Cairo University
Faculty of Veterinary Medicine

Scientific Research Skills & Ethics (NDC 1000)

Experimental study Designs

Hisham Abdelrahman
Lecturer, Department of Veterinary Hygiene and Management

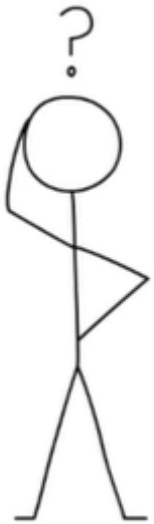
Hisham@auburn.edu

November 18th, 2019

Study

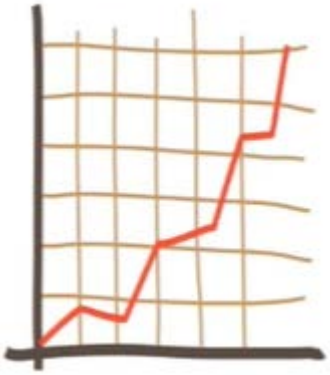
Is a scientific process of answering a question using data from a population

Study question

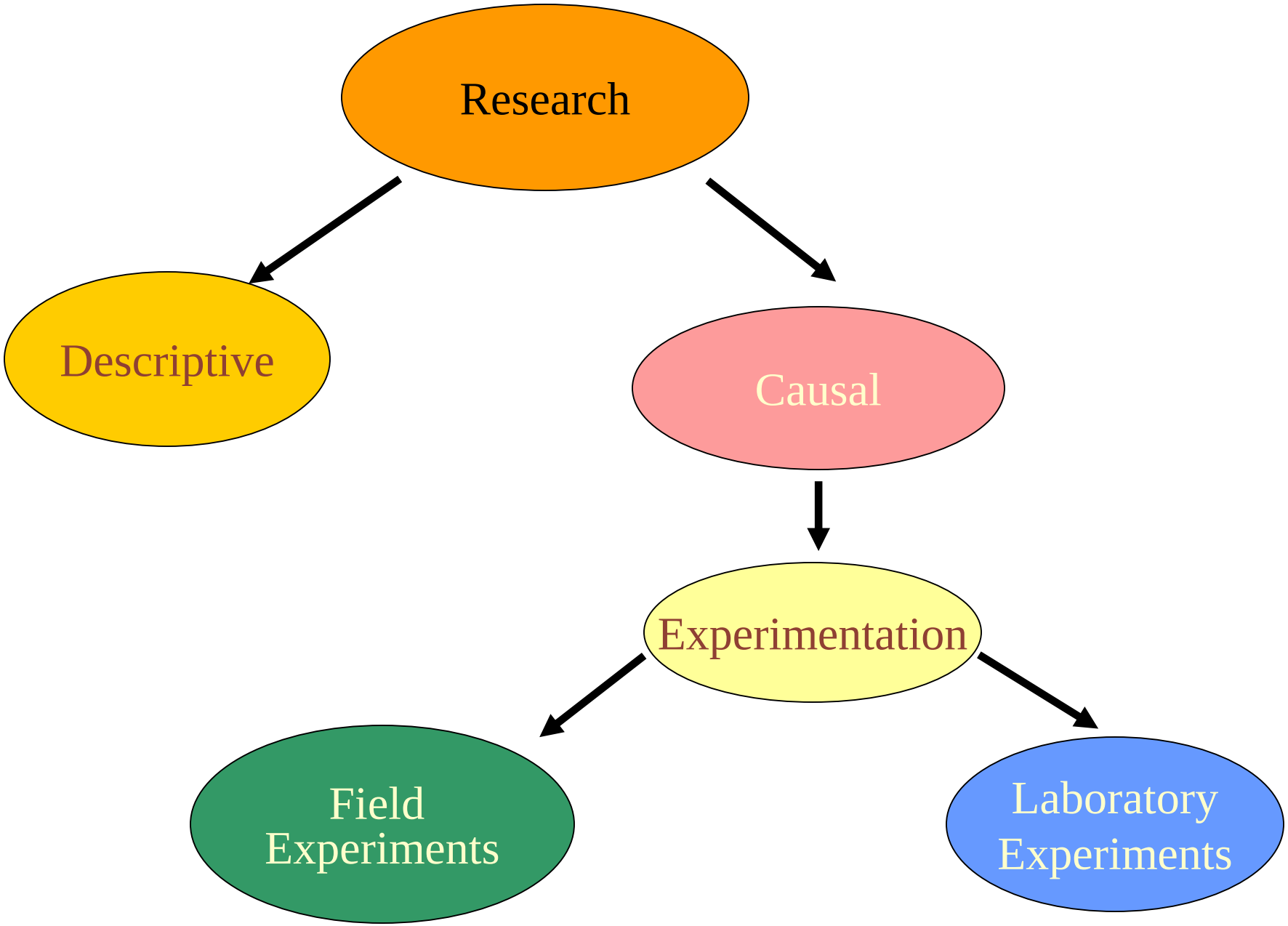


Select a study type

Collect and analyze data



Interpret and report results


Research
Descriptive
Causal
Experimentation
Field Experiments
Laboratory Experiments

What is an Experiment?

- Research method in which
  - conditions are controlled
  - so that 1 or more ***independent variables***
  - can be manipulated to test a hypothesis
  - about a ***dependent variable***.
- Allows
  - evaluation of causal relationships among variables
  - while all other variables are eliminated or controlled.

Some Definitions

- ***Dependent Variable***
  - Criterion by which the **results** of the experiment are judged.
  - Variable that is expected to be dependent on the manipulation of the independent variable
- ***Independent Variable***
  - Any variable that **can be manipulated**, or altered, independently of any other variable
  - Hypothesized to be the **causal influence**

More Definitions

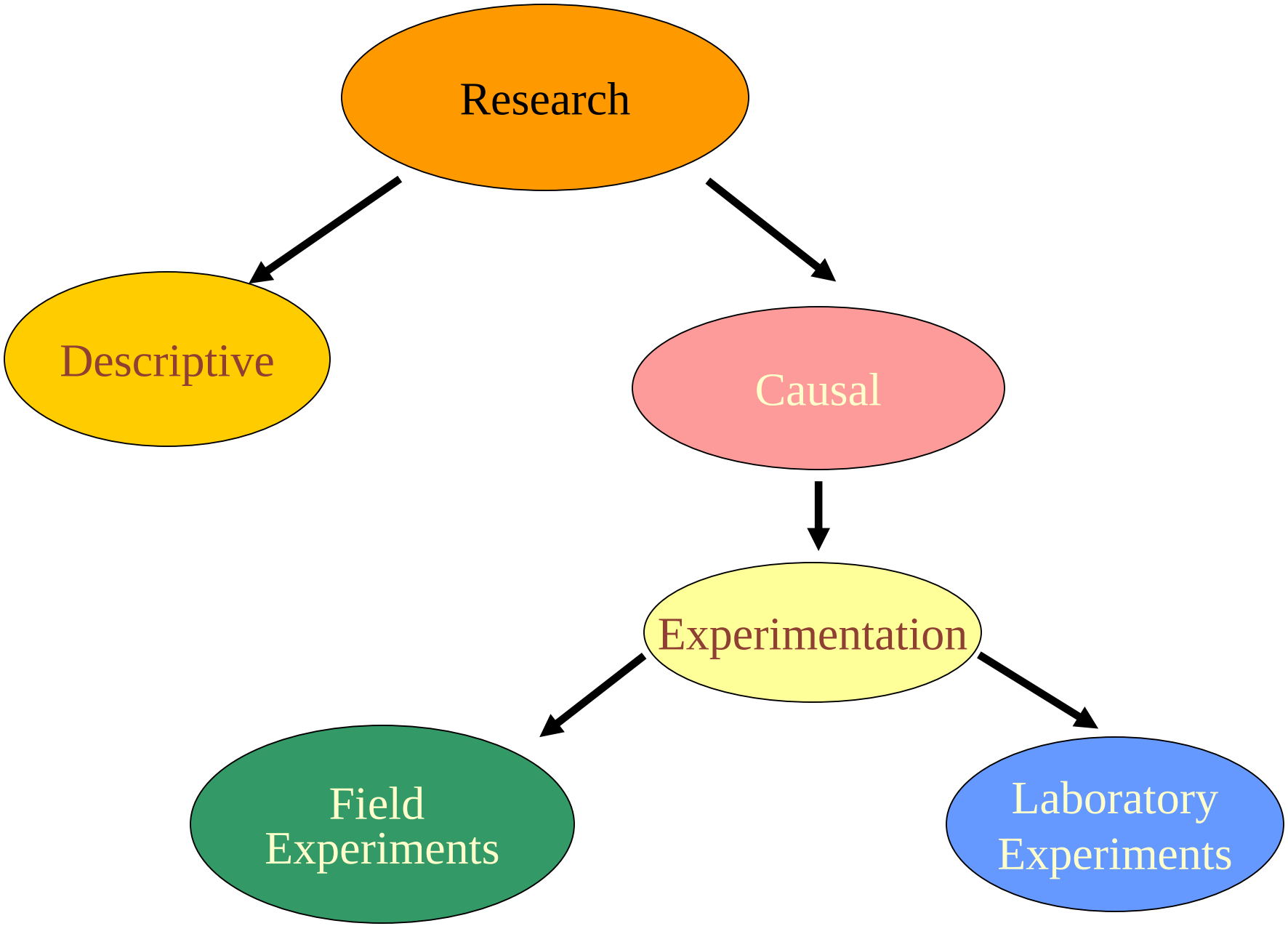
- ***Experimental Treatments***
  - **Alternative manipulations** of the independent variable being investigated
- ***Experimental Group***
  - Group of subjects exposed to the **experimental treatment**
- ***Control Group***
  - Group of subjects exposed to the **control condition**
  - Not exposed to the experimental treatment

