# Sociological Case Studies of Science

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(Review of “Science and its Fabrications”
by Alan Charmers, chapter 7)

- There are raise of sceptical views of science that it is not universally “objective”
  - We need to differ “cognitive” and “non-cognitive” aspects of science, and how social conditions affect both.
    - The latter is obvious and not debatable
    - The first one needs careful consideration

# Recall

# Two cases

## of sociological effect on cognitive aspect of science

1

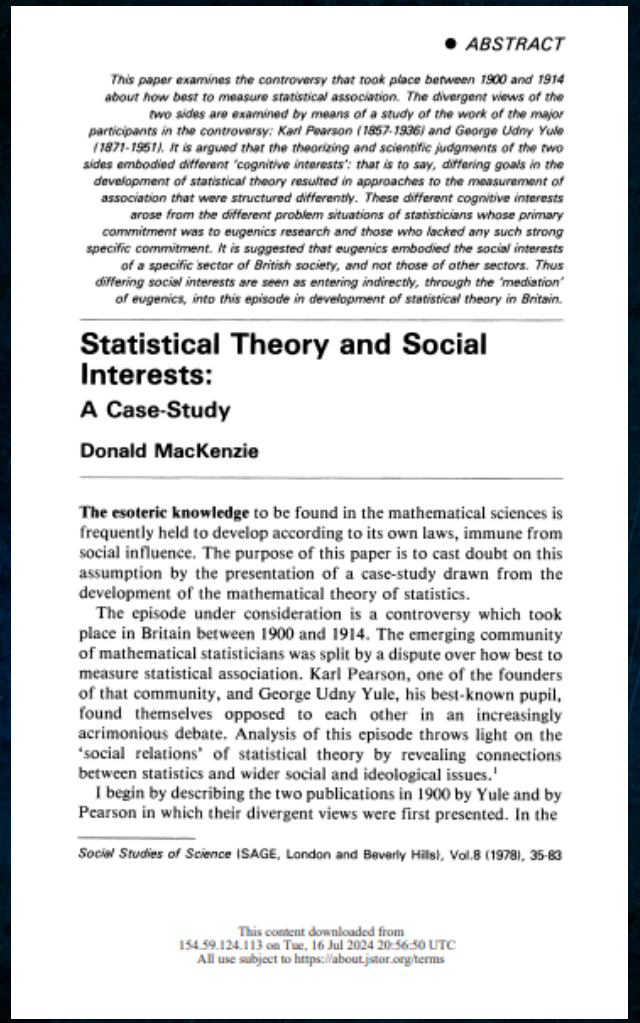
Britain
Statistics

2

Newton's
Principia

McKenzie, D. (1978). Statistical Theory and Social Interests: A Case Study. Social Studies of Science, 8: 35-83

McKenzie, D. (1981). Statistics in Britain: 1865-1930. Edinburgh, Edinburgh University Press




• ABSTRACT

*This paper examines the controversy that took place between 1900 and 1914 about how best to measure statistical association. The divergent views of the two sides are examined by means of a study of the work of the major participants in the controversy: Karl Pearson (1857-1936) and George Udny Yule (1871-1951). It is argued that the theorizing and scientific judgments of the two sides embodied different 'cognitive interests': that is to say, differing goals in the development of statistical theory resulted in approaches to the measurement of association that were structured differently. These different cognitive interests arose from the different problem situations of statisticians whose primary commitment was to eugenics research and those who lacked any such strong specific commitment. It is suggested that eugenics embodied the social interests of a specific sector of British society, and not those of other sectors. Thus differing social interests are seen as entering indirectly, through the 'mediation' of eugenics, into this episode in development of statistical theory in Britain.*


## Statistical Theory and Social Interests:

### A Case-Study


**Donald MacKenzie**

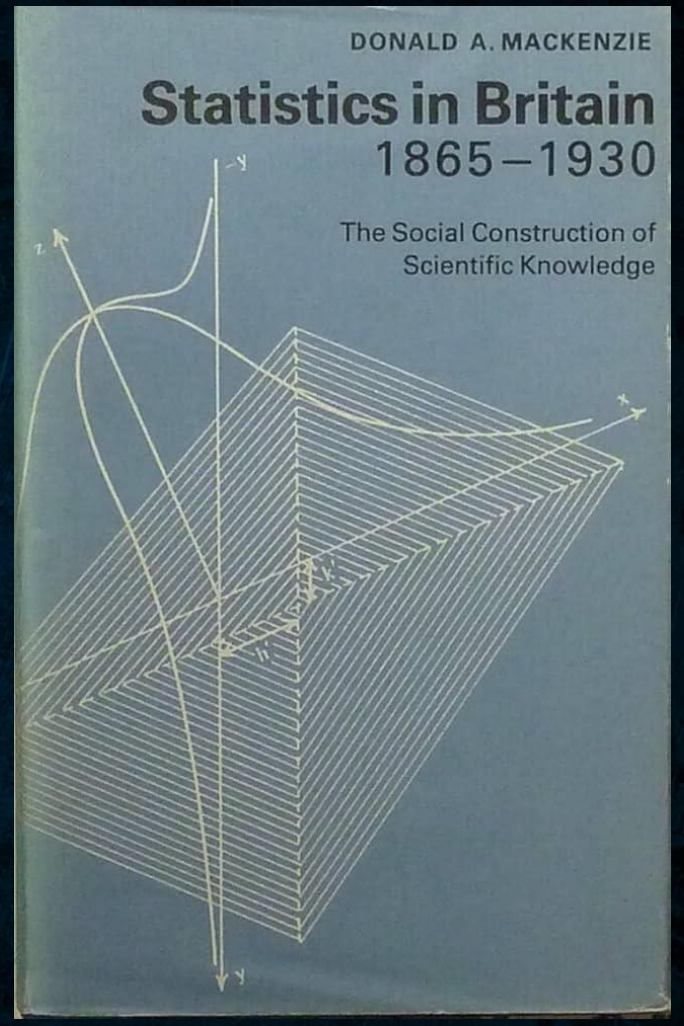

**The esoteric knowledge** to be found in the mathematical sciences is frequently held to develop according to its own laws, immune from social influence. The purpose of this paper is to cast doubt on this assumption by the presentation of a case-study drawn from the development of the mathematical theory of statistics.

