Introduction to Medical Psychology
Lecture 3: Intelligence and Learning

Richard Veale

Graduate School of Medicine
Kyoto University

https://youtu.be/l9s_PceZIVc

Lecture video at above link.

Today:
Intelligence and Learning

Intelligence

- Definition of intelligence
- Theories of intelligence & intelligence tests
- Intelligence and its consequences
- Heritability of intelligence

Learning (related to health)

- Classical conditioning and placebo effect
- Instrumental conditioning and phobia

Intelligence

What is intelligence?

Intelligence

What is intelligence?

When asked, laypersons refer to intelligence as:

practical problem solving

verbal ability

social competence

(Sternberg et al., 1981)

Intelligence

What is intelligence?

<u>"Experts" define intelligence as:</u>

- "power of good responses from the viewpoint of truths or facts" (Thorndike)
- "capability to receive education" (Asendorpf)
- "ability to carry on abstract thinking" (Terman)

Theories of Intelligence
Binet & Simon (Mental Age)

Alfred Binet and Theodore Simon developed the first intelligence test, the Binet-Simon test (1905, 1911).

It was commissioned in 1904 by the French Ministry of Public Instruction **to identify children that need special education.**

Theories of Intelligence
Binet & Simon (Mental Age)

To identify children that need special education.
Tasks in Binet & Simon test were:

- following a lighted match with eyes
- naming parts of the body
- counting coins
- picture naming
- recalling digits
- word definitions
- find rhymes for difficult words

Difficulty was increasing and the test would provide the **mental age** as a result.

A child with a mental age of 7 can do the tasks designed for children with age 7, but not those for age 8.

The tests were for ages 3-10, later up to 12/15 and for adults.

Theories of Intelligence: Stern (1912) – single IQ ratio

The Binet-Simon test provides the **mental age** as a result.

William Stern (1912) had the idea to compare it with the actual chronological age. This makes a **ratio**, a single number representing how advanced/retarded mental development is over chronological development.

7 / 6 = 1.17 (x 100 = 117)

Mental Age	Chronological Age	IQ
7	6	117
5	6	83
13	12	108
11	12	92

Theories of Intelligence
Spearman 1904: Factor Analysis

Charles Spearman (~1904) tested children in his surroundings with cognitive tests:

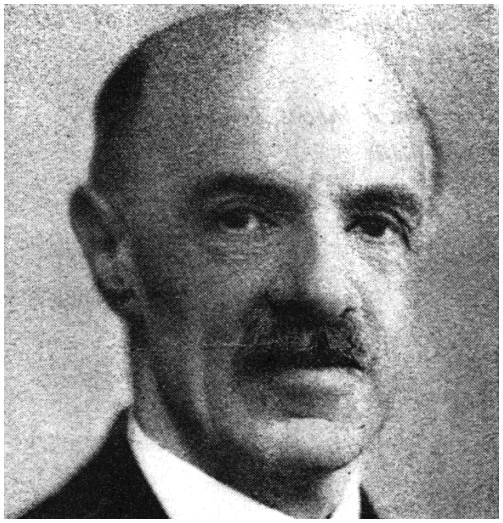
memory, light (detect changes), weight, and sound

He observed correlations between the different tests.

Using a statistical method called factor analysis, he postulated a two-factor theory of intelligence:

's': specific abilities
'g': general intelligence

Any cognitive ability is fueled by a general intelligence factor and a specific component.

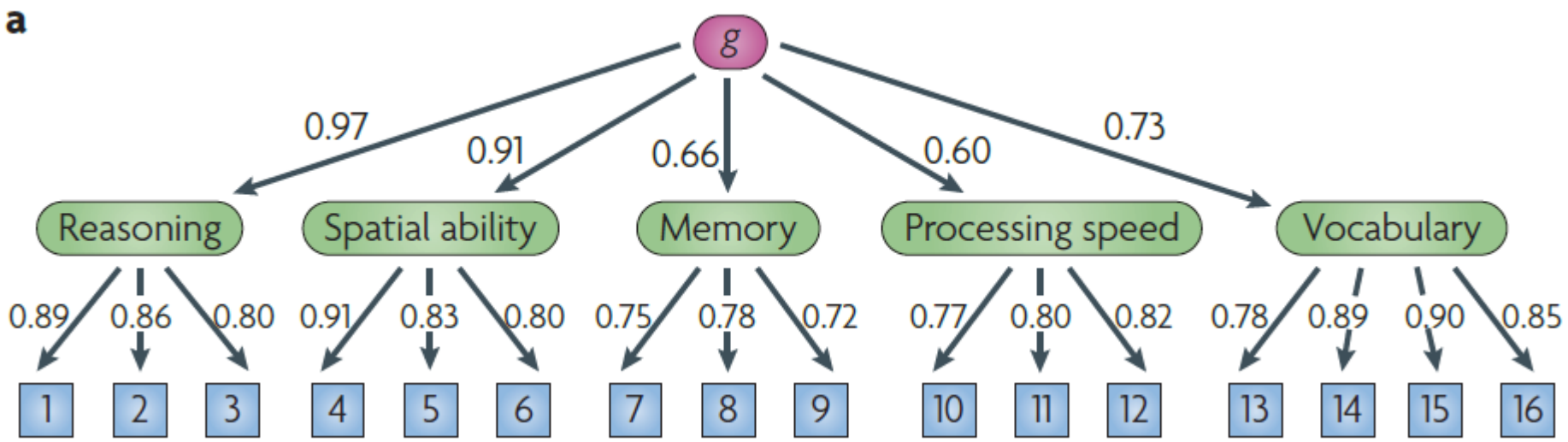


Charles Spearman
(1863-1945)

Theories of Intelligence
Factor Analysis

Correlating subtests (1,2, … 16) can be grouped into different specific abilities (reasoning, spatial ability, etc.). These have a common factor g – general intelligence.

Correlation coefficients of g with specific abilities and of these with subtest scores:



Deary et al., Nature Reviews Neuroscience, 2010

Theories of Intelligence
WAIS: Wechsler Adult Intelligence Scale

The Wechsler Adult Intelligence Scale (WAIS, first 1939; revisions 1955, 1981, 1997, 2008):

provides the following scores by summarizing the results in different subtests (newest version):

Full Scale IQ ('g', all tests)
General ability index (subset of tests, less vulnerable to deficits in processing and working memory)

→ Verbal comprehension index
→ Perceptual reasoning index
→ Working memory index
→ Processing speed index

With its sub-scores, the test is also widely used in neuropsychology to assess deficits in cognition due to brain damage.

Theories of Intelligence
WAIS: Wechsler Adult Intelligence Scale

The Wechsler Adult Intelligence Scale (WAIS, first 1939; revisions 1955, 1981, 1997, 2008):

provides the following scores by summarizing the results in different subtests (newest version):

Full Scale IQ ('g', all tests)
General ability index (subset of tests, less vulnerable to deficits in processing and working memory)

→ Verbal comprehension index
→ Perceptual reasoning index
→ Working memory index
→ Processing speed index

With its sub-scores, the test is also widely used in neuropsychology to assess deficits in cognition due to brain damage.

WAIS:
Verbal Comprehension

Information:

1) What is steam made of?
2) What is pepper?

Similarities:

1) In what way are a lion and a tiger alike?
2) In what way are an hour and a week alike?

Theories of Intelligence
WAIS: Wechsler Adult Intelligence Scale

The Wechsler Adult Intelligence Scale (WAIS, first 1939; revisions 1955, 1981, 1997, 2008):

provides the following scores by summarizing the results in different subtests (newest version):

Full Scale IQ ('g', all tests)
General ability index (subset of tests, less vulnerable to deficits in processing and working memory)

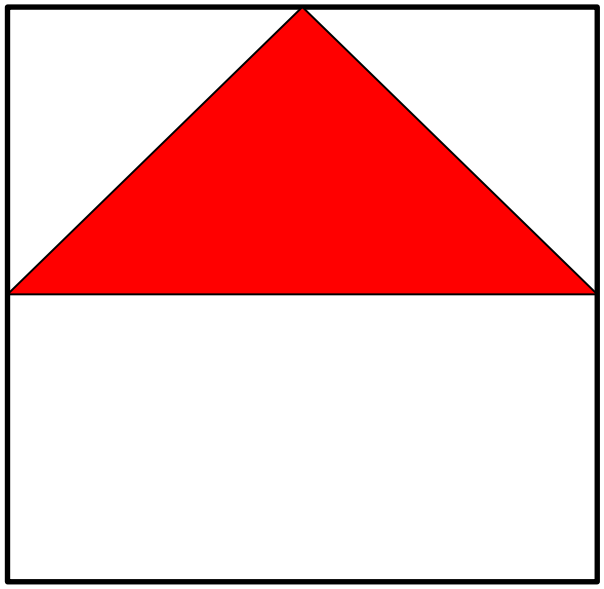
→ Verbal comprehension index
→ Perceptual reasoning index
→ Working memory index
→ Processing speed index

With its sub-scores, the test is also widely used in neuropsychology to assess deficits in cognition due to brain damage.

