Lecture -- 6 -- Start

Outline

1. Science, Method & Measurement
2. On Building An Index
3. Correlation & Causality
4. Probability & Statistics
5. Samples & Surveys
6. Experimental & Quasi-experimental Designs
7. Conceptual Models
8. Quantitative Models
9. Complexity & Chaos
10. Recapitulation - Envoi

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1. Science, Method & Measurement
2. On Building An Index
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6. **Experimental & Quasi-experimental Designs**
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Quantitative Techniques for Social Science Research

Lecture # 6:
Experimental And Quasi-Experimental Designs

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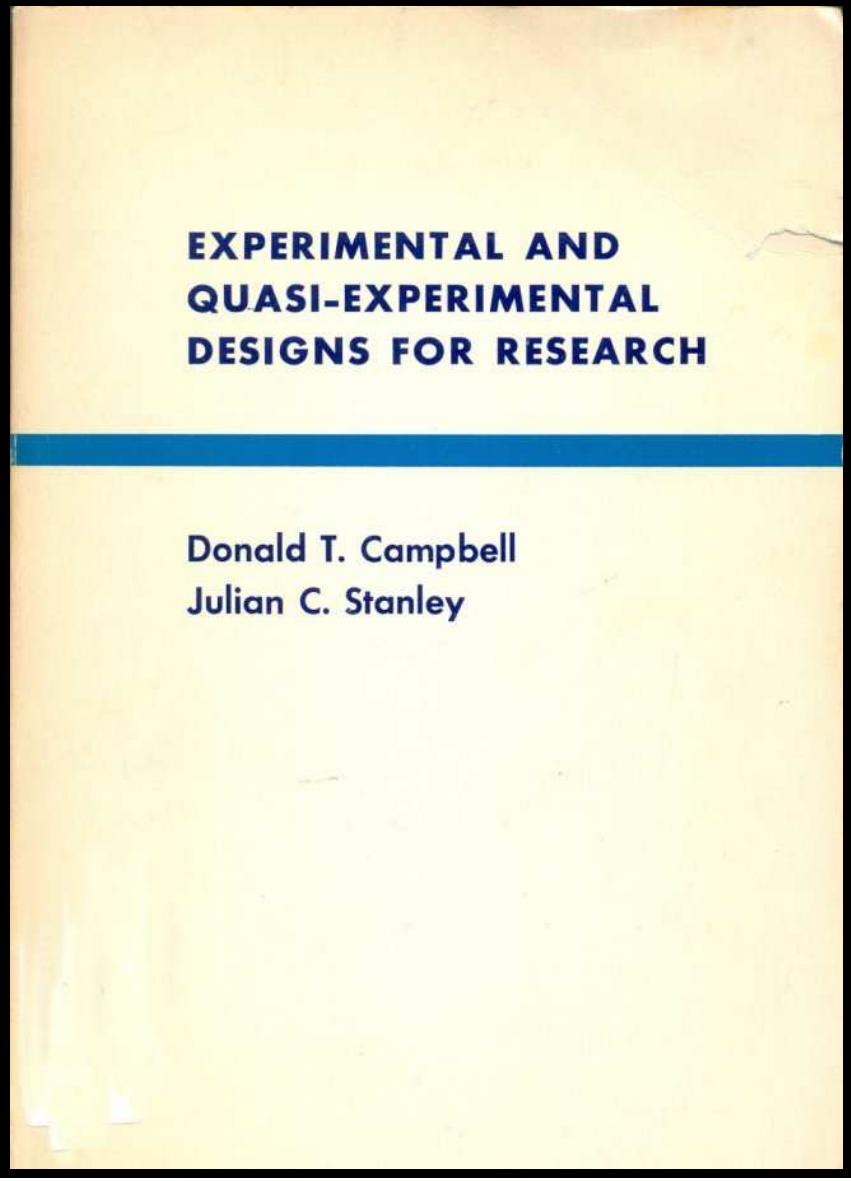
Alexandria

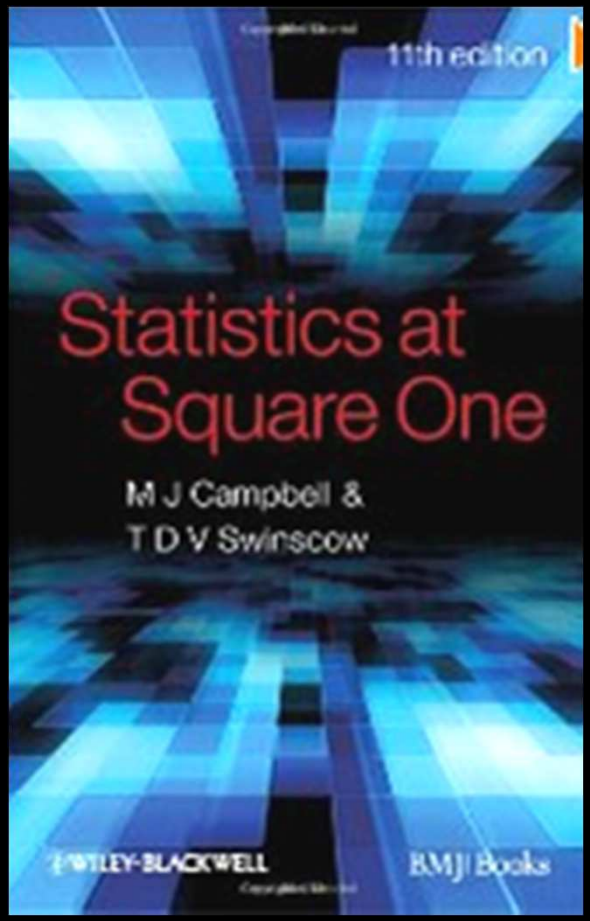
2012

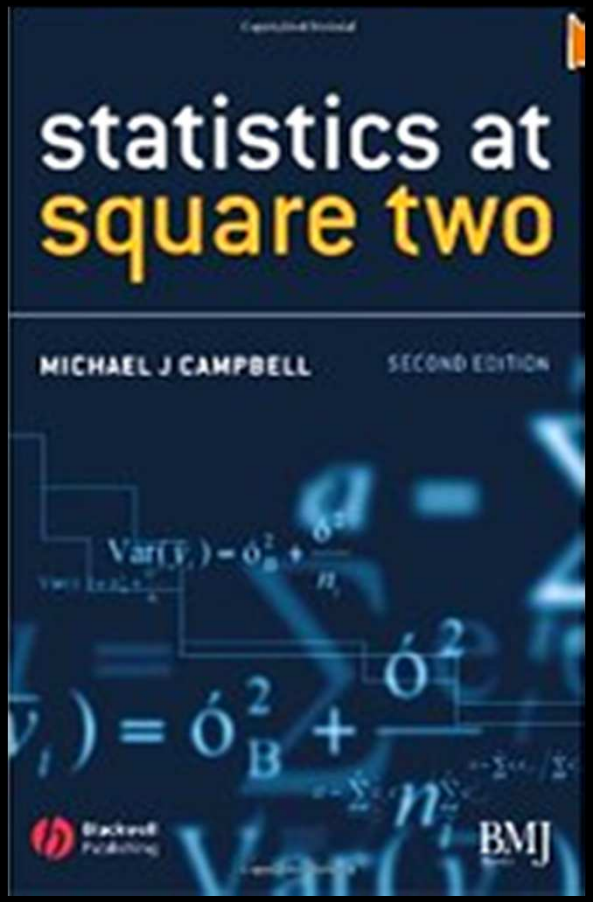
There are many outstanding texts for this section of the course…


Research Design
in Social Research
David de Vaus
EXPERIMENTAL AND
QUASI-EXPERIMENTAL
DESIGNS FOR RESEARCH
Donald T. Campbell
Julian C. Stanley
WILEY
Statistics for
Research
Third Edition
Shirley Dowdy
Stanley Wearden
Daniel Chilko
WILEY SERIES IN PROBABILITY AND STATISTICS
FOUNDATIONS OF MODERN PSYCHOLOGY SERIES
Tests
and Measurements
LEONA E. TYLER
THE RESEARCH METHODS
KNOWLEDGE BASE
WILLIAM M.K. TROCHIM · JAMES P. DONNELLY

This one is a classic:







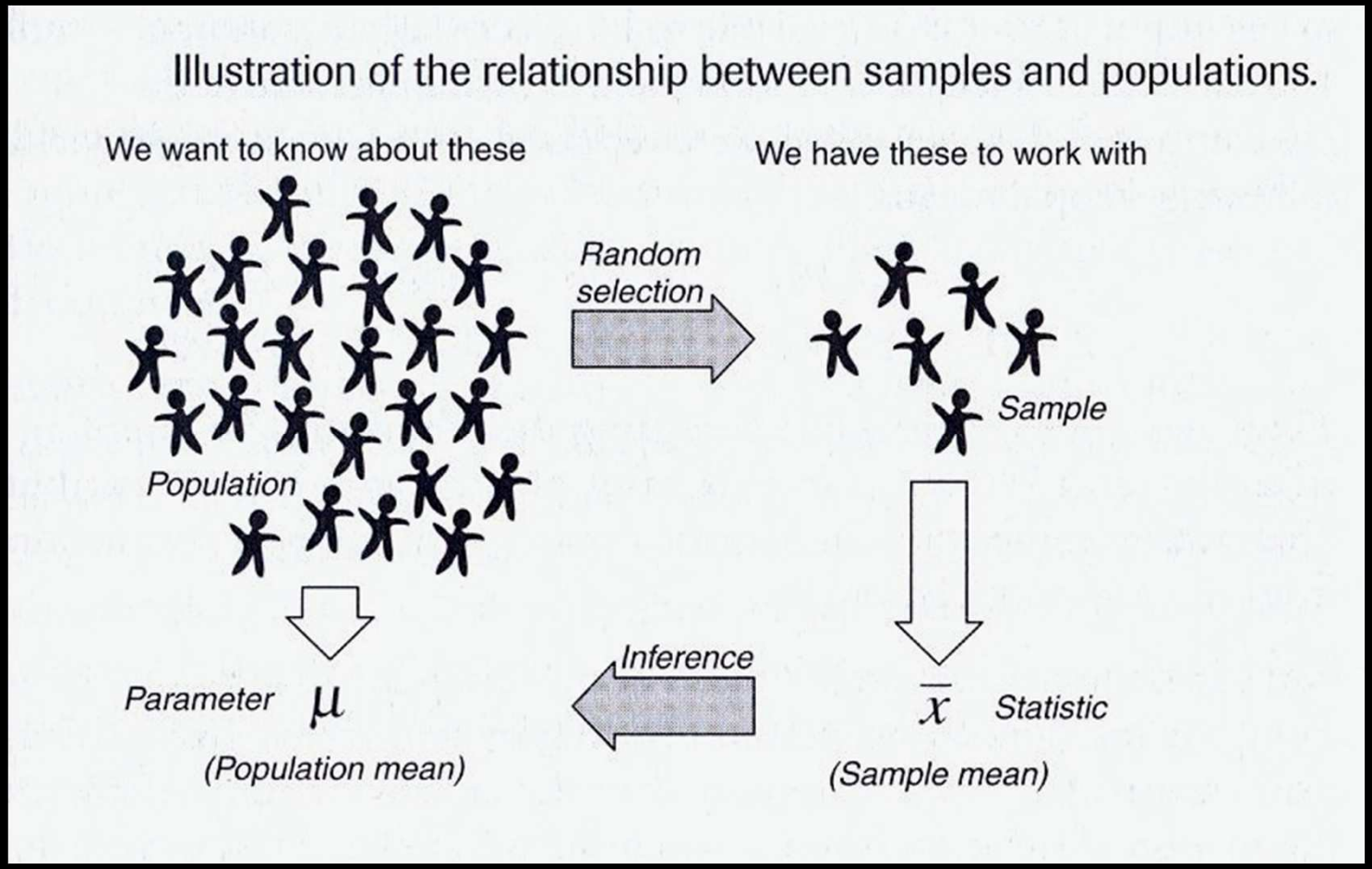
And these two are excellent for medical studies

