Week 8, 9

- Neuropsychological Tests : WAIS-4 & Others
- Interpretation of NP Test Results

Wechsler Adult Intelligence Scale (WAIS)

2009 - Killer with Low IQ Executed

By JAMES C. McKINLEY Jr. Published: December 3, 2009

HOUSTON — Bobby Wayne Woods was executed Thursday evening in Texas after his lawyers lost a battle to persuade the courts that he was too mentally impaired to qualify for capital punishment.

Mr. Woods, 44, was convicted of raping and killing an 11-year-old girl in 1997. He received a lethal injection and was pronounced dead at 6:48 p.m. in the death chamber at a state prison in Huntsville, Tex., after the United States Supreme Court denied a request from his lawyers to stay his execution. His last words, at 6:40, were: "Bye. I am ready." **Tests administered to Mr. Woods over the years placed his I.Q. between 68 and 86**, prompting a bitter debate between his lawyers and the state over whether he was too impaired to face execution. The state and federal courts repeatedly sided with prosecutors.


Mar 2014 - Supreme Court to Hear Hall v. Florida

- Atkins v. Virginia (2002) : Supreme Court : "Death is not a suitable punishment for a mentally retarded criminal"
- Freddie Lee Hall : "mentally retarded"
  - teachers, psychiatrists & psychologists
  - unable to cook, clean, dress or bathe himself regularly
  - in 1978 raped / murdered a 21 year old pregnant woman
    - had gouged out another woman's eyes in 1968
- Definition of Mentally Retarded: IQ of 70 or below
- IQ Test margin of error ± 5 points
- Q: can execution decision hang on imprecise test scores?

- Test scores...

Freddie Lee Hall's IQ Test Scores
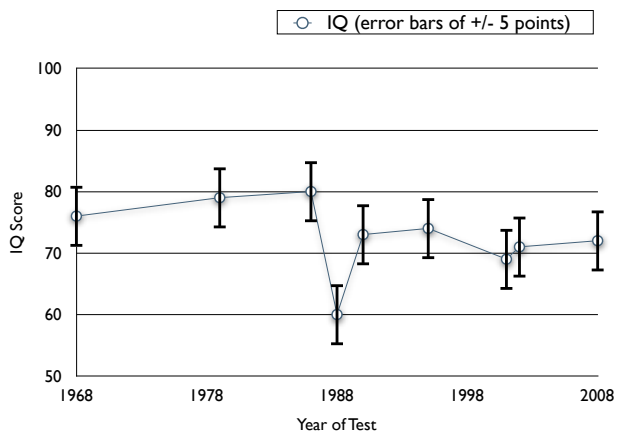
Wechsler Scales

- WAIS-4 : Adult Intelligence Scale (2008)
  - Evolved from Wechsler-Bellevue Intelligence Scale (1937)
  - Designed for Adults
  - Point scale rather than Age scale
  - Added Performance items (to fill void left by SB's reliance on language/verbal skills)
  - Focused on multiple abilities rather than "g"
- WISC-4 : Intelligence Scales for Children
- WPPSI-3 : Preschool and Primary Scale

David Wechsler

- "[...]Spearman's theory of general intelligence (g) was too narrow. [It is] an effect rather than a cause[...] Non-intellective factors, such as personality, contribute to the development of each person's intelligence."
- "Intelligence is the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment"
- Developer of major IQ assessment tests
- Deviation IQ (DQ) score replaced IQ=MA/CA

Cognitive / Info Processing 1

- **What is required to correctly answer a single item on an IQ test?**
  - Verbal comprehension: understand the instructions you hear or read
  - Short term memory: remember the instructions
  - Long term memory: retrieve answer or procedure
  - Working memory: juggle inforamation, do calculations, etc.
  - Judgement / Reasoning : decide between competing answers
  - Attention / Concentration: remain focused on task

Cognitive / Info Processing 2

- Verbal skills: give reply with voice
- Motor skills: respond with hand
- View response of examiner: praise? criticism?
- Meta cognition: judge performance, adjust strategy accordingly