The episode under consideration is a controversy which took place in Britain between 1900 and 1914. The emerging community of mathematical statisticians was split by a dispute over how best to measure statistical association. Karl Pearson, one of the founders of that community, and George Udny Yule, his best-known pupil, found themselves opposed to each other in an increasingly acrimonious debate. Analysis of this episode throws light on the 'social relations' of statistical theory by revealing connections between statistics and wider social and ideological issues.[1]

I begin by describing the two publications in 1900 by Yule and by Pearson in which their divergent views were first presented. In the


*Social Studies of Science* (SAGE, London and Beverly Hills), Vol.8 (1978), 35-83




# 1 Britain Statistics: Pearson vs Yule

Professional Middle Class

Eugenics

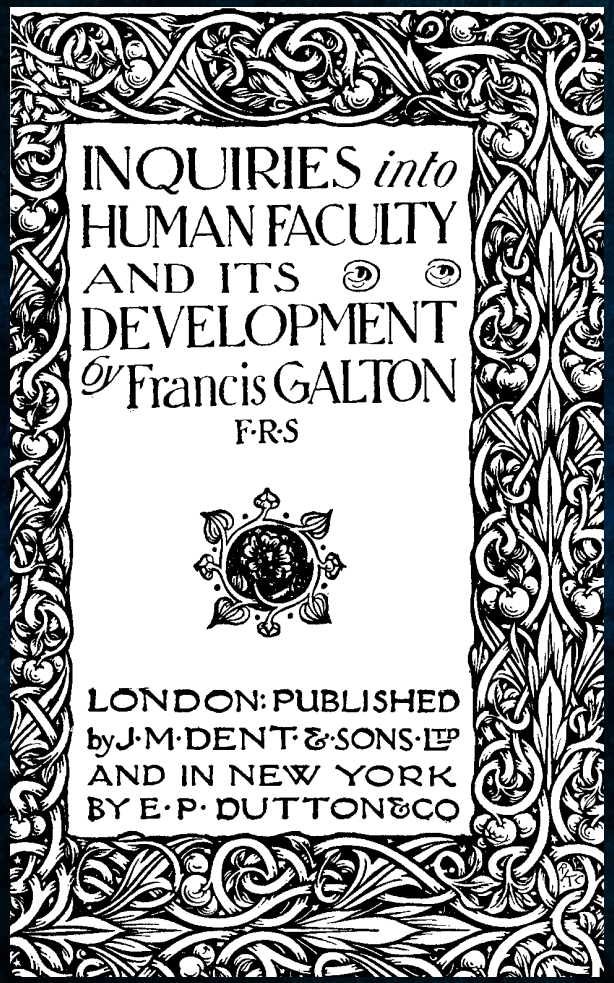
Coefficient of Correlation

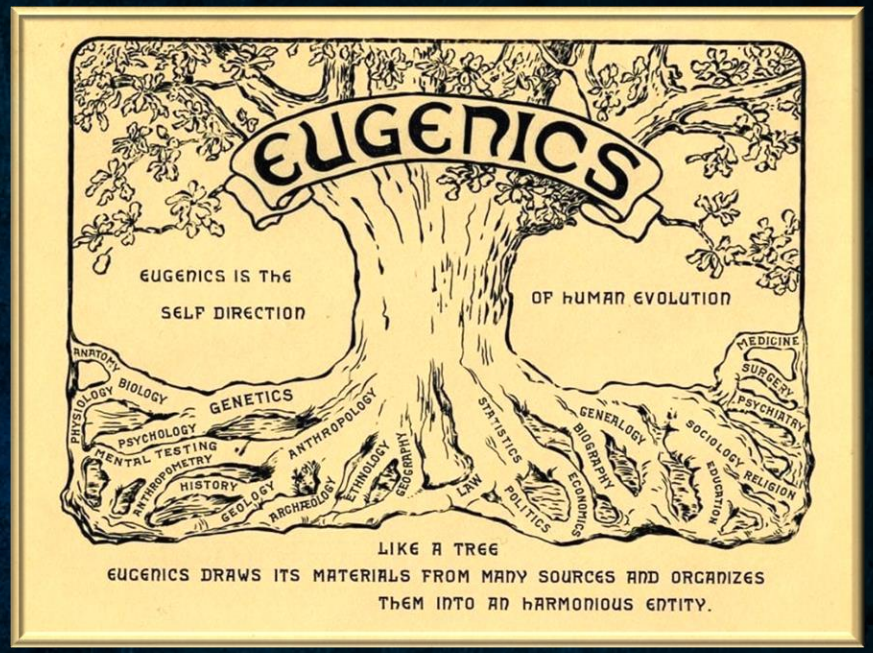
# Three important background concepts


| Working Class (Proletariat) | Professional Middle Class | Upper class (Borguise) |
| --- | --- | --- |
| • work with manual activity | • work for a wage<br>• work involves skilled mental | • live off the capital |