But for now, just follow the presentation

Experimental And Quasi-Experimental Designs

How to Design Studies To Test Hypotheses

We want to test a new treatment (teaching method, medicine, etc.) and know what effect it will have. We design a study based on studying small samples of the Population



Source: Statistics, Cliffs Quick Review, Wiley, NY, 2001

So we formulate the Null Hypothesis (no difference in applying the new treatment) and we think of how to sample and how to test.

Remember:
Two Types Of Error

- **Type I** (α): reject the null-hypothesis when the null-hypothesis is true, and
- **Type II** (β): fail to reject the null-hypothesis when the null-hypothesis is false
- These are also referred to as false positive and false negative

Experimental and Quasi-experimental Designs

Importance of Proper Experimental Design

- Confidence in validity of resulting data
- Confidence in appropriateness and quality of statistical analysis (in relation to the data sets)
- Appropriate controls of internal and external sources of invalidity

BUT:
Depending on how we set up the experiment we have two other types of problems:

Internal & External Validity

- **Internal Validity question:** Is the data I have collected interpretable? Can I say what I want to say about this data and my statement would be valid?
- **External Validity question:** Are these (valid) findings generalizable beyond this experiment? To what populations, settings, treatments, and measurable variables can the recorded effect be generalized?

So what affects
Internal Validity?

Internal Sources of Invalidity

- History
- Maturation
- Testing
- Instrumentation
- Regression
- Selection
- Mortality
- Interaction of selection and others

Source: Donald Campbell and Julian Stanley, *Experimental and quasi-experimental designs for Research*, Wadsworth Publishing; 1 edition (July 13, 1963)

And what affects
External Validity?

External Sources of Invalidity

- Interaction of Testing and X
- Interaction of selection and X
- Reactive arrangements
- Multiple X interference

Source: Donald Campbell and Julian Stanley, *Experimental and quasi-experimental designs for Research*, Wadsworth Publishing; 1 edition (July 13, 1963)

No Design Is Perfect --
Different Designs Have
Different Strengths

So let’s first discuss the Internal and External Validity issues

Noting that In many of our designs we will have :

- **More than one observation of the group (e.g. once before and once after the treatment)**
- **We may have more than one group only one of which is subjected to the treatment (the other being a control group)**
- **Some selections will be randomized samples, but not in all cases.**

Internal Validity Issues

- **Internal validity issues are those extraneous variables which, if not controlled in the experimental design, could produce results confused with the effect of the experimental stimulus. Thus each represents the effects of a possible source of invalidity in the conclusions.**

Internal Sources of Invalidity

- History
- Maturation
- Testing
- Instrumentation
- Regression
- Selection
- Mortality
- Interaction of selection and others

Internal Validity Issues

- **History:** The specific events occurring between the first and second measurement (other than the experimental variable).

- **Maturation:** Changes occurring in the respondents simply by the passage of time.

Internal Validity Issues (cont)

- **Testing:** The effect of taking a test on the scores of the second test.

- **Instrumentation:** Changes in the calibration of the instrument, the observers, or scorers, that could change the measurement.

Internal Validity Issues (cont)

- **Statistical regression:** The phenomenon occurs whenever the groups have been selected on the basis of extreme scores.

- **Selection:** Biases in the selection of the comparator groups.

Internal Validity Issues (cont)

- **Experimental Mortality:** The differential loss of respondents from the comparison groups.

- **Selection-Maturation Interaction:** In some complex design such effects could be confused for the effect of the experimental variable.

External Validity (representativeness) Issues

- These issues relate to the representativeness of the experiment, and hence to the generalizability of the measured result to the total population.

External Sources of Invalidity

- Interaction of Testing and X
- Interaction of selection and X
- Reactive arrangements
- Multiple X interference

External Validity (representativeness) Issues

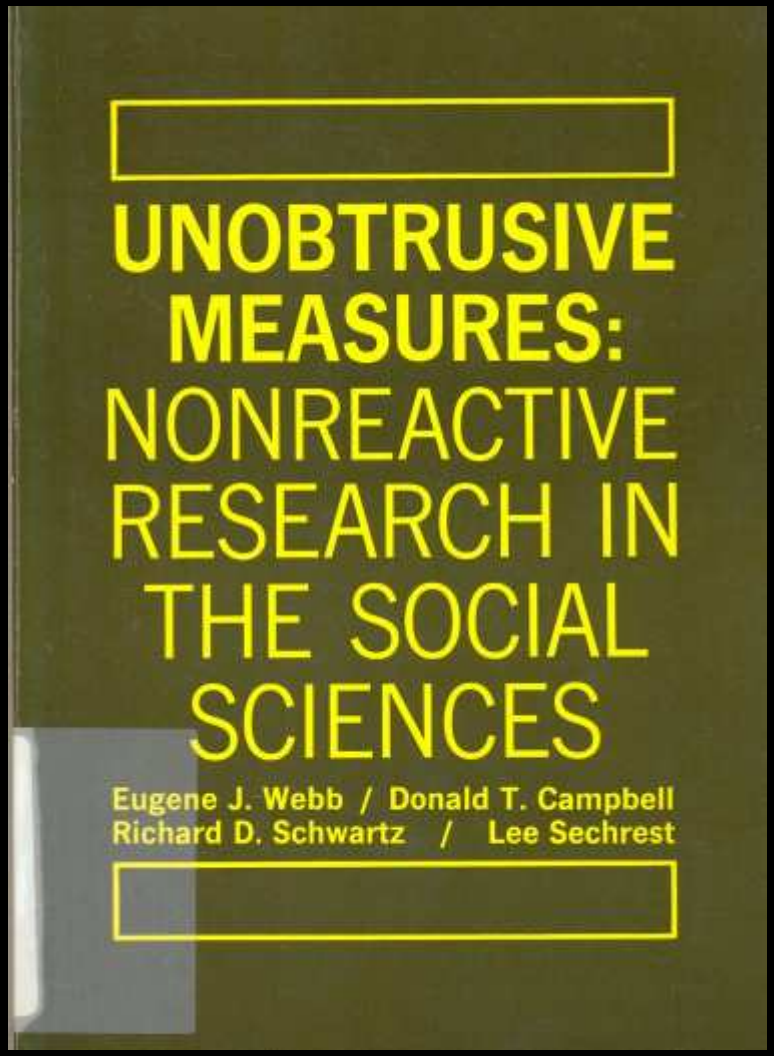
- **Interaction effects of Testing & X: : The effect of pretest loss of respondents from the comparison groups.**

- **Interaction effects of Selection & X: differential selection that can interact differently with the experimental variable could be confused for the effect of the experimental variable.**

External Validity (representativeness) Issues (cont)

- **Reactive Arrangements:** The interactive effect of pretest on the group being studied makes the group no longer representative of the population they were selected to represent.

- **Multiple Treatment Interference:** this is likely to occur whenever multiple treatments are applied to the same respondents, as the effects of prior treatments are usually not erasable. (This is a particular problem with one-group designs of type 8 & 9).



In fact, There is a whole area of study that looks for measures that do not impact directly on the respondents

Remember:

No Design Is Perfect --
Different Designs Have
Different Strengths

So let’s discuss experimental and quasi-experimental designs

Let's agree on some symbols:

- Left to right means movement over time
- O is an observation of that group
- O_1, O_2, … on the same line means multiple observations of the same group at different times
- O's placed on different lines means different groups
- O's vertically above each other means that the observations of the groups were at the same time
- X is the application of the treatment being studied
- (X) means treatment was applied but is not relevant to the experiment
- R before a group means that group was selected by randomization process.

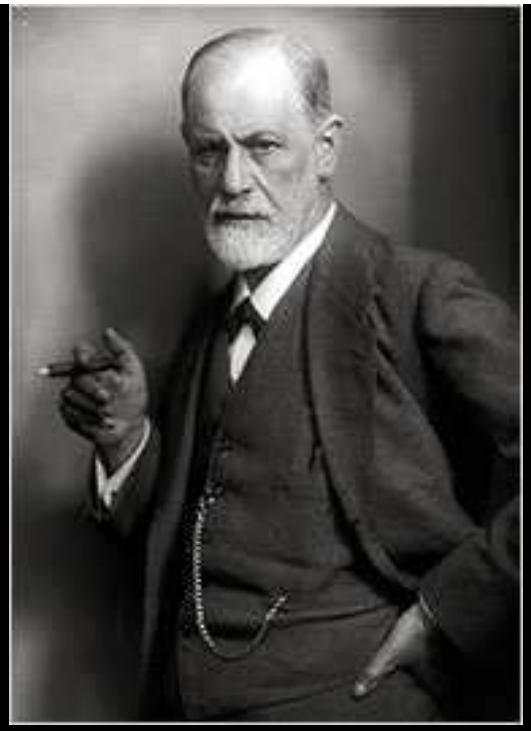
1. One Shot Case Study

X O

TABLE 1

SOURCES OF INVALIDITY FOR DESIGNS 1 THROUGH 6

	Sources of Invalidity												
	Internal								External				
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and *X*	Interaction of Selection and *X*	Reactive Arrangements	Multiple-*X* Interference
Pre-Experimental Designs:													
1. One-Shot Case Study *X O*	–	–				–	–			–			



- **Example**: **Freudian Psycho Analysis**
- **Individual Case Study**
- **No generalization possible**

2. One-Group Pretest-Posttest Design

O X O

This is a really BAD design

- Internal invalidity that can explain $O_1 - O_2$ difference:
  - **History:** many other things could have happened between O_1 & O_2 . In social science you cannot have experimental isolation as in the natural sciences labs.
  - **Maturation:** between O_1 & O_2 students could have grown older, hungrier, more tired, etc.
  - **Testing:** that is the effect measured is the effect of the pretest O_1 not the treatment X
  - **Instrumentation** (decay) The observers themselves can get tired, etc. accounting for a part if not all of the $O_1 - O_2$ change

TABLE 1

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Pre-Experimental Designs:												
1. One-Shot Case Study *X O*	−	−				−	−			−		
2. One-Group Pretest-Posttest Design *O X O*	−	−	−	−	?	+	+	−	−	−	?	

