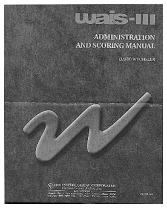
Psych 3102
Introduction to Behavior Genetics
Lecture 19
Genetics of cognitive abilities

Hierarchical, psychometric model of cognitive ability Spearman, 1904

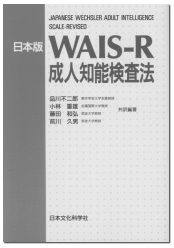
General cognitive ability (g)



Specific cognitive abilities:

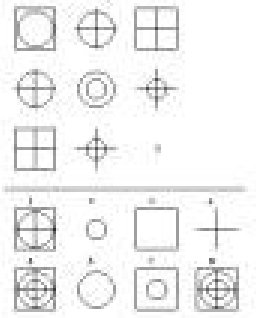
Measures (tests):

..

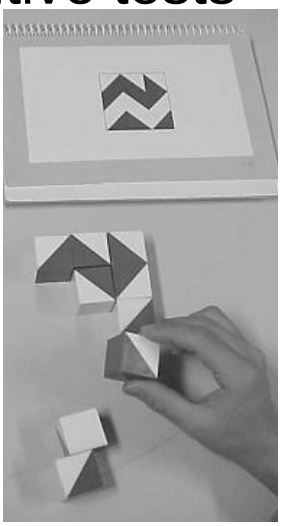


- weight given to an item is determined by its correlation with other items
  - items that correlate highly and items that measure more complex tasks are weighted more (contribute more to g)

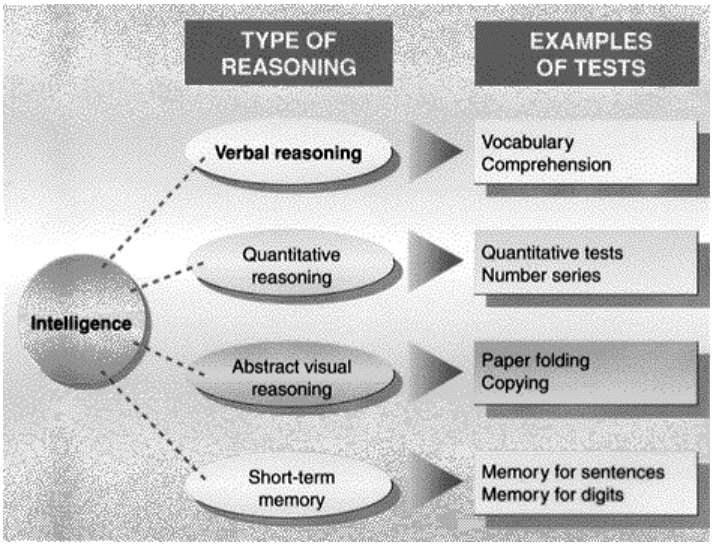
Examples of cognitive tests



Sample Item from Raven's Progressive Matrices

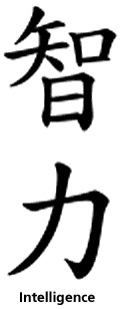


Wechsler block Design Task



Definitions of Intelligence:

Which one do we prefer?



Intelligence

- E. G. **Boring**, a well-known Harvard psychologist in the 1920's
  ..."whatever intelligence tests measure"
- Alfred **Binet** in The Individual
  ...the ability to "judge well, to comprehend well, to reason well."
- David **Wechsler** cited in Annual Editions
  ..."the global capacity of the individual to act purposefully, to think rationally, and to deal effectively with the environment."
- **Benjamin, Hopkins and Nation** in Psychology (a textbook)
  ..."the capacity to acquire and use knowledge, a capacity that is supported by a host of cognitive abilities such as perception, memory storage and retrieval, reasoning, problem solving and creativity."
- from the **Merriam-Webster Dictionary**
  (1) the ability to learn or understand or to deal with new or trying situations; also, the skilled use of reason
  (2) the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (such as tests)

Cattell's fluid and crystallized intelligence

- fluid intelligence (G_F) -

- crystallized intelligence (G_C) –

Executive functions –

in everyday life –

- may not be assessed well by some general IQ tests since only moderate correlations EFs:IQ

What does an estimate of 'g' tell us?

