UNIT 1 SINGLE FACTOR DESIGN

Structure

1.0 INTRODUCTION

There are several ways of collecting and understanding information and finding answers to question, research is one way. Research is a way of thinking. The main purpose of research is developing and testing new theories for the enhancement of knowledge. In research we work within a framework of a set of theories, use methods and try to be unbiased and objective.

When we intend to do research, the first thing we have to do is to decide *what research question we want to find answers to.* Having decided our research question or problem we now have to decide *how to go about finding their answer.* There are various steps through which we just pass in our research journey in order to find the answers to our research questions. Conceptualising a research design is one of the important steps in planning a research study. The main function of a research design is to explain how we will find answers to the research question. For any investigation the selection of an appropriate research design is crucial in enabling us to arrive at valid findings and conclusion. There are different types of research design. In this unit we will learn about one commonly used research design namely single factor design.

1.1 OBJECTIVES

After reading this unit, you will be able to:

- Define research design;
- Describe the function of a research design;
- Identify the terms of research design;
- Define Single factor research design;
- Explain Between group research design; and
- Describe Within subject research design.

1.2 MEANING OF RESEARCH DESIGN

Research design is the plan, structure and strategy of investigation conceived so as to obtain answers to research questions and to control variance. The plan is the overall scheme or the program of the research. It includes an outline of what the investigator will do from writing the hypothesis and their operational implications to the final analysis of data. Structure of the research is outline of the research design, and the scheme is the paradigm of operation of the variable. Strategy includes the methods to be used to gather and analyse the data. In other words, strategy implies how the research objective will be reached and how the problems encountered in the research will be tackled. (Kerlinger, 2007).

A traditional research design is a blueprint or detailed plan as to how a research study is to be completed. That is, how it would operationalise variables so that they can be measured, how to select a sample of interest to the research topic, how to collect data to be used as a basis for testing hypothesis, and how to analyse the results. (Thyer, 1993).

Thus in brief we can say that a research design is a plan adopted by the researcher to answer research question.

1.3 THE FUNCTION OF A RESEARCH DESIGN

On the basis of above definition it can be said that the function of research design is (i) to provide answer to research question and (ii) to enable the researcher to answer research question as validly, accurately and as economically as possible.

According to Kerlinger (2007), the research design has two basic purposes, (i) to provide answer to research question and (ii) to control variance. In other words, the purpose of research design is to get dependable and valid answers to research questions. Research problems are stated in the form of hypothesis. The research design guides the researcher how to collect data for testing the formulated hypothesis.

The main function of research design is to control variance. The statistical principle behind this mechanism is MAXMINCON *principle, that is, Maximise systematic variance, Control extraneous variance and Minimise error variance. (Kerlinger, 2007).*

Systematic variance is the variability in the dependent measure due to the manipulation of the independent variable. In addition to independent and dependent variables, there are other variables that may influence dependent variable known as extraneous variable. Different methods are used to control the extraneous variable and some of these methods are for example, randomisation, elimination and matching. The term error variance means those variance which occur due to the variables that are not controllable by the experimenter.

1.4 BASIC TERMINOLOGY IN RESEARCH DESIGN

It is essential to get familiar with some term for clear and better understanding of the design.

i) **Factors**

The independent variable of an experiment are known as factor of the experiment. An experiment always has at least one factor.

ii) **Levels**

A level is a particular value of an independent variable. An independent variable has at least two levels. For example if we are intended to see the effect of reward on verbal learning. Then reward is the factor and it has two levels, reward or no reward.

iii) **Treatment**

It refers to a particular set of experimental condition. For example in 2 × 2 factorial experiment the subject are assigned to 4 treatments.

Self Assessment Questions

1) Define research design and indicate its puposes.

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2) What are the functions of a research design.

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3) Define factors, levels and treatment in research design.

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1.5 SINGLE FACTOR DESIGN

When we have only one independent variable then we use single factor design. Single factor design can be classified into two categories :

i) Between group design

ii) Within subject design

i) ***Between group design***

Here subjects are assigned at random to different treatment conditions. Here the effect of different conditions on the subjects are computed. In this you can have (i) two randomised group design or (ii) Multigroup design.

As for the two randomised group design , in this we randomly assign the subjects into two groups. For this type of design, the experimenter first defines the independent variable, dependent variable and the research population. For example an investigator wants to see the effect of knowledge of result on the rate of learning of school students in a particular city. Researcher randomly selects a sample of 100 students from a city. Then researcher will randomly divide these 100 students in two groups with 50 students in experimental group and 50 students in control group. The random assignment of the subjects into two groups can be done by various methods.

The most common method of randomly assigning the subjects into two groups is to use the table of random number. To divide the subjects into experimental and control group, the researcher may write down the name of all the students in alphabetical order on a paper and assign 1st student in experimental group, the 2^{nd} in control group, 3^{rd} in experimental group and so on. The researcher also may write the name of the subjects on separate slips fold them and place them in a box and pick the slip one by one. The experimenter may place first slip in one group and second in the second group. It is expected that these two groups will not differ significantly at the start of the experiment. Now the students of experimental group will receive the knowledge of result of their performance and the students of control group do not receive the feedback of their performance. Then the scores of all subjects of experimental and control group will be recorded and subjected to statistical analysis. If the statistical test reveals that two groups differ significantly on dependent variable then it can be concluded that the difference in rate of learning is due to the manipulation of independent variable. If the rate of learning of experimental group is more than that of the control group, then we may conclude that knowledge of result facilitated the learning.