Further problems with design 2

- Again applies only to the group being tested (no generalizability), plus

There is also regression towards the mean…

Regression towards the mean

Prediction

From Homogeneous Pretest Groups → To Mean Posttest

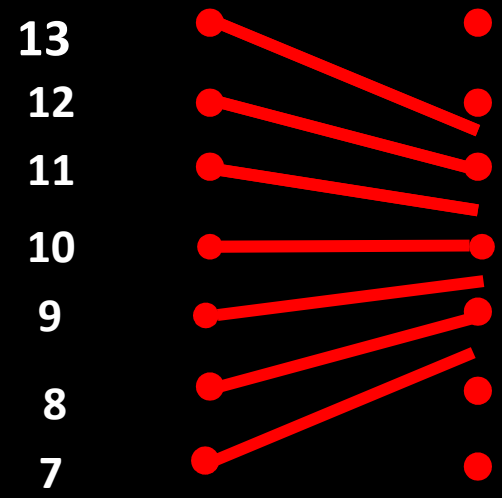

Fig. 1*b*.

Prediction

To Mean Posttest ← From Homogeneous Posttest Groups

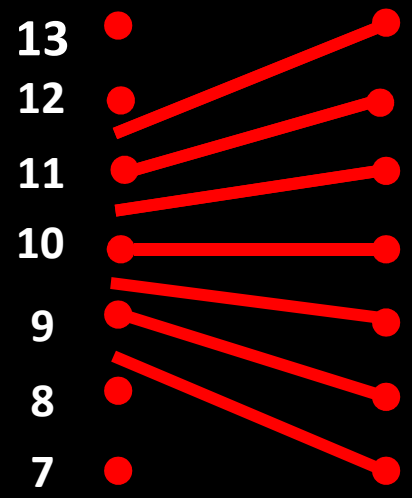

Fig. 1*c*.

Fig. 1. Regression in the Prediction of Posttest Scores from Pretest, and Vice Versa

Thus if you were to take observations and try to predict from the post test to the pre test or vice versa, you would get markedly different results, due to this phenomenon.

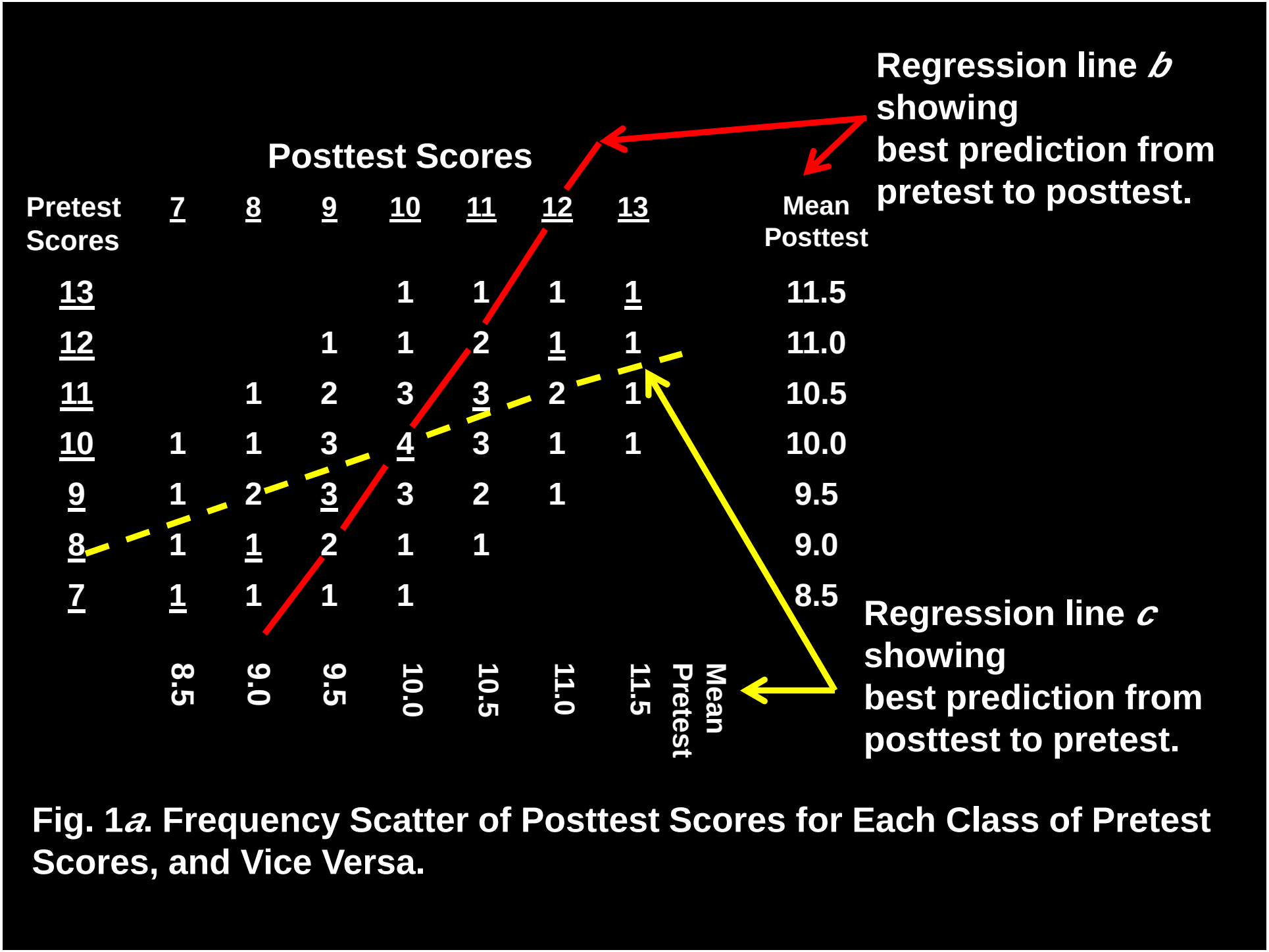

Fig. 1*a*. Frequency Scatter of Posttest Scores for Each Class of Pretest Scores, and Vice Versa.

3. Static group Comparison

X O

O

Examples

- Comparinga school system that requires a bachelor's degree for teachers with one that does not
- Comparing classes that have received extra lectures to others that have not

The fundamental problem:

- There is no way of certifying that the two groups would have been the same except for X (This will be controlled in Design 6 later)

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Pre-Experimental Designs:												
1. One-Shot Case Study *X O*	−	−				−	−			−		
2. One-Group Pretest-Posttest Design *O X O*	−	−	−	−	?	+	+	−	−	−	?	
3. Static-Group Comparison *X O* --- *O*	+	?	+	+	+	−	−	−		−		

4. Pretest-Posttest Control Group Design

R O X O

R O O

Now, this is much better…
Note:
we are comparing a single X with no X

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Pre-Experimental Designs:												
1. One-Shot Case Study *X O*	−	−				−	−			−		
2. One-Group Pretest-Posttest Design *O X O*	−	−	−	−	?	+	+	−	−	−	?	
3. Static-Group Comparison *X O* --- *O*	+	?	+	+	+	−	−	−		−		
True Experimental Designs:												
4. Pretest-Posttest Control Group Design *R O X O* *R O O*	+	+	+	+	+	+	+	+	−	?	?	

This type of test design, and the next (the Solomon Four-Group design) are standard in many of clinical studies.

Comparing medical treatments

Is this treatment really effective?

So we need careful clinical trials and careful statistical analysis

Double blind designs (control groups) is usually preferred

Does this medicine have unacceptable side effects?

Which is the real test medicine and which is the placebo?

Is it Medicine or a placebo?

Who is the test case and who is the control?

We want to be sure of the safety and effectiveness of the medicines we give our children…

But you also need to compare new treatments with existing (known) treatments

5. Solomon Four-Group Design

R	O_1	X	O_2
R	O_3		O_4
R		X	O_5
R			O_6

Even Better than previous design

- By adding the two bottom rows we have controlled for the possible effect of the pretest
- Generalizability is maintained by randomization
- Confidence in results that X has an effect will be greatly increased if : $O_1 > O_2$ and $O_2 > O_4$ and $O_5 > O_6$ and $O_5 > O_3$

Again:

R	O_1	X	O_2
R	O_3		O_4
R		X	O_5
R			O_6

- Confidence in results that X has an effect will be greatly increased if :

  $O_2 > O_1$ and

  $O_2 > O_4$ and

  $O_5 > O_6$ and

  $O_5 > O_3$

TABLE 1

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	Sources of Invalidity												
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	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and *X*	Interaction of Selection and *X*	Reactive Arrangements	Multiple-*X* Interference
Pre-Experimental Designs:												
1. One-Shot Case Study *X O*	−	−				−	−			−		
2. One-Group Pretest-Posttest Design *O X O*	−	−	−	−	?	+	+	−	−	−	?	
3. Static-Group Comparison *X O* --- *O*	+	?	+	+	+	−	−	−		−		
True Experimental Designs:												
4. Pretest-Posttest Control Group Design *R O X O* *R O O*	+	+	+	+	+	+	+	+	−	?	?	
5. Solomon Four-Group Design *R O X O* *R O O* *R X O* *R O*	+	+	+	+	+	+	+	+	+	?	?	

But do we really need all that?
Let’s look at the bottom part of the last design:

6. Posttest-Only Control Group Design

R	X	O
R		O

If you believe in randomization, then we do not really need the pretest and this design is just as good as the preceding ones with the pretest.

TABLE 1

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Pre-Experimental Designs:												
1. One-Shot Case Study *X O*	−	−				−	−			−		
2. One-Group Pretest-Posttest Design *O X O*	−	−	−	−	?	+	+	−		−	−	?	
3. Static-Group Comparison *X O* --- *O*	+	?	+	+	+	−	−	−			−		
True Experimental Designs:													
4. Pretest-Posttest Control Group Design *R O X O* *R O O*	+	+	+	+	+	+	+	+		−	?	?	
5. Solomon Four-Group Design *R O X O* *R O O* *R X O* *R O*	+	+	+	+	+	+	+	+		+	?	?	
6. Posttest-Only Control Group Design *R X O* *R O*	+	+	+	+	+	+	+	+		+	?	?	