More Definitions

- ***Test Unit***
  - Entity whose responses to experimental treatments are being observed or measured

- ***Internal Validity***
  - Indicates whether the independent variable was the sole cause of the change in the dependent variable

- ***External Validity***
  - Indicates the extent to which the results of the experiment are applicable to the real world


Research
Descriptive
Causal
Experimentation
Field Experiments
Laboratory Experiments

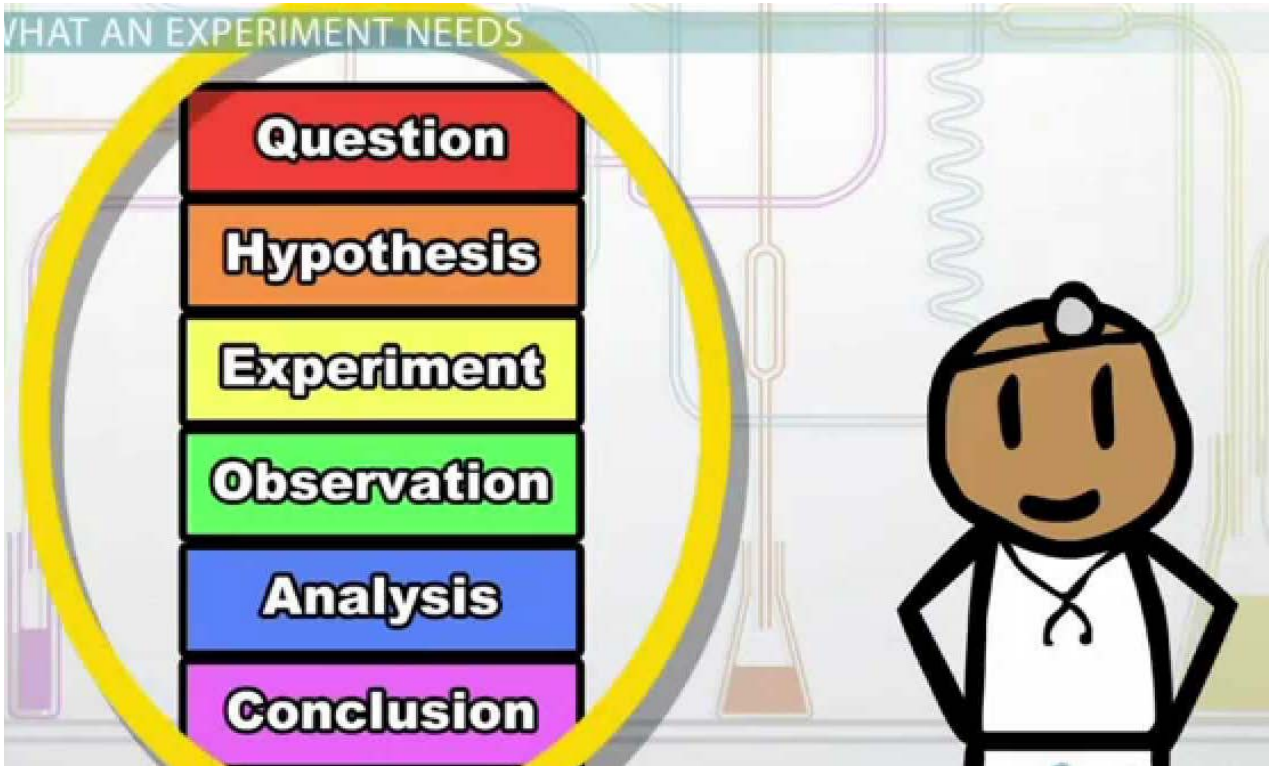
Laboratory Versus Field Experiments

FACTOR	LABORATORY	FIELD
Environment	Artificial	Realistic
Control	High	Low
Reactive error	High	Low
Demand artifacts	High	Low
Internal validity	High	Low
External validity	Low	High
Time	Short	Long
Number of units	Small	Large
Ease of implementation	High	Low
Cost	Low	High

What is Experimental Design?

❑ Experimental design **includes both**

- Strategies for organizing data collection
- Data analysis procedures ***matched*** to those data collection strategies



Why Do We Need Experimental Design?

We need experimental design to **control variability** so that treatment effects can be identified

We wouldn't need a science of experimental design if

- If all units (students, teachers, & schools) were identical

and

- If all units responded identically to treatments

1923 ➔ Fisher invented the basic principles of experimental design

1926 ➔ Fisher refined the theory of experimental design, introducing most other key concepts known today

Ronald Fisher
1890 - 1962

Principles of Experimental Design

Experimental design controls background variability so that systematic effects of treatments can be observed

Three basic principles

1. Control by **matching**
2. Control by **randomization**
3. Control by **statistical adjustment**

Their importance is in that order

Principles of Experimental Design

1- Control by Matching

- Elimination of **KNOWN** sources of variation by matching
  - ✓ **Eliminating genetic variation**
    (Compare animals from the same litter of mice
  - ✓ **Eliminating district or school effects**
    (Compare students within districts or schools)

- **BUT, matching is limited**
  - ✓ only to the possible **observable** characteristics
  - ✓ perfect matching is not always possible

Principles of Experimental Design

1- Control by Matching

Matching ensures that groups compared are **alike** on specific *known* *and* *observable* characteristics (everything we have thought of)

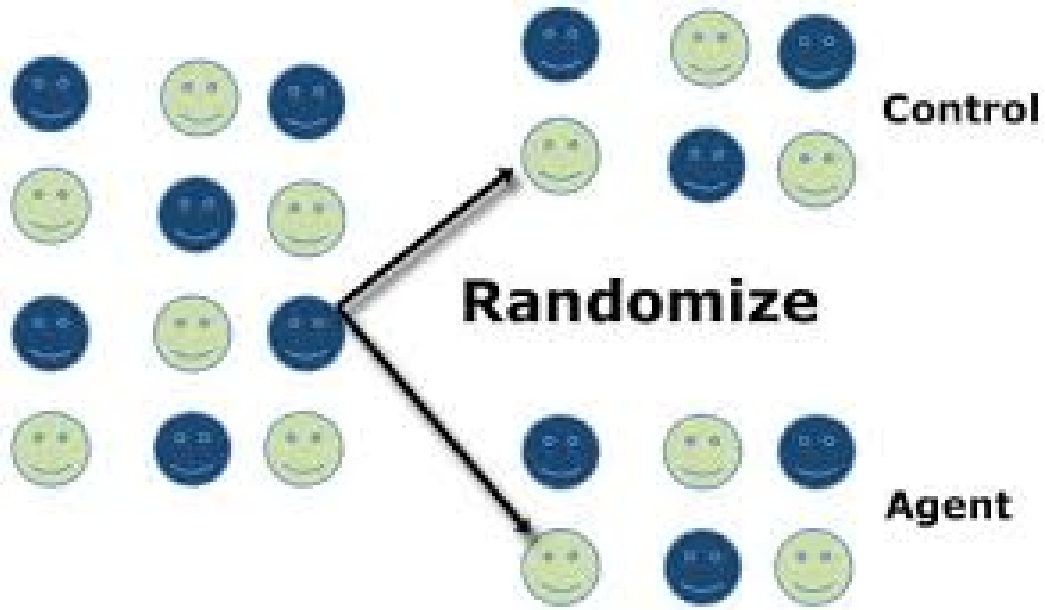
It will be great if there is a method of making groups alike on not only everything we have thought of, but **everything we didn't think of too**?

