Methods in behavioral genetics

Twin Studies:

the concordance estimation

To determine the role of heredity in the development of a trait, it is necessary to compare the proportion (%) of concordant pairs (identical for a particular trait) in groups of mono- and dizygotic twins.

C_{MZ} denotes a number of similar pairs of MZ twins or total amount of pairs of MZ twins · 100%;

C_{DZ} denotes a number of similar pairs of DZ twins or total amount of pairs of DZ twins · 100%.

The hereditary component is estimated by **K.J.Holzinger formula**

$$H_c = \frac{C_{MZ} - C_{DZ}}{1 - C_{DZ}}$$

The influence of environment is determined by the following formula

$$E = 1 - H_c$$

The other formula is suggested (Allen , 1979)

$$H'_c = \frac{C_{MZ} - C_{DZ}}{C_{MZ}} = 1 - \frac{C_{DZ}}{C_{MZ}}$$

as a better summary of twin concordance data than the familiar Holzinger equation.

H_c may be more useful than H'_c for high concordance rates, if $C_{MZ} + C_{DZ}$ greater than 1 .

The heritability coefficient might be also calculated from twin data as follows (Plomin, 1990).

$$H = (C_{MZ} - C_{DZ}) \cdot 2$$

Problem

Concordance of MZ twins in tuberculosis is 66.7%, and DZ ones is 23%.
What are both shares of heredity and the environment in the development of the disease?

The classical Holzinger formula allows to calculate the share of heredity (H) and the environment (E) in the development of the trait under study.

C_{MZ} = 0.667
C_{DZ} = 0.23

$$H_c = \frac{0.667 - 0.23}{1 - 0.23} = \frac{0.437}{0.77} = 0.567$$

$$E = 1 - H_c = 1 - 0.657 = 0.433$$

Calculations have shown that hereditary factors are essential in the development of this pathology.
The share of heredity in the development of tuberculosis is 0.567;
the share of the environment in the development of this disease is 0.433.

Problem

The concordance of MZ twins in schizophrenia is 79%, and DZ ones is 4.4%.

What are the shares of heredity and the environment in the development of schizophrenia?

Using classical Holzinger formula me can calculate the share of heredity (H) and the environment (E) in the development of the disorder.

C_{MZ} = 0.79
C_{DZ} = 0.044

$$H_c = \frac{0.79 - 0.044}{1 - 0.044} = \frac{0.746}{0.956} = 0.78$$

$$E = 1 - H_c = 1 - 0.78 = 0.22$$

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The share of heredity in the development of tuberculosis is 0.78;

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Intelligence Genes: Are there Genius Genes?

https://www.youtube.com/watch?v=7Ycjklr5yZ0

Methods in behavioral genetics

Adoption Studies

The method of adopted children

The method of adoptive children is considered the purest one of behavioral genetics with maximum resolution
It is based on a simple principle:
the earliest adoptive children, as well as their biological and adoptive parents are included in the study as soon as possible.

The children possess about 50% of the total number of genes with their biological parents, as close relatives, but do not of the general environment.

With the adoptive ones they have a common environment, but do not common genes.

If hereditary determination is stronger, greater resemblance to biological parents is expected.
If the result is the opposite, then this is due to the predominance of the influence of the environment, and the children will be similar to a foster parents.

There are two variants of this method: complete and partial

The complete one analyzes the combined data from adoptive siblings and two groups of separated relatives, such as parents and their biological children, given to adoption, and separated siblings, who all undergo an intergroup comparison.
Study of these three groups allows to identify reliably the factors that form the family resemblance.

Partial method is a research that is carried out with adoptive and separated siblings.

To provide the representability of the study it should include
-   the wide range of conditions in adoptive families and
- some substantial features which are similar , e.g. intelligence or nurture style of parents.

One of disadvantages of the adoption studies is the problem, whether the group of women that gives children away may be considered adequate to population.

The other problem is the characteristics of a new family. If they resemble the native one the correlation will be distorted.

The third point is a maternal affect on a child in uterus. The influence is environmental to the fetus and raises the similarity of the mother and the child.

Twin studies and adoption studies (10 min)

https://www.youtube.com/watch?v=usnv1_xRCvs

Methods in behavioral genetics

Population Studies

In biology population is 'the number of organisms of the same species that live in a particular geographic area at the same time, with the capability of random mating'.

This method of behaviour genetics is aimed at studying the inheritance of mental disorders in the families and it comparing to the frequency of the disease among the population living in similar conditions.

The human population has a number of demographic parameters:
size, birth and mortality rate, age structure, sex structure, occupation of its members, economic status, geographical and climatic living conditions, etc.

Small populations of between 1,500 and 4,000 people are called **demes**. They are characterized by a small proportion of people of other origin (1-2%), a high frequency of intragroup marriages (80-90%), a slight increase in population (about 20% in 25 years).

Groups of no more than 1,500 people are called **isolates**. The share of foreigners in them does not exceed 1%, the frequency of intra-group marriages is more than 90%, the natural increase over 25 years is less than 25%. If the isolate persists for 4 generations (about 100 years), then all its members become at least second cousins.