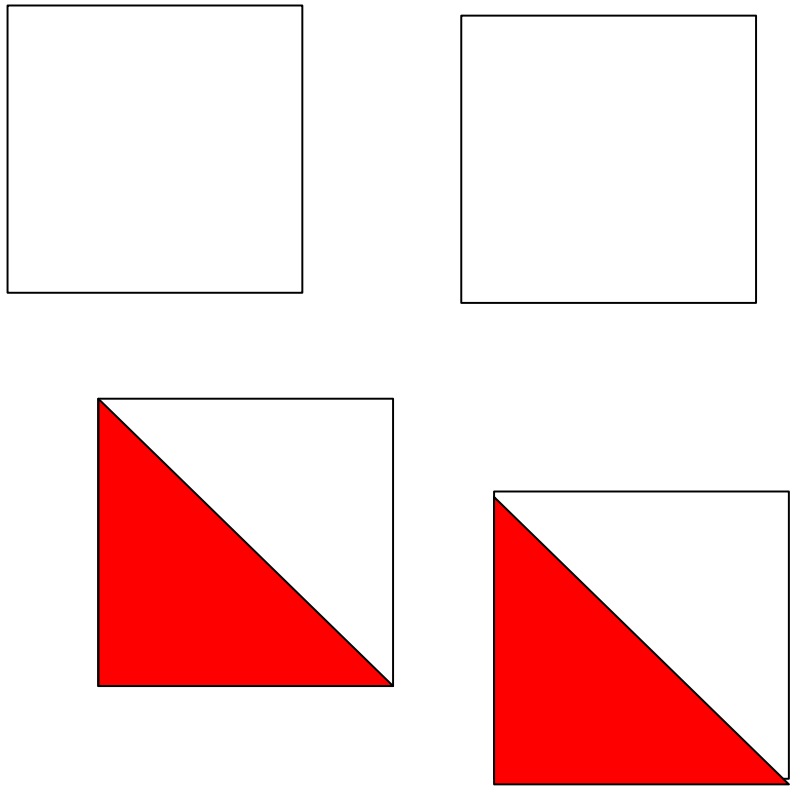
WAIS:
Perceptual Reasoning

Block design:

Please build this design (the template with the 4 blocks) in a limited time:



Template



Blocks

Theories of Intelligence
WAIS: Wechsler Adult Intelligence Scale

The Wechsler Adult Intelligence Scale (WAIS, first 1939; revisions 1955, 1981, 1997, 2008):

provides the following scores by summarizing the results in different subtests (newest version):

Full Scale IQ ('g', all tests)
General ability index (subset of tests, less vulnerable to deficits in processing and working memory)

→ Verbal comprehension index
→ Perceptual reasoning index
→ Working memory index
→ Processing speed index

With its sub-scores, the test is also widely used in neuropsychology to assess deficits in cognition due to brain damage.

WAIS:
Working Memory Index

Digit span:

I will read a list of digits.

When I give the signal, please write these digits down.

Backward Digit span:

I will read a list of digits.

When I give the signal, please write these digits down in reverse order.

for example: 3-2-4 becomes 4-2-3

Theories of Intelligence
WAIS: Wechsler Adult Intelligence Scale

The Wechsler Adult Intelligence Scale (WAIS, first 1939; revisions 1955, 1981, 1997, 2008):

provides the following scores by summarizing the results in different subtests (newest version):

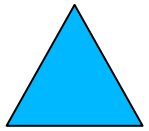
Full Scale IQ ('g', all tests)
General ability index (subset of tests, less vulnerable to deficits in processing and working memory)

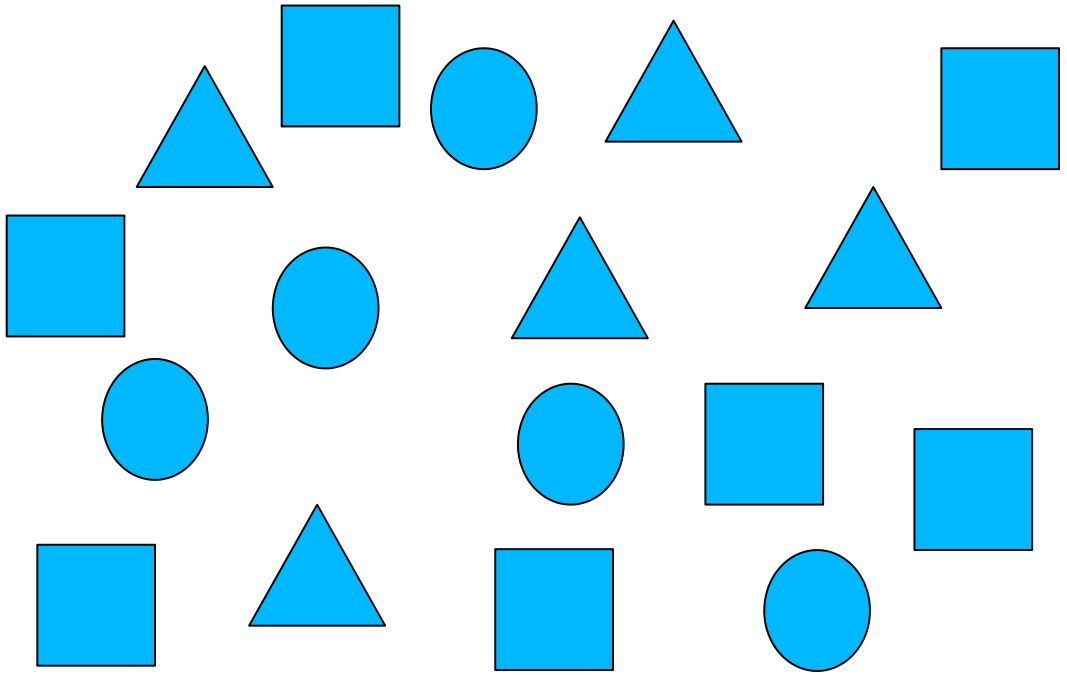
→ Verbal comprehension index
→ Perceptual reasoning index
→ Working memory index
→ Processing speed index

With its sub-scores, the test is also widely used in neuropsychology to assess deficits in cognition due to brain damage.

WAIS:
Processing Speed Index

Symbol search:

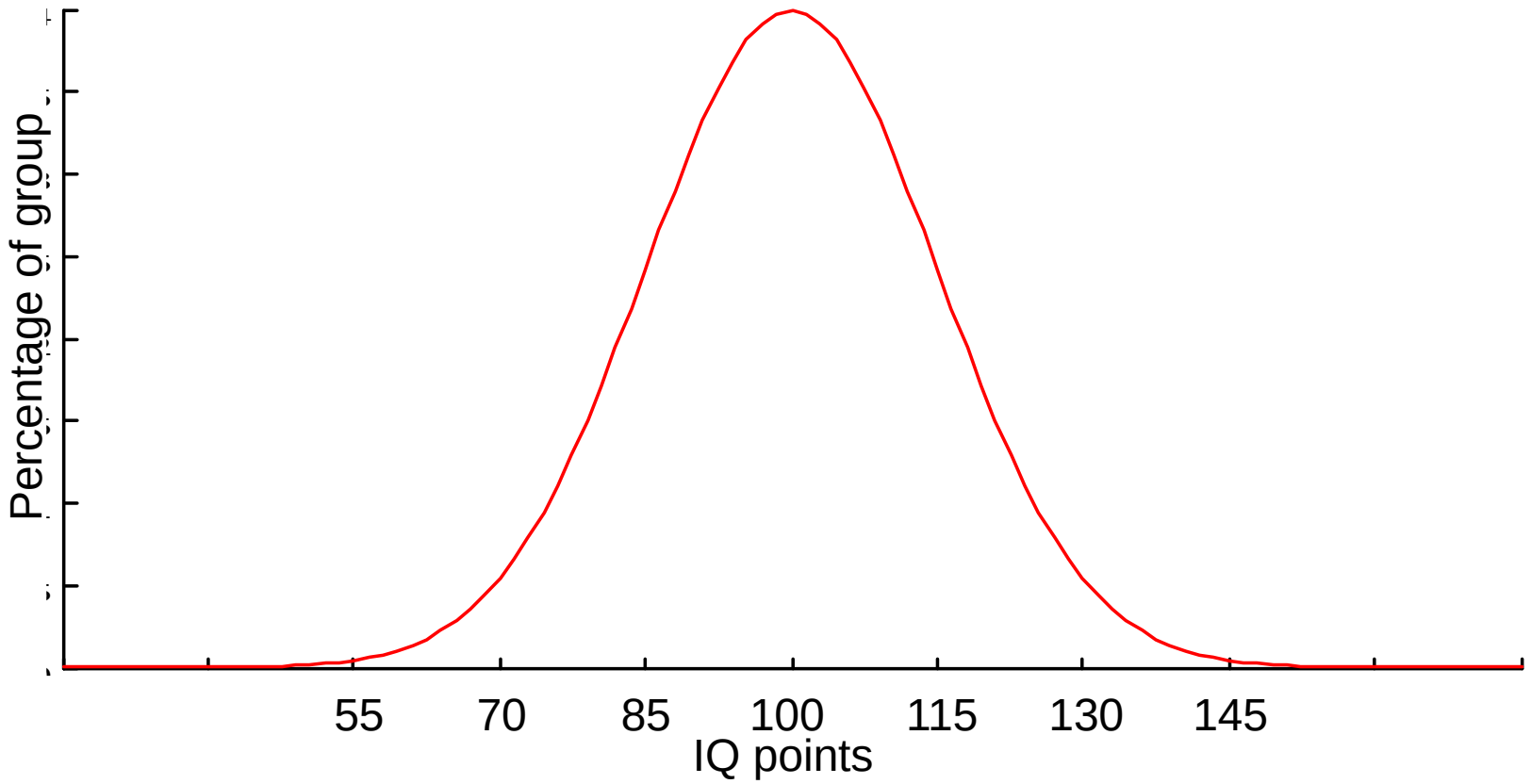
Find the symbol  in the picture below:



Modern “IQ”

Norm referencing of the Wechsler test:

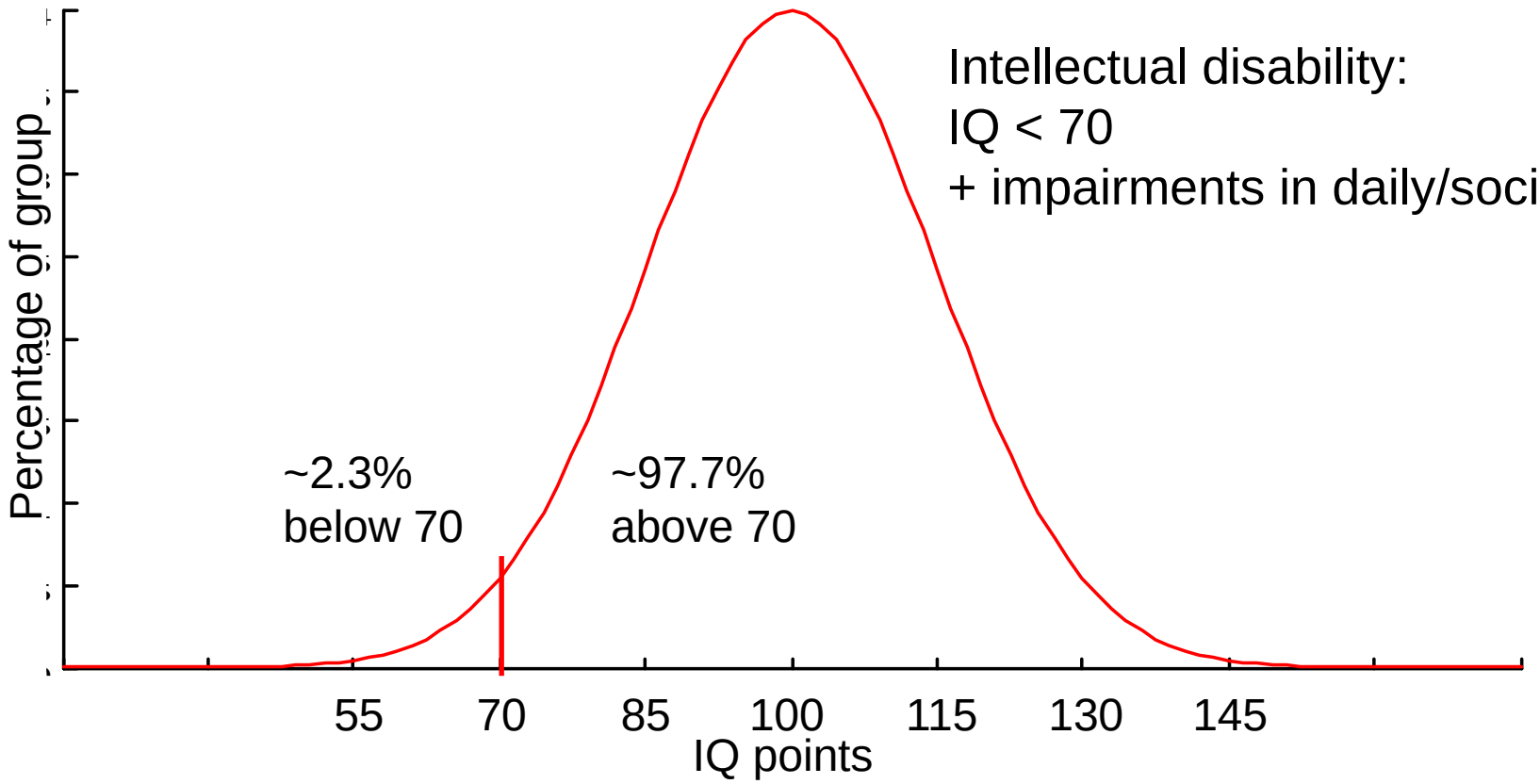
- IQ is defined in relation to a control population (same age)
- IQ is normally distributed (mean: 100, standard deviation:15)



Modern “IQ”

Norm referencing of the Wechsler test:

- IQ is defined in relation to a control population (same age)
- IQ is normally distributed (mean: 100, standard deviation:15)

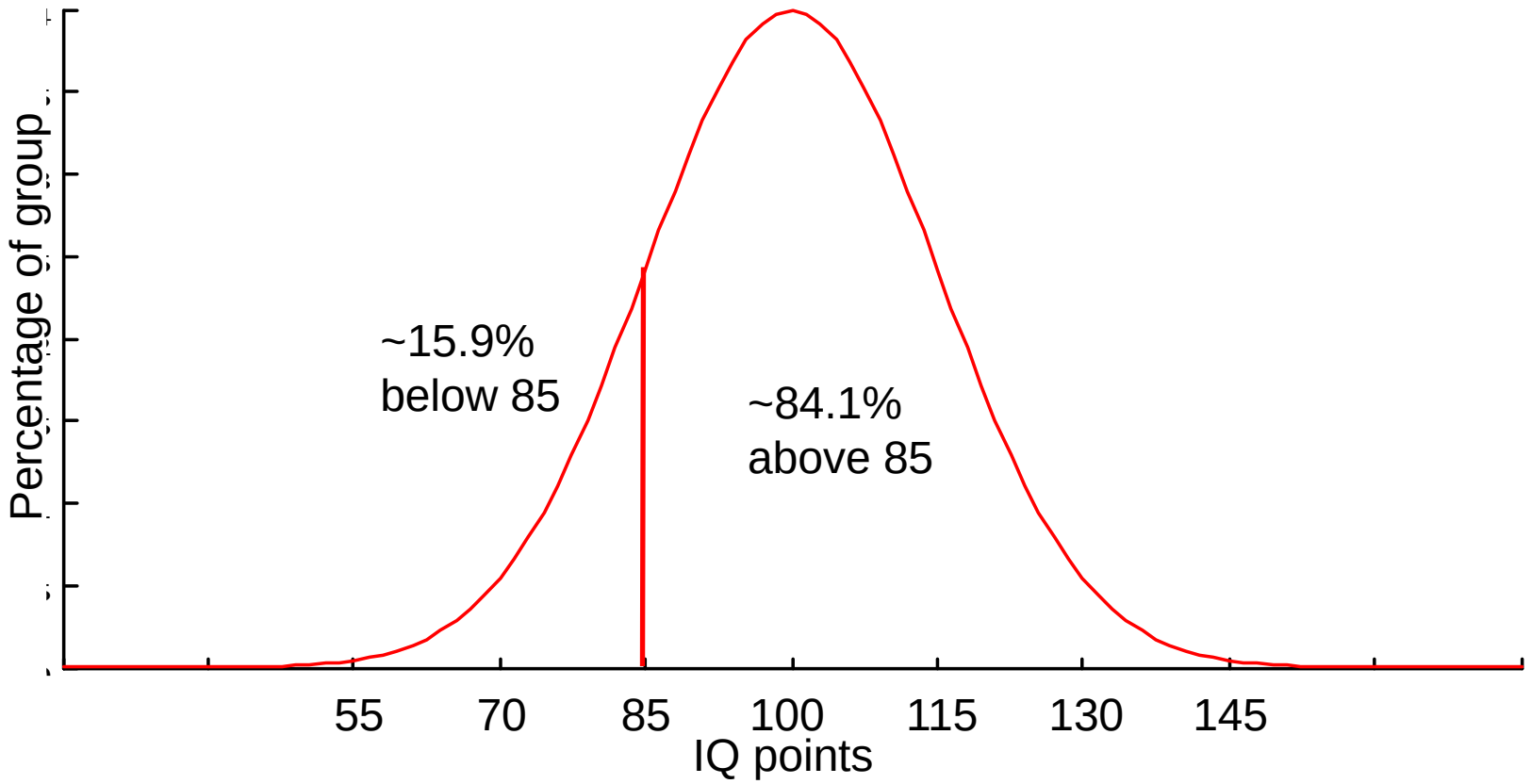


Intellectual disability:
IQ < 70
+ impairments in daily/social life

Modern “IQ”

Norm referencing of the Wechsler test:

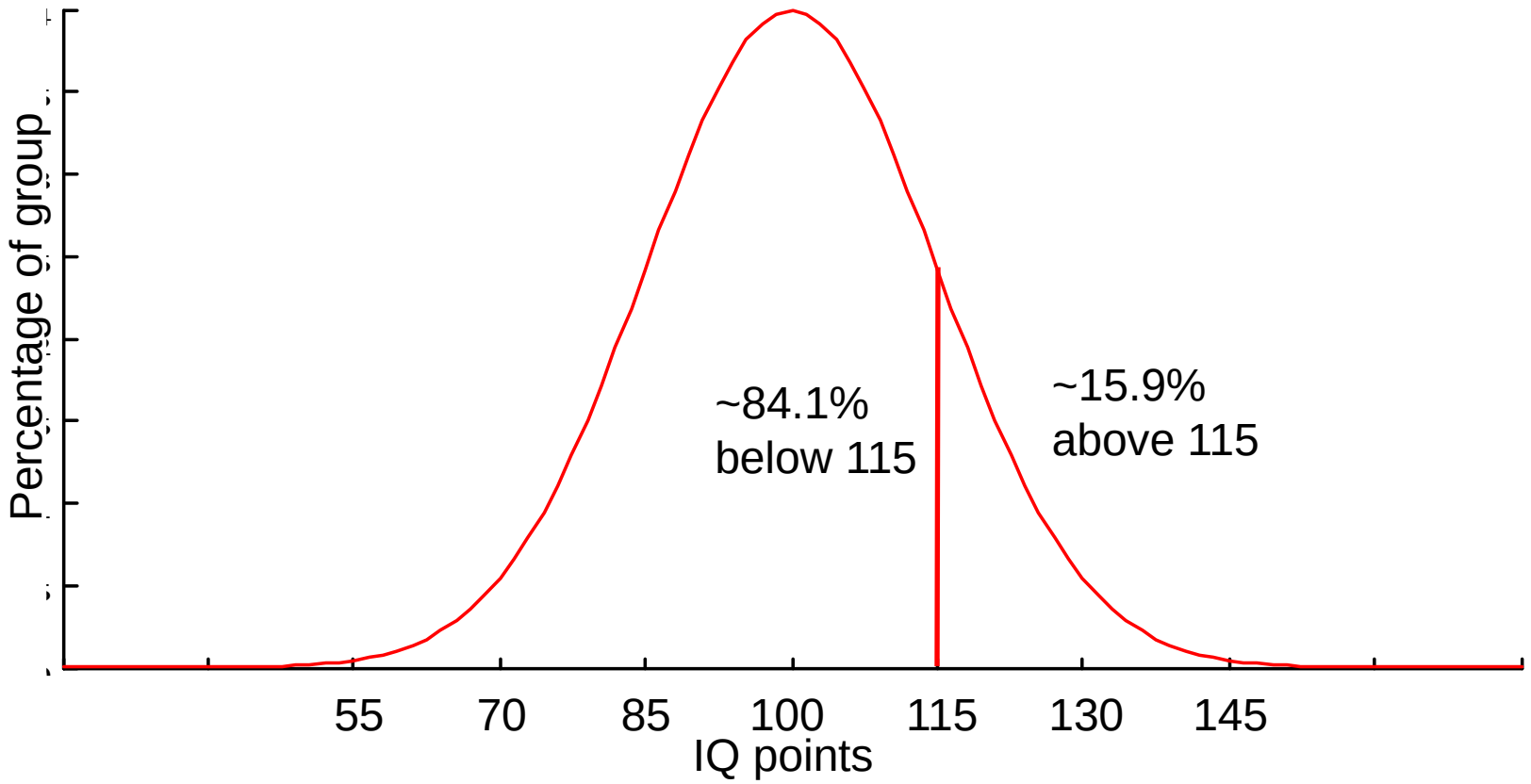
- IQ is defined in relation to a control population (same age)
- IQ is normally distributed (mean: 100, standard deviation:15)



Modern “IQ”

Norm referencing of the Wechsler test:

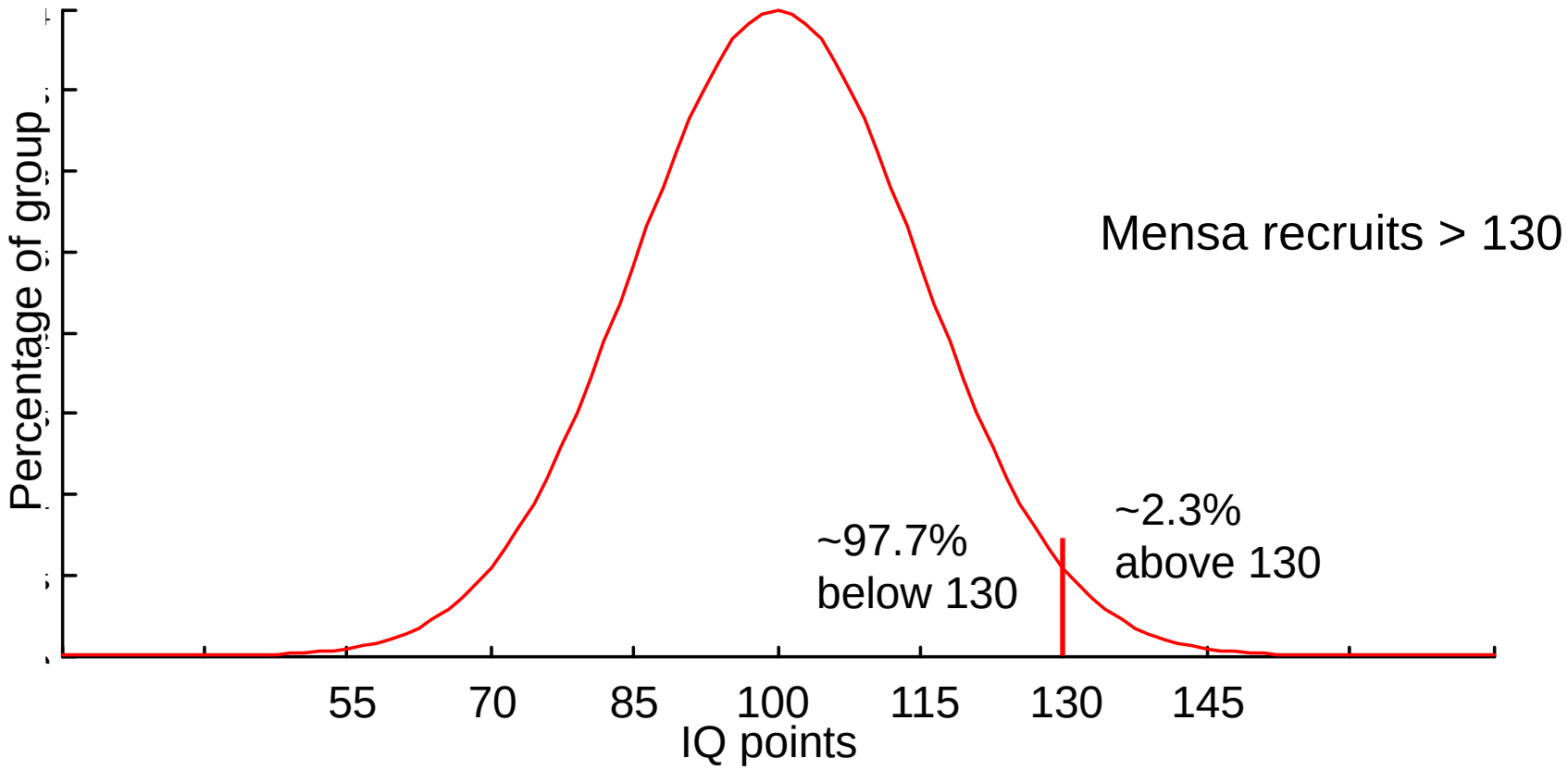
- IQ is defined in relation to a control population (same age)
- IQ is normally distributed (mean: 100, standard deviation:15)



Modern “IQ”

Norm referencing of the Wechsler test:

- IQ is defined in relation to a control population (same age)
- IQ is normally distributed (mean: 100, standard deviation:15)



Intellectual Disability

Intellectual disability are deficits in mental abilities (diagnosed before age 18):
i.e., deficits in reasoning, problem solving, planning, academic learning and learning from experience.

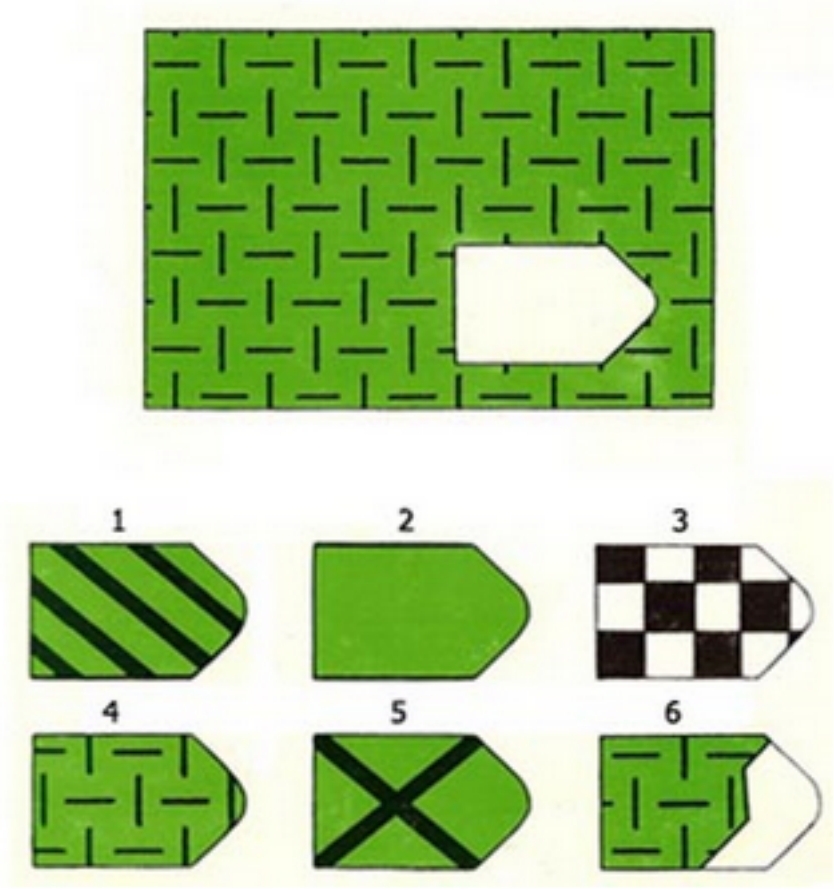
mild disability:	IQ 50/55-70
moderate disability:	IQ 35/40-50/55
severe disability:	IQ 20/25-35/40
profound disability:	IQ below 20/25

Typical causes are:

Down syndrome (trisomy 21)
(prevalence about 5.9/10000)
Brain damage before, during, or after birth
Phenylketonuria
Cranial anomalies (microcephaly)

Theories of Intelligence
Raven's Progressive Matrices

John C. Raven designed a test "free" of cultural influence, the Raven Progressive Matrices (1939):



The test is comprised of 60 items, an overall IQ is provided, it does not require language.