Principles of Experimental Design

2- Control by Randomization

- Randomization controls for the effects **all** (observable or non-observable, known or unknown) characteristics

- Randomization *makes groups equivalent* (on average) on all variables (known and unknown, observable or not)



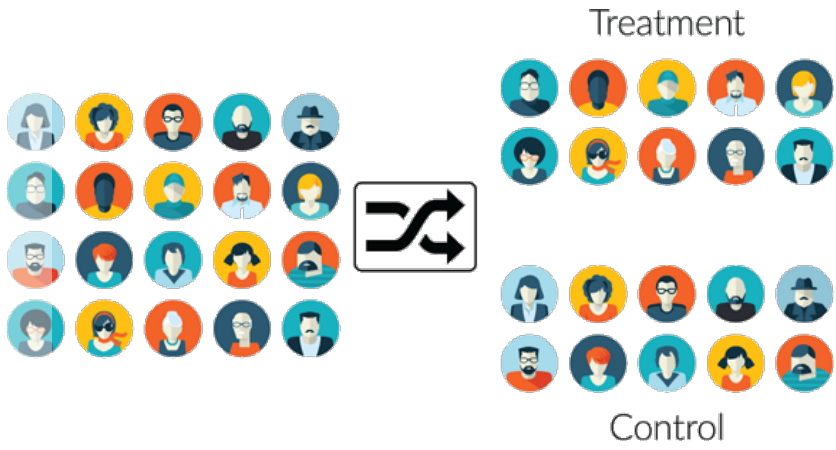
Principles of Experimental Design

2- Control by Randomization

- Random assignment is not assignment with no particular rule. It is a purposeful process

- It is a process which should ensure that each treatment will have an **equal chance** of being tested in any particular group/school

- Random assignment allows the assumption that the groups are identical with respect to all variables *except the experimental treatment*



Principles of Experimental Design

3- Control by Statistical Adjustment

- It uses statistical relations to simulate matching

- **Statistical control** is important for increasing precision
  (It will not control biases that may exist prior to assignment)

Using Principles of Experimental Design

- ✓ You must know a lot (be smart) to use matching and statistical control effectively

- ✓ You do not have to be smart to use randomization effectively

But

- ✓ Randomization is not as efficient as others (requires larger sample sizes)

Symbolism for Diagramming Experimental Designs

X = exposure of a group to an experimental treatment

O = observation or measurement of the dependent variable

If multiple observations or measurements are taken, subscripts indicate temporal order – I.e., O_1, O_2, etc.

R = random assignment of test units;

individuals selected as subjects for the experiment are randomly assigned to the experimental groups

RESEARCH DESIGNS

1) Pre-Experimental Designs

2) Experimental Designs

3) Completely Randomized Designs

4) Factorial designs

1) Pre-Experimental Designs

- Do not adequately control for the problems associated with loss of external or internal validity
- Cannot be classified as true experiments
- Often used in *exploratory research*

- **Three Examples of Pre-Experimental Designs**
  a. One-Shot Design
  b. One-Group Pretest-Posttest Design
  c. Static Group Design

1) Pre-Experimental Designs

a. One-Shot Design

= after-only design

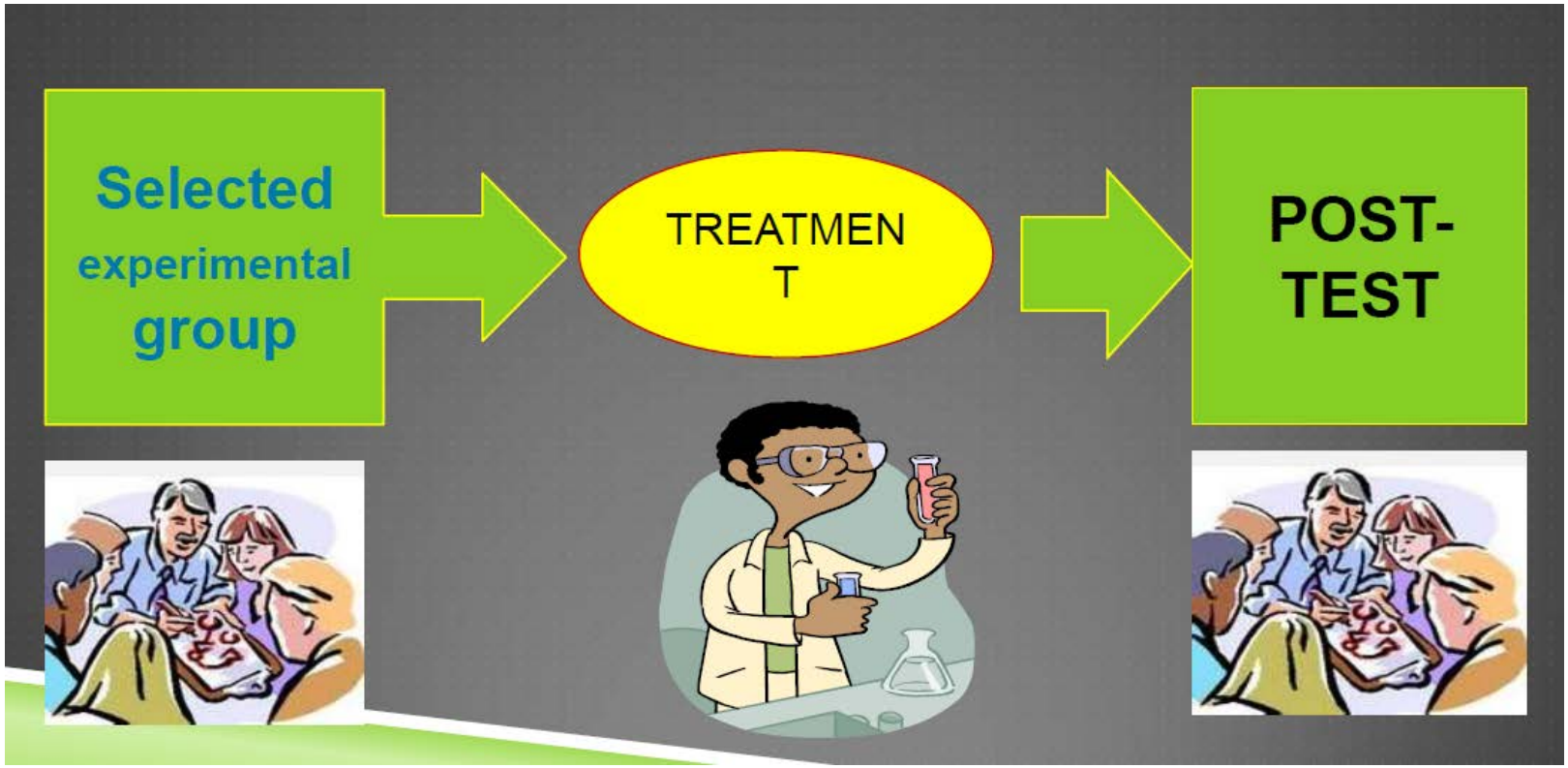
- A single measure is recorded after the treatment is administered
- Study lacks any comparison or control of extraneous influences
- No measure of test units not exposed to the experimental treatment
- No random assignment of subjects to the experimental group
- May be the only viable choice in taste tests