There are some peculiarities in populations of human.

Modern human populations are characterized by two traits:
1) an increase in numbers;
2) a decrease in natural selection pressure.

In economically developed countries mortality has significantly decreased, which has shifted the focus of the selection to reproductive selectivity.

Reducing the number of children in families has led to a narrowing of the field of selection.

In addition, modern human populations tend to
a) the destruction of marital isolates,
b) homogenization of the environment leads to the disappearance of causes of racial differences,
c) improvement of the environment that allows for full genotypic manifestation of the traits such as height, maturation rate, etc.,
d) replacement of the main causes of death by others, e.g. cardiovascular and oncological diseases instead of infectious and alimentary ones.

Mechanisms to maintain the genetic structure of populations

The genetic structure of the population is determined by the system of marriages and factors that change the frequency of genes.
Therefore, those mechanisms that maintain gene equilibrium or alter it are extremely important.

Stabilization of the frequency ratio of alleles in a number of generations obeys the **Hardy-Weinberg** equilibrium proposed in 1908.

The law states that allele and genotype frequencies in a population will remain constant from generation to generation in the absence of other evolutionary influences.

There are seven assumptions underlying Hardy–Weinberg equilibrium:
- organisms are diploid;
- only sexual reproduction occurs;
- generations have no overlapping;
- mating is random;
- population size is infinitely large;
- allele frequencies are equal in the sexes;
- there is no migration, gene flow, admixture, mutation or selection.

Deviations in proportion indicate the manifestation of certain population processes.

The simplest case is a single locus with two alleles denoted **A** (dominant) and **a** (recessive).

The frequency of **A** is called **p** and the same of **a** - **q**.

The sum frequency of both alleles is equal to 1

$$p + q = 1$$

To calculate the expected frequency of genotypes should use the Punnet square.

Phenotype		A	a
	Genotype	p	q
A	p	(AA) p^2	(Aa) pq
a	q	(Aa) pq	(aa) q^2

The resulting equation is

$$p^2 + 2pq + q^2 = 1$$

or

$$(p = q)^2 = 1$$

To estimate the expected phenotypes frequencies it is necessary to change parts of the equilibrium

$$p^2 = P \quad q^2 = Q \quad 2pq = H$$

$$P + H + Q = 1$$

The Hardy-Weinberg Principle: Watch your Ps and Qs (12 min)
https://www.youtube.com/watch?v=oG7ob-MtO8c

How to solve Hardy Weinberg problems (9 min)
https://www.youtube.com/watch?v=RRQK5HF00u0

Hardy-Weinberg practice problems
https://www.youtube.com/watch?v=IVGEusDdJGk

Problem

What is the frequency of heterozygotes Aa in a randomly mating population in which the frequency of all dominant phenotypes is 0.19?

Here (dominant phenotypes)

$$p^2 + 2pq = 0.19$$

applying the law

$$q^2 = 1 - 0.19 = 0.81$$
$$q = 0.9$$

we know that

$$p + q = 1,$$

then

$$p = 1 - q$$

here

$$p = 1 - q = 0.1$$

Frequency of heterozygotes

$$Aa\ (2pq) = 2(0.1 \cdot 0.9) = 0.18$$

Problem

αβγ is autosomal recessive mental disorder of human. The frequency of affected newborn infants is about 1 in 14,000.
Assuming random mating, what is the frequency of unaffected carriers?
Here

$$q^2 = 1/14,000$$
$$q^2 = 0.000071428$$
$$q = 0.0085$$

we know that

$$p + q = 1,$$

then

$$p = 1 - q = 1 - 0.0085$$

here

$$p = 0.9915$$

Frequency of carriers

$$Aa \ (2pq) = 2(0.9915 \cdot 0.0085) = 0.017$$

Problem

In a small village in Africa, 15% of the population is born with sickle-cell anemia (aa). (q^2=0.15)

1. What is the frequency for the "A" allele?
$$p = 1 - 0.3873 = 0.6127$$
2. What is the frequency for the "a" allele?
$$q = 0.3873$$
3. What are the three genotype frequencies?
$$AA = p^2 = 0(.6127)^2 = 0.3754$$
$$Aa = 2pq = 2(0.6127)(0.3873) = 0.4746$$
$$aa = 0.15$$
4. Assuming Hardy-Weinberg equilibrium, how many individuals in a neighboring village of 3,500 would be expected to be heterozygous?
$$3,500(0.4746) = 1661.1 = 1661 \text{ individuals}$$