It intends to measure the "abstract ability to see relationships between objects" (Maltby, Day, Macaskill, Personality, individual differences and intelligence).

Theories of Intelligence
Thurstone Multifactor Theory

Multifactor theories:

L.L. **Thurstone** (1887-1955) suggested seven primary mental abilities:

associative memory (rote memory)
number (mathematical operations)
perceptual speed (perceive details, searching)
reasoning
space (mental spatial transformations)
verbal comprehension
word fluency (generating words)

Theories of Intelligence
Cattell (Crystal vs Fluid Intelligence)

Raymond B. Cattell (1905-1998) suggested two main factors:

crystallized intelligence

knowledge and skills, experience
culture dependent
partly measured with WAIS (Wechsler Adult Intelligence Scale)
will increase with age (cumulative)

fluid intelligence

reasoning, acquisition of new information,
seeing patterns and relationships
culture independent
better measured with Raven Matrices
will increase in childhood, stabilizes in young adulthood

Theories of Intelligence
Cattell (Crystal vs Fluid Intelligence)

Raymond B. Cattell (1905-1998) suggested two main factors:

crystallized intelligence

These are all “Armchair Theories”

What does intelligence ***do***

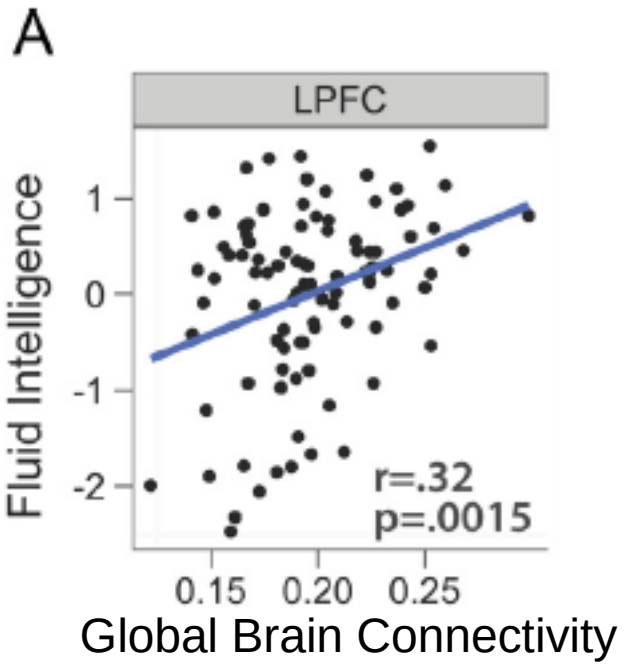
Different IQ = different brain?!

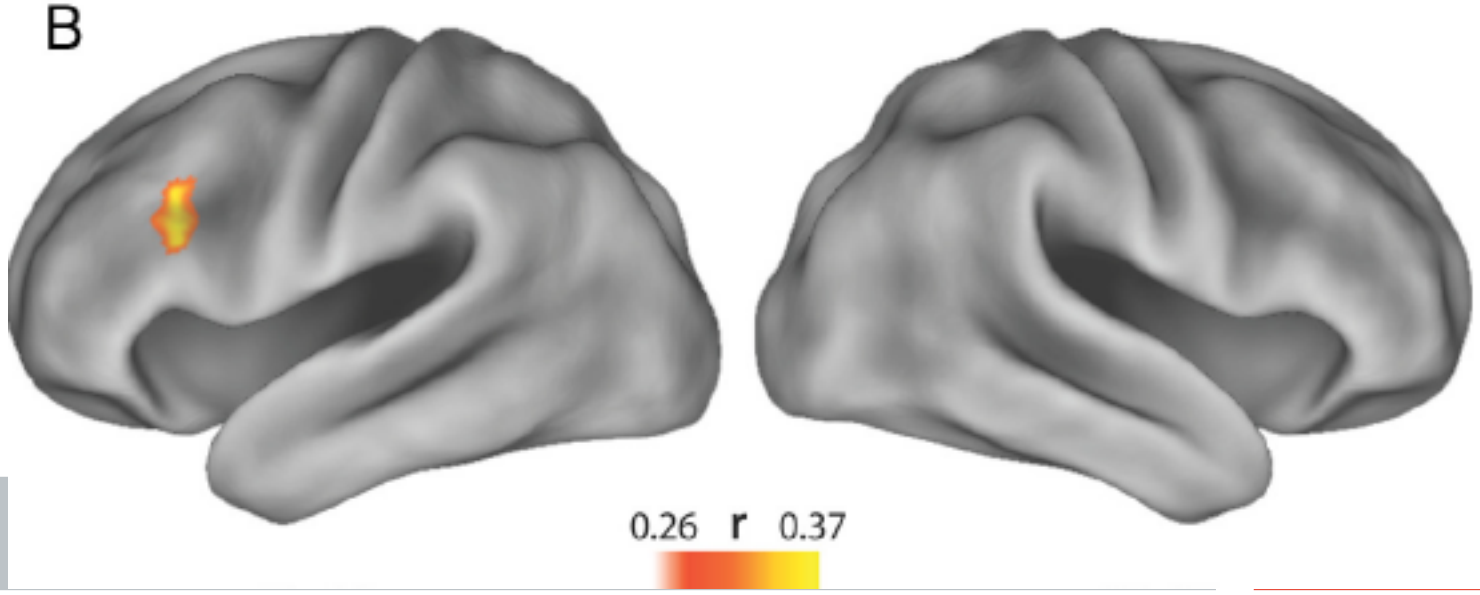
will increase in childhood, stabilizes in young adulthood

Theories of Intelligence
Can the brain predict IQ difference?

Neuro imaging: Connectivity of an area in left prefrontal cortex (LPFC) correlated with fluid IQ (Cole et al., 2012) → LPFC a global hub to implement control important for intelligence?

Global brain connectivity: correlation of LPFC with all other brain areas in terms of functional magnetic resonance imaging (fMRI) signal during resting-state (no task).





What does IQ *do?*
1) Predict academic success, job

General intelligence correlates with
(in the sense of predictive validity):

GCSE: r=0.69 (Deary et al., 2007)

(General Certificate of Secondary Education)

Academic achievement in USA (Jencks, 1979):
between r=0.4 and r=0.63

Job performance (Bertua et al., 2005)
between r=0.5 and r=0.6

another meta-analysis: Hunter and Hunter, 1984
showed a correlation job performance and IQ: r=0.54
(for comparison: later job performance and CV: 0.37;
later job performance and job interview: 0.14)

What does IQ *do?*
2) Predict health

General intelligence correlates with health:

Around 90,000 Scottish born in 1921 were tested with IQ tests in 1932.
This was repeated with Scottish born in 1936, IQ test in 1947.
In old age, some people were followed up to look at mortality (Deary et al., 2004).

	Mean IQ of sufferers	Mean IQ of non-sufferers	Statistical Significance
Death	97.7	104.6	Yes
Cancer	101.3	103.9	No
Cardiovascular disease	100.1	104.1	Yes

Possible reasons: education level → socioeconomic status, prevention, disease management (better care), psychiatric illness

Where does IQ come from…? Genes?

Heritability is often expressed as h^2, the percentage of variation in IQ scores explained by genetic differences

- h^2 = 100% means variation is completely explained by genetic differences.
- h^2 = 0% means genetic differences have no value in explaining variation.

We can estimate heritability with groups who share different amounts of genes and environment:

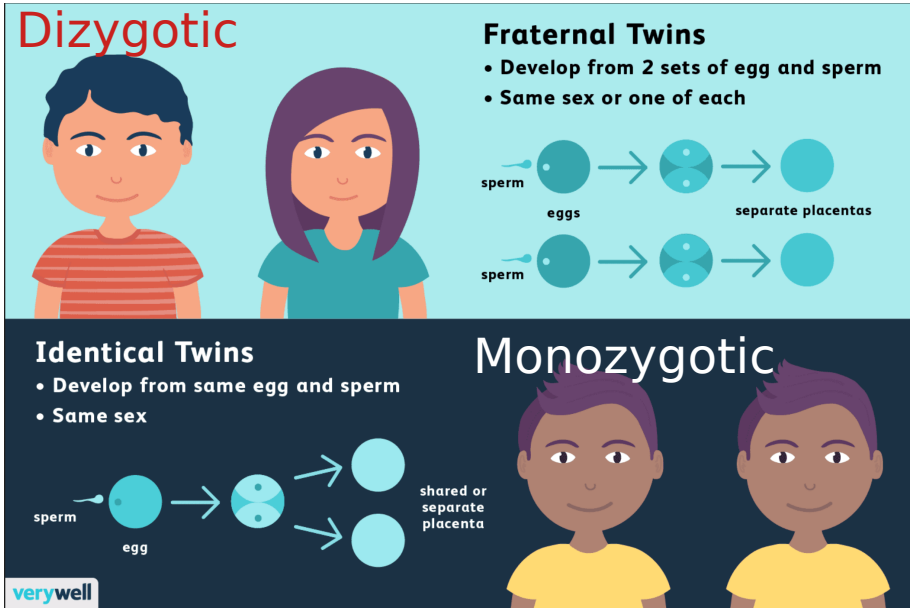
Monozygotic twins (reared together)
- genes shared: 100%, environment shared: 100%