	treatment	**observation**
• Diagrammed as:	X	O_1

1) Pre-Experimental Designs

a. One-Shot Design

= after-only design

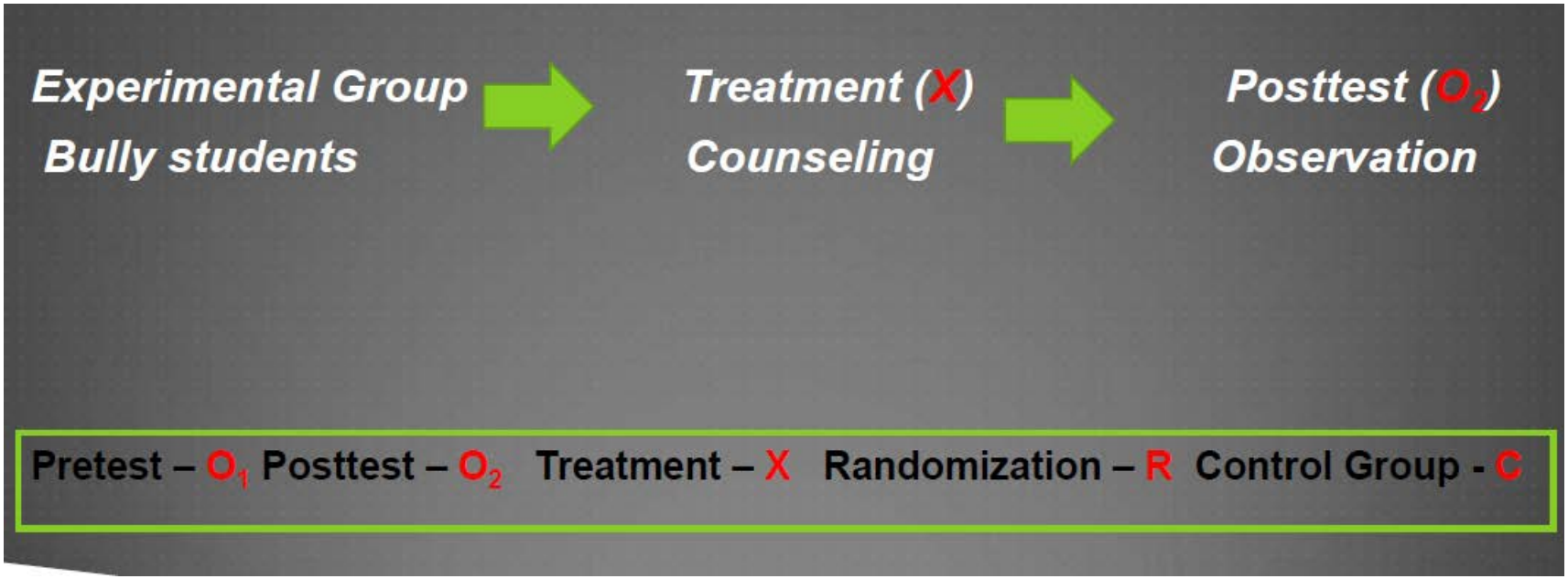


1) Pre-Experimental Designs

a. One-Shot Design

= after-only design

Example:
the effects of counseling sessions on the attitudes of identified bullies in school



1) Pre-Experimental Designs

b. One-Group Pretest-Posttest Design

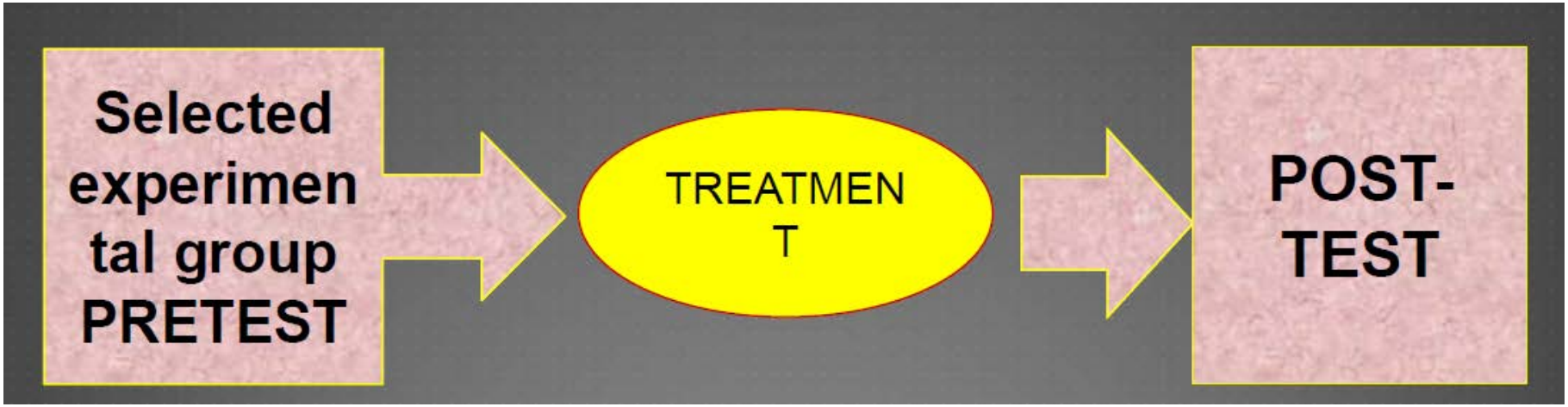
= Before and after design

- Subjects in the experimental group are measured before and after the treatment is administered.
- No control group
- Offers comparison of the same individuals before and after the treatment (e.g., training)
- If time between 1st & 2nd measurements is extended, may suffer *maturation*
- Can also suffer from history, mortality, and testing effects
- Diagrammed as O_1 X O_2

1) Pre-Experimental Designs

b. One-Group Pretest-Posttest Design

= Before and after design



1) Pre-Experimental Designs

b. One-Group Pretest-Posttest Design

= Before and after design

One way to examine Efficacy of a Drug:

O1	**X**	**O2**
Measure Patients' Condition (Pretest)	DRUG Experimental Condition/ intervention	→ Measure Patients' Condition (Posttest)

- **RESULT:** Significant Improvement from O1 to O2 (i.e., sig. O2 - O1 difference)
- **QUESTION:** Did X (the drug) cause the improvement?

1) Pre-Experimental Designs

b. One-Group Pretest-Posttest Design

= Before and after design

Example:

Testing the effectiveness of a DRUG A on capacity to recall words

Example:

You want to determine whether praising primary school children makes them do better in Mathematics

