Research Design

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Source:

C.R. Kothari, 'Research Methodology; Methods and Techniques', second edition, New Age International Publisher, 2004

- Decisions regarding what, where, when, how much

- A research design
  - the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure.”

- The designing decisions happen to be in respect of:
  - (i) What is the study about?
  - (ii) Why is the study being made?
  - (iii) Where will the study be carried out?
  - (iv) What type of data is required?
  - (v) Where can the required data be found?
  - (vi) What periods of time will the study include?
  - (vii) What will be the sample design?
  - (viii) What techniques of data collection will be used?
  - (ix) How will the data be analyzed?
  - (x) In what style will the report be prepared?

- Split the overall research design into the following parts:
  - (a) *sampling design*
    - the method of selecting items to be observed;
  - (b) *observational design*
    - the conditions under which the observations are to be made;
  - (c) *statistical design*
    - the question of how many items are to be observed and how the information and data gathered are to be analysed;
  - (d) *operational design*
    - the techniques by which the procedures specified in the sampling, statistical and observational designs can be carried out.

- The important features of a research design
  - (i) a plan
    - specifies the sources & types of information relevant to the research problem
  - (ii) a strategy
    - which approach will be used for gathering and analyzing the data.
  - (iii) the time and cost budgets
    - most studies are done under these two constraints

- Research design must, at least, contain—
  - (a) a clear statement of the **research problem**;
  - (b) **procedures and techniques** to be used for gathering information;
  - (c) the **population** to be studied;
  - (d) **methods** to be used in processing and analyzing data

- The various concepts relating to designs
- **1. Dependent and independent variables**
  - A concept which can take on different quantitative values (a variable)
  - Qualitative phenomena (or the attributes) are also quantified
  - If one variable depends upon or is a consequence of the other variable --- a dependent variable,
  - the variable that is antecedent to the dependent variable --- an independent variable.

- **2. Extraneous variable:**
  - Independent variables that are not related to the purpose of the study, but may affect the dependent variable
    - the researcher wants to test the hypothesis: a relationship between children's gains in social studies achievement and their self-concepts
      - self-concept is an independent variable, social studies achievement is a dependent variable.
      - Intelligence may as well affect the social studies achievement, but since it is not related to the purpose of the study undertaken by the researcher, it will be termed as an extraneous variable.
  - Whatever effect is noticed on dependent variable as a result of extraneous variable(s) is technically described as an '**experimental error**'.

- **3. Control**
  - One important characteristic of a good research design is to minimize the influence or effect of extraneous variable(s).
- **4. Confounded relationship**
  - When the dependent variable is not free from the influence of extraneous variable(s)
  - the relationship between the dependent and independent variables is said to be confounded/confused by an extraneous variable(s).

- **5. Research hypothesis**
  - When a prediction or a hypothesized relationship is to be tested by scientific methods, it is termed as **research hypothesis**.
  - The research hypothesis is a **predictive statement** that relates an independent variable to a dependent variable.

- **6. Experimental and non-experimental hypothesis-testing research:**
  - When the purpose of research is to test a research hypothesis, it is termed as **hypothesis-testing** research.
  - It can be of the **experimental design or of the non-experimental design**.
    - For instance, a researcher wants to study whether intelligence affects reading ability for a group of students and for this purpose he randomly selects 50 students and tests their intelligence and reading ability by calculating the coefficient of correlation between the two sets of scores.

- **7. Experimental and control groups**
  - An experimental hypothesis-testing research when a group is exposed to usual conditions, it is termed a ‘control group’, but when the group is exposed to some novel or special condition, it is termed an ‘experimental group’.
- **8. Treatments**
  - The two treatments are the usual studies programme and the special studies programme
    - For example, if we want to determine through an experiment the comparative impact of three varieties of fertilizers on the yield of wheat, in that case the three varieties of fertilizers will be treated as three treatments.

- **9. Experiment**
  - Examining the truth of a statistical hypothesis, relating to some research problem, is known as an experiment.
    - For example, an experiment to examine the usefulness of a certain newly developed drug
  - Experiments can be of two types viz., absolute experiment and comparative experiment.
    - If we want to determine the impact of a fertilizer on the yield of a crop, it is a case of absolute experiment;
    - but if we want to determine the impact of one fertilizer as compared to the impact of some other fertilizer, our experiment then will be termed as a comparative experiment.

