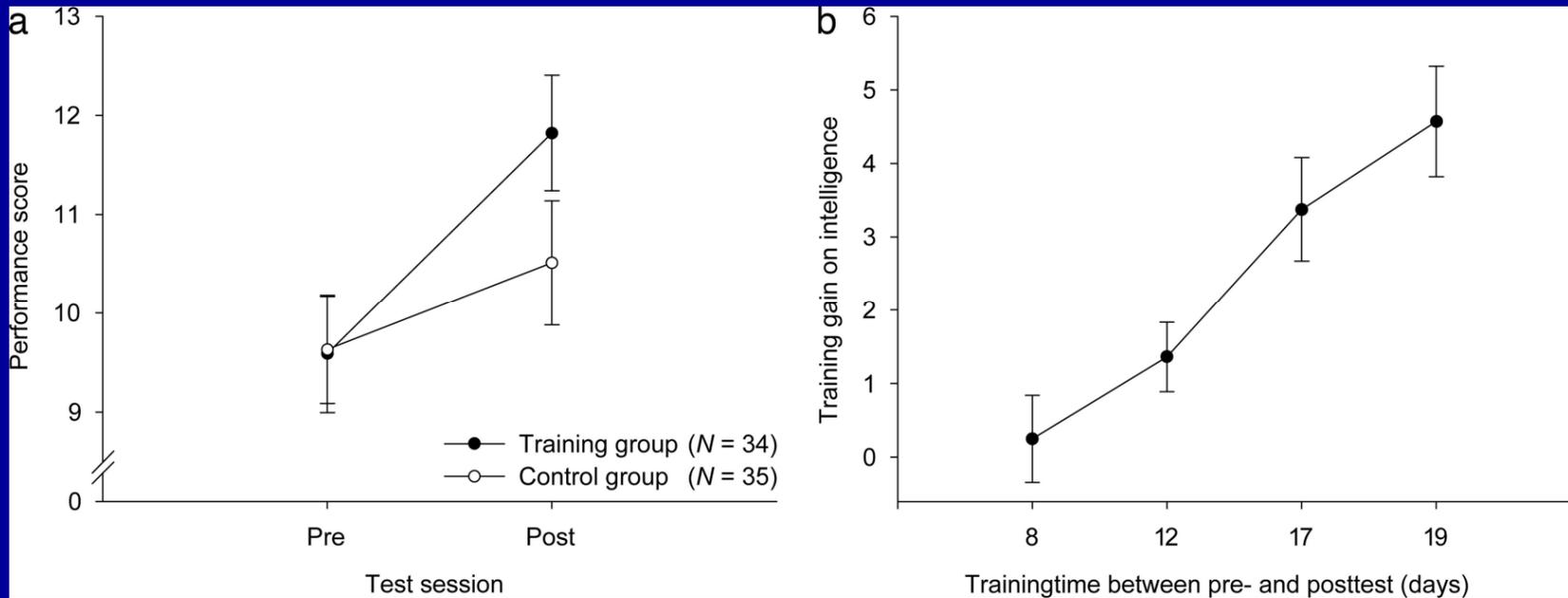
Intelligence: Group Differences

• **history of racism, sexism**
    US immigration Act of 1924
    "biologically weak stocks"
    Italians, Jews from Europe

99.9% genetic similarity - is "race" a biologically meaningful category?

Black-White Gap in US

- infancy - no difference

- age 4 - 4.5 points difference

- ages 4-24, 0.6/year, 83.4

- children fathered by black American GIs in Germany (WWII) brought up by German mothers same IQ as children of white American GIs and German mothers

- median household income

white ($50,700); black ($32,000); Hispanic ($37,800)

Stereotype Threat

- **Claude Steele**
verbal GRE items
blacks & whites
"laboratory experiment"
- equal scores
"test of intelligence"
-worse performance
-by blacks
- **List race**
laboratory experiment –
worse performance by
blacks

Figure 2
Mean Performance on a Difficult Verbal Test as a Function of Race and Test Characterization