- Cognitive science believes many of these to be independent processes subsumed by independent brain systems
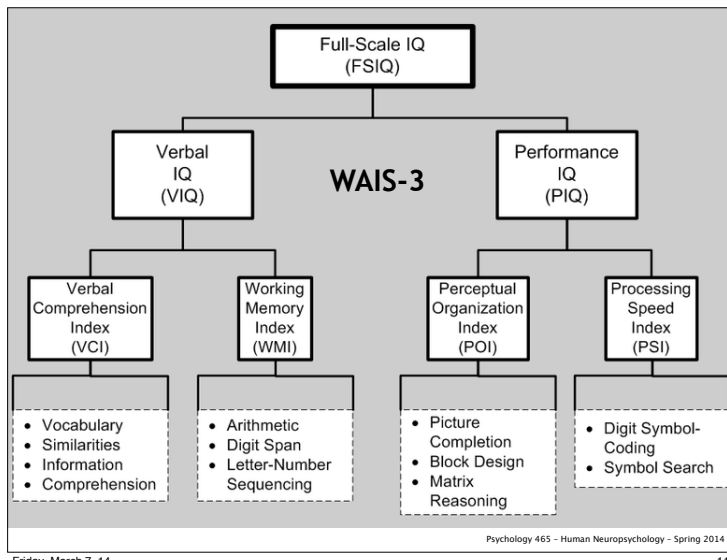
WAIS-4 is different from WAIS-3

- Reorganized:
  - Dropped the "Verbal/Performance" IQ scores
  - Renamed them "GAI" and "CPI"

- New "General Ability Index" (GAI)
  - GAI is supposed to be more insensitive to brain disorders, providing a possible estimate of pre-morbid functioning
  - Reduced reliance on Working Memory and processing Speed
  - "Theoretically, the GAI represents and individual's overall cognitive ability, if working memory and processing speed abilities were similar to verbal and non-verbal abilities"
- New "Cognitive Proficiency Index" (CPI)
  - measure of working memory & processing speed

WAIS-3

- Full-Scale IQ (FSIQ)
  - Verbal IQ (VIQ)
    - Verbal Comprehension Index (VCI): Vocabulary, Similarities, Information, Comprehension
    - Working Memory Index (WMI): Arithmetic, Digit Span, Letter-Number Sequencing
  - Performance IQ (PIQ)
    - Perceptual Organization Index (POI): Picture Completion, Block Design, Matrix Reasoning
    - Processing Speed Index (PSI): Digit Symbol-Coding, Symbol Search

WAIS-4

- Full-Scale IQ (FSIQ)
  - General Ability Index (GAI)
    - Verbal Comprehension (VCI): •Similarities •Vocabulary •Information •*Comprehension**
    - Perceptual Reasoning (PRI): •Block Design •Matrix Reasoning •Visual Puzzles •*Picture Completion** •*Figure Weights**
  - Cognitive Proficiency Index (CPI)
    - Working Memory (WMI): •Digit Span •Arithmetic •*Letter-Number sequencing**
    - Processing Speed (PSI): •Symbol Search •Coding •*Cancellation**

* is not part of core battery

WAIS-IV General Ability Index (GAI)

- Verbal Comprehension Index (VCI)
  - Vocabulary
  - Similarities
  - Information
  - *Comprehension*

- Perceptual-Reasoning (PRI)
  - Block Design
  - Matrix Reasoning
  - Visual Puzzles
  - *Picture Completion*
  - *Figure Weights*

WAIS-IV Vocabulary, Similarities, Information

- Vocabulary
  - "What is a guitar?"

- Similarities
  - "In what way are an apple and a pear alike?"

- Information
  - "How far is it from New York to Paris?"