Hardy–Weinberg proportions for two alleles: the horizontal axis shows the two allele frequencies p and q and the vertical axis shows the expected genotype frequencies. Each line shows one of the three possible genotypes.
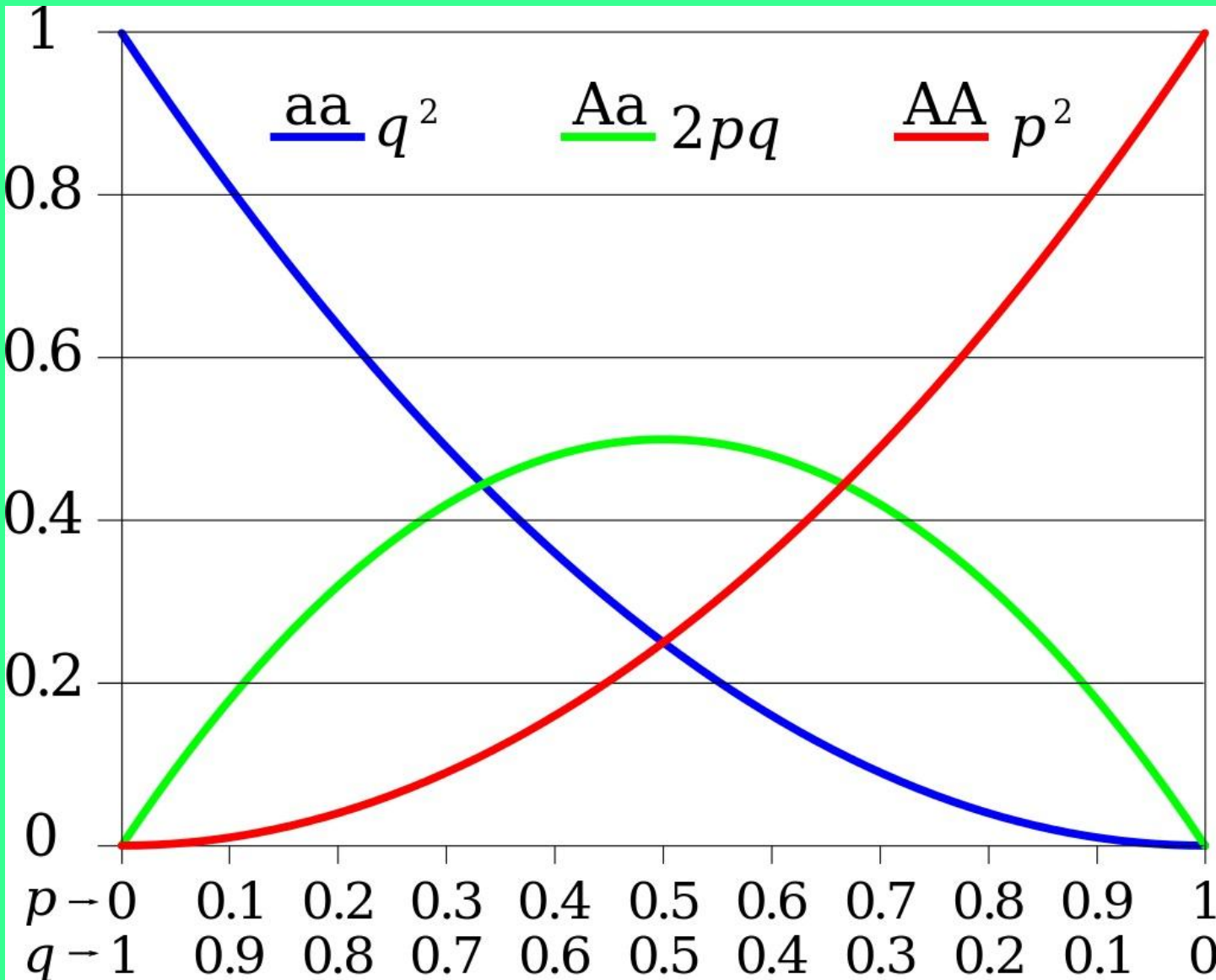
Equilibrium of genes by one autosomal allele is achieved through one generation and persists further if factors that disturb the balance do not intervene.

The proportion of heterozygotes in the population can not be over than 50% (if p = q = 0.5, then P + Q = H = 0.5).
Also, the number of heterozygotes can not be more than the frequency of one type of homozygotes.

The Hardy-Weinberg law can also be used for multiallel genes

$$(p + q + r + \ldots + s)^2 = 1$$

For the calculation of alleles for blood groups ABO, the scheme will be:

$$p = \sqrt{(i + I^A)}, \quad q = \sqrt{(i + I^B)}, \quad r = \sqrt{i},$$

where the frequencies are: p is I^A, q is I^B, and r is i.

Genes, environment and responsibility for behavior (42 min)
https://www.youtube.com/watch?time_continue=5&v=W_Z0TW4NPqg

Educational Achievement and Intelligence Robert Plomin (24 min)
https://www.youtube.com/watch?v=lk8sdMGJ3m4

Adaptive value of behavioral traits (13 min)
https://www.youtube.com/watch?v=tp4I9J5viS4

Categories of mental disorders (16 min)
https://www.youtube.com/watch?v=yar47jvr7M8

Biological basis of depression (9 min)
https://www.youtube.com/watch?v=QEjWLj5wAFM

Personality disorders (8 min)
https://www.youtube.com/watch?v=-Xv593jgyJ4