Legend: ■ Black Participants □ White Participants

X-axis: Diagnostic, Non-diagnostic
Y-axis: Mean items solved (adjusted by SAT score) 0–20
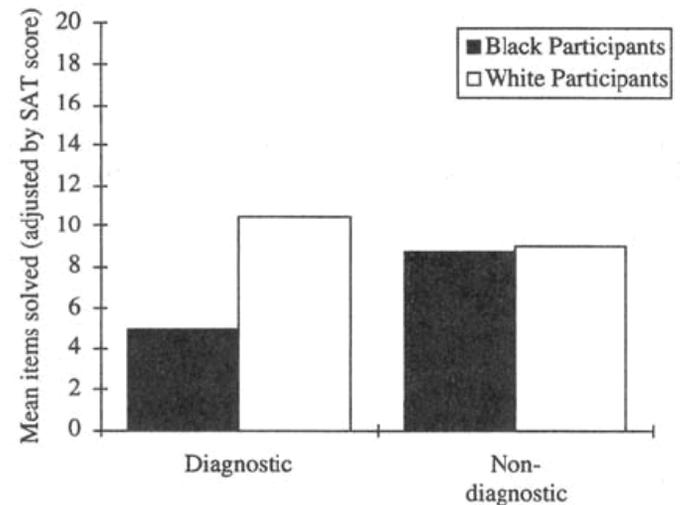
Note. SAT = Scholastic Assessment Test.

Source: Steele, C. M. "A Threat in the Air: How Stereotypes Shape Intellectual Identity and Performance." *American Psychologist* 52, no. 6 (1997): 613-29. Courtesy of the American Psychological Association. Used with permission.

Stereotype Threat

threat that others' judgments or one's own actions will confirm negative stereotypes about one's group

- women on math tests
- old people
- homosexual men
- athletic ability

- effects are greater with stronger group identification, importance of ability, or personally stigmatized

The Achievement Gap
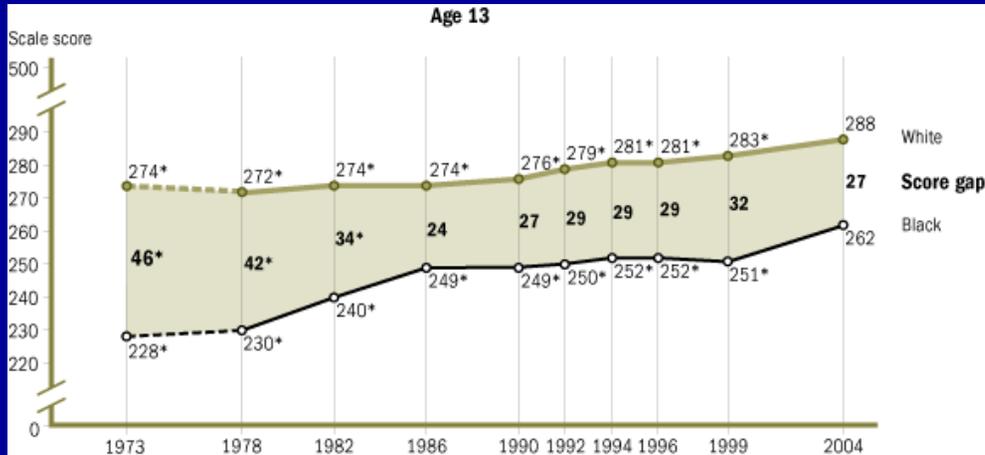
NAEP trends in average mathematics scores and score gaps
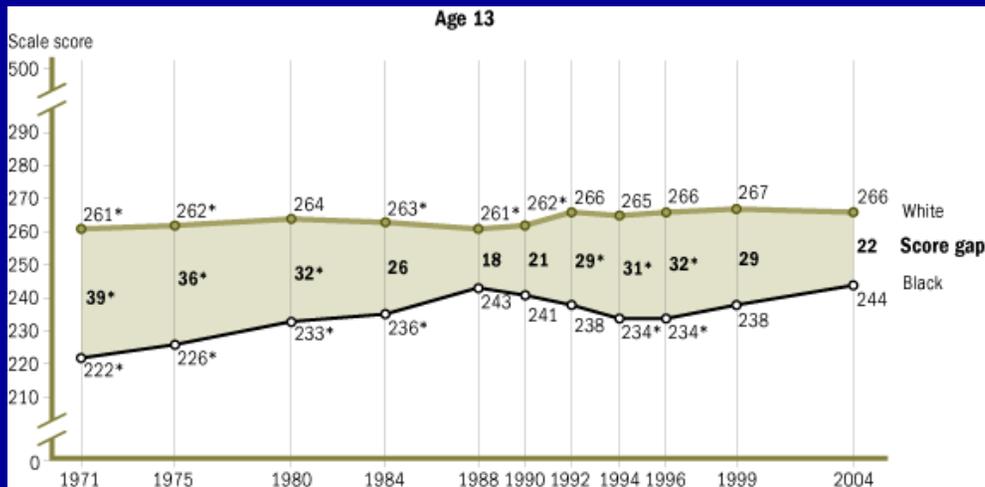
NAEP trends in average reading scores and score gaps

• "Nat'l Assessment of Ed. Progress (NAEP) also known as 'the Nation's Report Card,' is the only nationally representative and continuing assessment of what America's students know and can do in various subject areas…"

• In 2004, NAEP administered the latest long-term trend assessment to approximately 75,000 students at ages 9, 13, and 17 in public and nonpublic schools throughout the nation.