- Comprehension
  - "Why is food often sold in sealed containers?"
    - 1 point : to keep it clean
    - 1 point : to keep it fresh
    - 1 points : to make it easy to transport

WAIS-IV: Block Design

WAIS: Matrix Reasoning
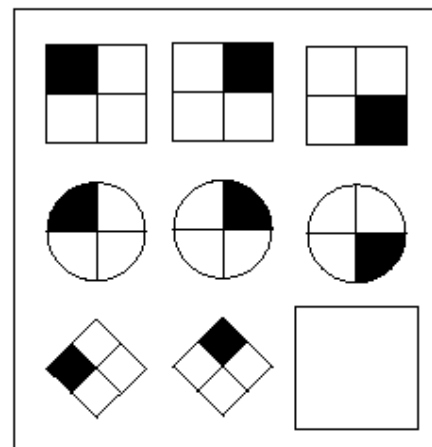
WAIS-IV: Visual Puzzles

Which 3 of these pieces go together to make this puzzle?
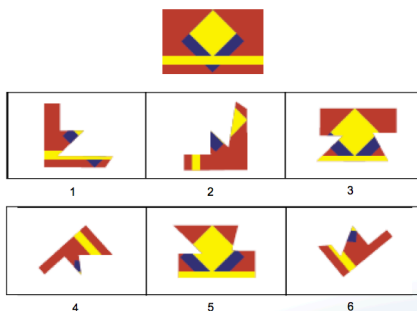
WAIS-IV Cognitive Proficiency Index (PCI)

- Working Memory Index (WMI)
  - Digit Span
  - Arithmetic
  - *Letter-Number Sequencing*

- Processing Speed Index (PSI)
  - Symbol Search
  - Coding
  - *Cancellation*

WAIS: Digit Span

68910

WAIS-IV Arithmetic & Letter-Number Sequencing

- Arithmetic
  - "How many 45-cent stamps can you buy for a dollar?"

- Letter-Number Sequencing
  - "Repeat Q-1-B-3-J-2 in numerical and alphabetical order"
    - ex. "123, BJQ"

WAIS : Digit Symbol Coding

WAIS-4

- Which of these tests are completely "pure" measures of an ability?
  - Verbal / language issues?
  - Cultural bias?
  - Motivation?
  - Expectancy effects?
  - Strategy : speed vs. accuracy?

Multiple Intelligences

- The WAIS-4 tests multiple _dimensions_ of intelligence, but this is not the same thing as _multiple intelligences_
- Which of Gardner's 8 intelligences are actually measured by the WAIS-4?

Gardner's 8 Intelligences

- logical-mathematical (*)
- verbal-linguistic (*)
- spatial (*)
- musical
- bodily-kinesthetic
- naturalist
- interpersonal
- intrapersonal

Interpretation of NP Test Results

"Good news. The test results show it's a metaphor."

"Good news. The test results show it's a metaphor."

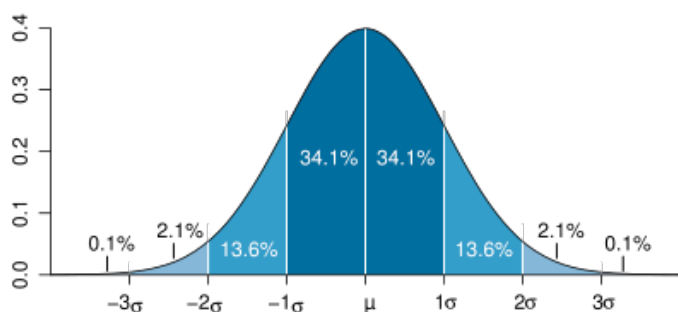## Interpretation of NP Test Results

- Standard Scores
- Normative Scores
- Demographic Corrections
  - Age, Education, Gender and Race/Ethnicity
  - Race
    - is it real?
  - Demographic Norms Example
    - Example paper (Diehr et al 1998)
- Premorbid Functioning
  - Qualitative Estimates
  - Quantitative Estimates
- Psychometric Issues