Monozygotic twins (reared apart)
- genes shared: 100%, environment shared: 0%

Dizygotic twins (reared together)
- genes shared: 50%, environment shared: 100%

Twins

Dizygotic twins are totally different sperm/egg, so just the same as normal siblings.
-Siblings share on average 50% (Mean: 0.498, SD: 0.036)



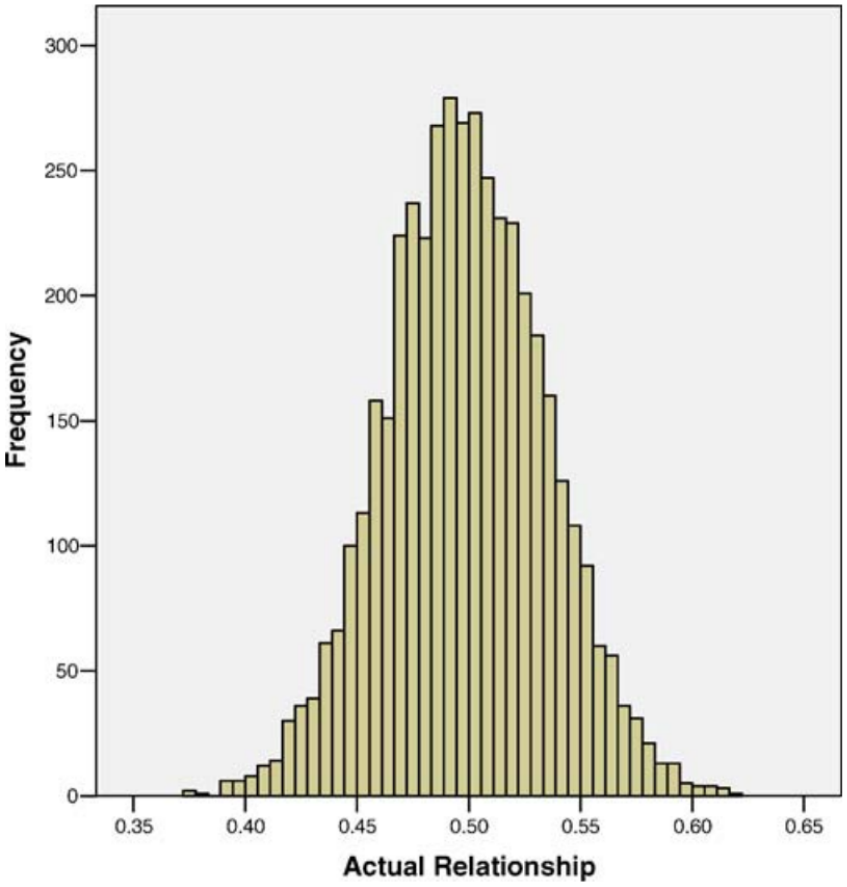
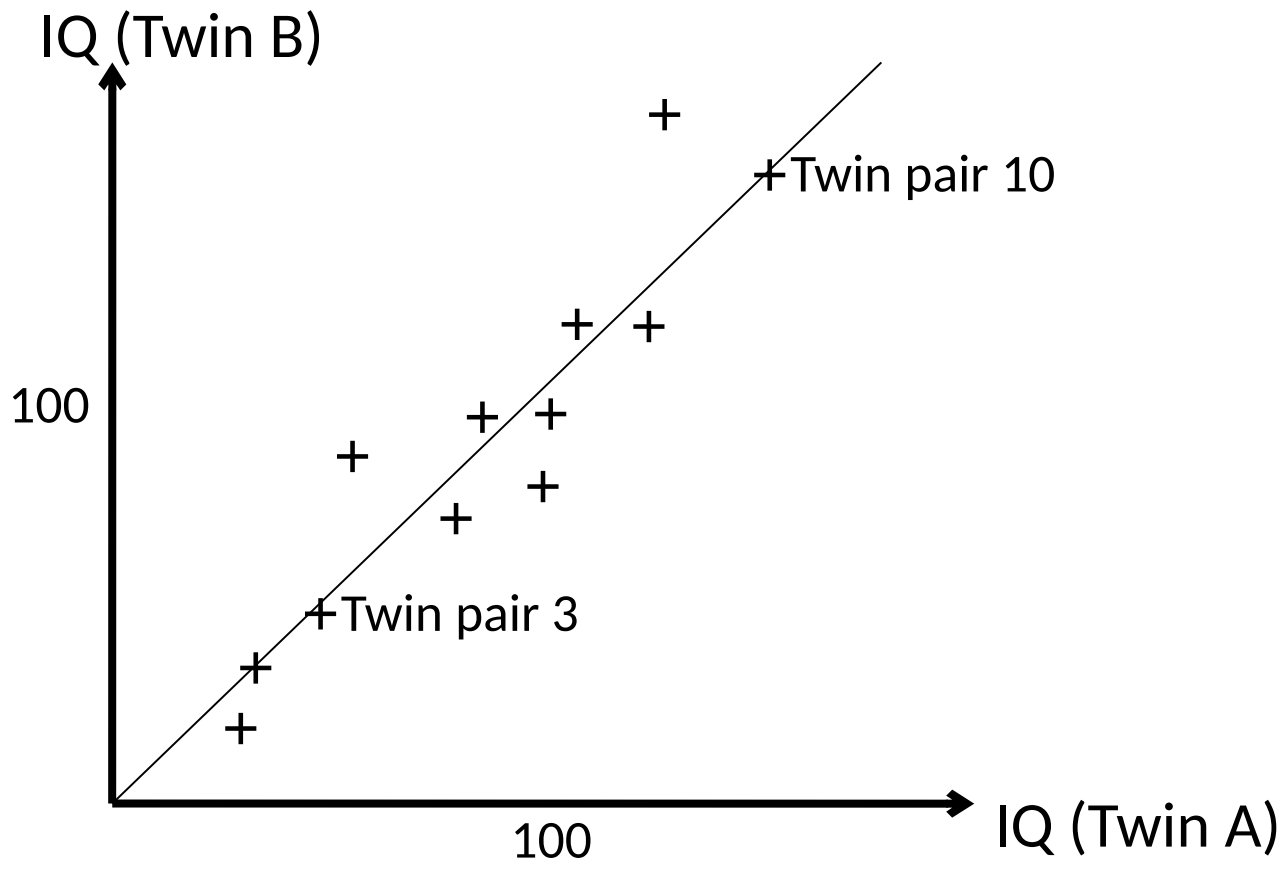


Figure 1. Empirical Distribution of Actual Additive Genetic Relationships of 4,401 Quasi-Independent Pairs of Full Sibs

Histogram of the genome-wide additive genetic relationships of full-sib pairs estimated from genetic markers.
DOI: 10.1371/journal.pgen.0020041.g001