- it is
- it is
- it predicts
- it may not tell us about
- distrusted by general public
- older tests were culturally, socially biased
- not true for newer alternative tests:
  information-processing methods
  direct assessment of brain functioning

Table 1 The Validity of Various Predictors of Job Performance

TECHNIQUE	VALIDITY
ABILITY COMPOSITE (Cognitive Ability Test Battery)	*.53*
JOB TRYOUT (Probationary Period)	*.44*
SITUATIONAL INTERVIEW (Structured/job related interview)	.37
REFERENCE CHECKS (Check with past employers)	.26
CLASS RANK OR GRADE POINT AVERAGE (Self-explanatory)	.21
AMOUNT OF EXPERIENCE (Years on the job)	.18
UNSTRUCTURED INTERVIEW (General discussion with applicant)	.14
TRAINING AND EXPERIENCE (Time spent in job/training)	.13
AMOUNT OF EDUCATION (Years in school)	.10

Hunter and Hunter, Michigan State University, (1984). American Psychological Association, 96 (1), 72-98.

- ***Economic and social correlates of IQ :***

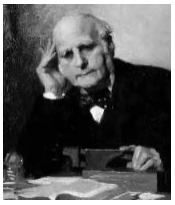
Factors	Correlation
School grades and IQ	0.5
Total years of education and IQ	0.55
IQ and parental socioeconomic status	0.33
Job performance and IQ	0.54
Negative social outcomes and IQ	−0.2
IQs of identical twins	0.86
IQs of husband and wife	0.4
Heights of parent and child	0.47

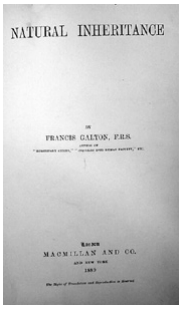
- ***Economic and social correlates of IQ in the USA :***

IQ	<75	75–90	90–110	110–125	>125
US population distribution	5	20	50	20	5
Married by age 30	72	81	81	72	67
Out of labor force more than 1 month out of year (men)	22	19	15	14	10
Unemployed more than 1 month out of year (men)	12	10	7	7	2
Divorced in 5 years	21	22	23	15	9
% of children w/ IQ in bottom decile (mothers)	39	17	6	7	< 1
Had an illegitimate baby (mothers)	32	17	8	4	2
Lives in poverty	30	16	6	3	2
Ever incarcerated (men)	7	7	3	1	< 1
Chronic welfare recipient (mothers)	31	17	8	2	< 1
High school dropout	55	35	6	0.4	< 0.4
Values are the percentage of each IQ sub-population, among non-Hispanic whites only, fitting each descriptor. Compiled by Gottfredson (1997) from a US study by Herrnstein & Murray (1994) pp. 171, 158, 163, 174, 230, 180, 132, 194, 247–248, 194, 146 respectively.					

Long history of research into cognitive ability:

Galton (1865) Sir Francis Galton (1865, 1869), Darwin's cousin, immediately recognized the implications for human variation. Galton carried out surveys and found that good and bad temperament, as well as intelligence, ran in families. He discovered the phenomenon of regression-to-the mean and the implication that family variation was heritable



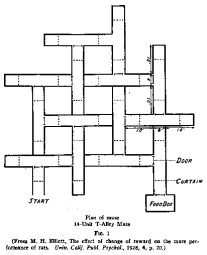


Burks (1928) Barbara Stoddard Burks, "The Relative Influence of Nature and Nurture Upon Mental Development; A Comparative Study of Foster Parent-Foster child Resemblance and True Parent-True Child Resemblance," *27th Yearbook of the NationalSocietyfor the Study of Education*, (1928)