Normal Distribution

Many measures show a normal distribution
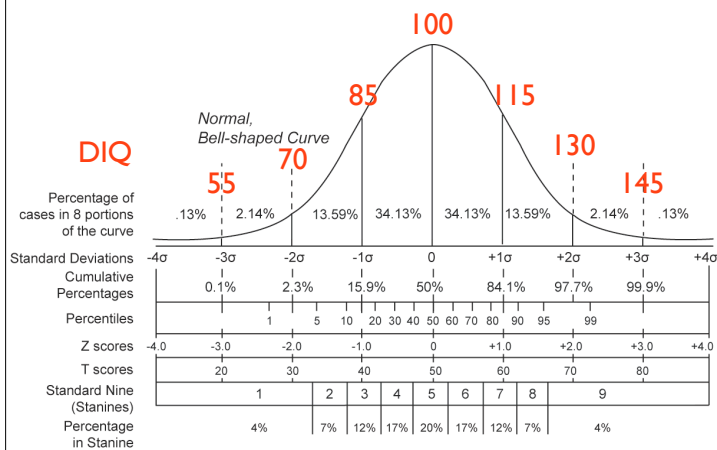

Raw vs. Standard Scores

- Raw score - the # or percent correct
  - range : depends on test
  - mean : depends on test
  - standard deviation : depends on test

- Standardizing scores
  - put all tests on same metric
  - allows comparisons across tests
  - method
    - Describe scores as distance from Mean, with distance measured against the SD

- Problem:
  - too many "standard" standard scores!

Standard Scores

Standard Scores

	Z scores	IQ scores	T scores
Mean	0.0	100	50
SD	1.0	15	10

top 3% is 97 percentile, a Z score of approximately 1.9, IQ score of 128.5, T score of 19, and scaled score of 15.7

Normative Data

- Normative Group
  - For each test, give test to a group of "normal" people and measure scores.
    - group should match society (age, education, SES, gender, ethnicity…)
  - Determine Mean (SD), call this "normal"

- For an individual under assessment…
  - compare observed score to normative data
    - data tables
    - formulas
    - computer programs

Demographic Variables

"It's a baby. Federal regulations prohibit our mentioning its race, age, or gender"

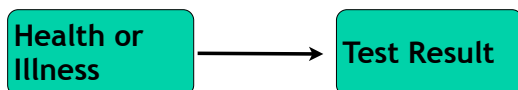"It's a baby. Federal regulations prohibit our mentioning its race, age, or gender."

Demographic Corrections

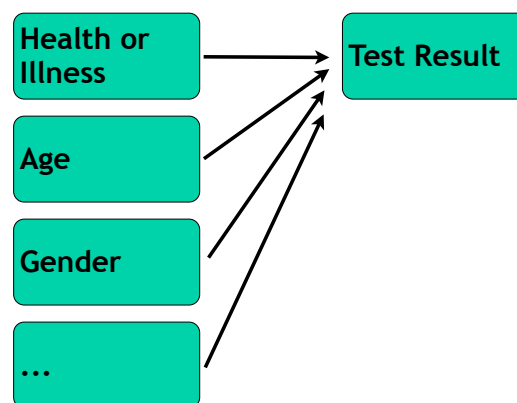- Normative Data would be simple if there was one definition of "normal"
- Simple model

Health or Illness → Test Result

Demographic Model

- More realistic model

Health or Illness
Age
Gender
…
→ Test Result

Common Demographic Covariates

- Age
- Sex
- Race/Ethnicity
- Education
- Language

Age

"I forget the name of the product, but the jingle on TV goes something like 'yum de ta dum de diddle dum dum dee dum'

Age

- Once you hit 35 years old, it's all downhill!
- Gets significantly worse
  - fluid reasoning
  - speed of processing
  - working memory
  - long term memory
- Gets a little worse or stays same
  - Crystallized information
  - semantic memory
- May get better
  - reasoning
  - vocabulary
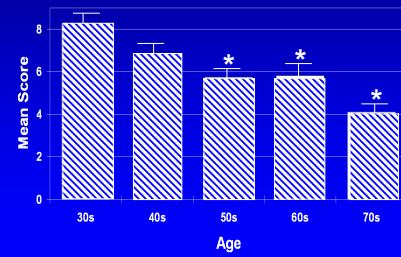 - emotion
  - metacognition

Delayed Story Recall

Differences in Delayed Recall with Age
(subjects 30 – 79 years old)