Note: In the tables, a minus indicates a definite weakness, a plus indicates that the factor is controlled, a question mark indicates a possible source of concern, and a blank indicates that the factor is not relevant.

WOW!

TABLE 1

SOURCES OF INVALIDITY FOR DESIGNS 1 THROUGH 6

	Sources of Invalidity												
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Pre-Experimental Designs:												
1. One-Shot Case Study X O	−	−				−	−			−		
2. One-Group Pretest-Posttest Design O X O	−	−	−	−	?	+	+	−	−	−	?	
3. Static-Group Comparison X O --- O	+	?	+	+	+	−	−	−		−		
True Experimental Designs:												
4. Pretest-Posttest Control Group Design R O X O R O O	+	+	+	+	+	+	+	+	−	?	?	
5. Solomon Four-Group Design R O X O R O O R X O R O	+	+	+	+	+	+	+	+	+	?	?	
6. Posttest-Only Control Group Design R X O R O	+	+	+	+	+	+	+	+	+	?	?	

Note: In the tables, a minus indicates a definite weakness, a plus indicates that the factor is controlled, a question mark indicates a possible source of concern, and a blank indicates that the factor is not relevant.

It is with extreme reluctance that these summary tables are presented because they are apt to be "too helpful," and to be depended upon in place of the more complex and qualified presentation in the text. No + or − indicator should be respected unless the reader comprehends why it is placed there. In particular, it is against the spirit of this presentation to create uncomprehended fears of, or confidence in, specific designs.

7. Time Series

o o o o x o o o o

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and *X*	Interaction of Selection and *X*	Reactive Arrangements	Multiple-*X* Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	

Remember the really BAD design 2…

Design 2: One-Group Pretest-Posttest Design:

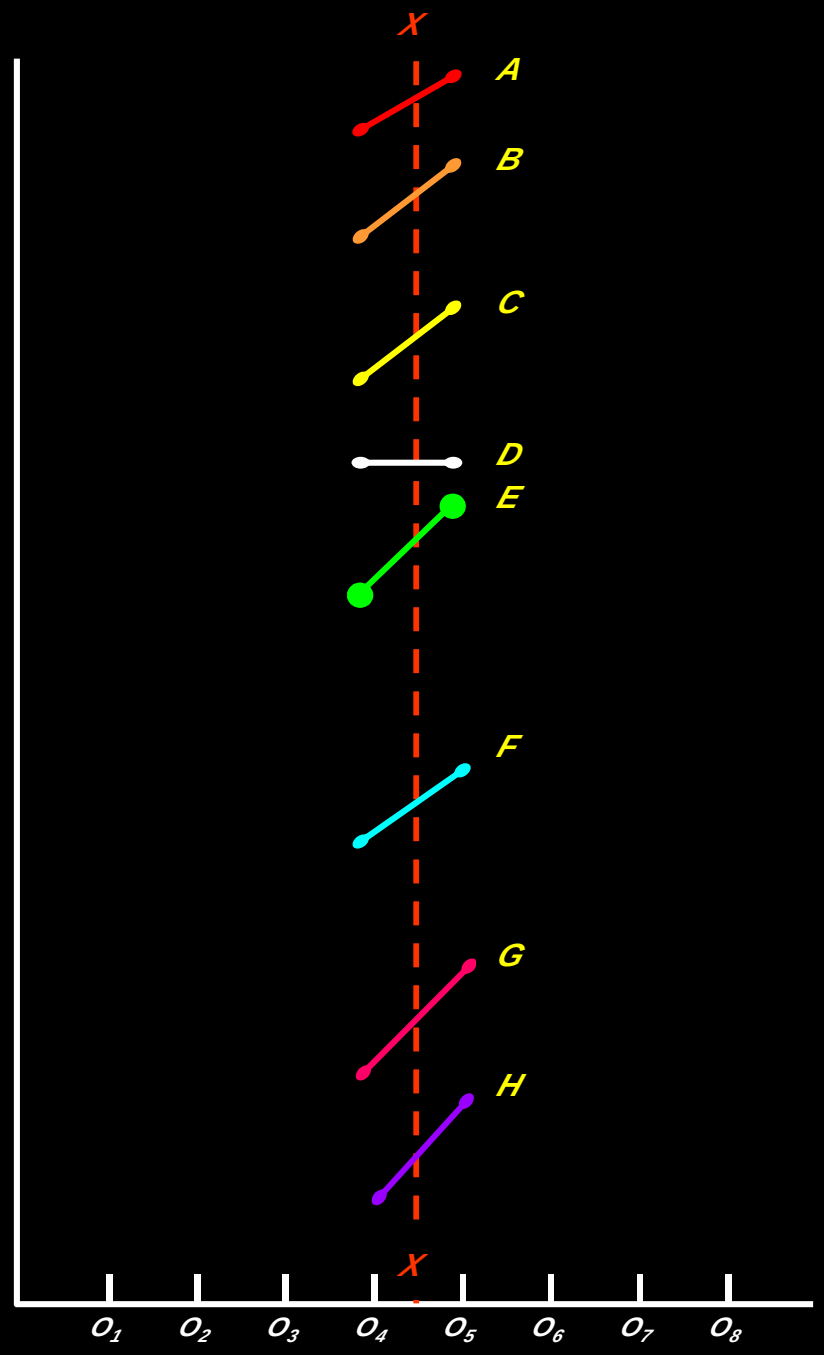
O X O

- If you take only the two points around the application of X you have design 2 applied to many different groups being tested for different Xs

Introduction of an experimental variable at point X into a time series of measurements, O_1 – O_8

Some possible outcome patterns

- Except for D , which is flat, the gain O_4 – O_5 is the same in all the time series



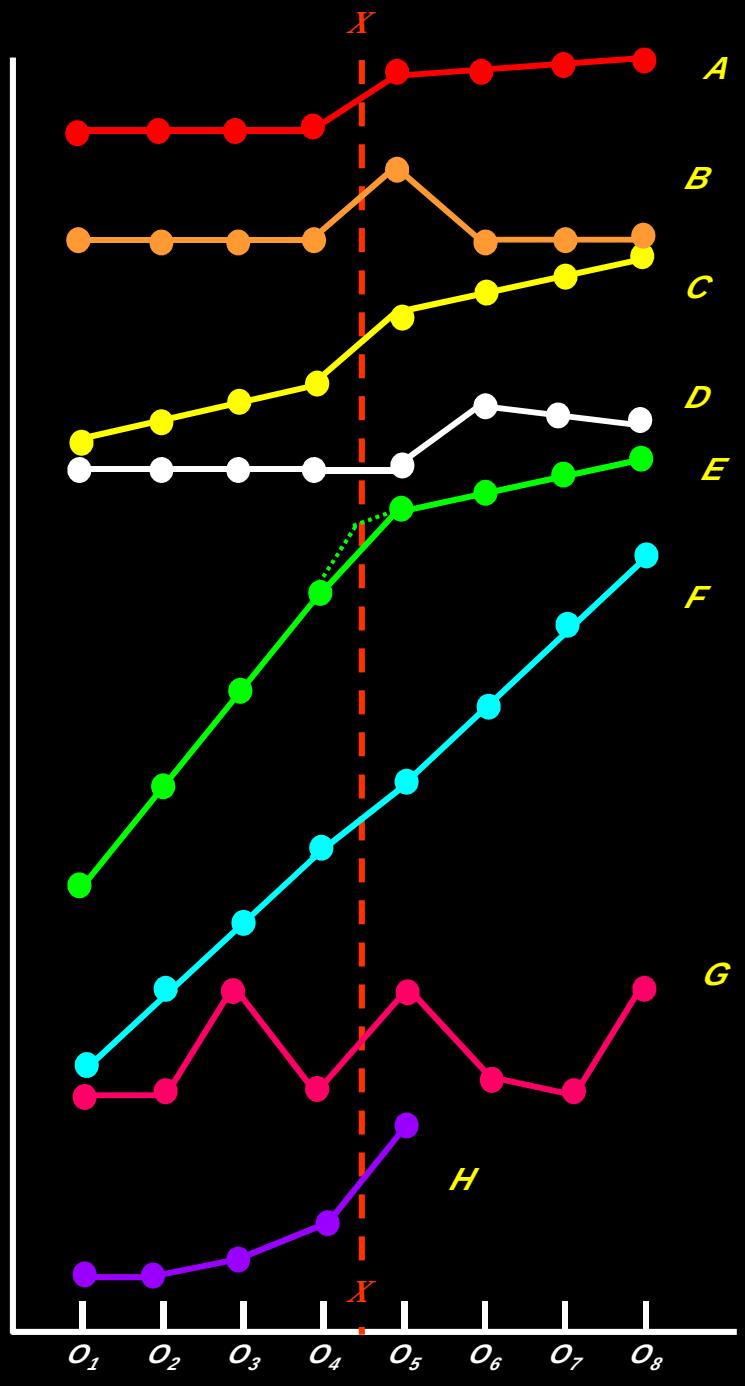
Source: Donald Campbell and Julian Stanley, *Experimental and quasi-experimental designs for Research*, Wadsworth Publishing; 1 edition (July 13, 1963)

Now lets give those two points some context:
Let’s add all the observations

Introduction of an experimental variable at point X into a time series of measurements, O_1 – O_8

Some possible outcome patterns

- Now Add Context:
- The legitimacy of inferring an effect varies widely:
  - Strongest in A and B
  - Possible in C, D and E
  - Totally unjustified in F, G and H.



Source: Donald Campbell and Julian Stanley, *Experimental and quasi-experimental designs for Research*, Wadsworth Publishing; 1 edition (July 13, 1963)

So

- Generally not very comforting design when we look at any one of the time series alone. Because of inability to control History (what other effects are affecting the group).
- Plus:
  - Absence of controls
  - Absence of generalizability

8. Equivalent Time Samples Design

X_1O X_0O X_1O X_0O, etc.

What is happening here…

- This is repeated testing and observation of a group
- The real test X_1 is introduced intermittently followed by an observation, with other (non) tests X_0 being introduced before other observations
- This can work if the effect of the X is transient
- **Example** telling students that “this is a test” and then doing it every week, but not telling them which ones of these tests will count for the final grade! Controls factors such as anxiety of respondents (students).

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity												
	Internal								External				
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and *X*	Interaction of Selection and *X*	Reactive Arrangements	Multiple-*X* Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design X_1O X_0O X_1O X_0O, etc.	+	+	+	+	+	+	+	+	−	?	−	−

9. Equivalent Materials Samples Design

M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.

9. Equivalent Materials Samples Design

M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.