Merriman (1924) twin methodology

Tolman (1924) selection for maze

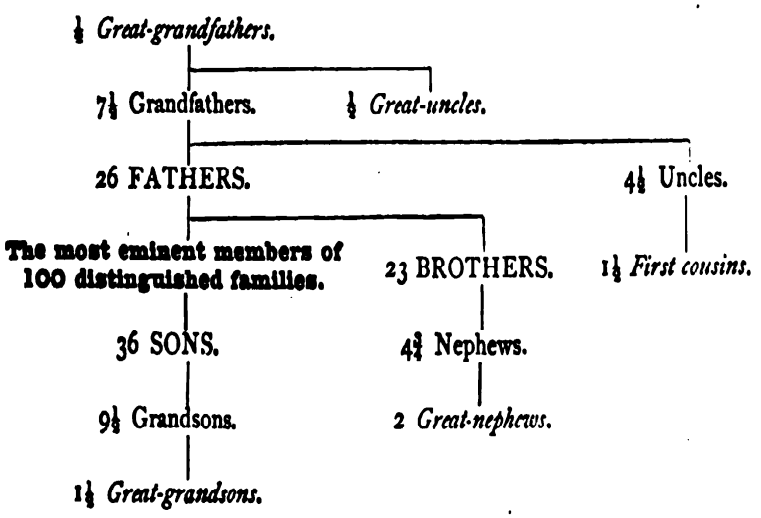
Tryon learning in rats

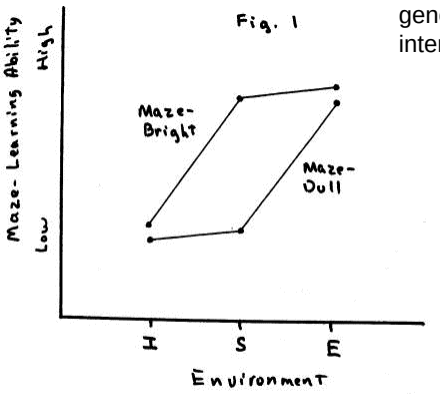


Cooper & Zubek (1958)

Galton (1869) Hereditary genius: An enquiry into its laws and consequences

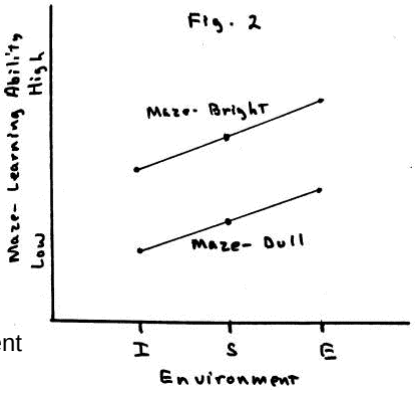
PERCENTAGE OF EMINENT MEN IN EACH DEGREE OF KINSHIP TO THE MOST GIFTED MEMBER OF DISTINGUISHED FAMILIES.





genotype/environment interaction

I = impoverished
S = standard
E = enriched



no genotype/environment interaction

Change in acceptance of genetic influence on cognitive ability in the 60's and 70's

- to this time, general acceptance of genetic influence on both animal and human cognition. Then, several things arose to change this view:

Typical psychology department in the 60's

reductionist theories – all behaviors could be traced to one basic single causative event **"intrapsychic conflicts of infancy"**

- all influences were entirely environmental
- individual differences were viewed as 'error'

Very unattractive connotations from recent past history

eugenics – idea that humanity can be improved by selective breeding

intelligence, aggression, antisocial behavior- all subject to eugenic practices in past

Bad science

Burt (UK) falsified data to enhance his results showing gene influence on g

Jensen (US) published unsupported conclusions showing ethnic differences in g

- whole area of research thrown under suspicion
- general view was that a genetic influence on human cognition did not exist

Why did this view not last long?

good empirical studies –

Kamin (1974): "… little or no evidence that intelligence is a heritable trait."

Brody (1990) "… it is inconceivable.. that any responsible scholar could.. take this position"

Current problems

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Commonly-used tests of cognitive ability

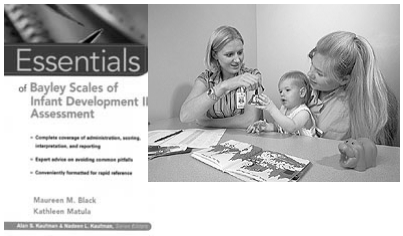
WISC – Wechsler intelligence scales

measurement error ± 5 points (score 70, range=65-75)

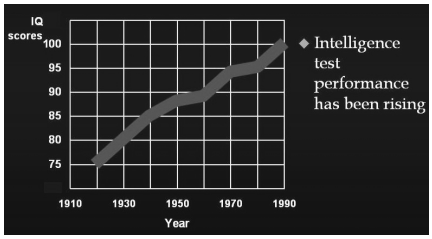
WAIS - Wechsler Adult intelligence scales

Stanford-Binet

Bayley Scales of Infant Development



Flynn effect



- average IQ has steadily been rising since measurement began

UK 27 point increase

US 24 point increase since WWII

- shown as overall increase in population mean
- due to environment that we all share (cultural environment)
- intelligence tests have to be re-normed periodically

Possible reasons for Flynn effect?

