Experimental Design

Basic Concept, Principles, Types and Significance

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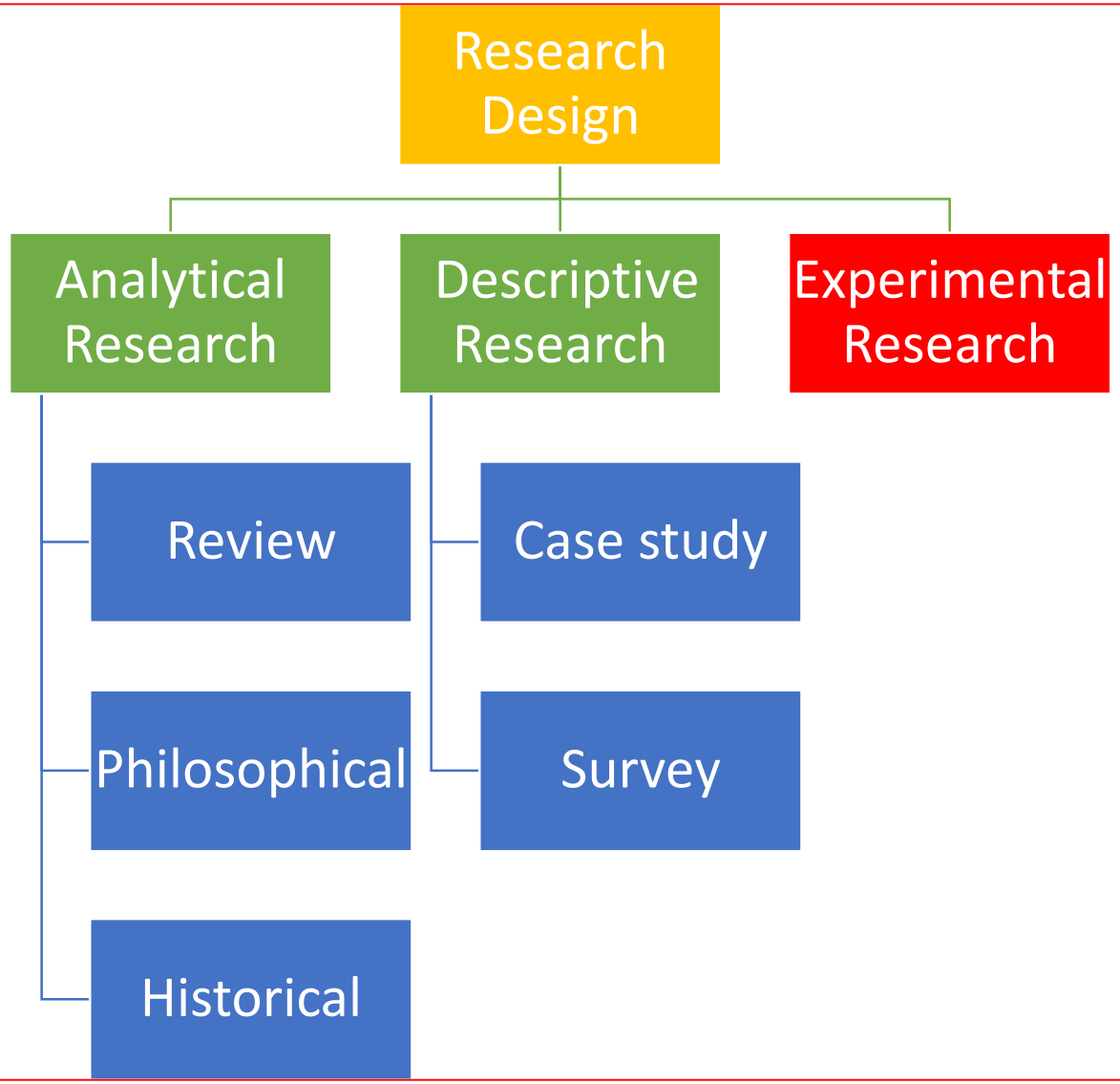
Research Study Designs

- Systematic investigation, done to establish the facts leading to:
  - ✓The discovery of new theories
  - ✓Establishment and interpretation of facts
  - ✓Revision of existing theories in the scenario of new facts
- For such an investigation, it is mandatory to formulate a suitable study design so as to obtain valid data to prove or disprove the hypothesis under study