This design changes some things in the materials used for the test itself in addition to the previous design which is interwoven with it. Internally valid, but again externally not valid

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity												
	Internal								External				
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design X_1O X_0O X_1O X_0O, etc.	+	+	+	+	+	+	+	+	−	?	−	−
9. Equivalent Materials Samples Design M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.	+	+	+	+	+	+	+	+	−	?	?	−

10. Nonequivalent Control Group Design

O X O

O O

Why would we use this design?

- Because you frequently cannot randomize, and have to use equivalent convenience samples, e.g. class rooms in schools or schools in a district, or production units in an institution and test all the people in that class, school or production unit.

- Accordingly, we cannot control interaction of selection and maturation etc.
- Again, external validity (i.e. generalizability) is questionable.

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design X_1O X_0O X_1O X_0O, etc.	+	+	+	+	+	+	+	+	−	?	−	−
9. Equivalent Materials Samples Design M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.	+	+	+	+	+	+	+	+	−	?	?	−
10. Nonequivalent Control Group Design $\frac{O \quad X \quad O}{O \qquad\qquad O}$	+	+	+	+	?	+	+	−	−	?	?	

11. Counterbalanced Designs

X_1O X_2O X_3O X_4O

X_2O X_4O X_1O X_3O

X_3O X_1O X_4O X_2O

X_4O X_3O X_2O X_1O

Why this complicated design?

- To enter each respondent (or respondent group) into each type of treatment once.
- The design is orthogonal (each combination of X_i and O_t occurs once).
- Good for multiple treatment testing.

- PS: the design is also called a Latin-square design.

Orthogonal:
you can change the columns and /or rows in the table(s)

	T_1	T_2	T_3O	T_4	X_1	X_2	X_3	X_4
A	X_1O	X_2O	X_3O	X_4O	T_1O	T_2O	T_3O	T_4O
B	X_2O	X_4O	X_1O	X_3O	T_2O	T_4O	T_1O	T_3O
C	X_3O	X_1O	X_4O	X_2O	T_3O	T_1O	T_4O	T_2O
D	X_4O	X_3O	X_2O	X_1O	T_4O	T_3O	T_2O	T_1O

Which of these medicines is most effective?

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity												
	Internal								External				
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design X_1O X_0O X_1O X_0O, etc.	+	+	+	+	+	+	+	+	−	?	−	−
9. Equivalent Materials Samples Design M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.	+	+	+	+	+	+	+	+	−	?	?	−
10. Nonequivalent Control Group Design *O X O* *O O*	+	+	+	+	?	+	+	−	−	?	?	
11. Counterbalanced Designs X_1O X_2O X_3O X_4O X_2O X_4O X_1O X_3O X_3O X_1O X_4O X_2O X_4O X_3O X_2O X_1O	+	+	+	+	+	+	+	?	?	?	?	−

12. Separate-Sample Pretest-Posttest Design

R O (X)

R X O

When to use this Design?

- When the X has to be administered to all, and we can control who gets it and who does not, but we want to test for its effect
- Thus we rely on the randomization to establish the representativity of the pre-test and the post-test.
- It is much stronger than Design 2 and should not be confused with it.

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design X_1O X_0O X_1O X_0O, etc.	+	+	+	+	+	+	+	+	−	?	−	−
9. Equivalent Materials Samples Design M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.	+	+	+	+	+	+	+	+	−	?	?	−
10. Nonequivalent Control Group Design *O X O* *O O*	+	+	+	+	?	+	+	−	−	?	?	
11. Counterbalanced Designs X_1O X_2O X_3O X_4O X_2O X_4O X_1O X_3O X_3O X_1O X_4O X_2O X_4O X_3O X_2O X_1O	+	+	+	+	+	+	+	?	?	?	?	−
12. Separate-Sample Pretest-Posttest Design *R O (X)* *R X O*	−	−	+	?	+	+	−	−	+	+	+	

12a. Separate-Sample Pretest-Posttest Design

R O (X)

R X O

R O (X)

R (X) O

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs:												
7. Time Series $O\ O\ O\ OXO\ O\ O\ O$	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design $X_1O\ X_0O\ X_1O\ X_0O$, etc.	+	+	+	+	+	+	+	+	−	?	−	−
9. Equivalent Materials Samples Design $M_aX_1O\ M_bX_0O\ M_cX_1O\ M_dX_0O$, etc.	+	+	+	+	+	+	+	+	−	?	?	−
10. Nonequivalent Control Group Design $O\ \ X\ \ O$ $O\ \ \ \ \ \ O$	+	+	+	+	?	+	+	−	−	?	?	
11. Counterbalanced Designs $X_1O\ X_2O\ X_3O\ X_4O$ $X_2O\ X_4O\ X_1O\ X_3O$ $X_3O\ X_1O\ X_4O\ X_2O$ $X_4O\ X_3O\ X_2O\ X_1O$	+	+	+	+	+	+	+	?	?	?	?	−
12. Separate-Sample Pretest-Posttest Design $R\ O\ (X)$ $R\ \ \ X\ O$	−	−	+	?	+	+	−	−	+	+	+	
12*a*. $R\ O\ (X)$ $R\ \ \ X\ O$ $R\ \ \ \ \ O\ (X)$ $R\ \ \ \ \ X\ O$	+	−	+	?	+	+	−	+	+	+	+	

12b. Separate-Sample Pretest-Posttest Design

R	O_1		(X)	
R		O_2	(X)	
R			X	O_3

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design X_1O X_0O X_1O X_0O, etc.	+	+	+	+	+	+	+	+	−	?	−	−
9. Equivalent Materials Samples Design M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.	+	+	+	+	+	+	+	+	−	?	?	−
10. Nonequivalent Control Group Design *O X O* *O O*	+	+	+	+	?	+	+	−	−	?	?	
11. Counterbalanced Designs X_1O X_2O X_3O X_4O X_2O X_4O X_1O X_3O X_3O X_1O X_4O X_2O X_4O X_3O X_2O X_1O	+	+	+	+	+	+	+	?	?	?	?	−
12. Separate-Sample Pretest-Posttest Design *R O (X)* *R X O*	−	−	+	?	+	+	−	−	+	+	+	
12*a*. *R O (X)* *R X O* *R O (X)* *R X O*	+	−	+	?	+	+	−	+	+	+	+	
12*b*. *R* O_1 (X) *R* O_2 (X) *R X* O_3	−	+	+	?	+	+	−	?	+	+	+	

12c. Separate-Sample Pretest-Posttest Design

R	O_1	X	O_2
R		X	O_3

TABLE 2

SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 7 THROUGH 12

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs:												
7. Time Series *O O O OXO O O O*	−	+	+	?	+	+	+	+	−	?	?	
8. Equivalent Time Samples Design X_1O X_0O X_1O X_0O, etc.	+	+	+	+	+	+	+	+	−	?	−	−
9. Equivalent Materials Samples Design M_aX_1O M_bX_0O M_cX_1O M_dX_0O, etc.	+	+	+	+	+	+	+	+	−	?	?	−
10. Nonequivalent Control Group Design *O X O* *O O*	+	+	+	+	?	+	+	−	−	?	?	
11. Counterbalanced Designs X_1O X_2O X_3O X_4O X_2O X_4O X_1O X_3O X_3O X_1O X_4O X_2O X_4O X_3O X_2O X_1O	+	+	+	+	+	+	+	?	?	?	?	−
12. Separate-Sample Pretest-Posttest Design *R O (X)* *R X O*	−	−	+	?	+	+	−	−	+	+	+	
12*a*. *R O (X)* *R X O* *R O (X)* *R X O*	+	−	+	?	+	+	−	+	+	+	+	
12*b*. *R* O_1 (X) *R* O_2 (X) *R X* O_3	−	+	+	?	+	+	−	?	+	+	+	
12*c*. *R* O_1 *X* O_2 *R X* O_3	−	−	+	?	+	+	+	−	+	+	+	

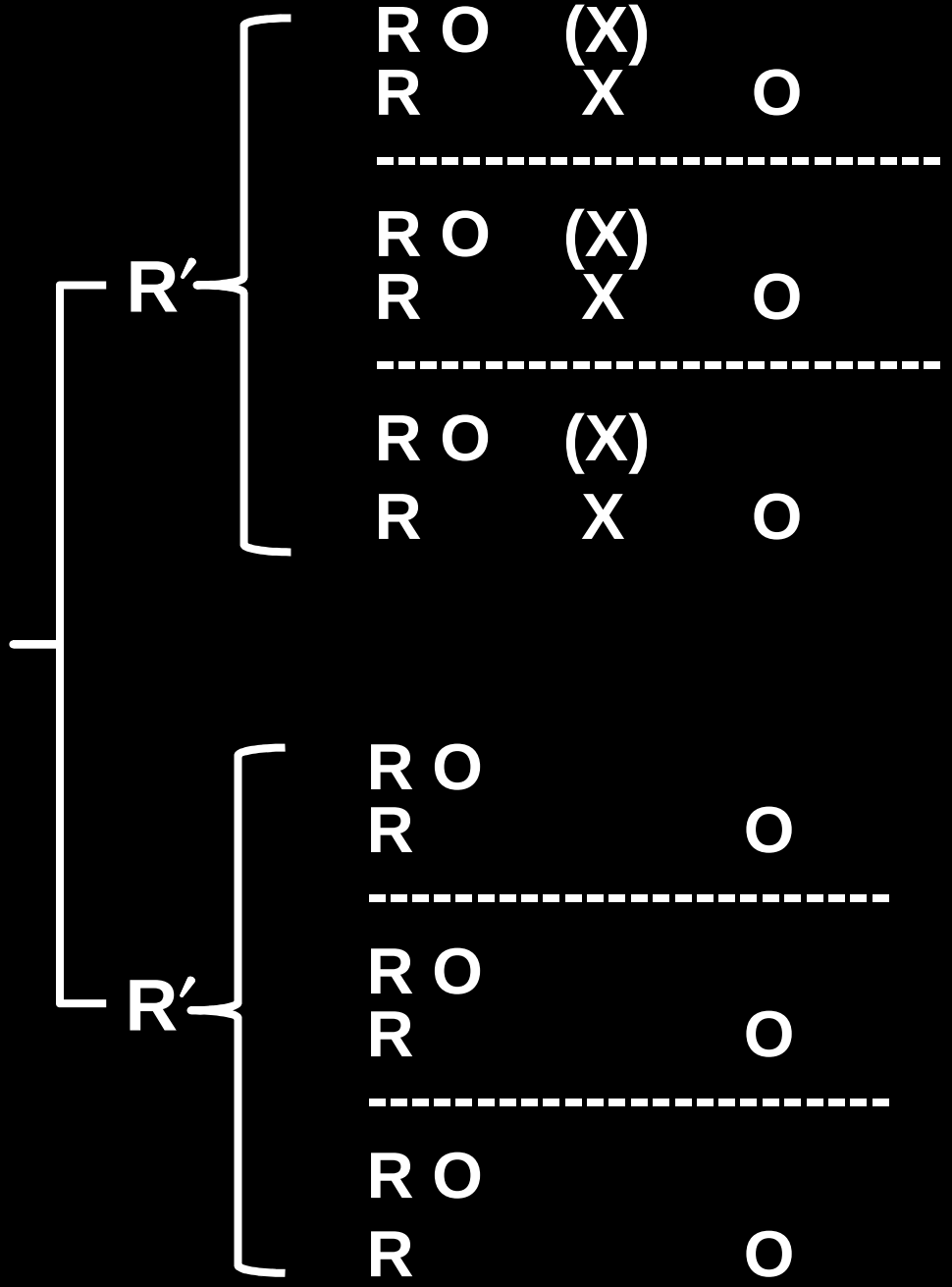
13. Separate-Sample Pretest-Posttest Control Group Design

```
R    O    (X)
R          X    O
-------------------------
R    O
R               O
```

If we can add a control group where X is not given, then we can transform design 12 to Design 13.