Summary of evidence for influence of genes on cognitive ability

Bouchard & McGue (1981)

- summary of results from many studies

Adoption studies Reared apart P/O, sibs r = 0.24

-

Twin studies Adolescence Reared together MZ r = 0.86
DZ r = 0.60

- test/retest reliability = 0.8-0.9 MZs are as similar as same person tested twice

-

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Adopted apart later age MZ r = 0..67 - .79

Similar data from other parts of world not included in Bouchard& McGue

Russia E. Germany and from information-processing tests

What is ‘g’?

- important predictor of social outcomes such as educational , occupational success
- widely accepted as a valuable concept by experts in the field
- shows substantial heritability

But what exactly is it?

a single general process such as executive functioning or speed of information processing?

a combination of more specific cognitive processes?

Does ‘general intelligence’ exist ? - evidence for ‘g’

- meta-analysis of results from 322 studies of cognitive ability
- in spite of hundreds of different tests being used, average correlation among tests was 0.30

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- more studies on g than any other human characteristic

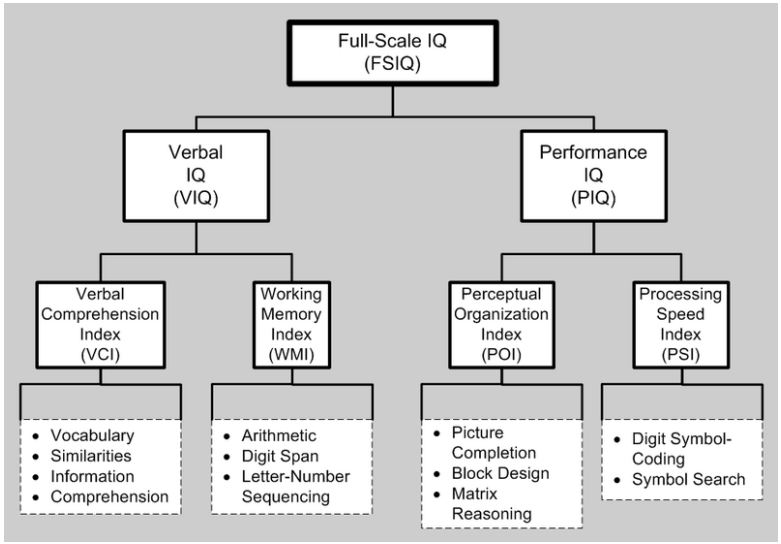
80,000 parent/offspring pairs

25,000 sib pairs

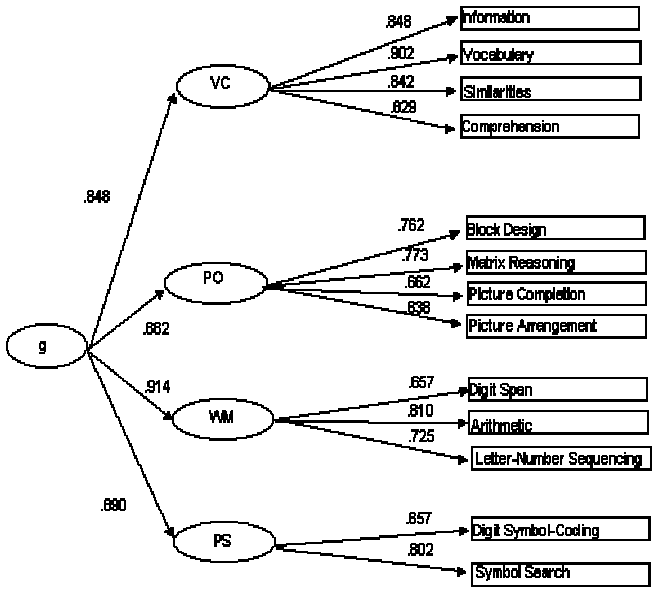
10,000 twin pairs + adoptive family data

correlations across tests

Wechsler adult intelligence scale (WAIS)



g from the WAIS-III



Examples of intercorrelation between specific abilities

Mathematics ability Plomin et al (2004)

- many studies indicate high heritability

phenotypic correlations with g score and other cognitive measures at age 7:

reading and math scores	r = 0.70
math and g scores	r = 0.43
reading and g scores	r = 0.47

'Generalist' genes:

Genes for specific abilities:

Environmental influences

- heritability of 50% indicates the environment also accounts for 50% of the variation

- adoptive family data indicates that shared environment is important:

  P/adopted child r = 0.19

  Adoptive sibs r = 0.32

- family and twin data indicate that non-shared environment is less important and accounts for less than 20% of variance