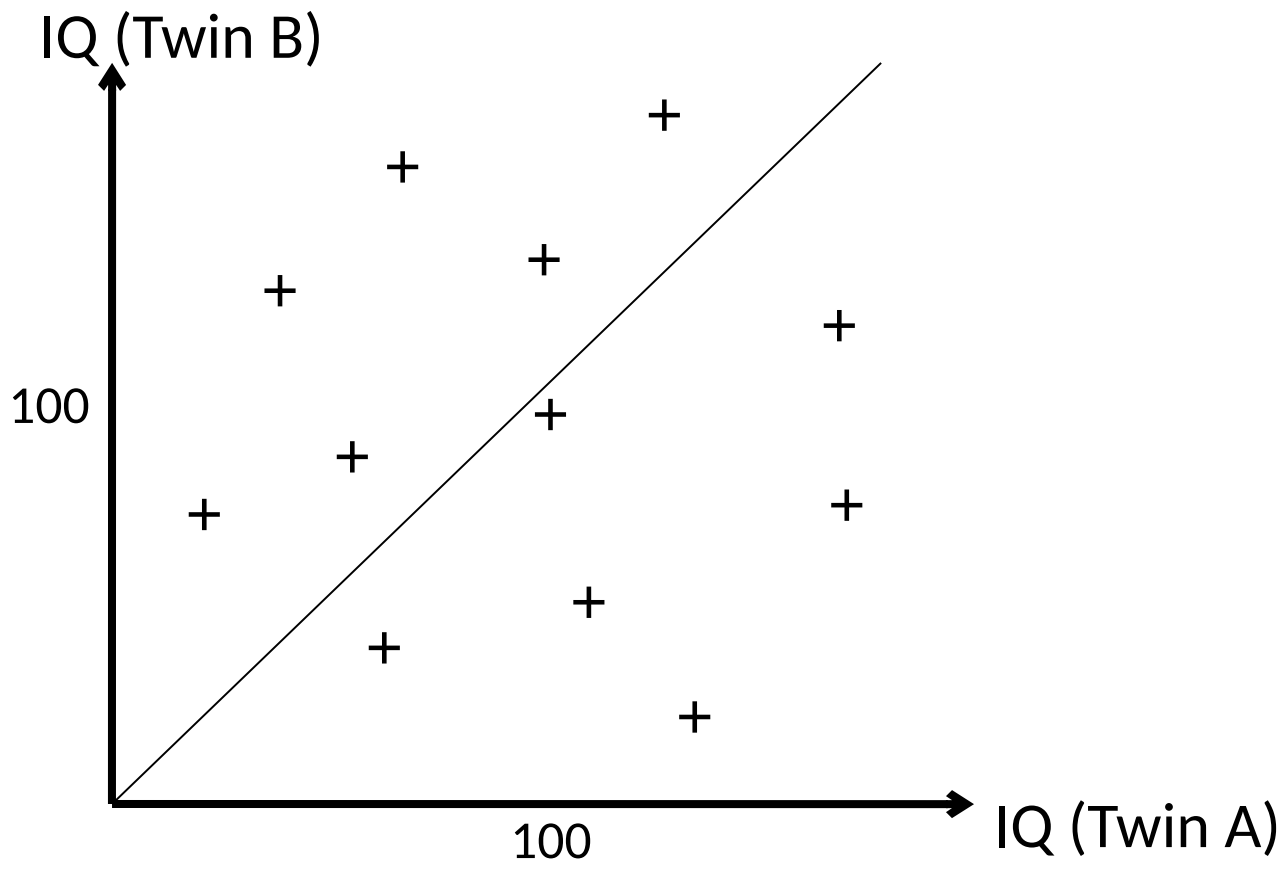
Concordance Rate

When twin pairs are very similar -> Concordance close to 100%



Concordance Rate

When twin pairs are not very similar -> Concordance close to 0%



Heretebility of Intelligence

	Theoretical Concordance Genes	Theoretical Concordance Environment	Measured IQ Concordance
Monozygotic Twins (reared together)	100%	100%	86%
Monozygotic Twins (reared apart)	100%	0%	76%
Dizygotic Twins (reared together)	50%	100%	55%

from Ridley, 1999
concordance: presence of same intelligence level in two individuals;
full concordance 100% = exactly same IQ in pairs

Heretebility of Intelligence

	Theoretical Concordance Genes	Theoretical Concordance Environment	Measured IQ Concordance
Monozygotic Twins (reared together)	100%	100%	86%
Monozygotic Twins (reared apart)	100%	0%	76%
Dizygotic Twins (reared together)	50%	100%	55%

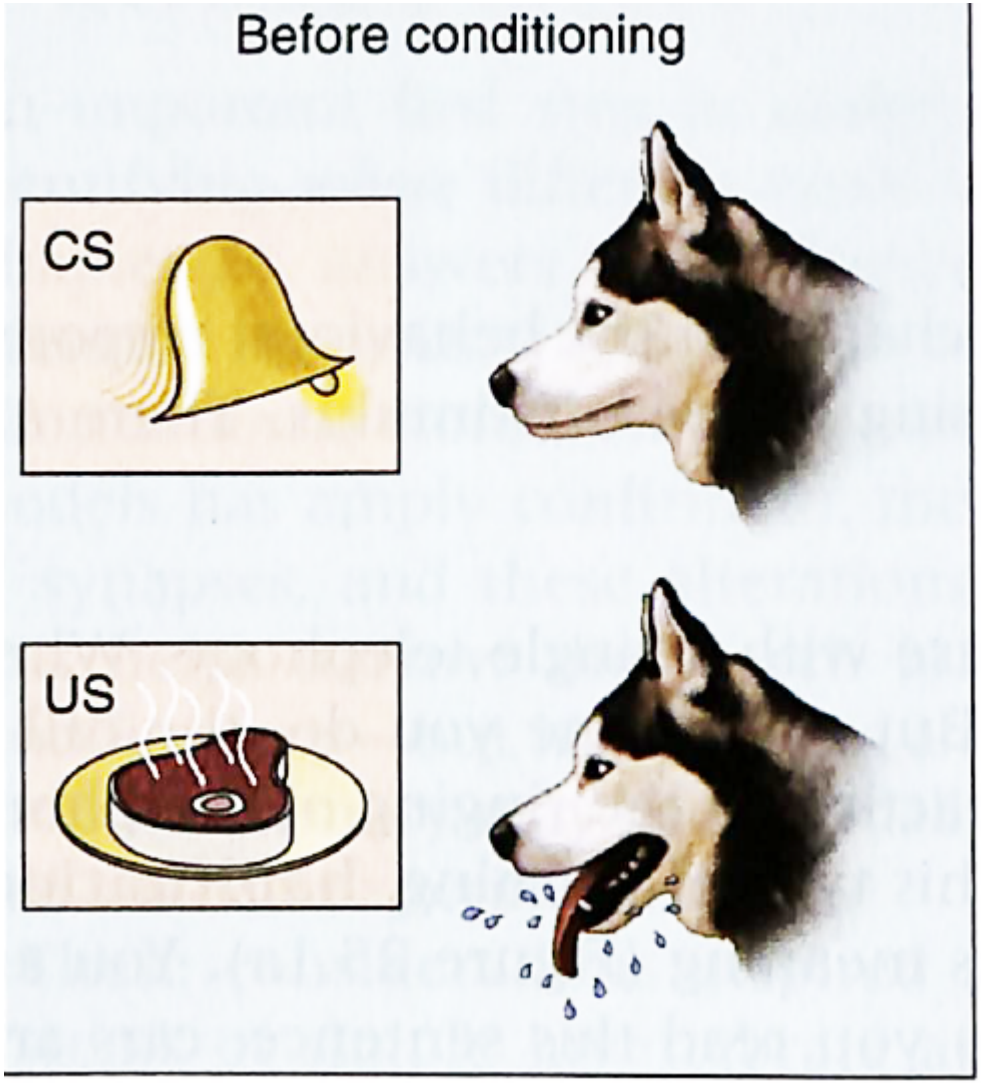
from Ridley, 1999

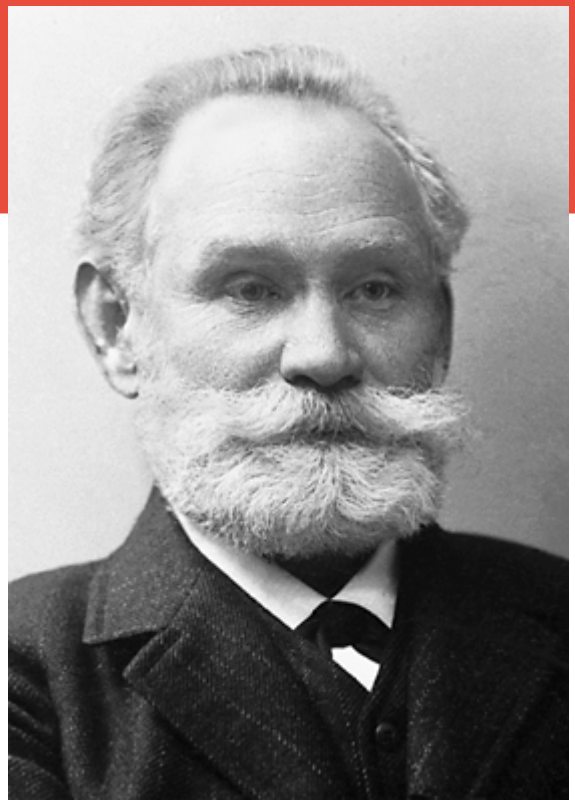
$h^2 = 2 \times (r(MT\_together) - r(DT\_together)) = 2 \times (86-55)\% = 62\%$

Many studies show heritability estimates for intelligence in the range of 60-80% (Gray and Thompson, Nature Reviews Neuroscience, 2004).