TABLE 3
SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 13 THROUGH 16

	Sources of Invalidity												
	Internal								External				
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs Continued:												
13. Separate-Sample Pretest-Posttest Control Group Design R O (X) R X O --- R O R O	+	+	+	+	+	+	+	−	+	+	+	



13a. Separate-Sample Pretest-Posttest Control Group Design

TABLE 3
SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 13 THROUGH 16

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs Continued:												
13. Separate-Sample Pretest-Posttest Control Group Design R O (X) X O R O R O	+	+	+	+	+	+	+	−	+	+	+	
13a. R O (X) X O R O R′ R O (X) X O R O (X) X O R O R O R′ R O R O R O	+	+	+	+	+	+	+	+	+	+	+	

14. Multiple Time-Series

o o o x o o o

---

o o o o o o

TABLE 3
SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 13 THROUGH 16

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs Continued:												
13. Separate-Sample Pretest-Posttest Control Group Design R O (X) O R X O --- R O R O	+	+	+	+	+	+	+	−	+	+	+	
13a. R O (X) O R X O --- R′ { R O (X) O R X O --- R O (X) R X O --- R O R O --- R′ { R O R O --- R O R O	+	+	+	+	+	+	+	+	+	+	+	
14. Multiple Time-Series O O O X O O O --- O O O O O O	+	+	+	+	+	+	+	+	−	−	?	

15. Institutional Cycle Design

Class A	X	O_1			
Class B_1	R	O_2	X	O_3	
Class B_2	R		X	O_4	
Class C				O_5	X

$O_2 < O_1$

$O_5 < O_4$

$O_2 < O_3$

$O_2 < O_4$

$O_6 = O_7$

$O_{2y} = O_{2o}$

A complicated patch-up ex-post design.
Let’s just ignore it for now.

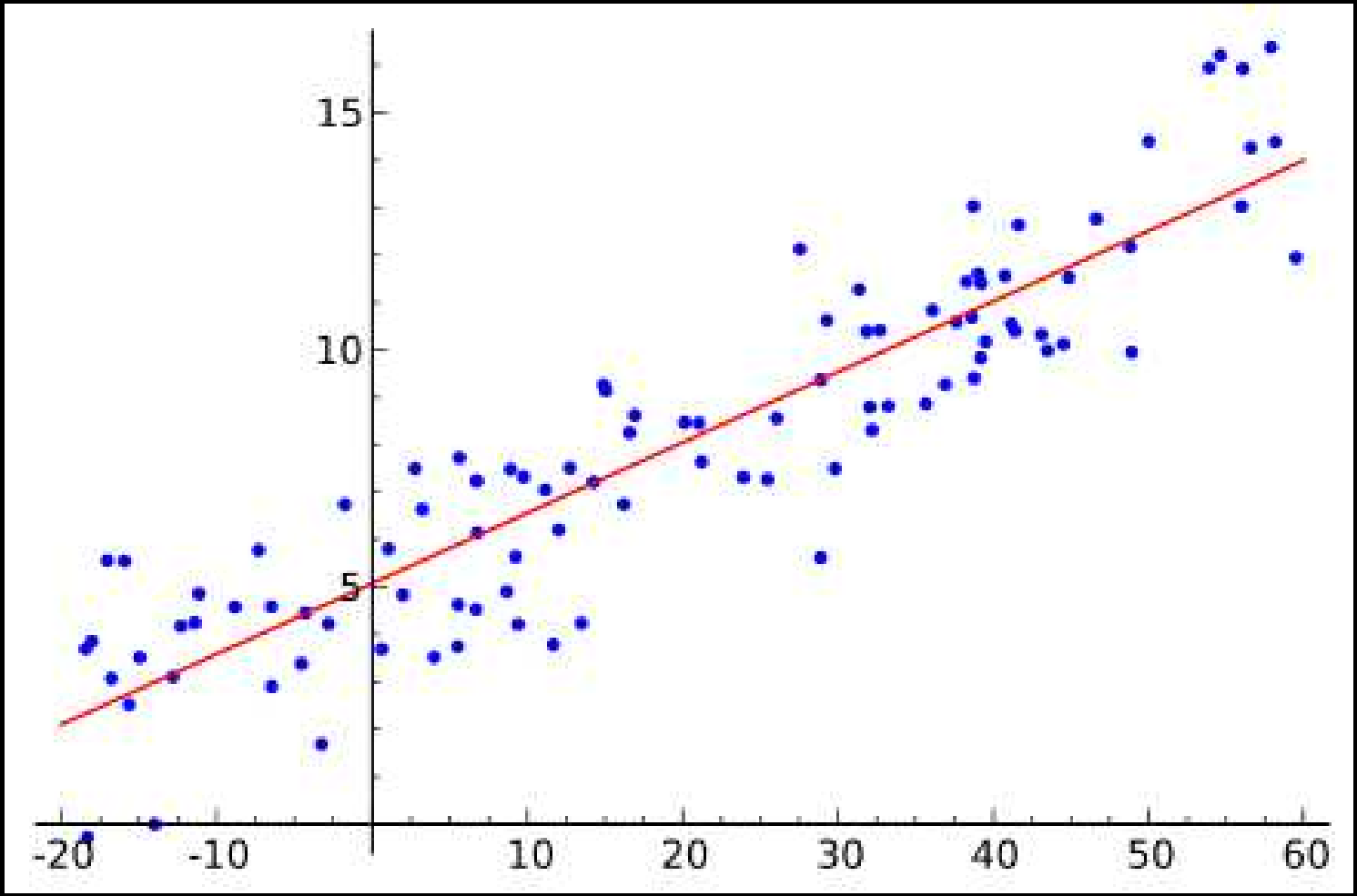
TABLE 3
SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 13 THROUGH 16

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs Continued:												
13. Separate-Sample Pretest-Posttest Control Group Design R O (X) X O R O R O	+	+	+	+	+	+	+	−	+	+	+	
13a. R O (X) X O R O (X) X O R O (X) X O R O R O R O R O R O	+	+	+	+	+	+	+	+	+	+	+	
14. Multiple Time-Series O O O X O O O O O O O O O O	+	+	+	+	+	+	+	+	−	−	?	
15. Institutional Cycle Design Class A X O_1 Class B_1 R O_2 X O_3 Class B_2 R X O_4 Class C O_5 X [a]Gen. Pop. Con. Cl. B O_6 [a]Gen. Pop. Con. Cl. C O_7												
$O_2 < O_1$ $O_5 < O_4$	+	−	+	+	?	−	?		+	?	+	
$O_2 < O_3$	−	−	−	?	?	+	+		−	?	+	
$O_2 < O_4$	−	−	+	?	?	+	?		+	?	?	
$O_6 = O_7$ $O_{2y} = O_{2o}$		+						−				

16. Regression

- It is used when experimental studies are impossible and only pre-existing data are available, (usually the case in economics).
- It relates independent variable(s) to a dependent variable and usually assumes causation by the independent variable(s).
- Regression analysis is widely used for prediction and forecasting, and fits in our discussion under quantitative models rather than here.