Albert et al, 1987

CANTAB Paired Associate Learning

Paired Associate Learning (errors)– Computerized Task (n=1444)
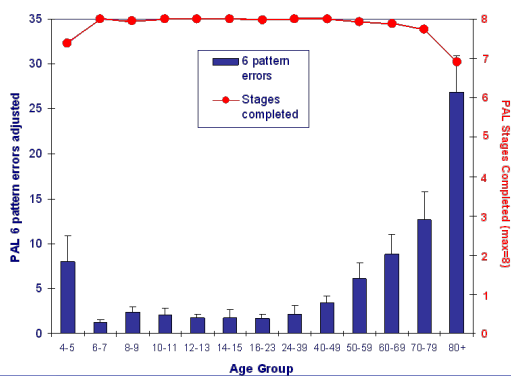
Rate of Change with Age

Rate of Change in Visual Memory with Age
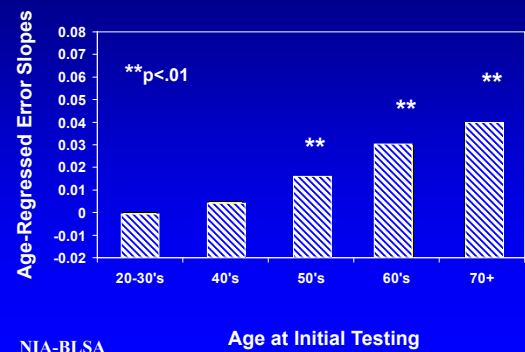
**p<.01

NIA-BLSA

Gender

GENDER-SPECIFIC CLOTHING

Gender

- Historical conceptions
- Modern data

Gender and IQ

- It was commonly accepted in the 1800s that men were intellectually superior to women
- Darwin, <u>Descent of Man</u> (1871) "The chief distinction in the intellectual powers of the two sexes is shewn by man's attaining to a higher eminence, in whatever he takes up, than can woman - whether requiring deep thought, reason, or imagination, or merely the use of the senses and hands"
- Book was edited by Darwin's daughter Henrietta and wife Emma.
- Darwin was in other ways socially liberal

Gender and IQ

- Modern scientific consensus is that men and women, on average, have equal IQ scores.
- Differences are small and generally insignificant (1-3 IQ points when differences are found)
- Men's IQ scores tend to be slightly more variable (higher variance) so more men tend to fall at either end of the spectrum
- Some evidence that males are better at stereotypical "male" tasks (visuospatial skills) whereas women are better at "female" tasks (language).   Evolutionary reasons? Testosterone?

Race

"I don't know anything about the bell curve, but I say heredity is everything"

Race vs. Ethnicity

- Race - genetic heritage
- Ethnic group -- population whose members identify with each other
- "National, religious, geographic, linguistic and cultural groups do not necessarily coincide with racial groups: and the cultural traits of such groups have no demonstrated genetic connection with racial traits. Because serious errors of this kind are habitually committed when the term "race" is used in popular parlance, it would be better when speaking of human races to drop the term "race" altogether and speak of 'ethnic groups'.

Pre-DNA views

Gold, silver, brass, iron

"Citizens, we shall say to them in our tale, you are brothers, yet God has framed you differently. Some of you have the power of command, and in the composition of these he has mingled gold, wherefore also they have the greatest honor; others he has made of silver, to be auxiliaries; others again who are to be husbandmen and craftsmen he has composed of brass and iron; and the species will generally be preserved in the children. But as all are of the same original stock, a golden parent will sometimes have a silver son, or a silver parent a golden son."

-- Plato, *The Republic*, circa 380 BC

Racial Attitudes of the 1800s

- "[...]There is a physical difference between the white and black races which I believe will for ever forbid the two races living together on terms of social and political equality.   And inasmuch as they cannot so live, while they do remain together there must be the position of superior and inferior, and I as much as any other man am in favor of having the superior position assigned to the white race."