In two randomised group design 't' test or Mann-Whitney U test is most commonly applied statistical techniques design.

- *More than two randomised group design or multi group design*

In behavioural science, the researcher some times uses more than two randomised group design. In such studies, there are more than two or three experimental groups and one control group. For example in an educational experiment, let us say that we want to study the effect of schedule of reinforcement on the rate of learning of a verbal task. We have three experimental groups and one control group. The experimental group (G_1) receives reinforcement of every response , while the experimental group 2 (G_2) receives reinforcement at regular time interval, and the third experimental group (G_3) receives reinforcement at random interval and the control group (G_4) receives no reinforcement. We measure the rate of learning on the verbal tasks of all these groups and use statistical technique to answer research question.

In more than two randomised group design some time we have three or four experimental groups only. For example an experimenter wants to study the effect

of four teaching methods on learning of a particular task. Suppose for this, the researcher randomly selects 100 students and assign 25 subject randomly in each group. These groups are supposed to be equivalent groups after random assignment. In the experiment, one group will be taught by method A, the second by method B, third by method C and fourth by method D. All subjects were administered a particular task and the scores are obtained on dependent variable. Through appropriate statistical technique we can find out which method of teaching is most effective. In multi group design the two most commonly applied statistic is the one way analysis of variance and Duncan Range test.

- *Matched group design*

This design is also known as randomised block design (Edwards, 1968). In matched group design all subjects are first tested on a common task and then they are formed into groups. The groups thus formed are known as equivalent groups. Subsequently, the different values of the independent variable is introduced to each group and the mean scores of the dependent variable is taken of both the groups. The matching variable is usually different from the variable under study but is, in general related to it. The two groups are not necessarily of the same sise although there should not be large differences in the number of subjects of two groups.

When we use the matched group design the most important factor is the identification of the variables on which matching has to be done. The matching variable should have high correlation with dependent variable. Some time the dependent variable itself is used as matching variable. Some time an independent measure may be used as matching variable. But the variable selected should be somewhat related to the dependent variable. For example in a study the researcher wants to see the effect of praise on subject's performance on intelligence test. We have two groups, one group is praised for its performance on the test and urged to try to better its scores and the second group does not receive any comment. For assigning the subjects into two groups the researcher may find the scores on form A of the intelligence test and obtained the set of scores. On the basis of the obtained scores on form A subjects can be paired off. Those subjects who scored 100 were selected for the study. They were divided into two groups randomly and form B of the same test was administered to see the effect of incentive on subject's score. Suitable statistical test is used to find-out the significant difference in the mean scores of two groups.

In matched group design we may use two methods of matching.

Matching by pairs

In this type of research, matching is done initially by pairs so that each person in the first group has a match in the second group. For example researcher wants to study the effect of two teaching methods on mathematical achievement of the IX grade students. Subjects Intelligence and academic achievement was taken as matching variable. All subjects were administered mathematical academic achievement test and scores were obtained. If for instance two subjects scored 80, then one subject is placed in one group and another is placed in another group. In this way two groups are formed. One group is taught by one method and another group is taught by another method and academic achievement scores of both the groups are compared.

Matching in terms of mean and SD

When it is impractical or impossible to set up groups in which subjects have been matched person to person, investigators often resort to matching of groups in terms of Mean and Standard Deviation. The matching variable is somewhat related to the dependent variable. For example intelligence is a matching variable and the researcher obtained the mean and SD of inelligence scores of two groups.

In the matched group design the subject may be matched on age, educational level, learning ability and so on. However one should be very careful in choosing the matching variables.

Self Assessment Questions

1) Define Single Factor Design.

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2) What is between group design? Describe the same with examples.

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3) Describe more than two randomised group design or Multi group design.

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4) What is Matched group design?

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5) How do we match in Matched Group Design?

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ii) ***Within subject design***

Within subject design is also known as repeated measure design, because the same individual is treated differently at different times and we compare their scores after they have been subjected to different treatment conditions. For example, let us say a researcher wants to study the effect of colours on reaction time. The investigator selects three colours say red, green and yellow and let us say that 10 subjects are selected for the experiment from the population of interest. After exposing them to different colours, their reaction time is noted and compared.

Within subject design is further divided into two categories, viz., (i) two conditions within subject design and (ii) multiple condition within subject design.

- *Two conditions, within subject design*

The two conditions design is the simplest design. The two conditions are labeled as 'condition 1' and 'condition 2'. All subjects experience both the conditions. Let us say that the researcher wants to compare the reaction time of red and green colour. We select 10 subjects from the population of interest, and the reaction time of all the subjects is noted down for the two colours. Despite its simplicity, this design is not used as often as one might expect because many experimenters involve more than two conditions and there is possibility of carryover effect from one condition to the other.