- **10. Experimental unit(s)**
  - The pre-determined plots or the blocks, where different treatments are used, are known as experimental units.
  - Such experimental units must be selected (defined) very carefully.

- **DIFFERENT RESEARCH DESIGNS**
- **1. Exploratory research studies**
  - also termed as **formulative** research studies
  - The main purpose
    - formulating a problem for more precise investigation
    - of developing the working hypotheses from an operational point of view
    - The major emphasis is on the discovery of ideas and insights

- Generally, three methods in the context of research design for such studies
  - (a) the survey of concerning literature;
  - (b) the experience survey; and
  - (c) the analysis of ‘insight-stimulating’ examples.

- *The survey of concerning literature*
  - to be the most simple and fruitful method of formulating precisely the research problem or developing hypothesis.
    - Hypotheses stated by earlier workers may be reviewed and their usefulness be evaluated as a basis for further research.
    - It may also be considered whether the already stated hypotheses suggest new hypothesis.

- *Experience survey*
  - To obtain insight into the relationships between variables and new ideas relating to the research problem
- **2. Descriptive and diagnostic research studies**
  - Descriptive research studies
    - describing the characteristics of a particular individual, or of a group
  - Diagnostic research studies
    - determine the frequency with which something occurs
    - or its association with something else

Research Design	*Type of study*	
	Exploratory of Formulative	*Descriptive/Diagnostic*
Overall design	Flexible design (design must provide opportunity for considering different aspects of the problem)	Rigid design (design must make enough provision for protection against bias and must maximise reliability)
(i) Sampling design	Non-probability sampling design (purposive or judgement sampling)	Probability sampling design (random sampling)
(ii) Statistical design	No pre-planned design for analysis	Pre-planned design for analysis
(iii) Observational design	Unstructured instruments for collection of data	Structured or well thought out instruments for collection of data
(iv) Operational design	No fixed decisions about the operational procedures	Advanced decisions about operational procedures.

- **3. hypothesis-testing research studies**
  - known as experimental studies or design of experiments
    - tests the hypotheses of causal relationships between variables
  - Usually experiments meet this requirement
  - Three basic principles of experimental designs
    - (1) the Principle of Replication;
    - (2) the Principle of Randomization;
    - (3) Principle of Local Control.

- *The Principle of Replication*
  - the experiment should be repeated more than once
  - The statistical accuracy of the experiments is increased
    - For example, if an experiment requiring a two-way analysis of variance is replicated, it will then require a three-way analysis of variance since replication itself may be a source of variation in the data

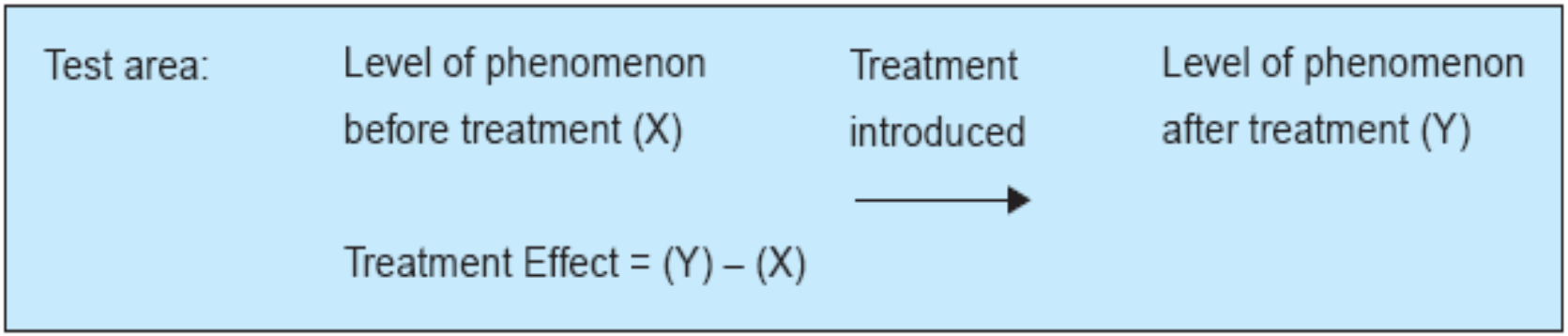
- **The *Principle of Randomization***
  - Design or plan the experiment that the variations caused by extraneous factors
    - For instance, if we grow one variety of rice, say, in the first half of the parts of a field and the other variety is grown in the other half, then it is just possible that the soil fertility may be different in the first half in comparison to the other half. If this is so, our results would not be realistic.
    - In such a situation, we may assign the variety of rice to be grown in different parts of the field on the basis of some random sampling technique i.e., we may apply randomization principle and protect ourselves against the effects of the extraneous factors.
  - The principle of randomization, have a better estimate of the experimental error.