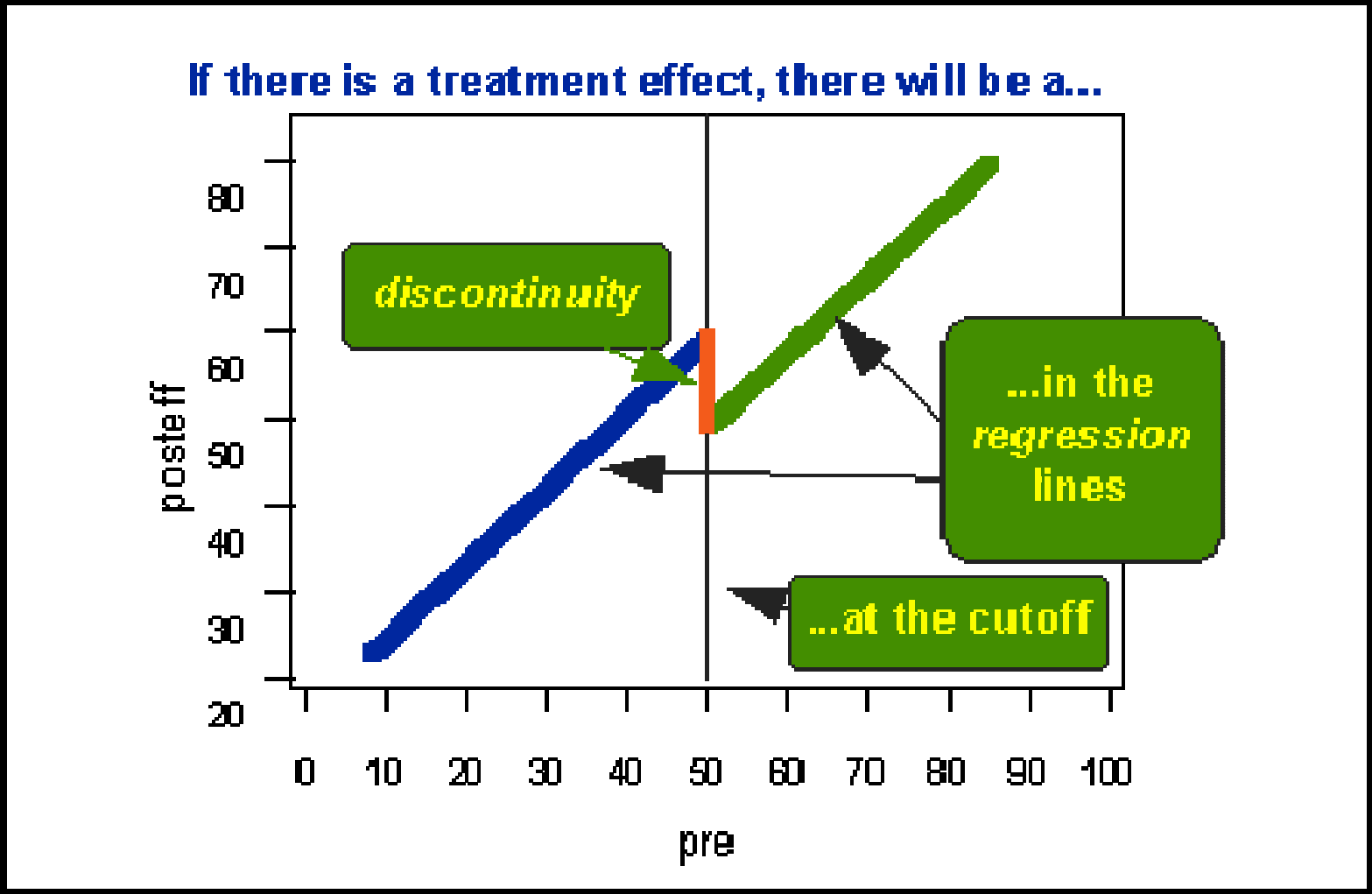
Typical linear regression



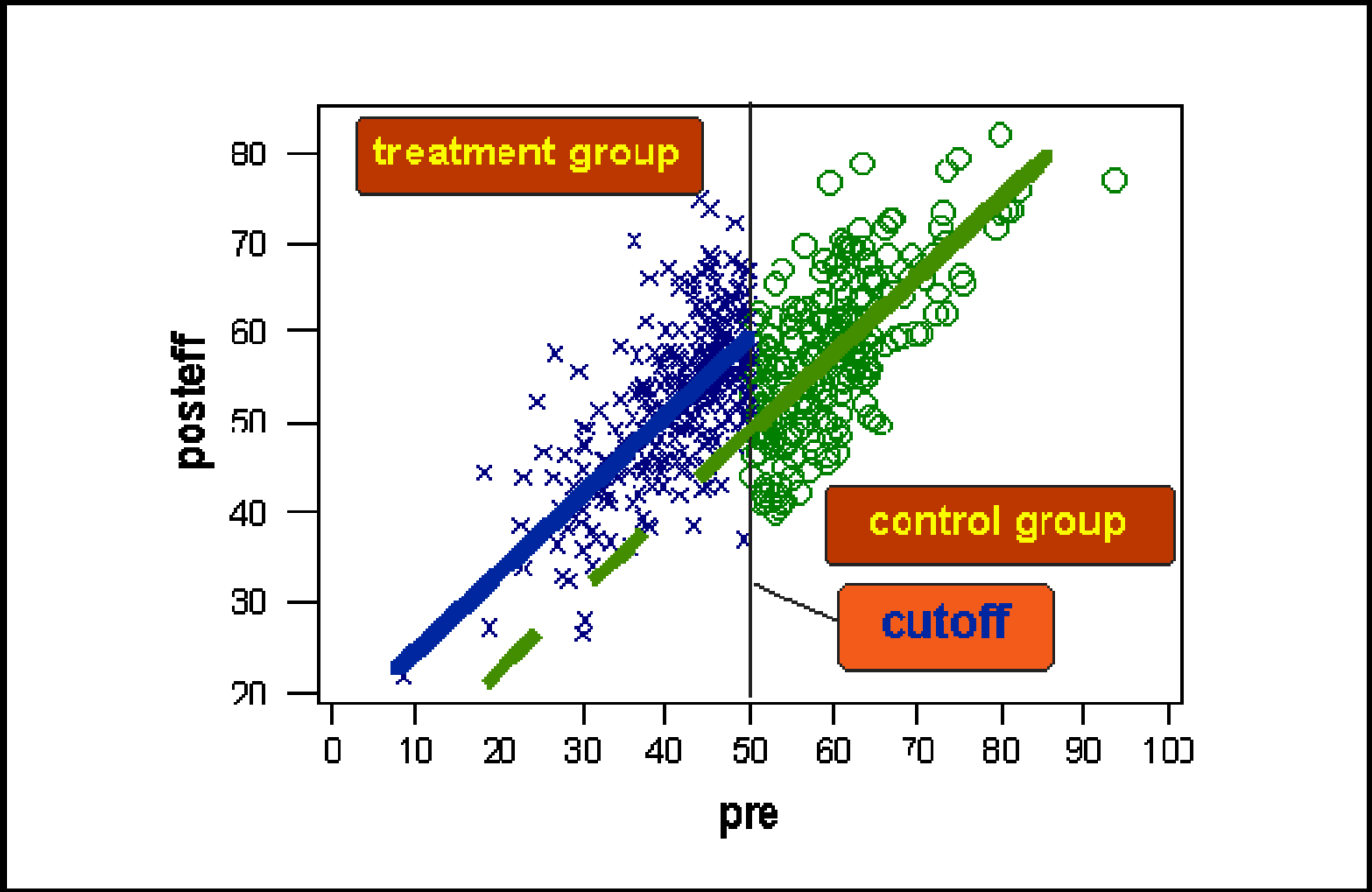
There are many types of regression analysis, e.g.:

- Linear regression
- Simple regression
- Ordinary least squares
- Polynomial regression
- General linear model
- Discrete choice
- Logistic regression
- Logit
- Multinomial logit
- Mixed logit
- Probit
- Multinomial probit
- Ordered logit or probit
- Poisson
- Multilevel model
- Fixed effects
- Random effects
- Mixed model
- Nonlinear regression
- Nonparametric
- Semiparametric

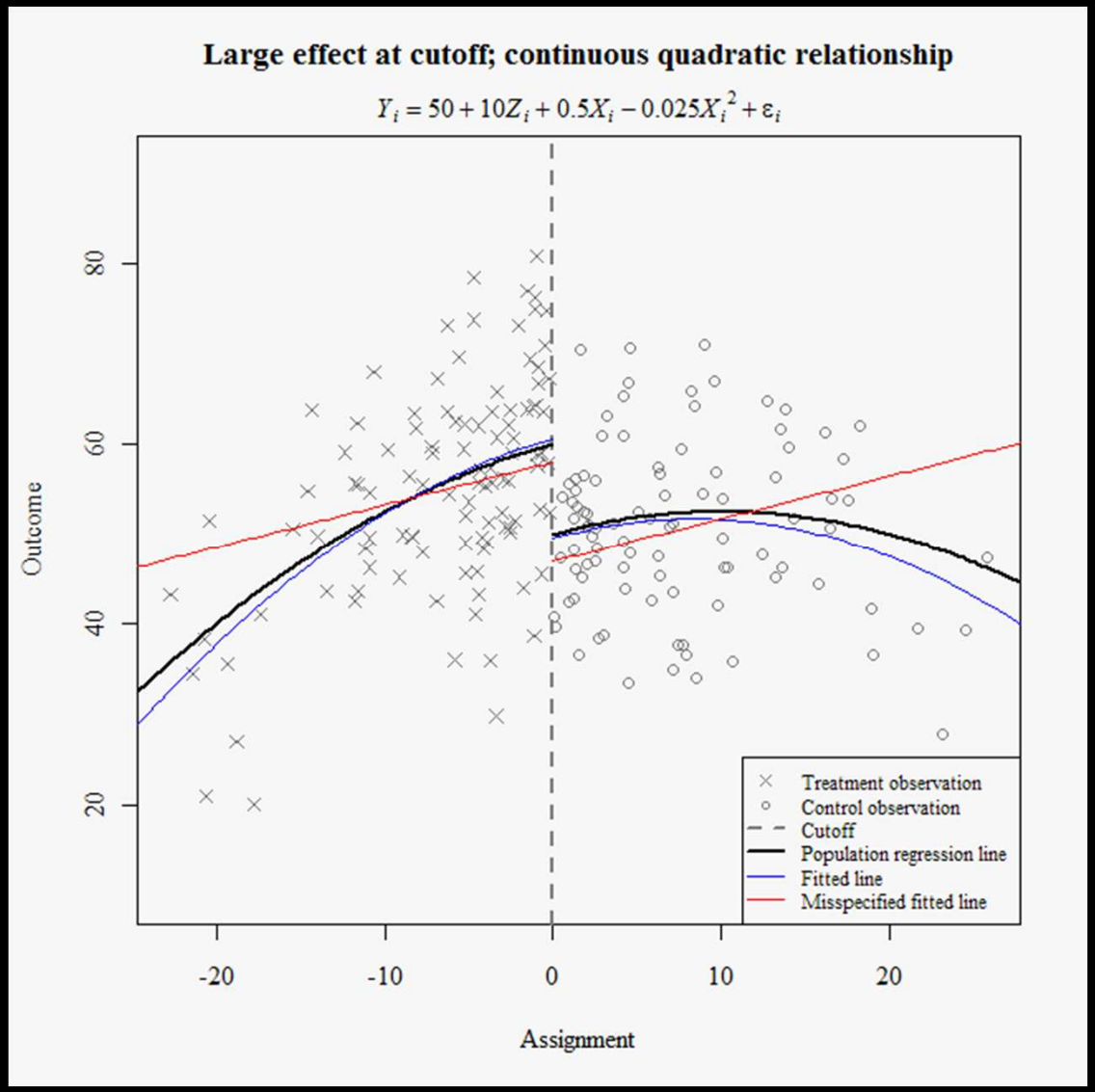
But in this section we are concerned with Regression Discontinuity Design



Linear Discontinuities



Linear Discontinuities



NON- Linear Discontinuities

Let’s take an example

Scholarship example using Regression Discontinuity Design (RDD) - Problem

- **Problem:**
  - Students who get high marks get scholarships
  - They would continue to get high marks even if they did not get the scholarship
  - How can I find out the effect of the scholarship?

Scholarship example using Regression Discontinuity Design (RDD) - Answer

- **Answer:**
  - say all students above 80% - are given the scholarship
  - Compare the performance over time of students scoring around the 80% cut-off: The intuition here is that a student scoring 79% is likely to be very similar to a student scoring 81%
  - However, one student will receive the scholarship while the other will not.
  - Comparing the pre and post award performance of the two will give the local treatment effect.