- *Multiple Conditions within subject design*

Psychology experiments generally employ more than two conditions. Usually the researcher wants to compare several variables or treatments and ascertain their effectiveness. Another reason for conducting multiple conditions experiment is to determine the shape of the function that relates the independent and dependent variables. For example a researcher may want to know how the sensation of brightness increases with the physiological intensity of a light. For this the researcher may present each of several intensities of the light to a group of subjects. From the responses to the various intensities, the researcher can plot the relation between intensity and brightness. This design can be explained by an example.

Fergus, Craik and Endel Tuluing (1975) examined whether different strategies of processing words would affect memory. They used different strategies for processing the word. They flashed words on a screen. Before each word appeared they asked the subject a question, "Is the word in capital letters ?" or "Does the word rhyme with train ?" or "Does the word fit in this sense ?" The first strategy focused on the visual properties of the word, the second on the acoustic properties and the third on the semantic properties. Researcher hypothesised that each successive type of strategy would induce greater "depth of processing". Their theory predicted that increasing the depth of processing, would increase the memory for that word.

The experimenter believed that subject could adopt different strategies of processing on different trials. The type of strategy used was randomly varied for each trial. After the words were all presented, the experimenter gave the subject a list which contained all of the words that the experimenter had presented along with an equal number of words that they had not presented. They asked the subjects to indicate which word they recognised from the list. The percentage

of words recognised varied as a function of the depth of processing induced by the question. The subject recognised only 18% of the visually processed words, but they recognised 70% of the acoustically processed and 96% of the semantically processed words. The following table shows schematically the above design :

Table 1.1: Subjects and treatment conditions

Subjects	Treatment		
	T_1	T_2	T_3
1	S_1	S_1	S_1
2	S_2	S_2	S_2
3	S_3	S_3	S_3
-	-	-	-
-	-	-	-
N	S_n	S_n	S_n

- *Controlling for order and sequence effects in within subjects design*

In the within subject experiment, because a subject experiences more than one experimental conditions, the possibility exists that **order** effect and **sequence** effect may influence the result of the repeated testing.

Order effects according to Mcburney and White (2007); "are those that result from the ordinal position in which the condition appears in an experiment, regardless of the specific condition that is experienced". On the other hand, according to them, the sequence effect "depends on an interaction between the specific conditions of the experiment." For example in an experiment when judging the heaviness of lifted weights, there is possibility that a light weight will feel even lighter if it is followed by a heavy one, and vice-versa.

Controlling for order and sequence effect is possible by randomisation, which can be used when each condition is given several times to each subject. For example if there are four conditions and each one is to be presented twice, we may use the following sequence BCAD, ADCB. This type of randomisation is particularly useful when conditions are presented several times to each subject.

When we have relatively fewer subjects, then several conditions can be presented only a few times. Then we can use the reverse **counterbalancing** to control for order effect. For example we have three conditions ABC then we can present them ABC, CBA sequence.

- *Comparison between group and within subject design*

In the within subject design each subject in the experiment receives a number of treatments or conditions whereas in the 'between subject' design, a subject receives only one treatment.

In within subject design the experimenter repeats the measures on the same group of subject and this increases the precision of the experiment by eliminating inter-subject differences as a source of error.

Whether we will use the between group design or within subject design depends on the experimental situation. When there are chances of practice or carry over

effect of one treatment to the subsequent task, then between group design should be preferred.

When we have small number of subjects, and they are available for extended period of experimentation and number of treatment is small then we should prefer within subject design.

Self Assessment Questions

1) Define within subject design. State the two categories of within subject design.

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2) Describe what is 2 conditions and Multiple conditions in "within subject design"? Give suitable examples.

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3) How do we control for order and sequence effects in "Within Subjects Design"?

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4) Compare Between group and within group designs.

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1.6 LET US SUM UP

Research design is a detailed plan as to how to do the research. The aim of research design is to give answer to research problem and control variance. There are different types of research design. When we have one independent variable then we use single factor research design. Single factor research design can be classified as between subject and within subject design and also known as repeated measure research design. In between subject design we have two groups, one is experimental group and other is control group. The allocation of subject in experimental and control groups is made randomly. In within subject design different subjects are treated differently at different times and we compare their scores after subjecting them to different treatment conditions. In within subject design, control of order and sequence effect is achieved through randomisation or counterbalancing.

1.7 UNIT END QUESTIONS

1) Given below are statement. Indicate whether they are true or false :
   i) The research design is used to control error variance.
   ii) When we have more than one independent variable we use single factor design.
   iii) Counterbalancing is used to equate the two groups.
   iv) Order effect occur in within group design.
   v) Matched group technique is used in between subject design.
2) Fill in the blanks :
   i) In the within subject design each subject receive ..... treatment.
   ii) In matched group technique the variable selected for matching should be related to ..... variable.
   iii) In two randomised group design ..... test is most commonly used.
   iv) In between subject design we have two groups one is ..... group and other is ..... group.
3) Descriptive Question :
   i) What do you mean by research design ?
   ii) Discuss in detail the functions of research design ?
   iii) Discuss with example when to use between subject research design ?
   iv) When to use within subject research design ? Explain with examples.
   v) Differentiate between within subject and between subject experimental design.

Answers:

1) . (i) T (ii) F (iii) F (iv) T (v) T
2) (i) number of (ii) dependent (iii) 't'
   (iv) experimental, control

1.8 GLOSSARY

Independent Variable : Independent variable is one that cause some change in the value of dependent variable.