- The *Principle of Local Control*
  - Plan the experiment for performing a two-way analysis of variance
  - In other words,
    - first divide the field into several homogeneous parts, known as blocks,
    - then each such block is divided into parts equal to the number of treatments.
    - Then the treatments are randomly assigned to these parts of a block.
- the principle of local control can eliminate the variability due to extraneous factor(s) from the experimental error

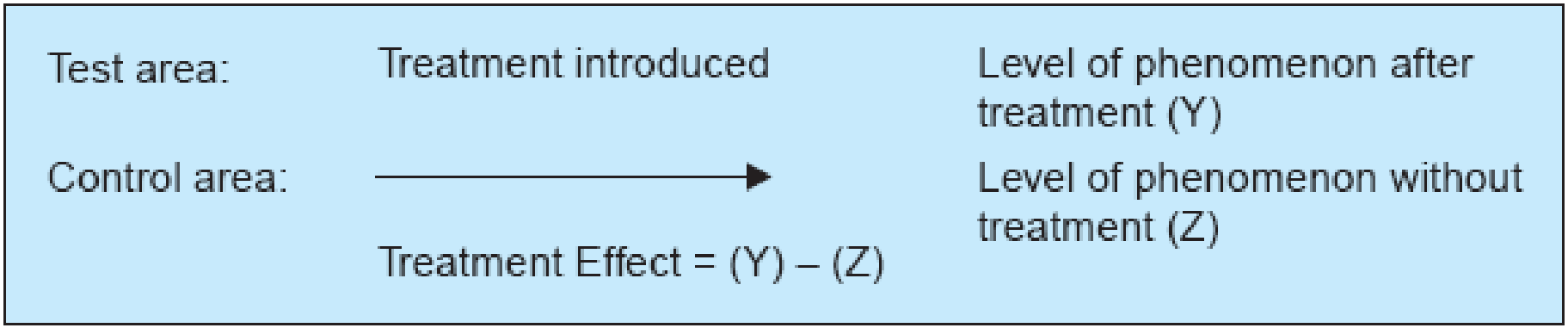
- Important experiment designs
  - (*a*) Informal experimental designs
    - (i) Before-and-after without control design.
    - (ii) After-only with control design.
    - (iii) Before-and-after with control design.
  - (*b*) Formal experimental designs
    - (i) Completely randomized design (C.R. Design).
    - (ii) Randomized block design (R.B. Design).
    - (iii) Latin square design (L.S. Design).
    - (iv) Factorial designs.

- **1. Before-and-after without control design**
  - A single test group or area is selected, and the dependent variable is measured
  - The treatment is then introduced and then the dependent variable is measured again
  - The effect of the treatment
    - the level of the phenomenon after the treatment - the level of the phenomenon before the treatment

- The design can be represented thus:



- **2. After-only with control design**
  - Two groups or areas (test area and control area) are selected and the treatment is introduced into the test area only