> -- 1858, in a debate with Stephen Douglas
>   Abraham Lincoln

Genetics

- Human genome contains about 4 billion pairs of deoxyribonucleic acid (DNA)
- DNA is Transcribed into RNA
- RNA is Translated into Proteins
- Proteins
  - serve as structural components
  - function as enzymes to catalyze biochemical reactions
- Human DNA is grouped into 46 chromosomes
  - 23 pairs, one of each pair comes from each parent
  - 22 pairs in both males and females (autosomes)
  - 1 pair determines sex: either "XX" (females) or "XY" (males)

Genetics : Species Differences

organism	estimated size (base pairs)	# genes	gene size	# chromosomes
Homo sapiens (human)	3.2 billion	~25,000	1 gene per 100,000 bases	46
Mus musculus (mouse)	2.6 billion	~25,000	1 gene per 100,000 bases	40
Drosophila melanogaster (fruit fly)	137 million	13,000	1 gene per 9,000 bases	8
Arabidopsis thaliana (plant)	100 million	25,000	1 gene per 4000 bases	10
Caenorhabditis elegans (roundworm)	97 million	19,000	1 gene per 5000 bases	12
Saccharomyces cerevisiae (yeast)	12.1 million	6000	1 gene per 2000 bases	32
Escherichia coli (bacteria)	4.6 million	3200	1 gene per 1400 bases	1
H. influenzae (bacteria)	1.8 million	1700	1 gene per 1000 bases	1

Nonconcordant traits

- Naive view : Race = Genetics or heritage
- Biochemical view : traits & genes are spread out among groups. Group difference occur, but often the differences have fuzzy edges

- Non concordance : visible traits (skin color, eye shape, hair texture, etc.) don't go together

- Visible vs. Invisible differences: differences on the genetic level often don't track what is seen in surface differences (such as skin color)

Nonconcordant traits

Race vs. Genetics
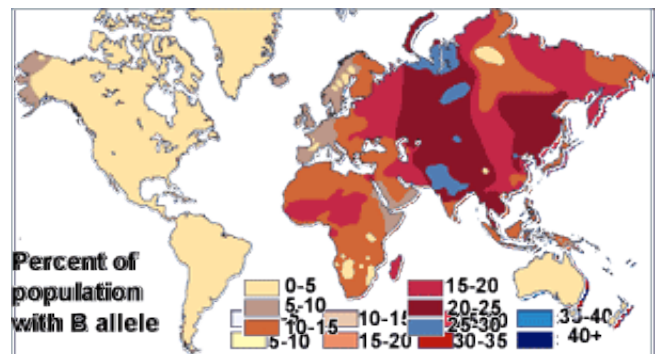
Visible differences?

Indigenous
Australian
Melanesia
African
European

Australian and Africans are most genetically different

Australian   Melanesian

African   European

Post-DNA views

- Variance
  - variation between individuals
  - variation within groups
  - variation between groups
- Variance
  - variation between individuals : 3mbp / person
  - variation within groups : 85%
  - variation between groups: 15%
    - about 5% - within "races"
    - about 10% - between races

Genetic Differences

- **Sub-Saharan African**
- **Indo-European**
- **East Asian**
- **Native American**
- **South Asian**
- **Aboriginal**

F_{st} = % of subpopulation variance

San (Bushmen)
Mbuti Pygmy
Bantu
Nilotic
West African
Ethiopian
Southeast Indian
Lapp
Berber North African
Sardinian
Indian
Southwest Asian
Iranian
Greek
Basque
Italian
Danish
English
Samoyed
Mongol
Tibetan
Korean
Japanese
Ainu
North Turkic
Eskimo
Chukchi
South American Indian
Central American indian
North American Indian
Northwest American Indian
South Chinese
Mon Khmer
Thai
Indonesian
Philippine
Malaysian
Polynesian
Micronesian
Melanesian
New Guinean
Australian

0.2   0.15   0.1   0.05   0
Genetic Distance (Fst)

Variance: Genetic Variation

- Within local populations
- Within "race"
- Between "race"