TABLE 3
SOURCES OF INVALIDITY FOR QUASI-EXPERIMENTAL DESIGNS 13 THROUGH 16

	Sources of Invalidity											
	Internal								External			
	History	Maturation	Testing	Instrumentation	Regression	Selection	Mortality	Interaction of Selection and Maturation, etc.	Interaction of Testing and X	Interaction of Selection and X	Reactive Arrangements	Multiple-X Interference
Quasi-Experimental Designs Continued:												
13. Separate-Sample Pretest-Posttest Control Group Design R O (X) X O R O R O	+	+	+	+	+	+	+	−	+	+	+	
13a. R O (X) X O R O (X) X O R O (X) X O R O R O R O R O R O	+	+	+	+	+	+	+	+	+	+	+	
14. Multiple Time-Series O O O X O O O O O O O O O O	+	+	+	+	+	+	+	+	−	−	?	
15. Institutional Cycle Design Class A X O_1 Class B_1 R O_2 X O_3 Class B_2 R X O_4 Class C O_5 X [a]Gen. Pop. Con. Cl. B O_6 [a]Gen. Pop. Con. Cl. C O_7												
$O_2 < O_1$ $O_5 < O_4$	+	−	+	+	?	−	?		+	?	+	
$O_2 < O_3$	−	−	−	?	?	+	+		−	?	+	
$O_2 < O_4$	−	−	+	?	?	+	?		+	?	?	
$O_6 = O_7$ $O_{2y} = O_{2o}$		+						−				
16. Regression Discontinuity	+	+	+	?	+	+	?	+	+	−	+	+

Conclusion:

There is no perfect design, you must choose the most appropriate for the study you are undertaking.

Sometimes, detailed and very thoughtful follow up studies are required to find subtle and unsuspected relationships and explanations – As we shall see in the following case study.

Important Case Study: Hormones and Heart Attacks

A famous Case Study:
Hormone Replacement Therapy (HRT) and Heart Attacks in Women

Hormone Therapy and Heart Attacks

- In a widely studied example, numerous epidemiological studies showed that women who were taking combined hormone replacement therapy (HRT) also had a lower-than-average incidence of coronary heart disease (CHD), leading doctors to propose that **HRT was protective against CHD**.

Source: Lawlor DA, Davey Smith G, Ebrahim S (June 2004). "Commentary: the hormone replacement-coronary heart disease conundrum: is this the death of observational epidemiology?". Int J Epidemiol 33 (3): 464–7. doi:10.1093/ije/dyh124. PMID 15166201.

So, Should I take HRT as a preventative against Heart Attacks?

BUT….

Hormone Therapy and Heart Attacks

- But randomized controlled trials showed that HRT caused a small but statistically significant increase in risk of CHD.
- So: How come?

Source: Lawlor DA, Davey Smith G, Ebrahim S (June 2004). "Commentary: the hormone replacement-coronary heart disease conundrum: is this the death of observational epidemiology?". Int J Epidemiol 33 (3): 464–7. doi:10.1093/ije/dyh124. PMID 15166201.

Hormone Therapy and Heart Attacks

- Re-analysis of the data from the epidemiological studies showed that women undertaking HRT were more likely to be from higher socio-economic groups.
- These wealthier women also had better than average diet and exercise regimens.
- The use of HRT and decreased incidence of coronary heart disease were coincident effects of a third and separate cause (i.e. the benefits associated with a higher socioeconomic status).
- They were not cause and effect, as had been supposed.

Source: Lawlor DA, Davey Smith G, Ebrahim S (June 2004). "Commentary: the hormone replacement-coronary heart disease conundrum: is this the death of observational epidemiology?". Int J Epidemiol 33 (3): 464–7. doi:10.1093/ije/dyh124. PMID 15166201.

This is so important, let’s go over it one more time…

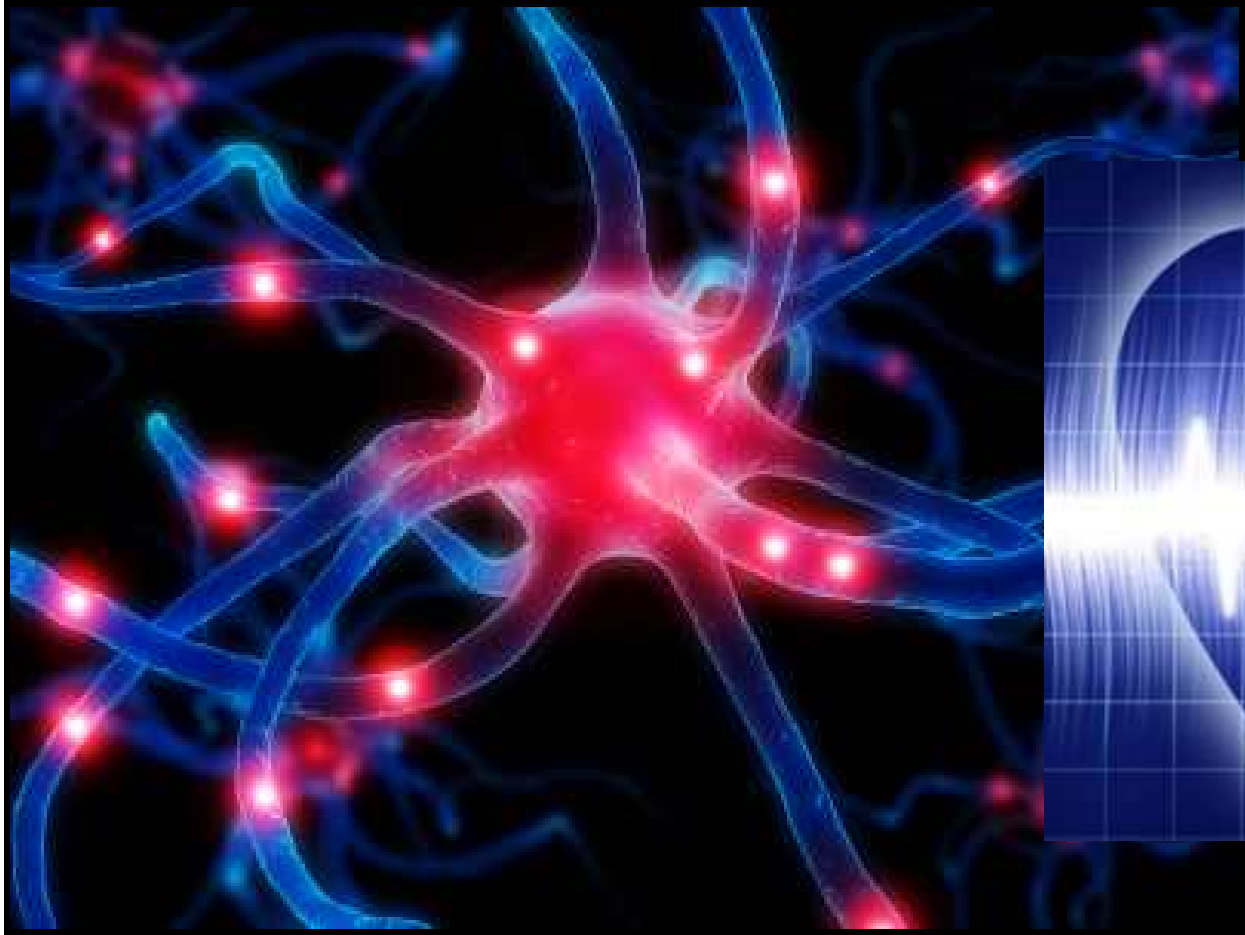
Hormone Replacement Therapy (HRT)

- After menopause or after surgery some women got HRT to replace the hormones their bodies were no longer producing.

Women who got HRT also had less heart attacks

Therefore HRT reduces incidence of Heart Attacks.

Actually The Opposite: HRT increases the risk of Heart Attacks



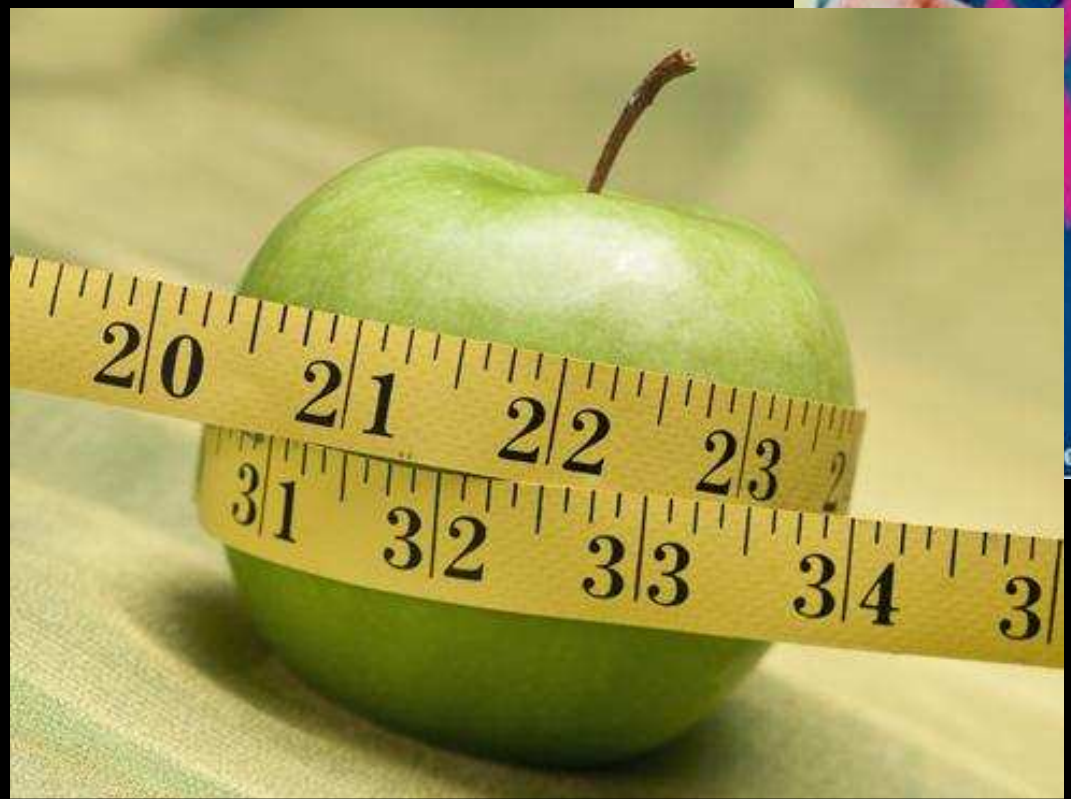
How come?

Women who got HRT tended to be wealthier

Wealthier women have better diet

Wealthier women exercise more

Diet and exercise tend to reduce incidence of heart attacks more than HRT raises it!



so...

The lesson of this important example:

- It is essential to be very careful in:
  - How you design your research,
  - How you collect the data
  - How you analyze the data and
  - How you draw your conclusions.

Now we are back to asking:

Are we sinking? Or Swimming?

I want you not just to swim!

Let’s all fly…

Fly Even Like Eagles

Soar like Eagles

Thank You