Extraneous Variable : Independent variable that are not related to the purpose of the study but may affect the dependent variable.

Experimental Group : Group in which subject receive treatment.

Control group : Subjects in an experiment who do not receive treatment.

Factor : The independent variable of an experiment.

Level : A particular value of an independent variable.

Treatment : Particular set of experimental condition.

Random assignment : Unbiased assignment process that gives each subjects an equal chance of being placed in any groups.

Counterbalancing : Controlling for order and sequence effect by arranging that subject experience the various condition in different orders.

1.9 SUGGESTED READINGS

Kerlinger, F.N. (2007), *"Foundation of Behavioural Research"* (10th reprint), Delhi, Surjeet publications.

McBurney, D.H. & White, T.L. (2007), *"Research Method 7"* Delhi, Thomson Wadsworth.

Thyer, B.A. (1993), Single-System research design in R.M. Grinnell (ed.), *"Social Work, Research and Evaluation"* (4th ed.), Itasca Illinois, F.E. Peacock Publishers.

UNIT 2 FACTORIAL DESIGN

Structure

2.0 INTRODUCTION

Research problems are stated in the form of hypothesis. They are stated so that they can be empirically tested. There is a wide range of possibilities of testing hypothesis. There are as many designs of research that exist as there are possibilities. Designs are carefully worked out to yield dependable and valid answers to the hypothesis. The results of the research depends on how the observation and the inferences are made. How dependable our observation and inferences will be, depends on how adequately we plan the research design. The planning of research design depends on the number of independent variables, the number of levels of each independent variable, the kinds of independent variable. If we have one independent variable then we use single factor experimental design. When we have more than one independent variable with more than one level than we use the factorial design. Factorial design may be two factor, three factor, four factor etc. In this unit we will discuss two factor design.

2.1 OBJECTIVES

After reading this unit, you will be able to:

- Define factorial design;
- Describe the terms related to factorial design;

- Formulate factorial design;
- Describe graphically the results of factorial experiment; and
- Identify the advantages and limitations of factorial design.

Traditional research method generally study the effect of one variable at a time because it is statistically easy to manipulate. However in many cases, two factors may be interdependent. One of the most significant developments in modern research design and statistics is, planning and analysis of simultaneous operation and interaction of two or more variables. Variables do not act independently. Rather they often act in concert. There is one design i.e. factorial design by which we can study the effect of more than one independent variable on dependent variable. The factorial designs have the advantage over the single factor design in that interaction of two or more variables can also be studied along with the main effect. In a single factor design the levels of only one factor is varied and the levels of other relevant variable are held constant. Thus the information provided by factorial design is far more complete than provided by single factor design.

2.2 MEANING OF FACTORIAL DESIGN

A factorial design is one in which two or more variable or factors are employed in such a way that all the possible combinations of selected values of each variable are used (Mcburney & White, 2007). According to Singh (1998), Factorial design is a design in which selected values of two or more independent variables are manipulated in all possible combinations so that their independent as well as interactive effect upon the dependent variable may be studied. On the basis of the above definition it can be said that the factorial design is one in which two or more independent variables are manipulated in all possible combinations and thus the factorial design enables the experimenter to study the independent effect as well as interactive effect of two or more independent variables.

2.3 TERMS RELATED TO FACTORIAL DESIGN

Factors : The term factor is broadly used to include the independent variable that is manipulated by the investigator in the experiment or that is manipulated through selection. In the research some time it is possible to manipulate the independent variable directly, for example in a study researcher wants to study the effect of different drugs on the recovery of the patient. The researcher may select three dosages 2 mg, 4 mg. and 6 mg. and administer the drug to the subjects. Further researcher may find that age is another important variable that may influence the rate of recovery from the diseases. The second independent variable that is age cannot be directly manipulated by the researcher. The manipulation of the variable 'age' is achieved through selection of the sample. The researcher then may divide the subjects into three age groups.

Main Effect

This is the simplest effect of a factor on a dependent variable. It is the effect of the factor alone averaged across the level of other factors.

According to Mcburney & White (2007) main effect in a factorial experiment, the effect of one independent variable, averaged over all levels of another independent variable.

Interaction : The conclusion based on the main effects of two independent variables may be at times misleading, unless we take into consideration the interaction effect of the two variables also.

According to Mcburney & White (2007) Interaction means when the effect of one independent variable depends on the level of another independent variable. An interaction is the variation among the difference between mean for different levels of one factor over different levels of the other factor. For example a cholestrol reduction clinic has two diets and one exercise regime. It was found that exercise alone was effective and diet alone was effective in reducing cholestrol levels (main effect of exercise and main effect of diet). Also for those patients who didn't exercise, the two diets worked equally well (the main effect of diet); those who follow diet A and exercised got the benefits of both (main effect of diet A & main effect of exercise). However it was found that those patients who followed diet B and exercised got the benefit of both plus a bonus, an interaction effect (main effect of diet B, main effect of exercise plus an interaction effect of diet and exercise).

Types of Interaction

1) **Antagonistic interaction :** When main effect is non-significant and interaction is significant. In this situation the two independent variables tend to reverse each others effect.