  MZ twins r = 0.86

Shared environment

- relationship is non-linear (not everyone is influenced by their environment in the same way), likely to be genotype x environment interaction
- interaction with socioeconomic status (SES):

Turkheimer et al (2001) 350 MZ and DZ twin pairs

middle-class environments –

poor environments –

Rowe et al (1999)ADD health study - a national longitudinal study of adolescent health

genotype/environment interaction

different heritabilities with different levels of education of parents

Genetic relatedness	Verbal IQ correlations by level of parental education	
	Low education	High education
High (MZ)	0.55	0.75
Moderate (DZ, sibs)	0.33	0.37
Low (half-sibs, cousins in SAME house)	0.32	0.10
	average h^2 =	h^2 =

- similar results from study of reading deficit (Olson)

Why? several theories put forward:

1. threshold effect (Scarr) - a ‘good enough’ environment is important in achieving genetic potential, rest doesn’t matter

2. more effective gene expression in good environments, poor environments ‘trap’ the individual (Bronfenbrenner & Ceci, Raine)

3. environment is more variable in low SES groups and accounts for more variation (Turkheimer, Rowe)

Assortative mating

Correlations between partners:

height r = 0.25 weight r = 0.20

personality measures r = 0.10 - 0.20

but, for g r =

- most mate selection is on basis of educational background

Table II. Spousal Correlations (**M**) and Assortative Mating (**D**) Parameters

	Verbal (V)	Spatial (S)	Perceptual speed (P)	Memory (M)
M[a]				
V	.332	.192	.180	.040
S	.077	.139	.084	.031
P	.139	.143	.155	.133
M	.040	.088	.011	.145
D[a]				
V	.383	−.017	.025	−.102
S	−.133	.125	−.031	−.056
P	−.022	−.017	.107	.132
M	−.049	.069	−.081	.145

[a] Rows, mothers; columns, fathers. $N = 418$ spouses.

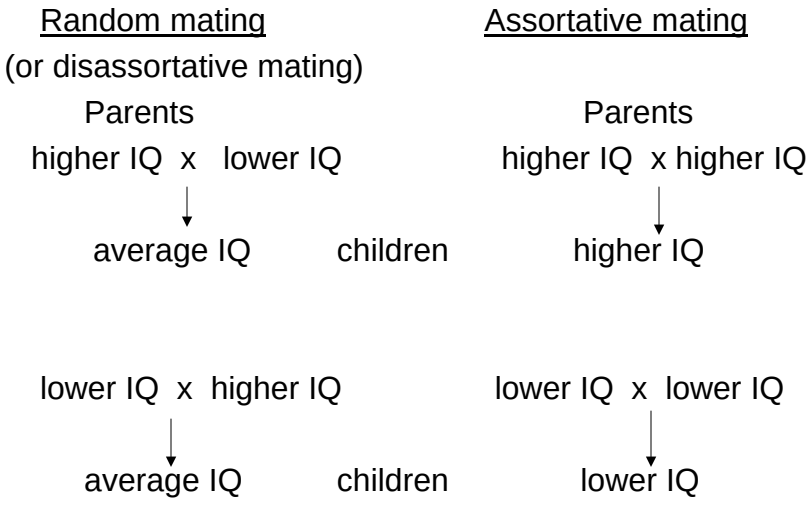
Effects of assortative mating

- decreases variation within families
- increases h^2 from family studies by increasing correlations within family

- underestimates h^2 from twin studies because it does not effect MZ twins but increases DZ correlation – effects of assortative mating seen as shared e

- increases population variation

- effects accumulate over generations



- effects of assortative mating have to be factored out of data before estimates of variance components are obtained

Non-additive gene effects epistasis dominance

- in twin and family data, non-additive gene effects will be masked by effects of assortative mating and shared environment:

shared environment – increases all correlations

assortative mating – increases all correlations except MZ twin

non-additive gene effects – decrease all correlations except MZ twin

If higher cognitive ability was related to higher fitness, would expect to find dominance for alleles for higher IQ levels

If alleles for higher cognitive ability were dominant, would expect to find a depression of scores on inbreeding

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Inbreeding and IQ scores

- Bashi (1977) + several studies since
  Raven's matrices test

Degree of consanguinity	Grade 4		Grade 6	
	n	mean	n	mean
Children of unrelated	1054	8.8	1054	13.1
Children of first cousins	503	8.6	467	12.3
Children of double first cousins	71	7.9	54	10.6