# a) Professional Middle Class

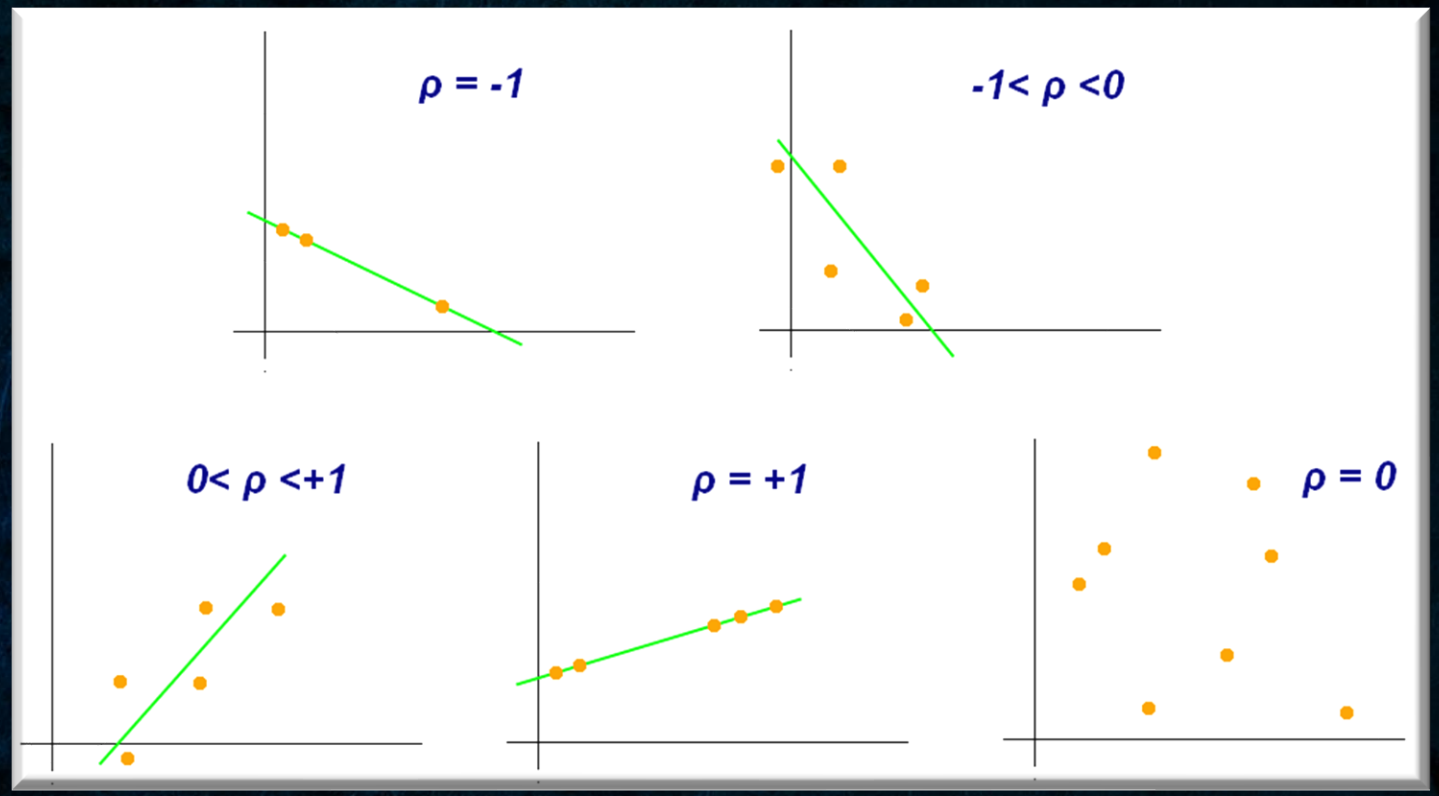
- Eugenics = “good creation.”
  - improving the human species by selectively mating people with specific desirable hereditary traits.
- First coined by scholar Sir Francis Galton in 1883 in his book, “*Inquiries into Human Faculty and Its Development*”
- Give the idea of civic worth (mental ability is a fixed natural characteristic of each individual human that was inherited)




# b) Eugenics

- Statistical theory is developed to find correlation between variables.
- Correlation should be computed in a way that it measures association of variables.
- Has root in Eugenics: Regression was originally a means of summing up how the expected characteristics of an offspring depended on those of its parents;




# c) Correlation

With those backgrounds, Britanian Statistics around 1870-1930 was filled with the debate of two statisticians

VS

Karl Pearson

George Udny Yule

# Karl Pearson

- Pearson was born into an upwardly mobile middle class and to the complacent superficiality of Cambridge University.
- Pearson come to be in a good position to further his class interests by developing mathematical statistics.
- Pearson saw war against "inferior races" as a logical implication of the theory of evolution.

*"My view – and I think it may be called the scientific view of a nation", he wrote, "is that of an organized whole, kept up to a high pitch of internal efficiency by insuring that its numbers are substantially recruited from the better stocks, and kept up to a high pitch of external efficiency by contest, chiefly by way of war with inferior races*

- In 1893, aged 22, Yule became Pearson's demonstrator, assisting in the teaching of mathematics.
- In 1895 he was elected to, and became an active member of, the Royal Statistical Society (Pearson never joined.
- The Statistical Society had shown little concern for the development  of statistical method, focusing instead on official statistics, on the facts of such topics as finance, trade, pauperism, crime, and epidemics.
- Yule had no commitment to eugenics

*"…The Eugenics Congress is rather a joke . . . "*

*"… I am not a eugenist, and I am not the least keenly interested in"*

# George Udny Yule

# Pearson vs Yule Debate: Association of Variables

If we have two discrete (nominal) variables, how does one associate with other?