2) **Synergistic interaction :** When higher level of one independent variable enhances the effect of another independent variable.

3) **Celling effect interaction :** When the higher level of one independent variable reduces the differential effect of another variable. that is one variable has a smaller effect when paired with higher level of a second variable (Mcburney & White, 2007).

All of these types of interaction are common in psychological research.

Randomisation : Randomisation is the process by which experimental units are allocated to treatment; that is by a random process and not by any subjective process. The treatment should be allocated to units in such a way that each treatment is equally likely to be applied to each unit.

Blocking: This is the procedure by which experimental units are grouped into homogenous cluster in an attempt to improve the comparison of treatment by randomly allocating the treatment within each cluster or block.

2.4 SIMPLE TWO FACTOR DESIGN

In the two factor design we have two independent variables, each of which has two values or levels. This is known as two by two (2x2) factorial design because of the two levels of each variables.

2.4.1 Layout of Factorial Design

2 × 2 Factorial Design

	Factor A	
Factor B	A_1	A_2
B_1	A_1B_1	A_2B_1
B_2	A_1B_2	A_2B_2

If we have two levels of one variable and three of another variable we would have two by three (2 × 3) factorial design.

2 × 3 Factorial Design

	Factor A		
Factors B	A_1	A_2	A_3
B_1	A_1B_1	A_2B_1	A_3B_1
B_2	A_1B_2	A_2B_2	A_3B_2

We may have as many factors and level as we desire but with increasing complexity we will require more time and data become complicated to interpret. Most experiment use two or three factors, with two to six levels on the various factors.

2.4.2 Example of Factorial Design

In an experiment Tulving and Pearlstone (1965) subjects were asked to learn a list of 12, 24 or 48 words (factor A with three levels). These words can be put in pairs by categories (for example apple and banana can be grouped as 'fruits'). Subjects were asked to learn these words and they were shown the category name at the same time as the words were presented. Subjects were told that they did not have to learn the category names. After a very short time, subjects were asked to recall the words. At that time half of the subjects were given the list of the category names, and the other half had to recall the words without the list of categories (factor B with two levels). The dependent variable is the number of words recalled by each subjects is given in the table below:

Table 2.1

Level of A

	A_1	A_2	A_3	**Total**
Levels of B	12 words	24 words	48 words	
B_1 Cued recall	A_1B_1 (10)	A_2B_1 (13)	A_3B_1 (19)	**42**
B_2 Free recall	A_1B_2 (10)	A_2B_2 (15)	A_3B_2 (29)	**54**
Total	**20**	**28**	**48**	**96**

Here we have two independent variables number of words and presence and absence of cues and one dependent variable, that is the number of words recalled by each subject. We could do two separate experiments, one which varied the number of words and the other which varied the presence or absence of cues.

The first experiment could be as in Table 2. This table shows the independent effect of number of words. The second experiments could be as in Table 3.

Table 2.2

Cued Recall

12 Words	24 Words	48 Words
A_1	A_2	A_3

Table 2.3

Free recall

12 Words	24 Words	48 Words
A_1	A_2	A_3

In the above example (Table 2.1) there are six cells into which the sample is divided. Each of the six combination would receive one treatment or experimental condition. Subjects are assigned at random to each treatment in same manner as in a randomised group design. The mean (shown in bracket) for different cells may be obtained along with the means for different rows and columns. Means of different cells represent the mean scores for the dependent variable and the column mean in the given design are termed the main effect for number of words without taking into account any differential effect that is due to the presence or absence cues. Similarly the row mean in the above design are termed the main effect for presence or absence of cues without regard to number of words. Thus through this design we can study not only the main effect of number of words and presence or absence of cues, but we can also study the interactive effect of number of words and presence or absence of cues, on the number of words recalled by the subject.

In this design we have two independent variables, we are able to examine two possible main effects. We found the main effect of number of words by averaging effect of number of words over the two levels of presence and absence of cues when we looked at the column mean. Similarly we found the main effect of presence or absence of categories by averaging the effect of presence or absence of categories over the three levels of number of words when we looked at the row mean.

By these results we can find out the interactive effect. Two variables interact if the effect of one variable depends on the level of the other. We have an interaction here. Because the effect of presence or absence of cues depends on the number of words. Similarly the retention is influence by the length of the test.

Interaction can be presented in a tabular form as well as in graphical form.

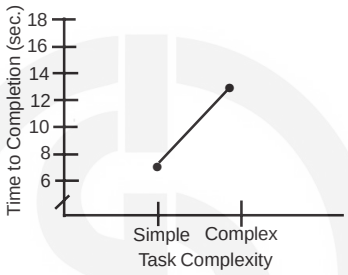
2.4.3 Representing Interaction in Graphic Form

We take the fictitious ons data to present the results in graphic form. One independent variable is task complexity with two levels and second independent variable is level of arousal, that is low arousal and high arousal and the dependent variable is average time (in second) to completion of a task. Result are shown in the Table 2.4.