1) Pre-Experimental Designs

c. Static Group Design

= after-only design with control group

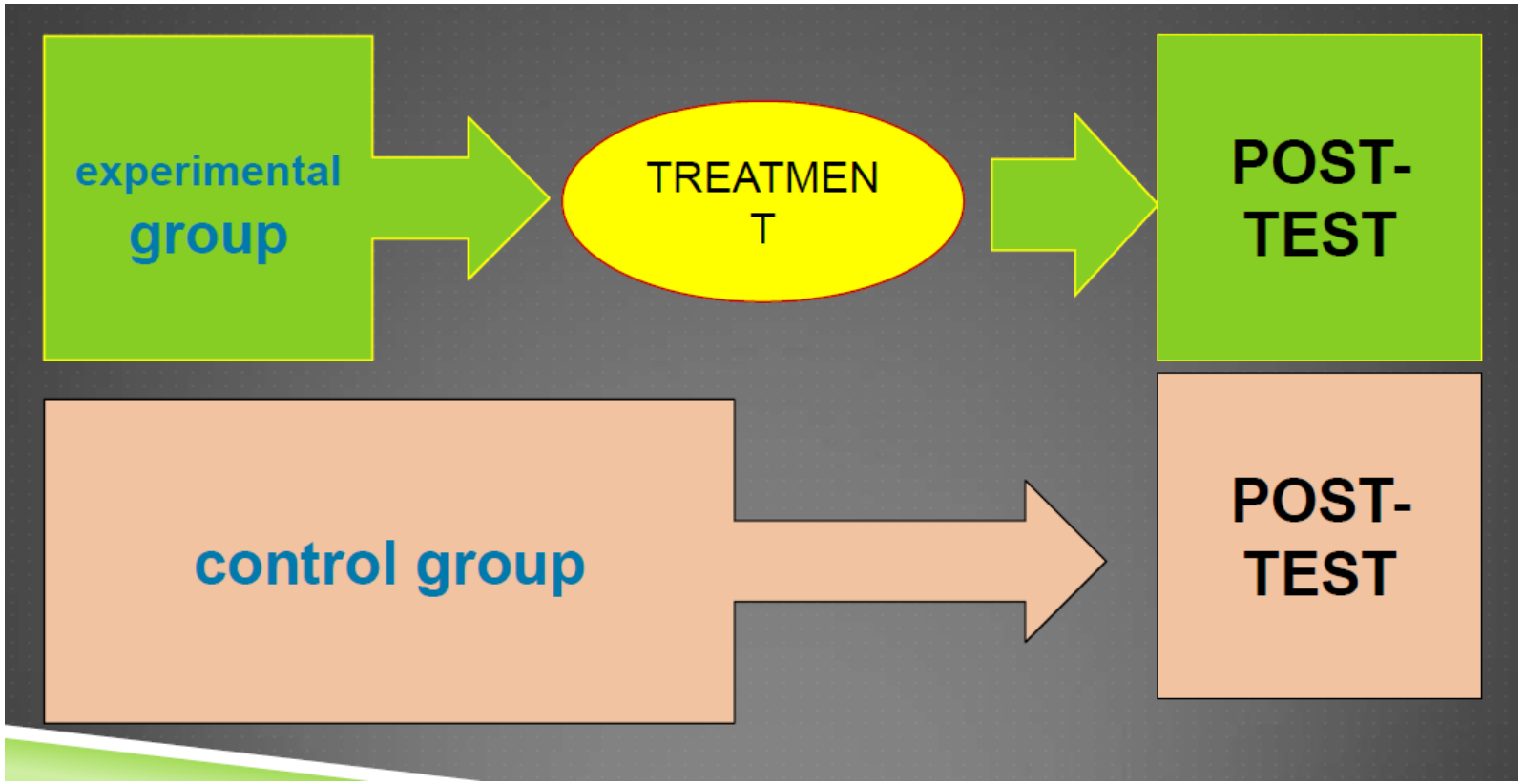
- Experimental group is measured after being exposed to the experimental treatment
- Control group is measured without having been exposed to the experimental treatment
- No pre-measure is taken
- Major weakness is lack of assurance that the groups were equal on variables of interest prior to the treatment
- Diagrammed as:

Experimental Group X	O_1
Control Group	O_2

1) Pre-Experimental Designs

c. Static Group Design

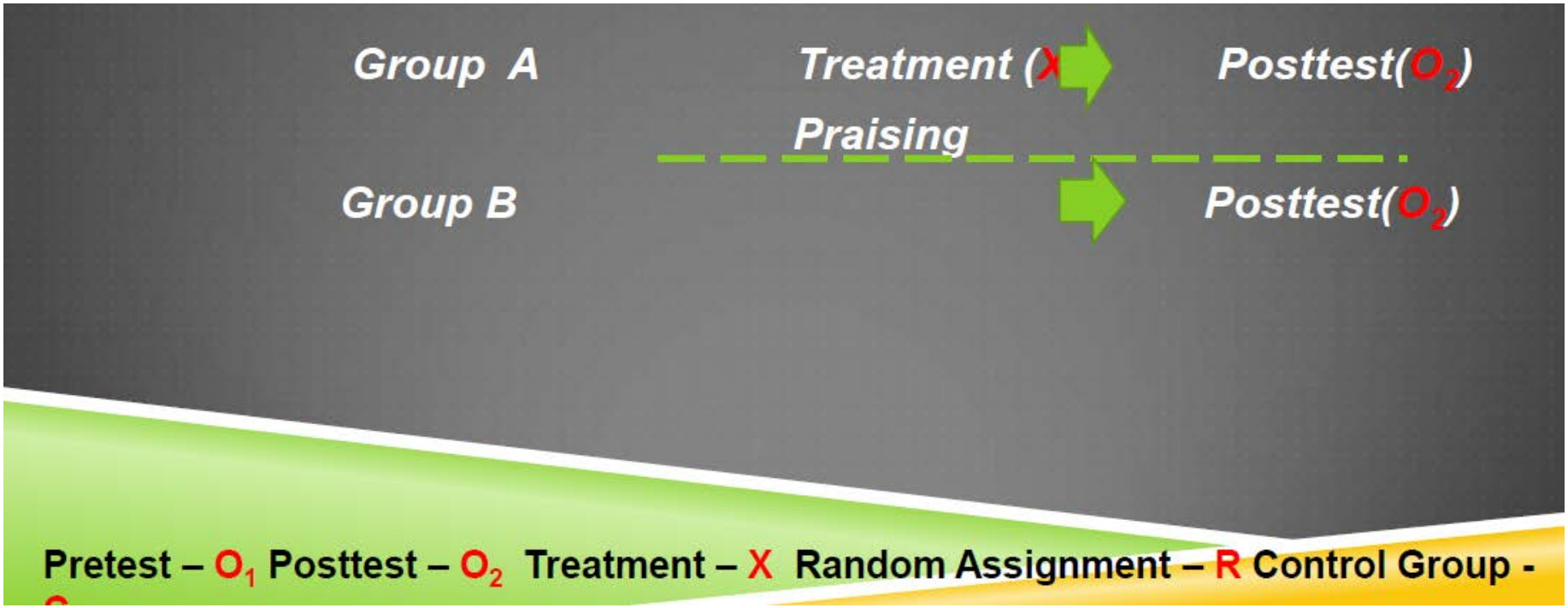
= after-only design with control group



1) Pre-Experimental Designs

c. Static Group Design

= after-only design with control group



2) Experimental Designs

Random assignment helps ensure that there is no pre-existing condition that will influence the variables and mess up the results.

a. Posttest only Control Group Design

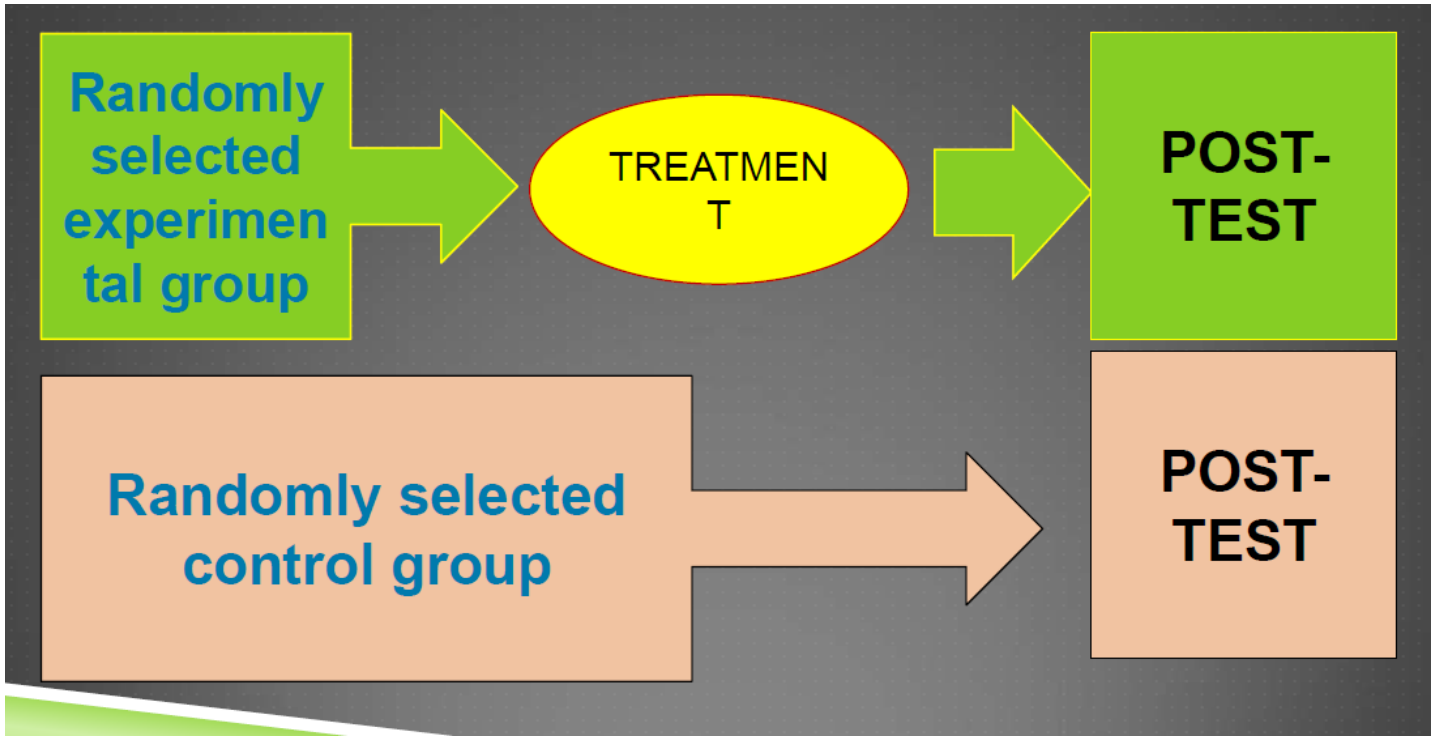
b. Pretest Posttest Control Group Design