Example:

Effectiveness of Vaccination.

Two variables:

vaccinated state and person's survival

We can set 4 conditions. If they are positively correlated, then A and D should be dominant. If negatively correlated, B and C should be dominant.

| | Vaccinated | Not Vaccinated |
|---|---|---|
| Survive | A | B |
| Dies | C | D |

The correlation should be:

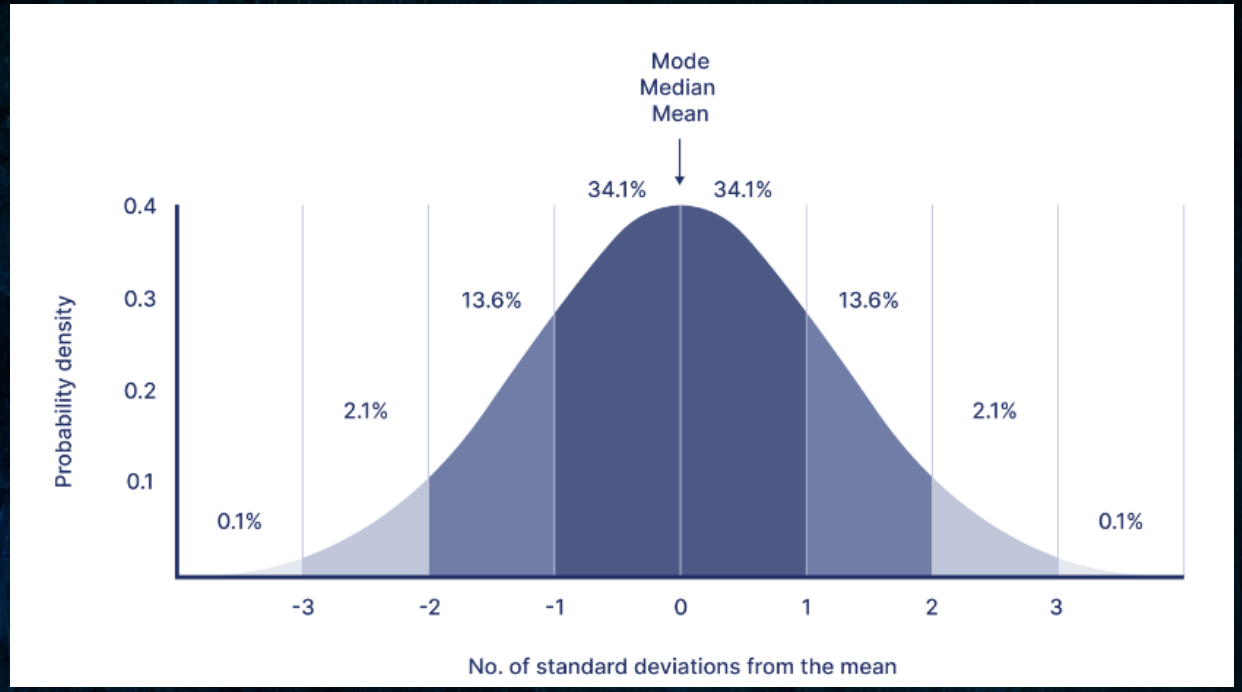
- +1 if C=0 or B=0
- -1 if A=0 or D=0
- 0 if AC = BD (equally proportional)

$$Q = \frac{AD - BC}{AD + BC}$$

# Yule's Method

# Normal Distribution

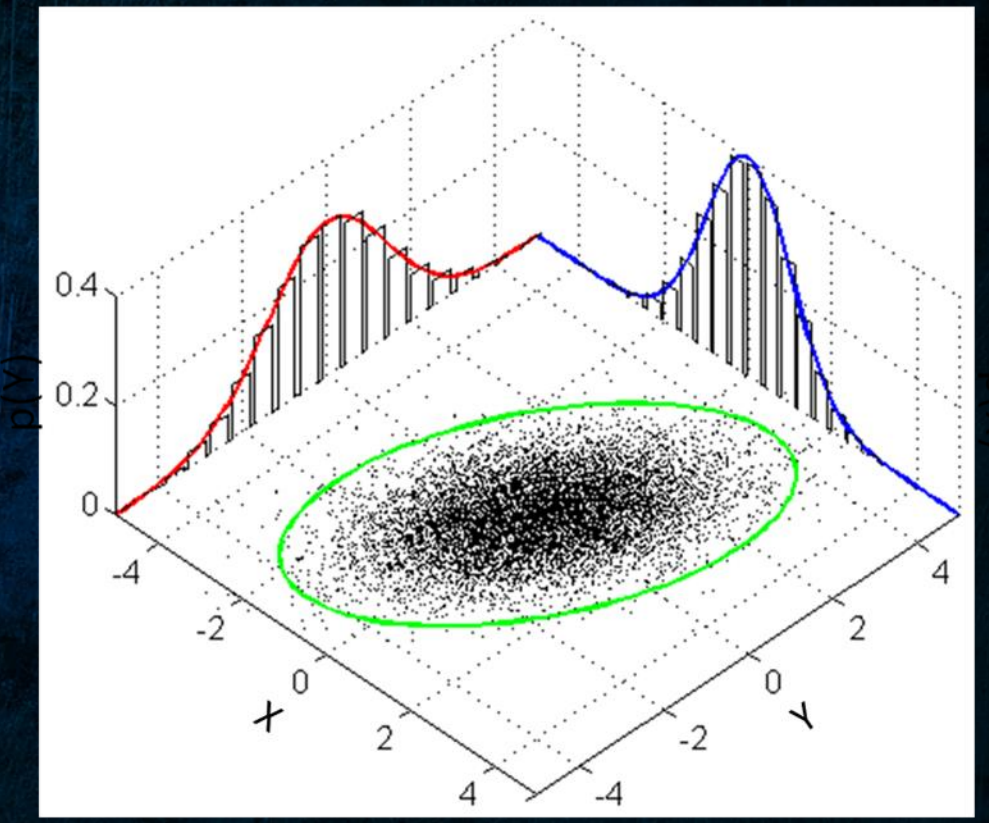
- Error in measurement were understood statistically to fluctuate about a mean value following a normal distribution.
- Carl Friedrich Gauss first developed it in connection with studies of astronomical observation errors.