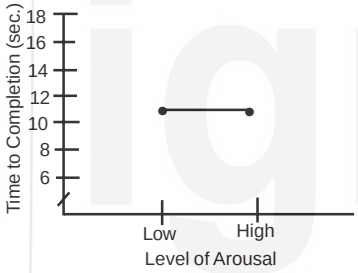
Table 2.4

Study 1	**Task Complexity**	
High arousal	Simple	Complex
	7.6	13.1
Study 2	**Level of arousal**	
	Low arousal	High arousal
	10.3	10.4
Study 3	**Task complexity x level of arousal**	
	Simple Task	Complex Task
Low arousal	9.0	11.8
High arousal	6.2	14.4

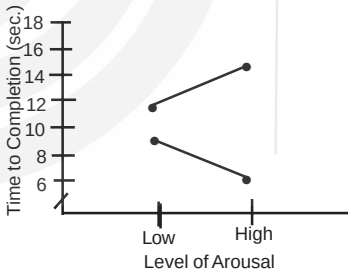
Graphs



a. Study I results



b. Study II results



c. Study III results

The concept of interaction can be understood clearly by looking at the graph rather than the table. The graph for study III shows the interaction between task complexity and arousal. The fact that the two lines on that graph for the simple and complex task groups, are not parallel to one another suggest that there is an interaction. Whether the lines diverge, converge or even cross whenever they are not parallel the variable interact. If they are parallel, then the relationship between the independent variables is an additive one.

Of course, in an actual research study the lines would rarely be perfectly parallel. There are statistical test that can tell us when they are close enough to parallel to indicate that there is no interaction, as well as when they deviate enough from parallel to indicate that there is an interaction.

2.4.4 Importance of Interaction

Main effect is an average effect. It can be misleading when an interaction is present. When interaction is present we should examine the effect of any factor of interest at each level of the interacting factor before making interpretation (Minimum et.al. 2001). The two factor design is really made up of several one factor experiments. In addition to main effect, the factorial design also allows us to test simple effect.

For example we have 2×2 design. One factor A has two levels A_1 and A_2 and other factor B has two levels B_1 and B_2. Main effects compare differences among the level of one factor averaged across all levels of the other. However, this particular design consists of four one way experiment and we may analyse each of them separately. We may be interested in effect of A (all two levels) specifically for condition B_2. Simple effects refer to the results of these one factor analysis. To make such comparison the interaction must first be significant.

Sometimes researcher is more interested in interaction than in a main effect. For example, a study involving two methods and learner of low and high intelligence. Research already established that individual with low intelligence learn more slowly than individuals with high intelligence. The researcher may not be interested in confirming the results, but may be interested to explore whether the relative difference in effectiveness of the two teaching methods is the same for slow learners and for fast learners, that is related to the question about the interaction between method and learning ability. It could be that method and learning ability interact to such a degree that one method is more effective with slow learner and the other is more effective with fast learner.

Self Assessment Questions

1) Given below are statement. Indicate whether they are true or false :

   i) Factorial design is used to study the effect of one independent variable.

   ii) Interaction effect can be study by single factor design.

   iii) The independent variables of an experiment is known as factors of the experiment.

   iv) In within subject factorial design each subject experience each condition.

   v) The 2×2 design means two independ variables with two levels.

2) Fill in the blanks :

   i) The interaction in which two independent variables tend to reverse each other's effect is known as .....

   ii) Interaction in which two independent variables reinforce each other's effect is known as .....

   iii) If graphical representation of a variables shows curves that are not parallel line it shows ..... between the variable.

   iv) The effect of one independent variable averaged over all levels of another independent variable is known as .....

2.5 TYPES OF FACTORIAL DESIGN

Factorial experiments may be conducted either within subject or between subject. A mixed factorial design is also used in psychology. A mixed factorial design is one that has at least one within subject variable and at least one between subject variable.

2.5.1 Within Subject Factorial Design

In an experiment by Godden & Baddeley (1975), researcher wants to study the effect of context on memory. They hypothesised that memory should be better when the condition at test are more similar to the conditions experienced during learning. To operationalise this idea Godden and Baddeley decided to use a very particular population : deepsea divers. The divers were asked to learn a list of 50 unrelated words either on the beach or under 10 feet of water. The divers were then tested either on beach or under sea. The divers were tested in both the environment in order to make sure that any effect observed could not be attributed to a global effect of one of the environment. The first independent variable is the place of learning. It has 2 levels (on the beach and under sea). The second independent variable is the place of testing. It has two levels (on the beach and under sea). These 2 independent variables gives 4 experimental conditions :

i) Learning on the beach and recalling on the beach.

ii) Learning on the beach and recalling under sea.

iii) Learning under sea and recalling on the beach.

iv) Learning under sea and recalling under sea.

Each subject in this experiment was tested in all four experimental condition. The list of words was randomly created and assigned to each subject. The order of testing was randomised in order to control the carry over effect. The layout of the within subject factorial design is presented below.

Table 2.5: A within subject factorial design

	learning place A	
Testing Place B	**Onland A_1**	**Under Sea A_2**
B_1	S_1 S_2 S_3 S_4 S_5 S_6	S_1 S_2 S_3 S_4 S_5 S_6
B_2	S_1 S_2 S_3 S_4 S_5 S_6	S_1 S_2 S_3 S_4 S_5 S_6

2.5.2 Between Subject Factorial Design

A between subject facotoria design is presented in the following table. The example is 2×2 design. Separate groups of six experience each condition, thus requiring 24 subjects to get six responses to each of four conditions.