Source: U. S. National Assessment of Educational Progress (NAEP), http://nces.ed.gov/nationsreportcard/studies/gaps/.

Does Stereotype Threat Intervention Decrease the Achievement Gap?

Legend:
- ☐ African Americans - Control
- ■ African Americans - Affirmation
- ☐ European Americans - Control
- ▨ European Americans - Affirmation

Left panel (Low performing students, Moderate performing students, High performing students): Raw means and error terms

Right panel (Low performing students, Moderate performing students, High performing students): Covariate-adjusted means and error terms

- 119 African American and 124 white 7th graders from middle- to lower-class families at a suburban northeastern middle school

- Affirmation: choose a value from a list and write an in-class essay about why the chosen value is important to *you*

- Control: choose a value from the same list and write an in-class essay about why the chosen value might be important to *someone else*

- African Americans in affirmation group had G.P.A.s .30 pts higher than their control counterparts, but no effect was seen for the white students in the affirmation group…

Affirmation reduced the achievement gap by 40%!

Cohen, G. L., Garcia, J., Apfel, N., & Master, A. (2006) "Reducing the racial achievement gap: A social-psychological intervention." *Science* , *313*, 1307-1310.

Writing About Testing Worries Boosts Exam Performance in the Classroom

Gauss's modular arithmetic
Take test (pretest)
Can earn monetary award
with partner; partner had
already improved;
Performance to be videotaped
and evaluated;
(pressure/anxiety)
10 minutes

- **Control = sit quietly (7% worse)**
- **Expressive = write about thoughts/feelings (4% better)**
- **Unrelated writing (7% better)**
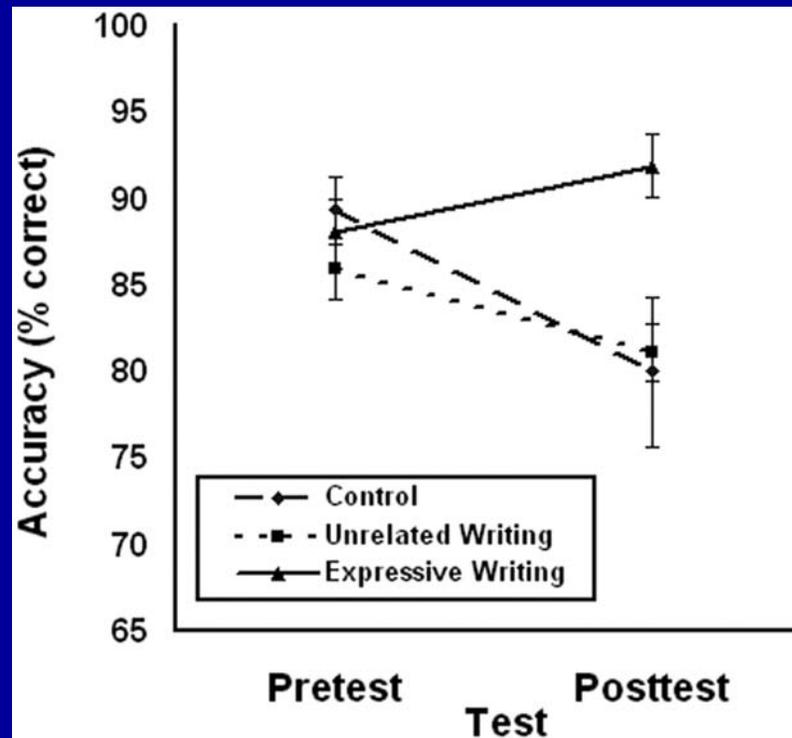
[Corrected from video]

Ramirez & Beilock, Science, 2011

78

Entity vs. Growth/Incremental

• how much does ability come from genes or the past (entity) vs. effort/practice (growth)?