Central Limit Theorem: any distribution of the sum of large number i.i.d random variables tends to approach normal distribution, regardless the original distribution shape

- Normal distribution can be extended to two variables: bivariate distribution
- Francis Galton developed it while studying the relationship  between two populations connected by heredity.
- First constructed in an investigation of the joint distribution of parental and offspring characteristics.

Pearson's work continued this link between the math of correlation and the eugenic problem of the hereditary relationship of successive generations.




# Bivariate Normal Distribution

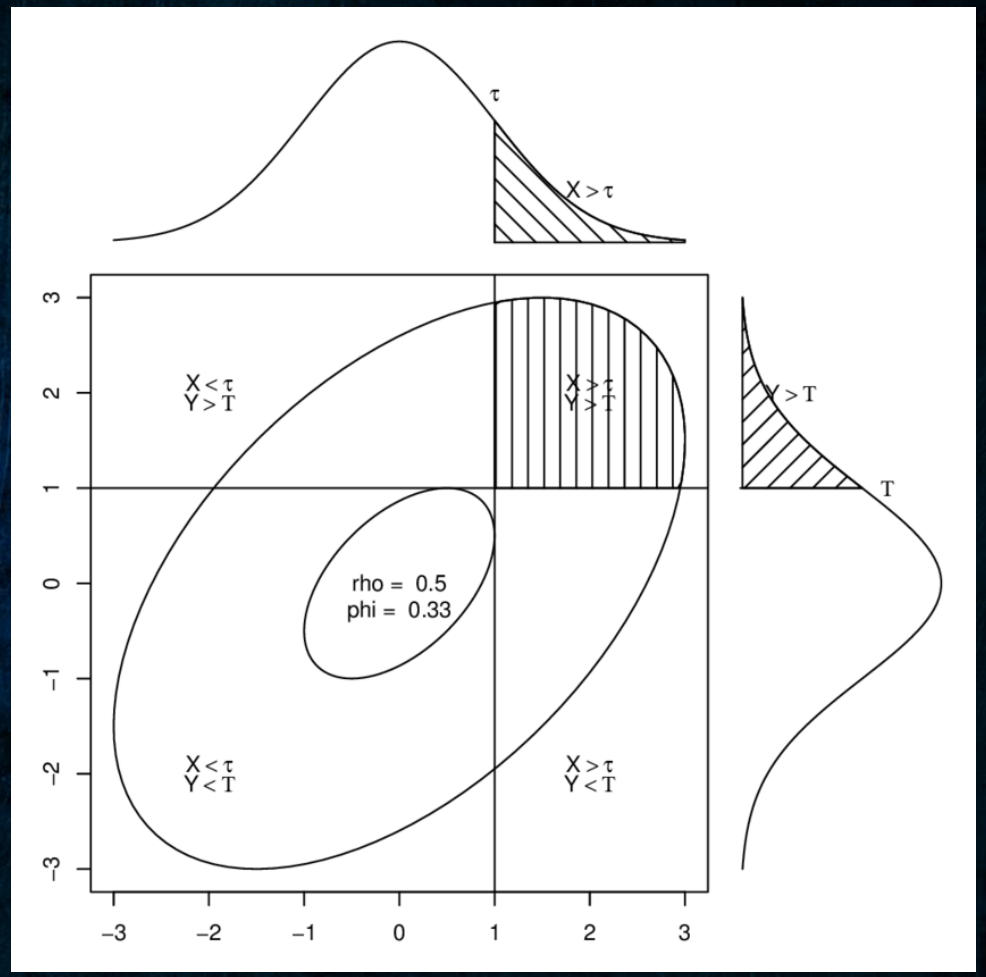
All variables are **assumed** to have underlying continuous factor

- Vaccination state -> $x$
- Survival -> $y$

$x$ and $y$ are normally distributed.

We set threshold $\tau$ and $T$, such that

- If $x > \tau$, the person is vaccinated. Otherwise, not.
- If $y > T$, the person survives. Otherwise, dies.




# Pearson's Method

# Pearson vs Yule Debate

*It is the old controversy of nominalism against realism. Mr Yule is juggling with class-names as if they represented real entities, and his statistics are only a form of symbolic logic. No knowledge of a practical kind ever came out of these logical theories.*

*As exercises for students of logic they may be of educational value, but great harm will arise to modern statistical practice, if Mr Yule's mnethods of treating all individuals under a class-index as identities become widespread, and there is grave danger of such a result, for his path is easy to follow and most men shirk the ard*

VS

*. . .all those who have died of small-pox are all equally dead: no one of them is more dead or less dead than another, and the dead are quite distinct from the survivor*

*The introduction of needless and unverifiable hypotheses does not appear to me 26 a desirable proceeding in scientific work*

*At the best the normal coefficient can only be said to give us in cases like these a hypothetical correlation between supposititious variab*

Pearson: Yule's method is not realistic and binary

Yule: the assumption of Pearson is unreasonable

# Underlying Pearson's Cognitive Interest

Statistics provide good theory on continuous variables, such as heights.