85%   5%   10%
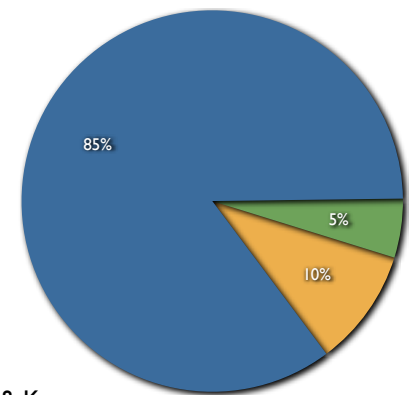
For example:
- 85% within Japanese
- 5% between Japanese & Korean
- 10% between Asian and Caucasian

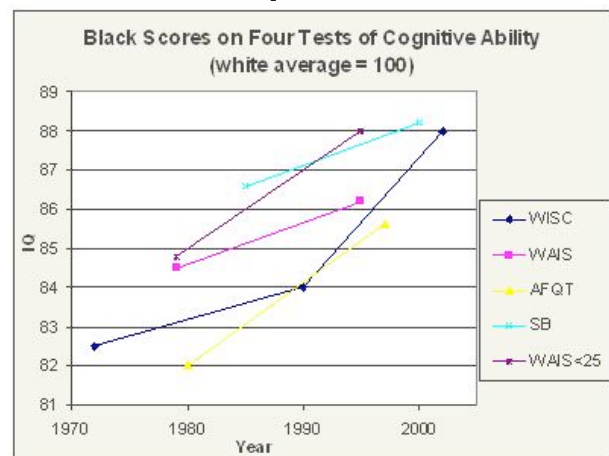### Effects of Race & Ethnicity on NP Scores

- Many NP tests show effects of Race
  - widespread agreement
- Reasons for these differences?
  - great disagreement
  - Proxy for other variables (nutrition, education, social & environmental opportunities & rewards, money...)
  - Genetics?

The Flynn Effect

Black Scores on Four Tests of Cognitive Ability
(white average = 100)

WISC
WAIS
AFQT
SB
WAIS<25

Diehr et al (2003)

- Paced Auditory Serial Addition Test

- Demographic variables:
  - ethnicity : self-identified as either White / Black
  - age
  - gender
  - education
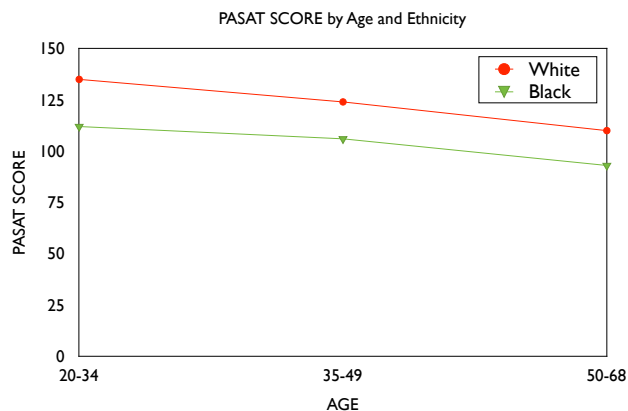

Diehr et al (2003) Results

- Statistically and Clinically-significant differences in PASAT test result found for
  - Age
  - Education
  - Ethnicity
- Results not statistically significant:
  - Gender

Diehr et al (2003) Results

PASAT SCORE by Age and Ethnicity

Education

- Is education a demographic variable?

- Can educational level be a result, not a cause, of brain development?

Demographic Variables: Conclusions

- Age difference : Large
- Gender differences on IQ tests are small (less than .2 SD) but still controversial
- Ethnic differences are fairly large (1.0 SD)
  - Explanations:
    - Test bias? some found, but doesn't explain most of difference
    - Genetic differences? yes, but recent results suggest this % has been vastly over-estimated.
    - Environmental differences? yes, explains a great deal, and explains recent reductions (e.g. Flynn effect)
- Education differences : Large
  - probably a proxy for other factors, but works well

Estimating Premorbid Functioning

"It's a concussion, Sven, you're sitting out the next siege"

Estimating Premorbid Functioning

- Interpretation of NP test results is most accurate when comparing pre- and post- test results
- Rarely have premorbid tests
- What to do?