• Carol Dweck

Implicit Theories of Intelligence Sample Questions

Strongly Agree	*Agree*	*Mostly Agree*	*Mostly Disagree*	*Disagree*	*Strongly Disagree*
1	*2*	*3*	*4*	*5*	*6*

1. **You have a certain amount of intelligence, and you really can't do much to change it.**

2. **Your intelligence is something about you that you can't change very much.**

3. **You can learn new things, but you can't really change your basic intelligence.**

# Entity vs. Growth/Incremental

• **theory of intelligence & adolescents' mathematics achievement**

• **belief that intelligence can grow associated with gains on math grades**

• **belief that intelligence is fixed associated with no gains on math grades**
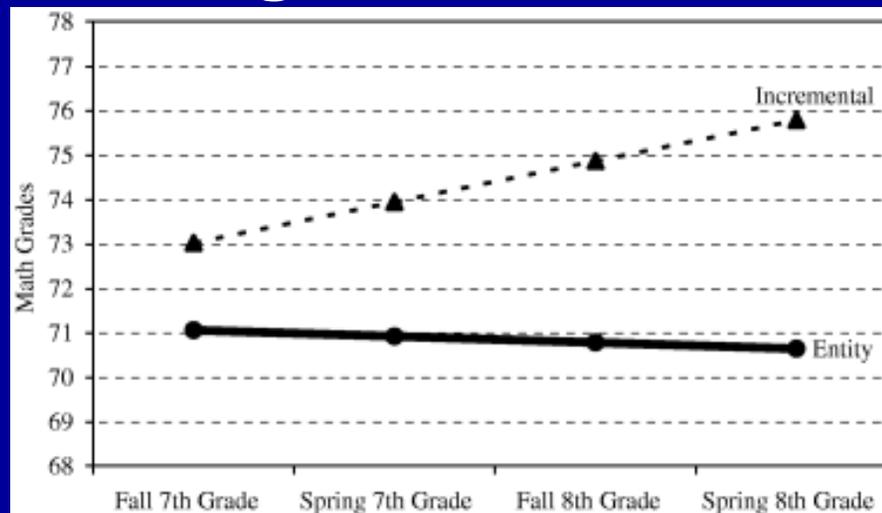
Perry Preschool Study – Lifelong Success After Fleeting Test Score Gains

- followed into adulthood 123 low SE children from African American families from around Perry Preschool in Ypsilanti, Michigan, in 1962
- youngsters participating in study were randomly divided into a *program group*, who received a high-quality, active learning preschool program and home visits, and a *no-program group*, who received no preschool program
- status of the two groups assessed annually from ages 3 to 11, at ages 14-15, at age 19, age 27 and again at age 40
- rare random-assignment, longitudinal study

Perry Preschool IQ Over Time
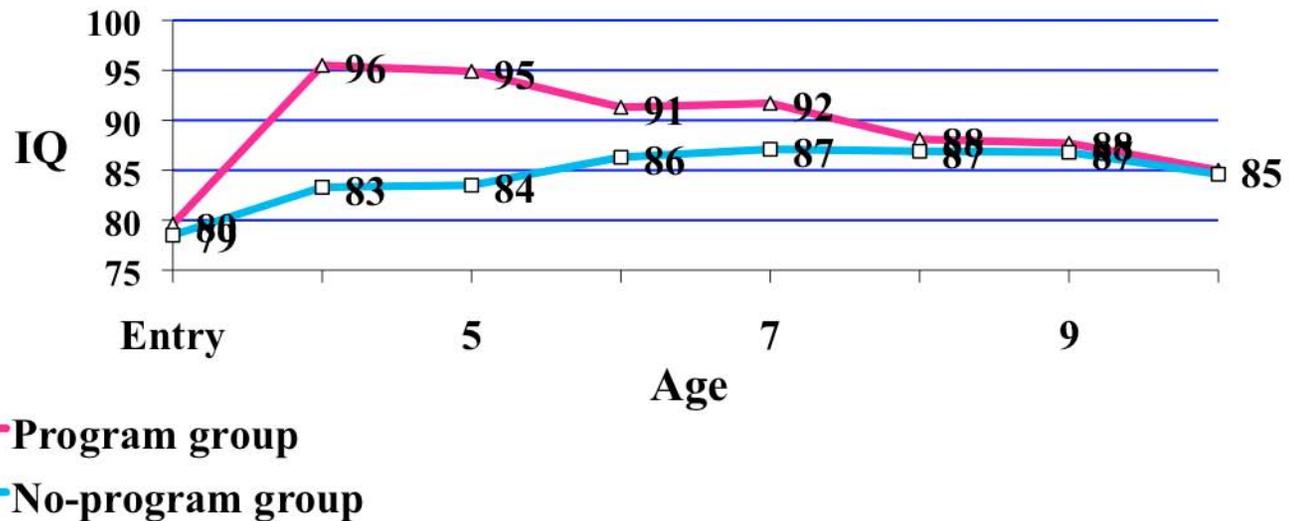
Program benefits seem to disappear over time, but... 83