However, Hereditary criteria sometimes nominal (e.g. mental ability).

Pearson want to have "comparable" parameter of correlation.

*"It is clear that if the theory of correlation can be extended so as to readily apply to such cases, we shall have much widened the field within which we can make numerical investigations into the intensity of heredity, as well as much lessened the labour of collecting data and forming records."*

# What‘s the problem?

Yule’s Q-method is not sufficient

Q depends on the arbitrary boundary between categories.

Values of Q cannot be compared with that of the coefficient of correlation; nor can height and mental ability data both be analyzed by the use of Q

# Example

Pearson gather data of siblings as follows:

| Second Brother | First Brother | | |
|---|---|---|---|
| | 'Intelligent' and 'Quick intelligent' | Other | Totals |
| 'Intelligent' and 'Quick intelligent' | 526 | 324 | 850 |
| Other | 324 | 694 | 1018 |
| Totals | 850 | 1018 | 1868 |

From these table, the correlation value is 0.46.

# Example

He compute similar value to for 9 mental and 9 physical characteristics

## Assumption

- The **comparability** of the coefficients of correlation for interval data and the value of correlation for nominal data;
- The interpretation of these coefficients as measures of the **'strength of heredity'**.

## Conclusion:

- The strength of inheritance for a wide range of human mental and physical characteristics was virtually **identical at around 0.5**.
- **Environment** played no significant part, and thus residual effects (the fact that the correlation was not 1.0) were simply the **result of chance variations**.

# Chalmers's Conclusion

Social analysis should attempt to understand the social situation in such a way that various groups or classes and their interests are identified.

Eugenics provided opportunities that could be exploited in the interest of professional middle class.

Development of eugenics required developments in mathematical statistics

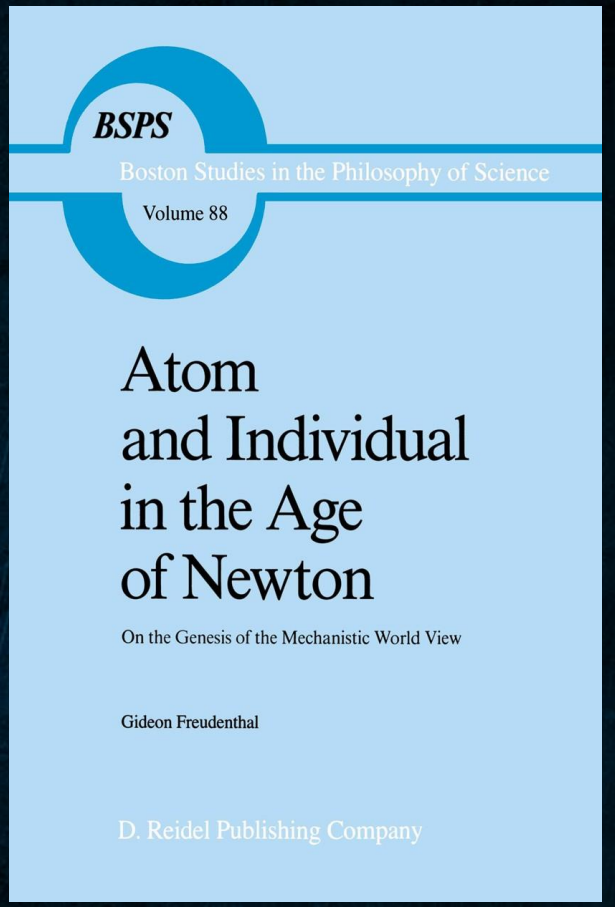
Development of mathematical statistics provided opportunities for futhering the interests of professional middle class.

# Chalmers's Conclusion

But, it is not enough!

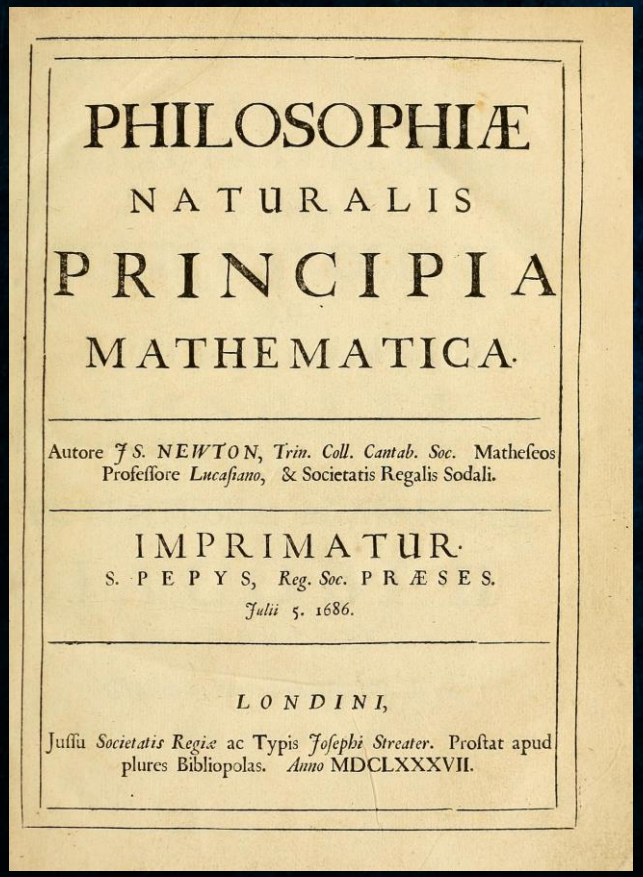
- Fails to supply an adequate general characerrization of the form of his sociological explanation
- His social analysis points to "a match" of beliefs and social interests. However, it can be interpreted in a very weak sense
- Eugenic theories, served the interests of the professional middle class to a much greater degree than tehy served the aim to produce knowledge
- it is not sufficient to establish strong claim about sociological determination of good sience