Learning

Classical Conditioning

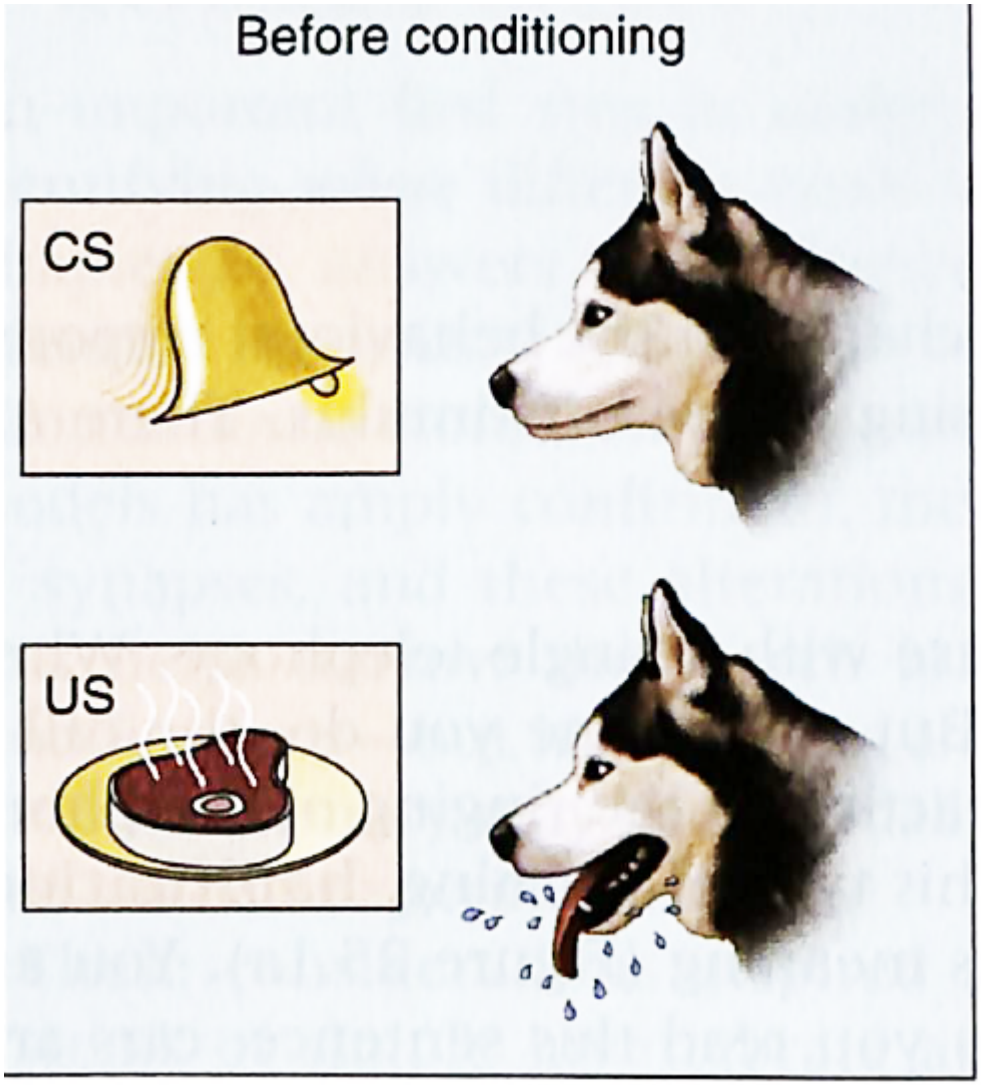




Ivan Pavlov (1846-1936)
(nobelprize.org)

Classical conditioning is the association of two stimuli, such that a stimulus that first did not elicit a response (usually from the autonomic nervous system) will elicit it after conditioning.

Classical Conditioning



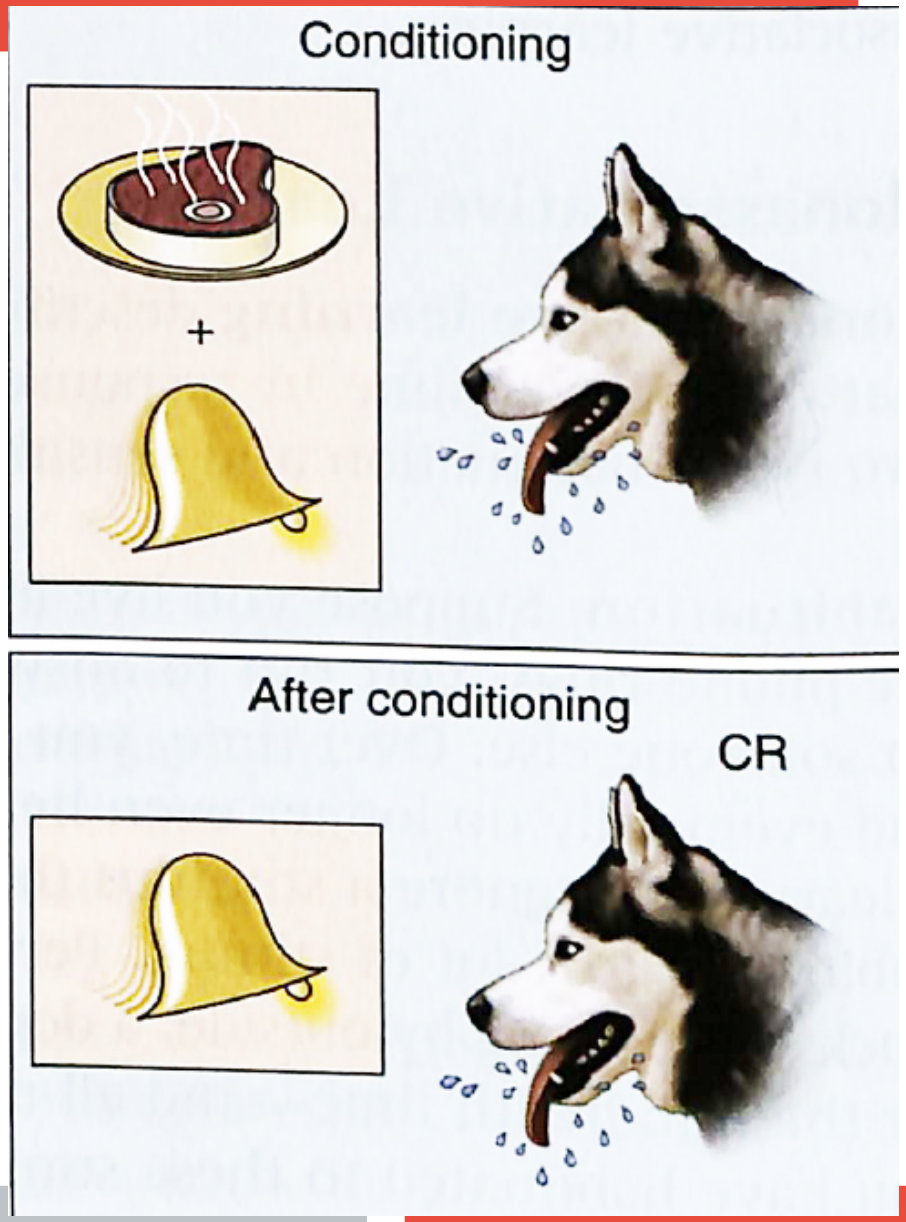
CS: Conditioned stimulus (bell),
will not elicit response (salivating).

US: Unconditioned stimulus (meat),
will elicit response (salivating).
→ unconditioned response (UR).

Classical Conditioning

During conditioning, US (meat) and CS (bell) are paired.

After conditioning, the conditioned stimulus (bell), will elicit the response (salivating).
→ Conditioned response (CR).



Clasical Conditioning
Real-world Example: Placebo

Before conditioning

CS: pill shape

CS: Conditioned stimulus (pill),
will not elicit response (immediate pain relief).

US: active drug

e.g., Aspirin

US: Unconditioned stimulus (pain killer), will elicit response (immediate pain relief).
→ unconditioned response (UR).

Classical Conditioning
Real-world Example: Placebo

During conditioning, US (active drug) and CS (pill shape) are paired.

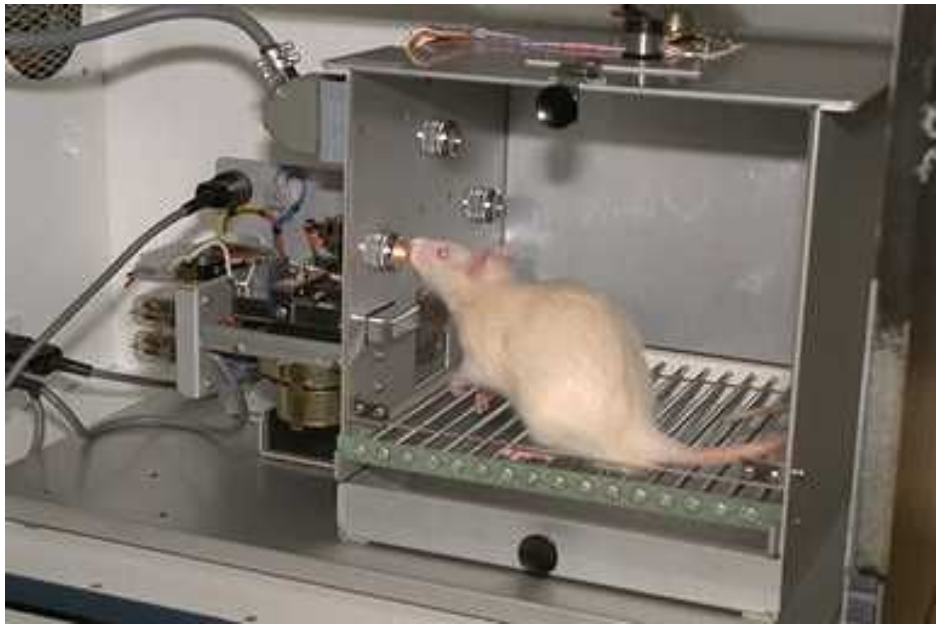
+ e.g., Aspirin

After conditioning, the conditioned stimulus (pill shape), will elicit the response (immediate pain response) in absence of the US.
→ Conditioned response (CR).

+ placebo, e.g., sugar

Instrumental Conditioning

(Also known as *Operant conditioning)*



In instrumental conditioning, a behavior is learned to result in a consequence. If this consequence is rewarding, the likelihood of the behavior will increase.

For example, here the rat might learn that in this box, when the left red light is on (stimulus) and it pushes the lever (response), it will get a food pellet (reward/consequence).

Stimulus → Response → Consequence

Real-world Example
Avoidance learning in Phobias

If you had an accident in a tunnel, you have learnt that the tunnel should be avoided.

You have learnt that the stimulus “tunnel” results in physical pain. You have also learnt that this pain can be avoided by not entering the tunnel.

Avoiding the tunnel → Reward: no punishment by physical pain

However, if you never question the relation [tunnel → physical pain] you cannot relearn → [tunnel → no pain], i.e. no extinction of avoidance behavior

→ thus, tunnel phobia

Summary
What we covered today

Intelligence and Learning

- Intelligence
  - Definition of intelligence
  - Theories of intelligence & intelligence tests
  - Intelligence and its consequences
  - Heritability of intelligence
- Learning (related to health)
  - Classical conditioning and placebo effect
  - Instrumental conditioning and phobia