Research Design Continuum



Classification of Research Studies

Research Studies can be broadly classified under two heads:

- **Observational: In observational studies, the researcher collects information about subjects without applying any treatments to the subject, just by observation**
- **Experimental: In experimental studies, the researcher deliberately introduces interventions and investigates the impact of the intervention**

Another way of classifying research study design is based on the period for which the data is collected

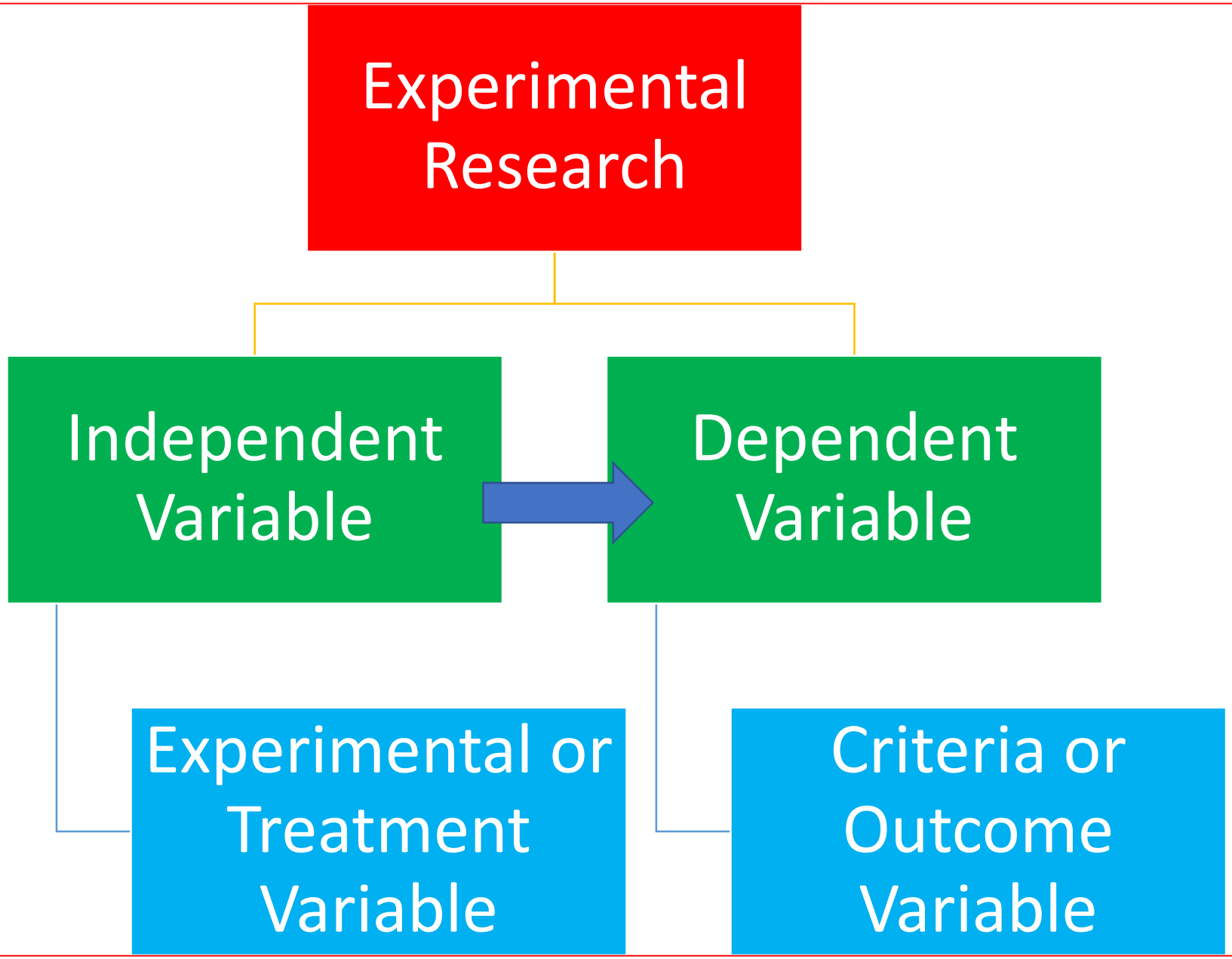
- **Prospective: In this type, the current data is obtained starting from the date, when the study formally begins**