Freudenthal, G (1986) Atom and Individual in the Age of Newton. Dordrecth, Reidel




# 2 Atomism on Newton's Principia

In 1686, Newton writes Philosophiae Naturalis Principia Mathematics, containing theory of motion and gravity.
It is also the start of reductionistic and deterministic view of physics

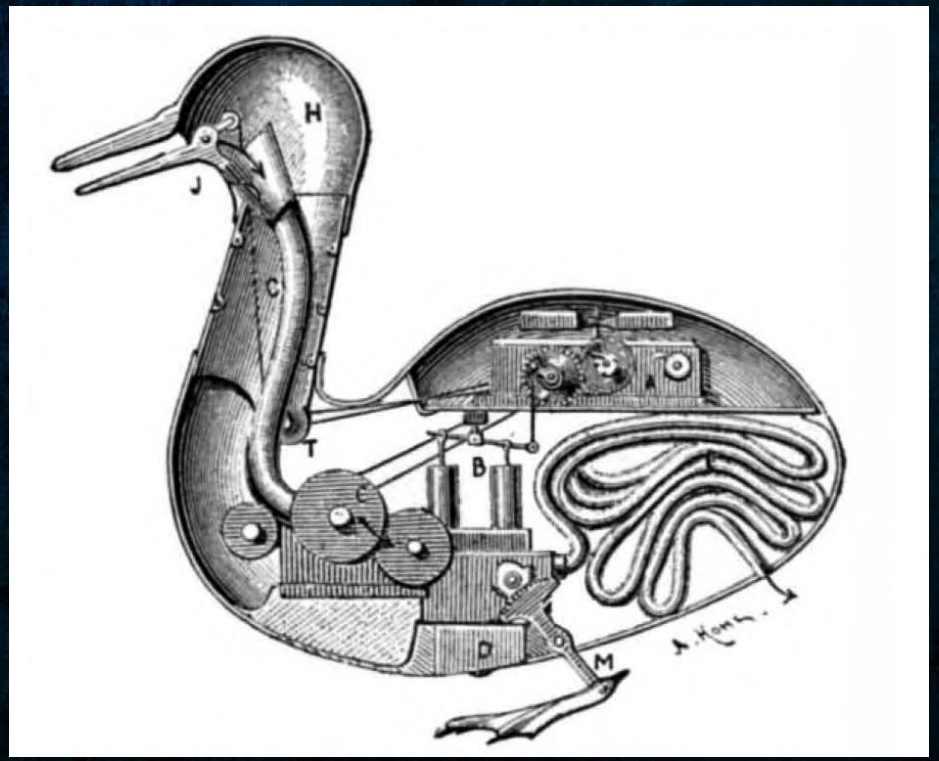


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *J S. NEWTON, Trin. Coll. Cantab. Soc.* Matheſeos Profeſſore *Lucaſiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
*Julii* 5. 1686.

*LONDINI,*
Juſſu *Societatis Regiæ* ac Typis *Joſephi Streater*. Proſtat apud plures Bibliopolas. *Anno* MDCLXXXVII.



# Principia's Problem (Freudenthal)

## Conception of absolute space

- bucket experiment (deformation of water surface in the rotating bucket)
- rotation of two particles connected by a spring (extension of spring joining the particles).

## Newton's distinction between essential and universal properties of matter.

- Universal -> possessed by all material bodies encountered in empirical and experimental situations, as are essential properties.
- Some stronger requirement needed for essential.
- E.g., Gravity is universal but not essential. Extension is universal and essential

## Circuclar concept

- Quantity of matter = density x volume
- Density is mass per unit volume.
- Mass and quantity of matter is ambiguous

## Materials differ in density

- They must contain vacuous spaces in varying degrees

# Underlying Assumption

material world is composed of equal particles each possessing the same essential properties*

*properties a particle would continue to possess even if it were alone in empty space

Weaker version:

*"The extension, hardness, impenetrability, mobility, and force of inertia of the whole, result from the extension, hardness, impenetrability, mobility, and force of inertia of the parts; and hence we conclude the least particles of all bodies to be also all extended, hard and impenetrable, and moveable, and endowed with their proper forces of inertia. And this is the foundation of all philosophy"*

# Principia's Problem (Freudenthal) "solution"

## Conception of absolute space

- Directly solved by the essentiality of particles

## Newton's distinction between essential and universal properties of matter.

- Essentiality defined properly by elementary particle assumption

## Circuclar concept

- Distinct concept of "density of mass" and "density of quantity"

## Materials differ in density

- Differing densities do require the existence of varying degrees of space between particles