- Estimates from demographic variables
  - age, education, gender, ethnicity
- Estimates from vocation/skills
  - nature of work done

- Ideal: a test which is highly correlated with IQ but not affected by most forms of brain damage

Premorbid Functioning : the NAART

- North American Adult Reading Test
- Pronunciation of 61 word reading list
- Correlates highly with IQ
- Correlates very weakly with many forms of brain damage

- Automatic Process
- Not timed

Premorbid Functioning : the NAART

Debt	Placebo	Detente	Sidereal
Debris	Procreate	Impugn	Abstemious
Aisle	Psalm	Capon	Beatify
Reign	Banal	Radix	Gaoled
Depot	Rarefy	Aeon	Demesne
Smile	Gist	Epitome	Syncope
Lingerie	Corps	Equivocal	Ennui
Recipe	Hor d'oeuvre	Reify	Drachm
Gouge	Sieve	Indices	Cidevant
Heir	Hiatus	Assignate	Epergne
Subtle	Gauche	Topiary	Vivace
Catacomb	Zealot	Caveat	Talipes
Bouquet	Paradigm	Superfluous	Synecdoche
Gauge	Facade	Leviathan	
Colonel	Cellist	Prelate	
Subpoena	Indict	Quadruped	

NAART Estimating Premorbid Verbal IQ

- Given NAART score, estimate premorbid Verbal IQ (via on their Vocabulary test Scaled Score)

- 4th equation includes Education correction

ADULT READING TEST   1129

$$\text{WAIS–R Vocabulary} = 31.30 + 0.622 \times \text{NAART} \ (\text{SEE} = 5.14)$$

$$\text{WAIS–R Vocabulary} = 25.71 + 0.566 \times \text{NAART} + 0.508 \times \text{Education} \ (\text{SEE} = 5.02)$$

$$\text{WAIS–R Vocabulary Scaled} = 5.383 + 0.179 \times \text{NAART} \ (\text{SEE} = 1.71)$$

$$\text{WAIS–R Vocabulary Scaled} = 4.112 + 0.167 \times \text{NAART} + 0.115 \times \text{Education} \ (\text{SEE} = 1.69)$$

Psychometric Issues

"I'll have a quarter pound of your most reliable cheese."

Psychometric Issues

- Standardization
- Reliability
- Validity
- Type I and II errors - Prevalence & Hit Rates

Standardization

- Tests must be standardized in methodology

- Issues
  - feedback, encouragement
  - motivation

Reliability

- Reliability
  - whether a test gives a consistent result in the same situation
  - how much statistical noise is present
  - Example:
    - We believe IQ is relatively fixed
    - IQ test should give same results when administered
      - over time
      - by different examiners

Validity

- Validity
  - whether a test result "means what it says"
  - is the conclusion (or prediction) made using the test accurate

  - Example:
    - We believe IQ is related to employment success
    - Someone with low IQ
      - Prediction: "They will not win Jeopardy"
      - Result : ???

Types Of Errors

		The patient actually is...	
		Sick	Healthy
You decide patient is...	Sick	True Positive $1-\beta$ **"Hit"**	False Positive Type I Error α **"False Alarm"**
	Healthy	False Negative Type II Error β **"Miss"**	True Negative $1-\alpha$ **"Hit"**

Hit Rates

- Hit Rate
  - % of people correctly classified
- Sensitivity
  - probability of detecting illness
- Specificity
  - probability of detecting health
- Positive Predictive Value
  - probability of being ill when you test ill
- Negative Predictive Value
  - probability of being healthy when you test healthy

Base Rates (Prevalence) and Hit Rates

- If the disease is very rare (has a low Base Rate or Prevalence)
  - most of the diagnoses are false positives

- SPIN / SNOUT:

- SPIN : When **S**pecificity is high, **P**ositive result rules **IN** the condition
- SNOUT : When **S**ensitivity is high, **N**egative result rules **OUT** the condition.

Low Prevalence Example

- Imagine a disease that's only found in 1/1000 patients.
- You have a test with 95% specificity, 95% sensitivity (in other words, a good test).

- In a group of 1000 patients,
  - you will diagnose 50 of them as having the disease
  - but only 1 actually does