Ex. Experiments & Survival studies

- **Retrospective: In this type, the data refer to past events and is acquired from existing sources by personal interviews, surveys, official records (hospital records, bank records, etc.)**

Ex. Case-control studies

Retrospective studies usually consume lesser time that prospective studies and is also cheap to obtain but the data obtained may be inaccurate by the virtue of recall errors


Experimental Research
Independent Variable
Dependent Variable
Experimental or Treatment Variable
Criteria or Outcome Variable

Experimental Design

- How the observations or measurements should be obtained to answer a query in a valid, efficient and economical way
- The designing of the experiment is inseparable to the analysis of obtained data
- If the experiment is designed properly keeping in mind the question, then the data generated is valid and proper analysis of data provides the valid statistical inferences

Experimental Studies

1. Community trials:

- These are also called community intervention studies, including whole communities (such as cities or states) as experimental units
- The researcher in this case ensures that the treatment or study is ethical and possess no harm to the subjects

2. Clinical trials:

- A clinical trial is defined as an experiment performed by a health care organization or professional to evaluate the effect of a treatment against a control in a clinical environment
- It is designed for the safety, efficacy of new drugs/ products
- Investigators are usually blinded to avoid external bias on the data collected from treatment and control group

Basic Terminologies used in The Experimental Design

Experimental unit: It is a small part of experimental material, may be a treatment or factor

Experiment: It is a way of getting an answer to a question which the experimenter wants to know

Treatment: These are different objects or procedures to be compared in an experiment

Sampling unit: It is the object measured in an experiment

Factor: It is a variable defining a categorization, may be fixed (all the levels of interest included) or random (all the levels of interest not included)

Replication: It is the repetition of the experimental situation by replicating the experimental unit

Experimental error: The unexplained random part of the variation in any experiment

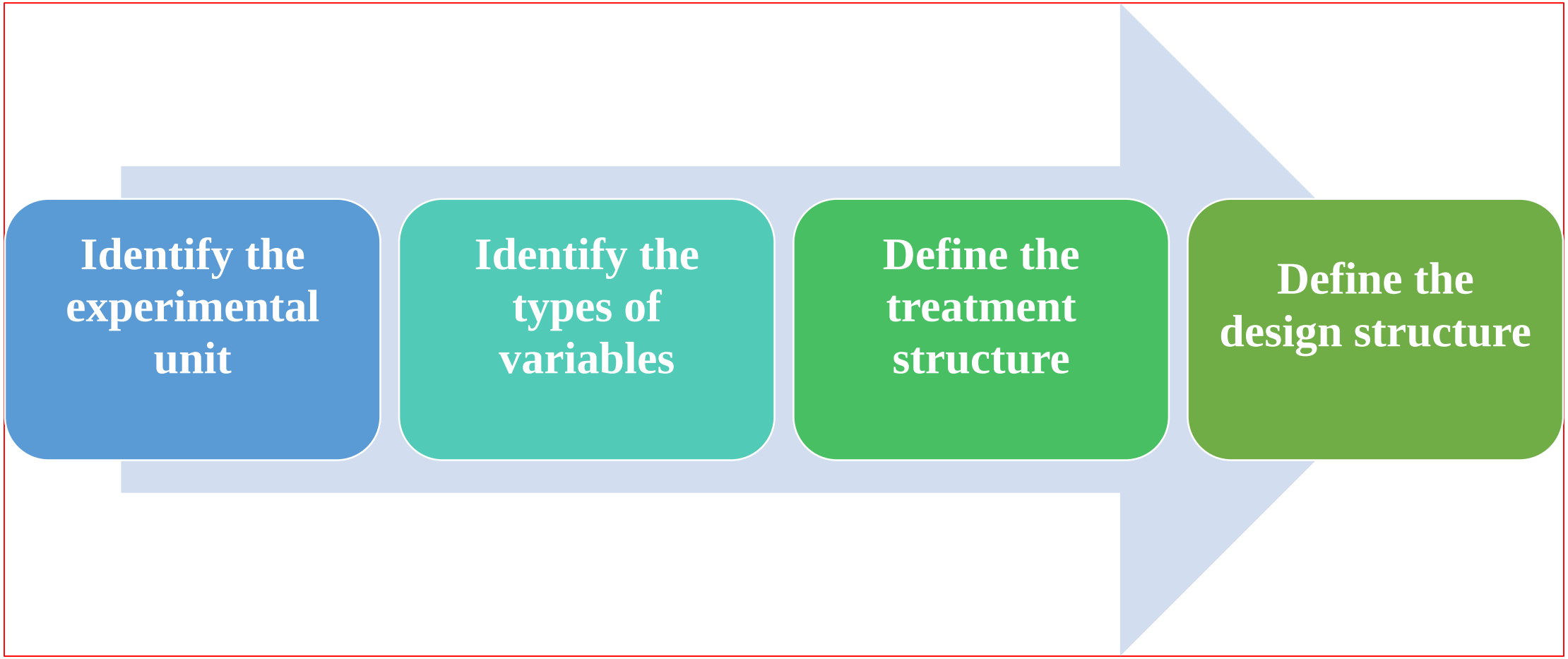
Treatment design: It is the manner in which the levels of treatments are arranged in an experiment