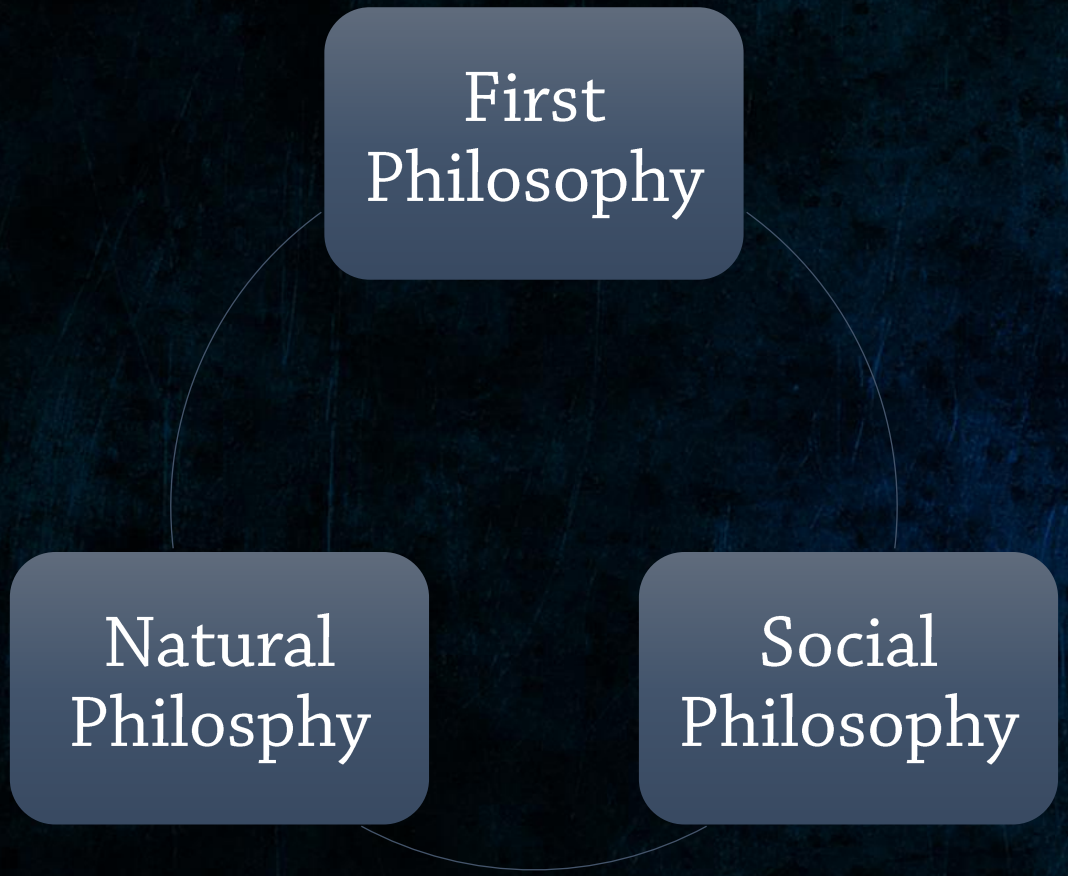
# Background:
# Beyond the assumption

Individualist conception of society that emerged in the 17th century as feudal society gave way to early forms of capitalist society, with the market coming to play as increasingly fundamental role.

(Context: this was way before 1st industrial revolution and Adam Smith's Wealth of Nation)

# Background:
# Beyond the assumption

Social change from feudalism to early forms of capitalism engenders a conception of society according to which the latter is to be understood in terms of the essential properties of the individuals of which is composed




17-18th century: 3 branches of philosophy

- The first philosophy represent the body of abstract generalization.
- Hobbes assumption on social philosophy: society should be understood in terms of the essential properties of the individuals
- This assumption become general and part of the first philosophy.
- Newton followed Hobbes in extracting social theory as it become general.

# Three branch of philosophy

# Additional Newton's Interest

Capitalist society emerged

Political struggle involving the suppression of the Levellers, Newton played a partisan role.

The culmination of that struggle in England involved a compromise with the King.

The limited power that was remain with the King was justified on the grounds that it was necessary for the maintenance of social order.

Outside intervention is necessary.

Newton appaling to divine intervention: God is governor of the world

# Chalmers's Conclusion

it is still not enough!

- Freudenthal distinguishes between aspects of Principia that have a scientific justification (laws of motion) and assumptions that do not. The latter he attempts to explain socially.
- Something needs to be added to mere individualism or atomism for Freudenthal to be able to complete his social explanation
- Newton's view that God as governor of the world can best be regarded as ideological extension of his physics rather than as parts of it.
- Other physicist were able to construe Newton's physics in ways that differed radically from Newton's own interpretation explained socially by Freudenthal. Example: Maxwell's electromagnetic theory

# Chalmers's General Remark

Britain
Statistics

Newton's
Principia

- Natural world does not behave in one way for capitalists and in another way for socialist
- As science involves the attempt to construct generalizations that characterize the natural world, such characterizations are independent of interests of individuals or groups that construct and espouse them.
- Sociological case studies indicate how interests other than those serving the aim of science can influence the practice of science.
- The practice of science is inevitably interconnected with other practices which have oter aims and serve other interests.
- In other words, cognitive aspect of science is always objective. (personal conclusion)

*Any cognitive sociological explanation must, at the least assert a causal relationship between some belief x, of a thinker y, and y's social situation z*

*It will do so by invoking a general law which asserts that all (or most) believers in situation type z adopt beliefs of type x*

*(Laudan, 1977)*

# Personal remark

If Newton did not discover his theory of motion, will someone else discover it the same way?

Is it possible that Einstein can develop
its relativity without Newton's theory of motion?

Relativity is more general and adequate,
and not "build upon" Newton's theory.

# Personal remark

In the case of math, yes.

Math has two very strong criteria of what can be accepted:
consistency and completeness

Social (or other external) factors only affect what will be "discovered" first. It is like a world that anyone can explore. Anywhere you start, you will still draw the same map.

In the case of Pearson, if he didn't develop his concept of correlation, someone else will, even without interest in Eugenics.

# More cases to be studied



The Man Who Killed Millions and Saved Billions (Clean Version)

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Ve Veritasium

Fritz Haber is the scientist who arguably most transformed the world.

0:07 It was given to German scientist Fritz Haber for solving one of the biggest problems ...

4K Subtitles

To be continued next month on the next section:

# Ch.8: The Social and Political Dimension of Science

By Satriososo

Thank you