Table 2.6: A between subject factorial design

Factor - A

Factor-B	A_1	A_2
B_1	S_1 S_2 S_3 S_4 S_5 S_6	S_{13} S_{14} S_{15} S_{16} S_{17} S_{18}
B_2	S_7 S_8 S_9 S_{10} S_{11} S_{12}	S_{19} S_{20} S_{21} S_{22} S_{23} S_{24}

2.5.3 Mixed Factorial Design

Some time the researcher uses mixed factorial design. Researcher has two independent variable A and B. Variable A is the within subject variable and variable B is the between subject variable. Subject either experiences B_1, once with A_1 and also with A_2; or they experience B_2 once with A_1 and also with A_2.

For example we want to study the effect of gender and alcohol on risk taking while driving. Here we have two independent variables gender (A) and alcohol level (B). Suppose we have decided to operationalise the independent variable 'alcohol level' by having four concentration levels. We decide to have each subject observed in each alcohol condition. The order of administration of each condition will be randomised for each subject. The measures are non repeated for the factor (A) gender and repeated for the factor (B) alcohol level.

Suppose we have 10 subjects 5 males and 5 females. The experimental lay out will be as follows :

Table 2.7

Between Subject Variables	Within Subject Variable			
A	B_1	B_2	B_3	B_4
A_1	S_1 S_2 S_3	S_1 S_2 S_3	S_1 S_2 S_3	S_1 S_2 S_3

	S_4 S_5	S_4 S_5	S_4 S_5	S_4 S_5
A_2	S_6 S_7 S_8 S_9 S_{10}	S_6 S_7 S_8 S_9 S_{10}	S_6 S_7 S_8 S_9 S_{10}	S_6 S_7 S_8 S_9 S_{10}

This example shows a situation in which you would have to use a mixed design.

2.6 ADVANTAGE OF FACTORIAL DESIGN

Factorial design enables the researcher to manipulate and control two or more independent variables simultaneously. By this design we can study the separate and combined effect of number of independent variables.

Factorial design is more precise than single factor design (Kerlinger, 2007).

By factorial design we can find out the independent or main effect of independent variables and interactive effect of two or more independent variables.

The experimental results of a factorial experiment are more comprehensive and can be generalised to a wider range due to the manipulation of several independent variables is one experiment.

2.7 LIMITATION OF FACTORIAL DESIGN

Sometime especially when we have more than three independent variables each with three or more levels are to be manipulated together, the experimental setup and statistical analysis become very complicated.

In factorial experiments when the number of treatment combinations or treatments become large, it becomes difficult for the experimenter to select a homogeneous group.

2.8 LET US SUM UP

Factorial designs are employed when one wants to study the independent and joint effect of two or more independent variables. There are different types of interaction such as antagonistic, synergistic and ceiling effect. Factorial designs may be conducted as within subject, between subject or they may be used in mixed experiments that have one within subject and one between subject variable.

2.9 UNIT END QUESTIONS

1) What do you mean by factorial design. Explain with example.

2) Differential with illustration the between group factorial design and within subject factorial design.

3) Discuss the advantage and limitation of factorial design.

4) What do you mean by interaction in factorial design. Discuss various types of interaction.

SAQ ANSWERS :

1) i) F ii) F iii) T iv) T v) T

2) i) antagonistic interaction ii) synergistic interaction
iii) interaction iv) main effect

2.10 GLOSSARY

Factorial design : Research design that involve all combination of at least two values of two or more independent variables.

Main effect : The effect of one independent variable averaged over all levels of another independent variable.

Interaction : When the effect of one independent variable depends on the level of another independent variable.

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UNIT 3 QUASI EXPERIMENTAL DESIGN

Structure

3.0 INTRODUCTION

For most of the history of scientific psychology, it has been accepted that experimental research, with its twin assets of random assignment and manipulation of the independent variable by the researcher, is the ideal method for psychological research. Some researchers believe this so strongly that they avoid studying important questions about human personality, sex differences in behaviour, and other subjects that do not lend themselves to experimental research.

A few decades ago researchers in psychology were interested in applied psychology issues conducting research on how students learnt in school, how social factors influenced the behaviour of an individual, how to motivate factory workers to perform at a higher level etc. These research questions cannot be answered by lab experiments as one has to go to the field and the real life situation like the classroom etc., to find answers to the research issues mentioned above. Thus the quasi experimental research came into existence. Quasi-experimental research design can be more easily implemented in natural settings and one can make direct assessment of subjects, find out the effects of a specific treatment introduced by the researcher, and while doing so the researcher can also minimise the influence of extraneous variables. In this unit we will discuss the quasi experimental design.

3.1 OBJECTIVES

After reading this unit, you will be able to:

- Define quasi experimental design;
- Differentiate between quasi experimental and true experimental design;
- Elucidate the different types of quasi experimental design; and
- Enumerate the advantages and disadvantages of quasi experimental design.

3.2 MEANING OF QUASI EXPERIMENTAL DESIGN

The word quasi means 'as if' or 'to a degree'. Thus quasi experimental design is one that resembles an experiment but lacks at least one of its defining characteristics.

According to Mcburney & White (2007) 'quasi experiment is a research procedure in which the scientist must select subjects for different conditions from preexisting groups'.