Control Group: The sampling unit, that do not receive ant treatment but treated by the same way till experimentation

Objectives of Experimental Design

- **To verify** the hypothesis in an efficient and economical way to obtain the data such that the assumptions are met and the data is readily available for the application of tools like analysis of variance
- **To find out** a method by which the treatments are placed at random on the experimental units for estimation of result with possible accuracy

Steps of Experimental Design



The Block Designs

- The Block Design is a practice in any available experiment where the experimental units are grouped into **blocks** having more or less identical characteristics
- The number of experimental units in a block is called the **block size**

Complete block design: If size of block = number of treatments and each treatment in each block is randomly allocated

Incomplete block designs: When the number of treatments is so large to makes it too heterogeneous with respect to the characteristic under study, then smaller but homogeneous blocks which do not contain a full replicate of the treatments are used under study

Principles of Experimental Design

There are three basic principles of design which were developed by Sir Ronald A. Fisher

(i) Randomization

(ii) Replication

(iii) Local control

1. Randomization

* **At random allocation of treatment to experimental units**

This results in the following outcomes:

a) It eliminates systematic bias

b) It is needed to obtain a representative sample from the population

c) It helps in distributing the unknown variation throughout the experiment

* **If the randomization process is such that every experimental unit has an equal chance of receiving each treatment, it is called complete randomization**

2. Replication

- This is repetition of treatment a number of times to obtain a valid and more reliable which is not possible with one observation only
- Replication provides an efficient way of increasing the precision of an experiment
- Usually, less than 05 replicates in any experiment is not considered good for further analysis

3. Local Control (Error Control)

- This results in formation of homogeneous blocks for acceptance or elimination during calculations
- This can support the assumption that among the blocks the variation is due to the treatments only
- It is used with replication to reduce the experimental error

Types of Experimental Design

- **Pre-experimental:** It is also called pseudo experimental design, no Randomization and Control group, very simple, convenient to conduct, suitable for beginners
- **Quasi-experimental:** It is based on natural experiment, absence of either Randomization or Control group, manipulation of independent variable, only correlation can be demonstrated
- **True-experimental:** Presence of both Randomization and Control group

Key Terms of True Experimental Design:

- **Manipulation:** Control of independent variable by the researcher through treatment or intervention
- **Control:** Use of control group on dependent variable
- **Randomization:** Every subject gets equal chance to experimental and control group

Examples of True Experimental Design

- Completely Randomized Design
- Randomized Block Design
- Latin Square Design
- Post Test Only Control Design
- Pre test-Post- test - Only Design
- Solomon Four Group Design
- Factorial Design
- Cross Over Design

Completely Randomized Design (CRD)

- It is the most simplest method of design, all experimental units are considered the same and no division or grouping among them
- Design is entirely flexible as the number of replications for different treatments need **not be equal** and may vary from treatment to treatment
- CRD is used when the experimental material is homogeneous and the experiments are conducted inside the lab
- It is well suited for the small number of treatments