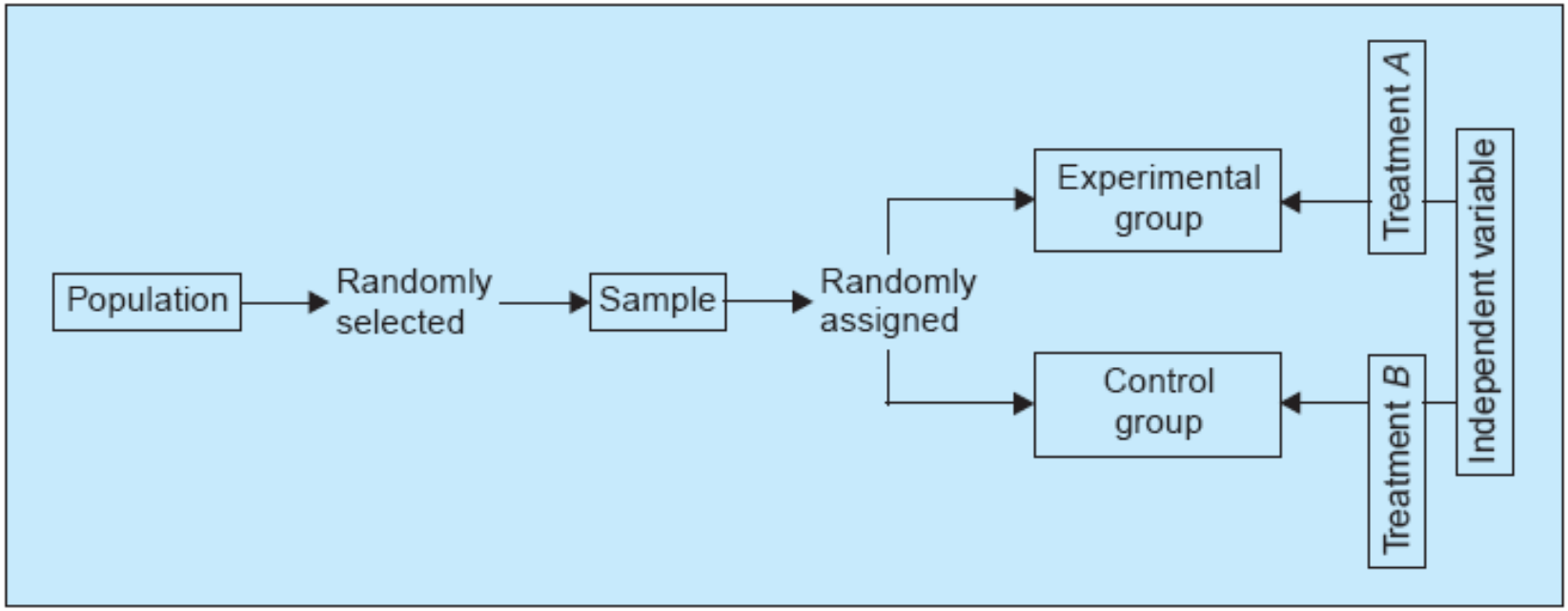


- **3. Before-and-after with control design**

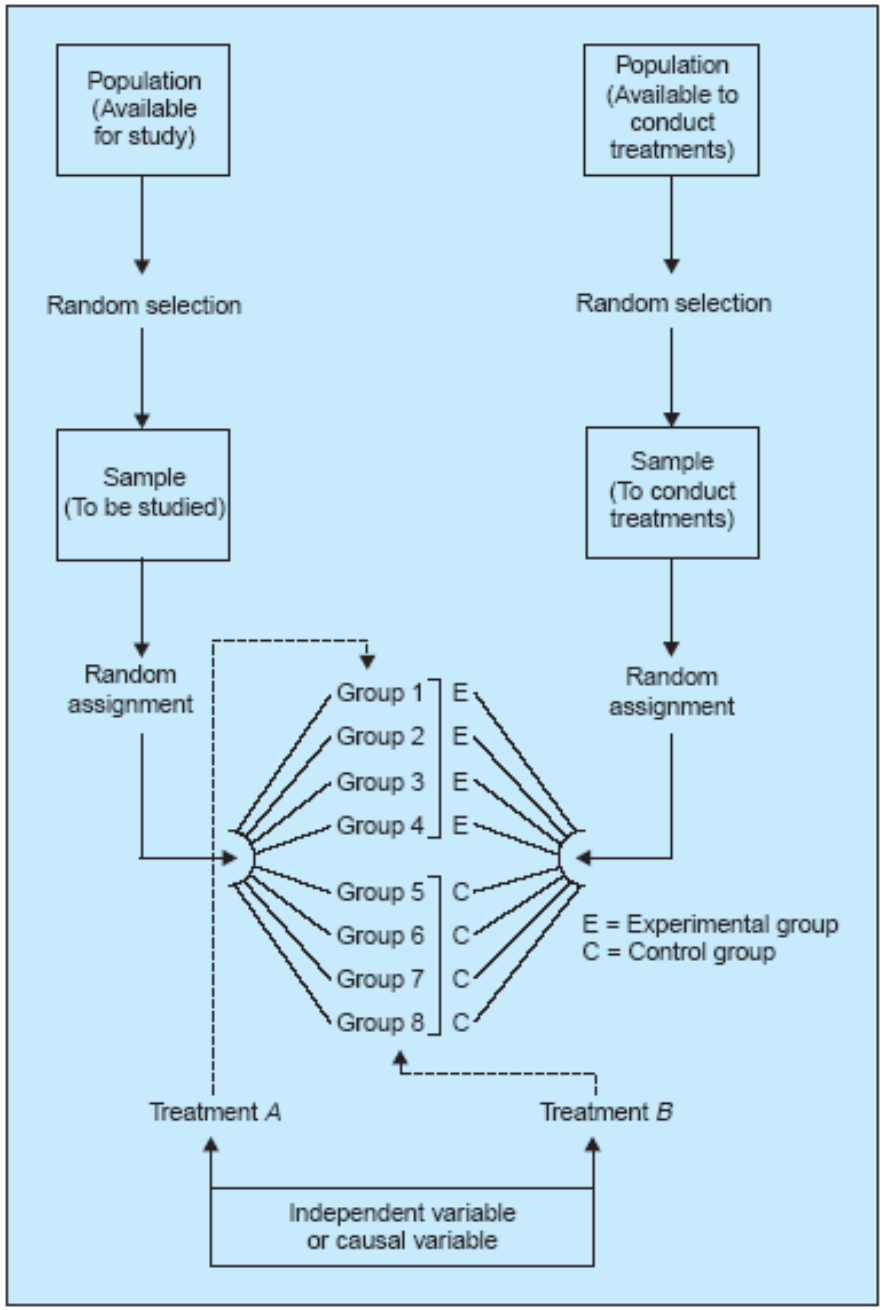
	Time Period I		Time Period II
Test area:	Level of phenomenon before treatment (X)	Treatment introduced →	Level of phenomenon after treatment (Y)
Control area:	Level of phenomenon without treatment (A)		Level of phenomenon without treatment (Z)

Treatment Effect = (Y – X) – (Z – A)

- **4. Completely randomized design (C.R. design)**
  - **(i) Two-group simple randomized**



- **(ii) Random replications design**



5. Randomized block design (R.B. design)

	Very low I.Q.	Low I.Q.	Average I.Q.	High I.Q.	Very high I.Q.
	Student A	Student B	Student C	Student D	Student E
Form 1	82	67	57	71	73
Form 2	90	68	54	70	81
Form 3	86	73	51	69	84
Form 4	93	77	60	65	71