c. Solomon Four Group Design

2) Experimental Designs

a. Posttest only Control Group Design

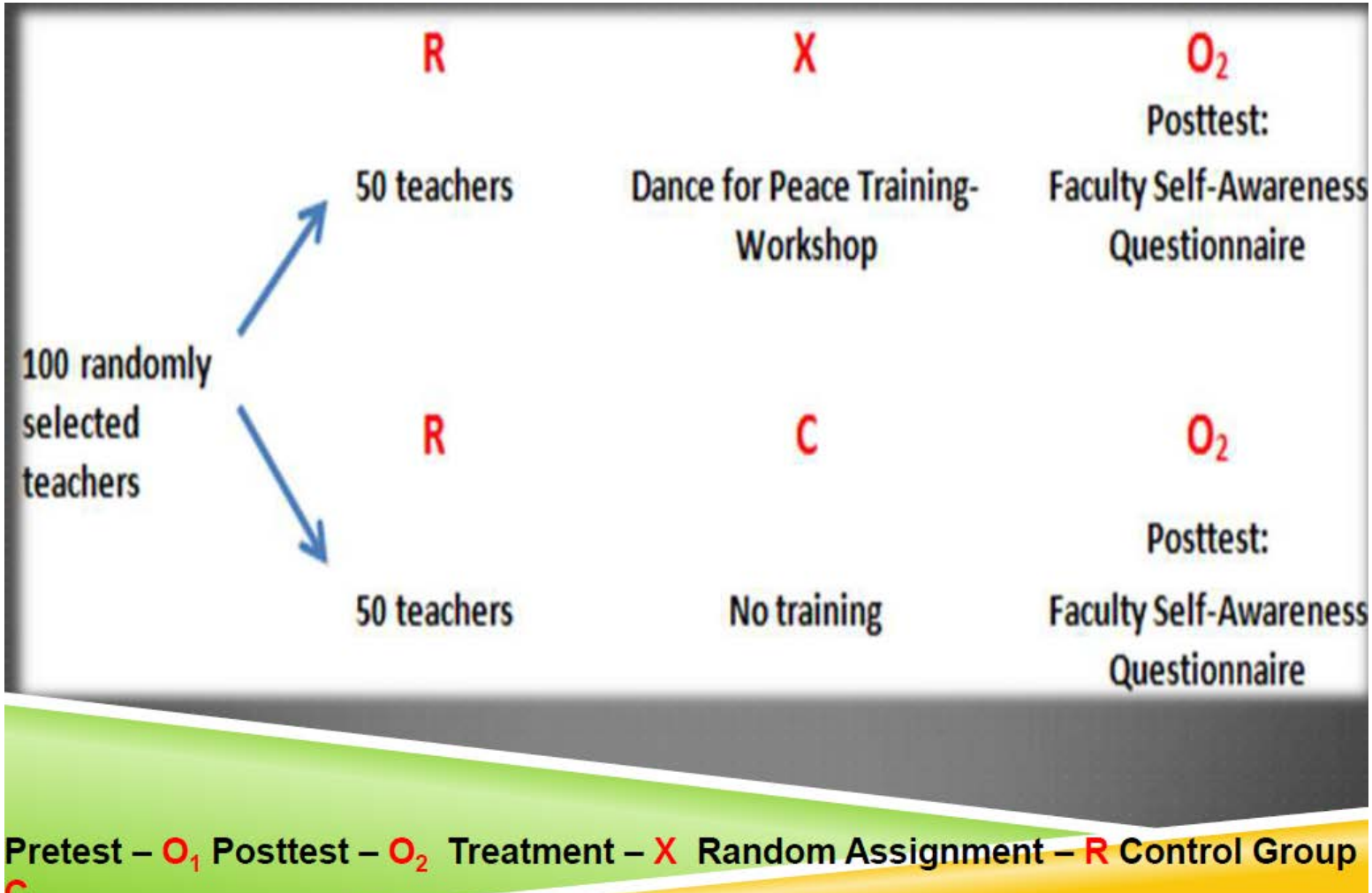
= After-Only with Control



2) Experimental Designs

a. Posttest only Control Group Design

= *After-Only with Control*



2) Experimental Designs

a. Posttest only Control Group Design

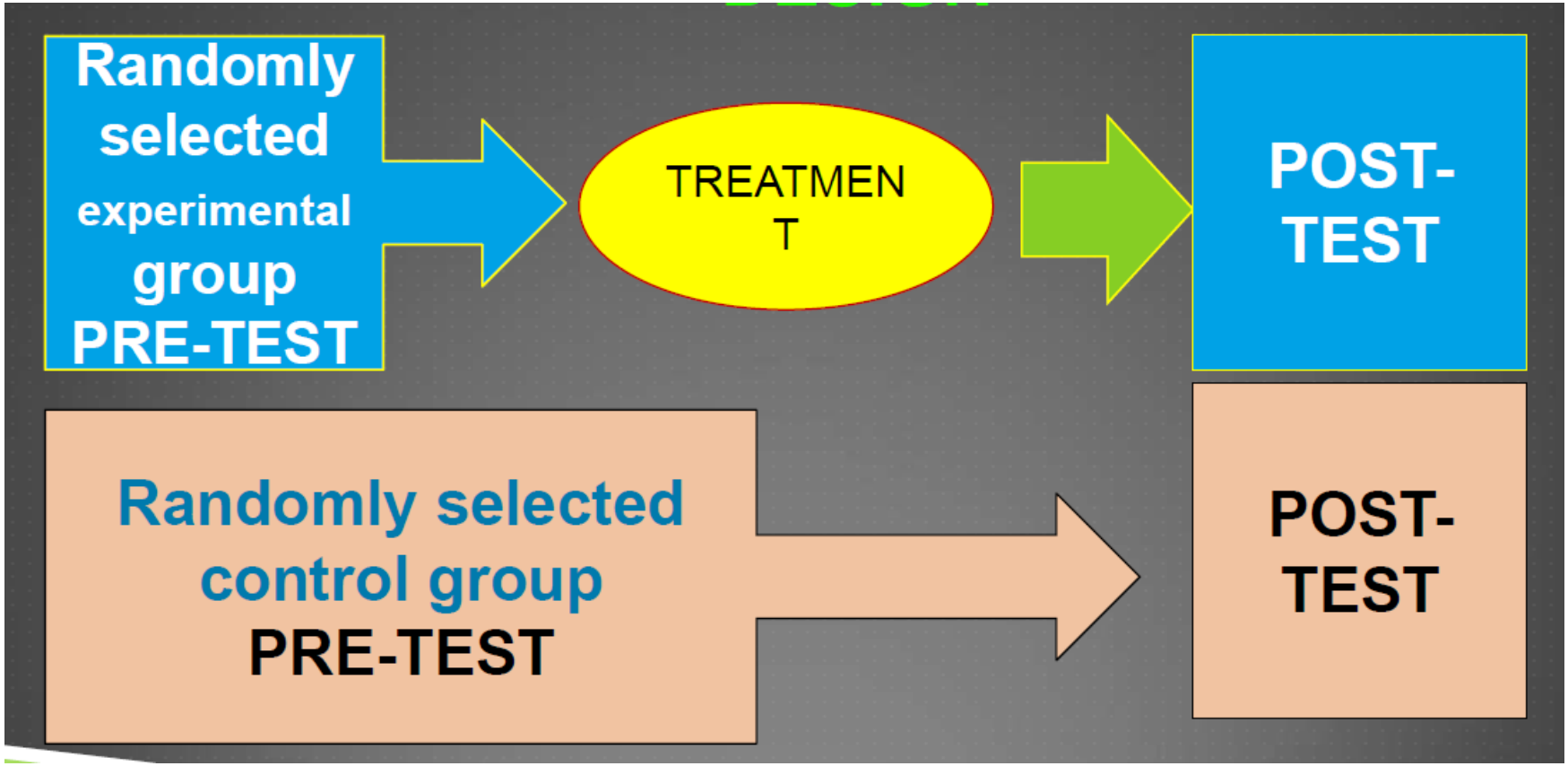
= After-Only with Control

- ✓ True experimental design
- ✓ Experimental group tested after treatment exposure
- ✓ Control group tested at same time without exposure to experimental treatment