Example:

Suppose there are 4 treatments and 20 experimental units

a. The treatment 1 is replicated, say 3 times and is given to 3 experimental units
b. The treatment 2 is replicated, say 5 times and is given to 5 experimental units
c. The treatment 3 is replicated, say 6 times and is given to 6 experimental units
d. So the treatment 4 is replicated [20-(6+5+3)=]6 times and is given to the remaining 6 experimental units

Randomized Block Design (RBD)

- This method of experimental design is used when a large number of treatments are to be compared and a large number of experimental units are required
- The experimental material is grouped into blocks of sizes Vs units
- Blocks are constructed such that the experimental units within a block are relatively homogeneous and resemble to each other more closely than the units in the different blocks

Suppose there are 7 treatments denoted as T corresponding to 7 levels of a factor to be included in 4 blocks

The possible layout of the assignment of 7 treatments to 4 different blocks in an RBD will be:

1	T2	T7	T3	T5	T1	T4	T6
2	T1	T3	T6	T2	T4	T5	T7
3	T7	T4	T1	T6	T3	T5	T2
4	T4	T1	T6	T7	T5	T2	T3

Type of Hypertensive Drug	Blocks	Blocks	Blocks
	Patient with Hypertension (I)	Patient with Diabetes and Hypertension (II)	Patient with Heart disease and Hypertension (III)
A	A I	A II	A III
B	B I	B II	B III
C	C I	C II	C III

Latin Square Design (LSD)

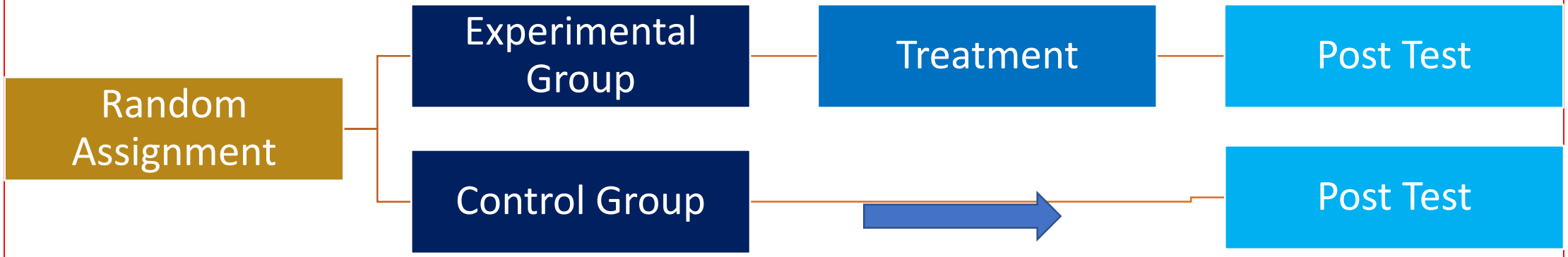
- The experimental material is divided into rows and columns, each having the same number of experimental units which is equal to the number of treatments
- The treatments are allocated to the rows and the columns such that each treatment occurs once and only once in each row and in each column

- In Latin square of order design, Latin letters are used as symbols as A, B, C and D
- Each of them are written in a way such that each of the letters out of A, B, C and D occurs once and only once in each row and each column