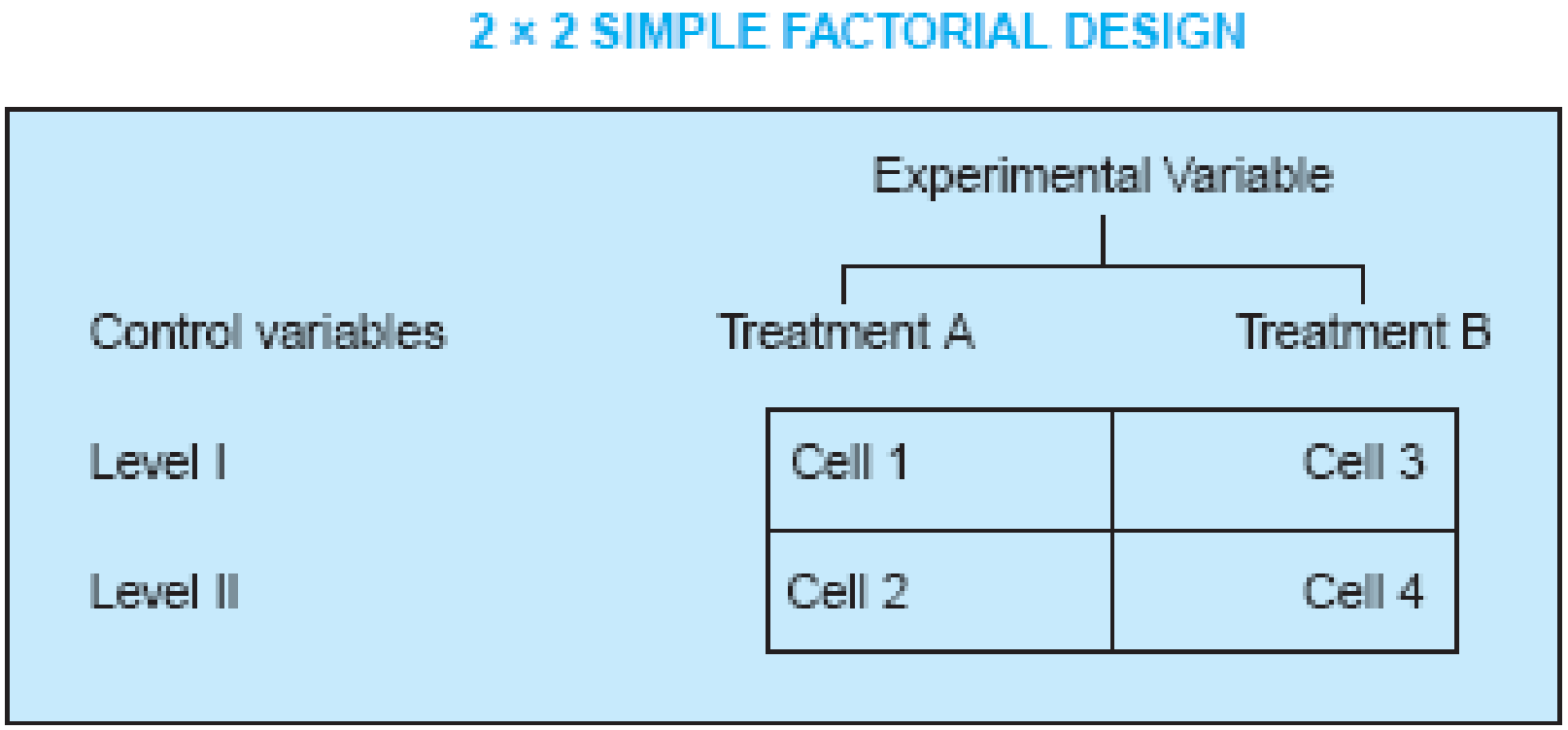
- **6. Latin square design (L.S. design)**
  - **A**n experimental design very frequently used in agricultural research

FERTILITY LEVEL

Seeds differences	I	II	III	IV	V
X_1	A	B	C	D	E
X_2	B	C	D	E	A
X_3	C	D	E	A	B
X_4	D	E	A	B	C
X_5	E	A	B	C	D

- **7. Factorial designs**
  - where the effects of varying more than one factor are to be determined.
  - important in several economic and social phenomena
  - Factorial designs can be of two types:
    - (i) simple factorial designs
    - (ii) complex factorial designs

- ***Illustration 1:*** (2 × 2 simple factorial design). A 2 × 2 simple factorial design can graphically be depicted as follows:

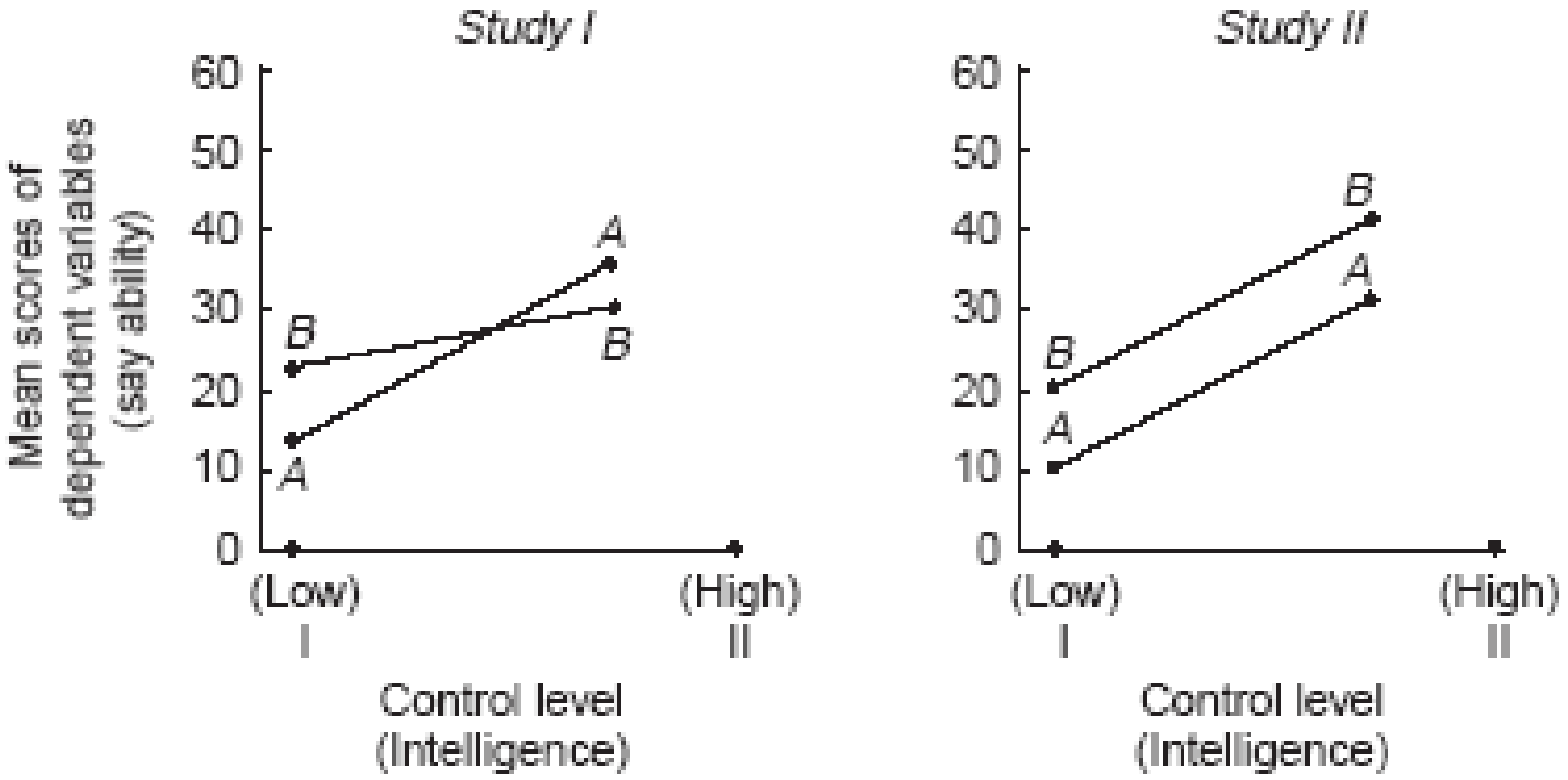


STUDY I DATA

		Training		
		Treatment A	Treatment B	Row Mean
Control (Intelligence)	Level I (Low)	15.5	23.3	19.4
	Level II (High)	35.8	30.2	33.0
	Column mean	25.6	26.7	

STUDY II DATA

		Training		
		Treatment A	Treatment B	Row Mean
Control (Intelligence)	Level I (Low)	10.4	20.6	15.5
	Level II (High)	30.6	40.4	35.5
	Column mean	20.5	30.5	