- ✓ Includes random assignment to groups
- ✓ Effect of all extraneous variables assumed to be the same on both groups
- ✓ Do not run the risk of a testing effect
- ✓ Use in situations when cannot pretest

2) Experimental Designs

b. Pretest Posttest Control Group Design

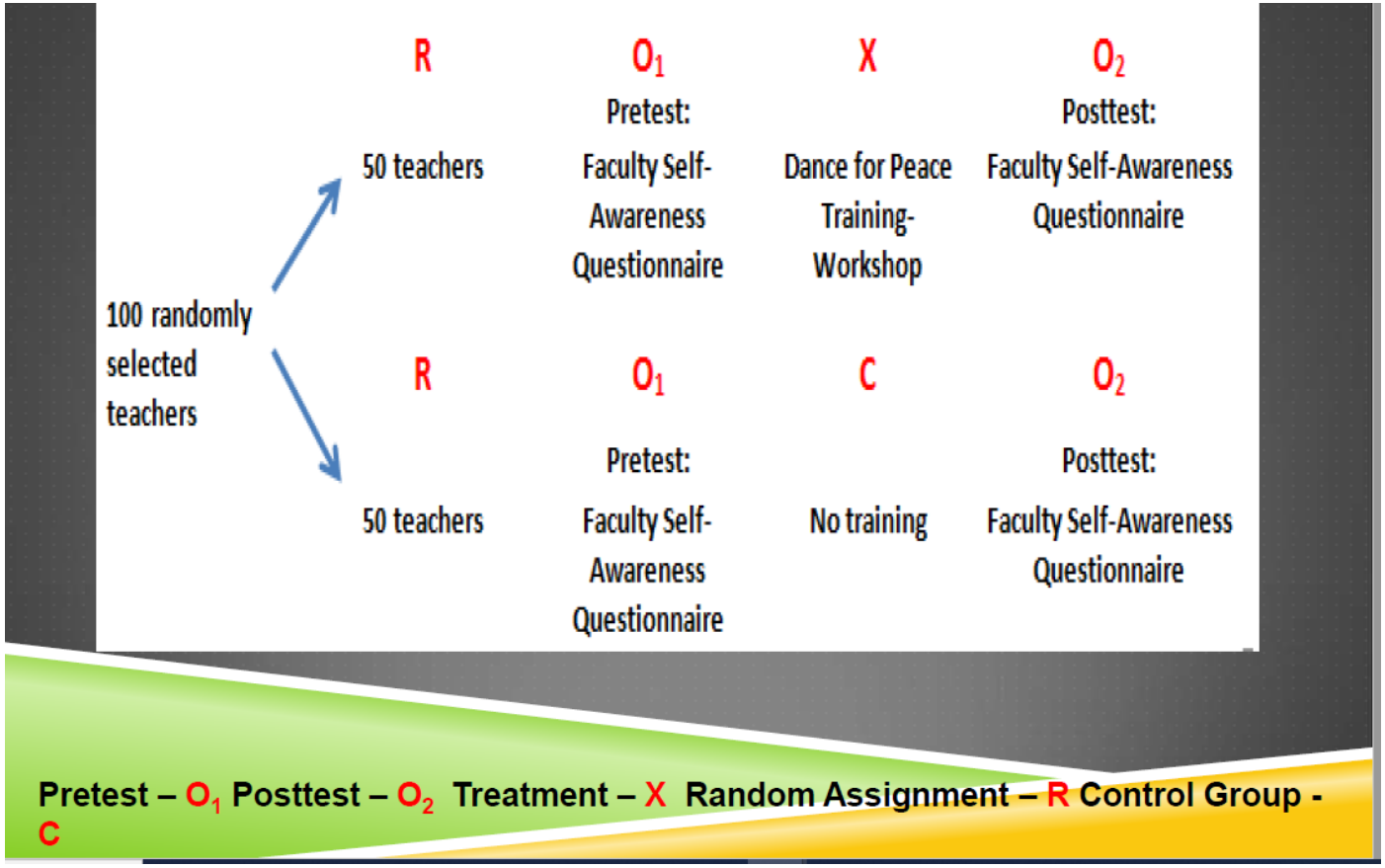
= Before-After with Control



2) Experimental Designs

b. Pretest Posttest Control Group Design

= Before-After with Control



2) Experimental Designs

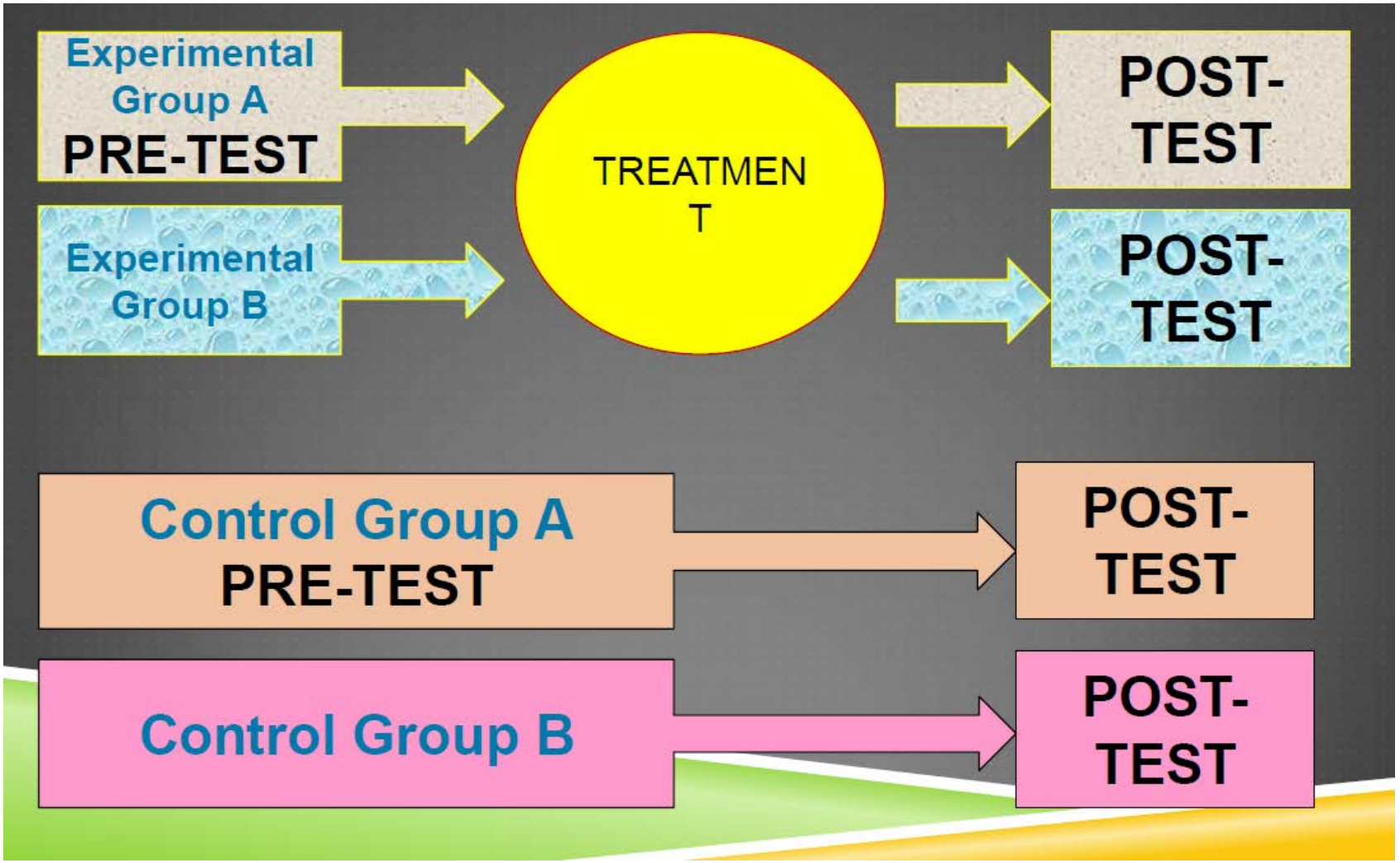
b. Pretest Posttest Control Group Design