A	B	C	D
B	C	D	A
C	D	A	B
D	A	B	C

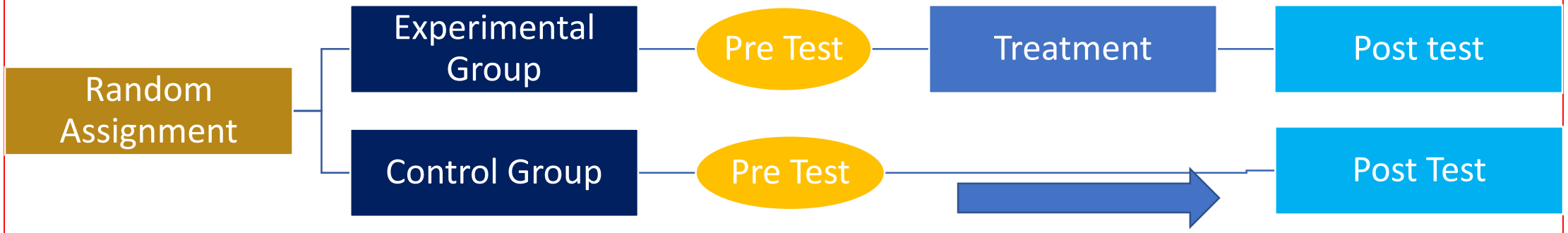
Post Test Only Control Design

* It is composed of two randomly assign groups, Experimental and Control group
* Treatment is implemented on experimental group and observations are made on both the groups



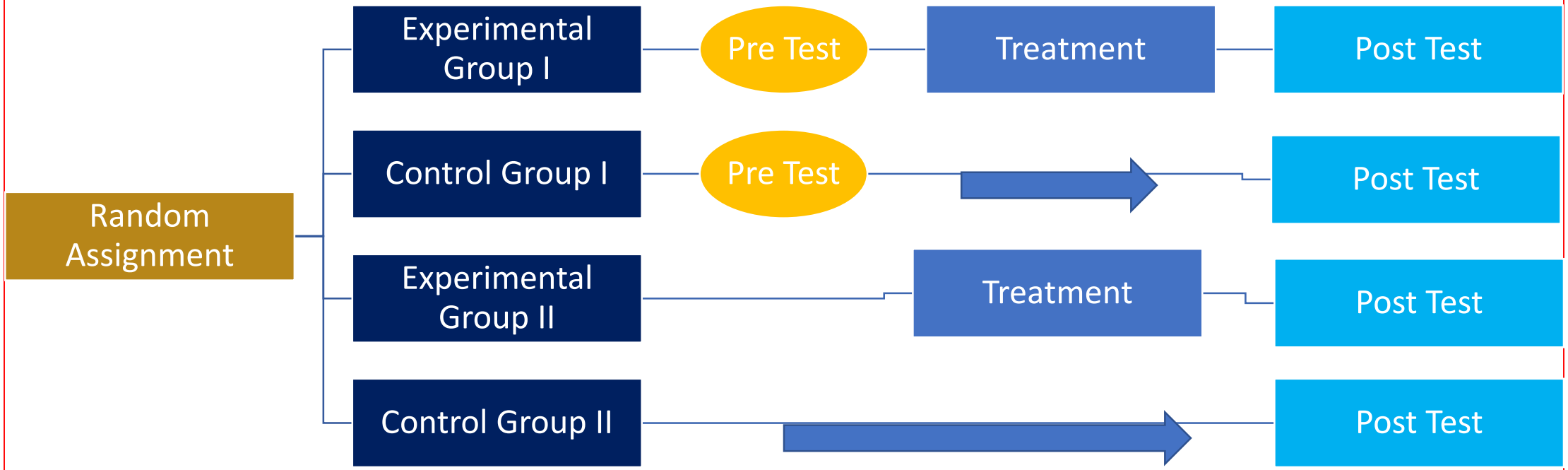
Pre test-Post- test - Only Design

- In this design, subjects are randomly assigned to either experimental or Control group
- The treatment is carried out on experimental group only



Solomon Four Group Design

- There are two Experimental and two Control Groups
- This design requires a large samples



Factorial Design

- Manipulation of two or more independent variable to observe their effects on dependent variables
- This is useful when there are more than two independent variables are to be tested

Frequency of Treatment	Protocols of Treatment	Protocols of Treatments
	Alpha I (Drug I)	Beta II (Drug II)
4 hrs (B1)	A1 B1	A2 B1
6 hrs (B2)	A1 B2	A2 B2
8 hrs (B3)	A1 B3	A2 B3

Cross over Design

- The study subjects are exposed to more than one treatment
- Also known as Repeat Measure Design

Group	Treatment Protocol	Treatment Protocol
Group I	Treatment I	Treatment II
Group II	Treatment II	Treatment I

References

- Experimental Design and Analysis, Howard J. Seltman
- ePathshala: A gateway to all Post Graduate Courses
- www. slideshare.net

Thank You…….