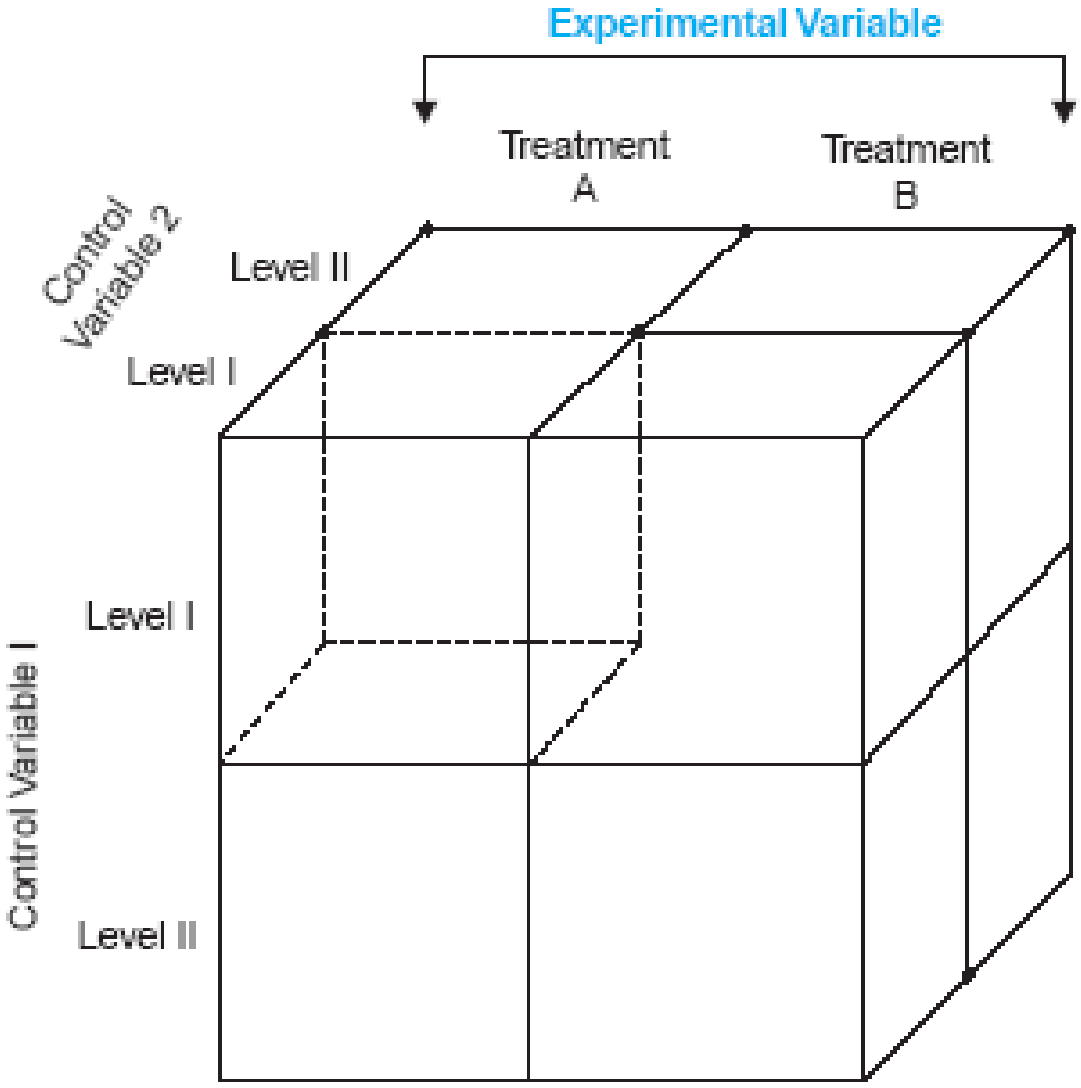
- The graph relating to Study I indicates that there is **an interaction** between the treatment and the level which, in other words, means that the treatment and the level are not independent of each other.
- The graph relating to Study II shows that there is **no interaction** effect which means that treatment and level in this study are relatively independent of each other.

4 × 3 SIMPLE FACTORIAL DESIGN

Control Variable	Experimental Variable			
	Treatment A	Treatment B	Treatment C	Treatment D
Level I	Cell 1	Cell 4	Cell 7	Cell 10
Level II	Cell 2	Cell 5	Cell 8	Cell 11
Level III	Cell 3	Cell 6	Cell 9	Cell 12

2 × 2 × 2 COMPLEX FACTORIAL DESIGN

		Experimental Variable			
		Treatment A		Treatment B	
		Control Variable 2 Level I	Control Variable 2 Level II	Control Variable 2 Level I	Control Variable 2 Level II
Control Variable 1	Level I	Cell 1	Cell 3	Cell 5	Cell 7
	Level II	Cell 2	Cell 4	Cell 6	Cell 8


Experimental Variable
Treatment A
Treatment B
Control Variable 2
Level II
Level I
Level I
Level II
Control Variable I

- Factorial designs are used mainly because of the two advantages
  - (i) provide equivalent accuracy
    - determine the main effects of two (in simple factorial design) or more (in case of complex factorial design) factors (or variables) in one single experiment.
  - (ii) permit various other comparisons of interest