= Before-After with Control

- ✓ True experimental design
- ✓ Experimental group tested before and after treatment exposure
- ✓ Control group tested at same two times without exposure to experimental treatment
- ✓ Includes random assignment to groups
- ✓ Effect of all extraneous variables assumed to be the same on both groups
- ✓ Do run the risk of a testing effect

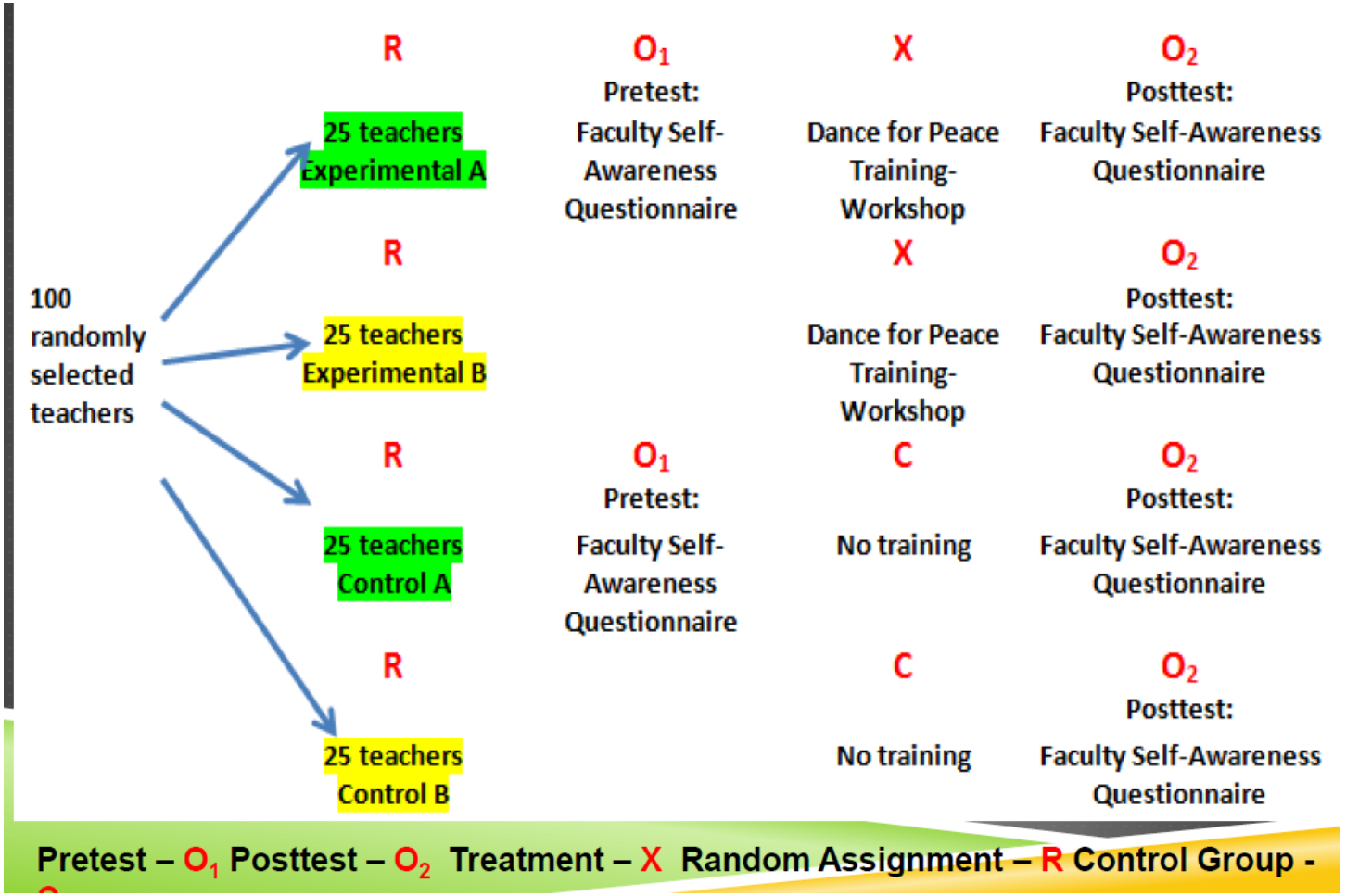
2) Experimental Designs

c. Solomon Four Group Design



2) Experimental Designs

c. Solomon Four Group Design



2) Experimental Designs

c. Solomon Four Group Design

- ✓ True experimental design
- ✓ Combines pretest-posttest with control group design and the posttest-only with control group design
- ✓ Provides means for controlling the interactive testing effect and other sources of extraneous variation
- ✓ Does include random assignment

3) Completely Randomized Designs

- Involves randomly assigning treatments to group members
  - Allows control over all extraneous treatments while manipulating the treatment variable
  - Simple to administer, but should NOT be used unless test members are similar, and they are also alike regarding a particular extraneous variable
  - Different forms of the independent variable are called “levels.”

3) Completely Randomized Designs

- Grocery store chain trying to motivate consumers to shop in their stores
- 3 possible sales promotional efforts

X_1 = offer discount of 5% off total shopping bill

X_2 = offer taste sample of selected foods

X_3 = control group, no sales promotional effort applied

3) Completely Randomized Designs

	SALES PROMOTION TECHNIQUE		
LEVELS	**5% discount**	**Taste samples**	**No sales promotion**
STORES	Sales, store 3	Sales, store 5	Sales, store 9
	Sales, store 1	Sales, store 8	Sales, store 7
	Sales, store 6	Sales, store 4	Sales, store 2
	Average sales	**Average sales**	**Average sales**

4) Factorial Design

- Used to examine the effects that the manipulation of at least 2 independent variables (simultaneously at different levels) has upon the dependent variable

- The impact that each independent variable has on the dependent variable is referred to as the ***main effect***

- Dependent variable may also be impacted by the interaction of the independent variables. This is called the ***interaction effect***

4) Factorial Design

- Grocery store chain wants to use 12 of its stores to examine whether sales would change at 3 different hours of operation and 2 different types of sales promotions
- Dependent variable is change in sales
- Independent variables
  - Store open 6 am to 6 pm
  - Store open 6 am to midnight
  - Store open 24 hours/day
  - Sales promotion: samples for a free gift
  - Sales promotion: food samples
- Called a 3 x 2 factorial design
- Need 6 experimental groups (3 x 2 = 6)

4) Factorial Design

HOURS OF OPERATION

SALES PROMOTION	6 am – 6 pm	6 am – midnight	24 hours
Gift stamps			
Food samples			

4) Factorial Design

Example:

Driver frustration under low, medium, and high-density traffic conditions and under traffic flow controlled by a police officer or a traffic signal was investigated. The measure of frustration was the number of Horns honked by drivers before receiving the right-of-way at a controlled intersection

Traffic Density	Type of controlled intersection: Officer	Type of controlled intersection: Signal	
Low	2	4	**Mean = 3**
Medium	4	6	**Mean = 5**
High	8	10	**Mean = 9**
	Mean = 4.67	**Mean = 6.67**	