Major Benefits in Important Life Outcomes

Major Findings: High/Scope Perry Preschool Study at 40

Program group   No-program group

| | 0% | 20% | 40% | 60% | 80% | 100% |

Arrested 5+ times by 40 — 36% (Program), 55% (No-program)

Earned $20K+ at 40 — 60% (Program), 40% (No-program)

Graduated regular high school — 65% (Program), 45% (No-program)

Basic achievement at 14 — 49% (Program), 15% (No-program)

Homework at 15 — 61% (Program), 38% (No-program)
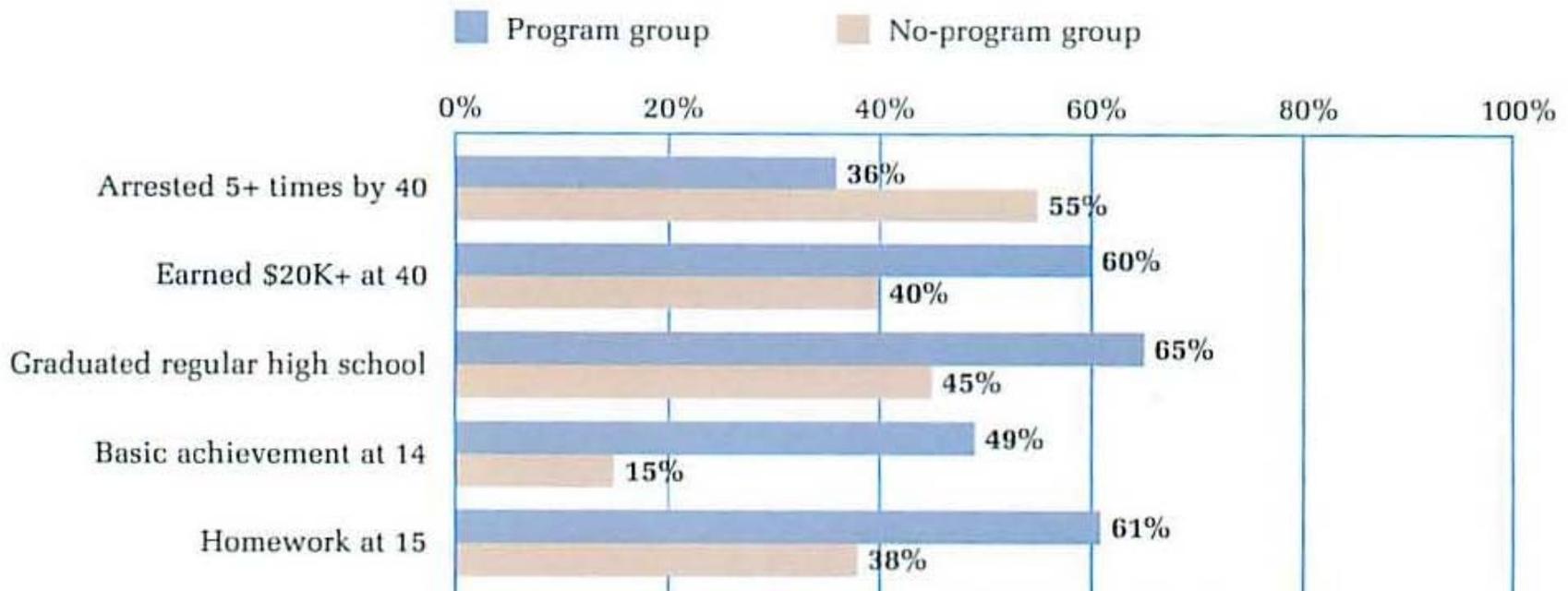
From *Lifetime Effects: The HighScope Perry Preschool Study Through Age 40* (page XV) by Schweinhart, L., Montie, J., Xiang, Z., Barnett, S., Belfield, C., Nores, M. Ypsilanti, MI: HighScope Press © 2005, HighScope Educational Research Foundation. Used with permission.

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