According to Broota (1989) "All such experimental situations in which the experimenter does not have full control over the assignment of experimental units randomly to the treatment conditions or the treatment cannot be manipulated are called quasi experimental design."

According to Singh (1998) "A quasi experimental design is one that applies an experimental interpretation to results that do not meet all the requirement of a true experiment."

According to Wikipedia, The quasi experimental design are related to the setting up a particular type of an experiment or other study in which one has little or no control over the allocation of the treatment or other factors being studied.

According to Shadish, Cook & Cambell (2002), "The term quasi experimental design refer to a type of research design that lacks the element of random assignment."

Quasi experimental designs are sometimes called ex-post facto design or after the fact experiment, because the experiment is conducted after the groups have been formed. The independent variable has already occurred and hence, the experimenter studies the effect after the occurrence of the variable. For example if we are interested in gender differences in verbal learning figures we would have to conduct a quasi experiment because we cannot assign participant to the two conditions male and female. We cannot create groups of males and females but instead select members from preexisting groups. In other words, we can say that in quasi experiments we do not manipulate variables but we observe categories of subjects. Matching instead of randomisation is used.

3.3 DIFFERENCE BETWEEN QUASI EXPERIMENTAL DESIGN AND TRUE EXPERIMENTAL DESIGN

In true experimental situation experimenter has complete control over the experiment. In quasi experimental situation, the experimenter does not have control over the assignment of subject to condition.

In true experimental design we manipulate variables but in quasi experimental design manipulation of variable is not possible, we observe categories of subjects. For example, If we want to study the effect of gender then we cannot manipulate gender we simply label groups according to what we think is the important difference between them.

In quasi experimental design we present some independent variables to two preexisting groups. We may not know whether the difference in behaviour was caused by difference between the groups or by the independent variable. A quasi experiment leaves open the possibility that other differences exist between the experimental and control conditions and thus permit other potential differences to remain.

Self Assessment Questions

1) Given below are statement, state whether statement are true or false :
   i) Trait anxiety is a quasi experimental variable.
   ii) Quasi experimental design have high internal validity.
   iii) Quasi experiment may be performed when a true experiment would be impossible.
   iv) In quasi experiment there is lack of random assignment of subjects in groups.
   v) These design are not useful in psychological research.
2) Fill in the blanks :
   i) It is possible to ..... subjects to conditions in a true experiment, in a quasi experiment it is necessary to ..... subject from preexisting groups.
   ii) The ..... validity of a quasi experiment is higher than true experiment.
   iii) The research design that allows the same group to be compared over time to known .....
   iv) In multiple time series design we have ..... groups.
   v) Manipulation of independent variable is made by ..... in quasi experimental design.
3) Descriptive question :

Answers:

1) (i) T (ii) F (iii) T (iv) T (v) F
2) (i) assign, select (ii) external (iii) time series design (iv) two (v) selection

3.4 TYPES OF QUASI EXPERIMENTAL DESIGN

There are many different types of quasi experimental designs that have a variety of applications in specific context. Here we will study some important quasi experimental designs.

3.4.1 Non-Equivalent Group, Posttest only Design

The non-equivalent, posttest only design consists of administering an outcome measure to two groups or to a program/treatment group and a comparison. For example, one group of students might receive reading instruction using a whole language program while the other group of students receives a phonetics based program. After twelve weeks, a reading comprehension test can be administered to see which program was more effective.

A major problem with this design is that the two groups might not be necessarily the same before any instruction takes place and may differ in important ways that influence what reading progress they are able to make. For instance, if it is found that the students in the phonetics groups perform better, there is no way of determining if they are better prepared or better readers even before the program and/or whether other factors are influential to their better performance.

3.4.2 Non-Equivalent Control Group Design

In this design both a control group and an experimental group is compared. However the groups are chosen and assigned out of convenience rather than through randomisation. The problem with this design is in determining how to compare results between the experimental and control group. For example, we are interested to study the effect of special training programmes, on the grade point average of 10^{th} grade students. The experimenter could not draw random sample as the school will not permit the experimenter to regroup the classes. Therefore researcher selected two sections of X grade from the same school. Because the subjects were not randomly allocated to the two groups we cannot say that groups are equivalent before the experimental manipulation was performed. We find out the grade point at the start of the programme and then again after the program. The group who does not receive treatment (training) is our control group.

This design may be diagrammed as shown below :

G_1	O_1	O_2
G_2	O_3	O_4

O = Observation

X = Treatment or experimental variable

Here we cannot say whatever difference we find in the grade point of two groups is because of training programme or because of some other confounding variable. It is possible that the student of one section who participate in training programme were inherently different in terms of motivation abilities, intelligence from those who did not participate.

3.4.3 The Separate Pretest -Posttest Sample Design

The basic idea in this design is that the people we use for the pretest are not the same as the people we use for posttest. The design may be diagrammed as shown below :

G_1	0	
G_1	X	0
G_2	0	
G_2		0

There are four groups but two of these one groups come from a single non equivalent group and the other two also come from other single non equivalent group. For example let us say, you have two organisations that you think are similar. You want to implement your study in one organisation and use other as a control. You design a program to improve customer satisfaction. Because customers routinely cycle through your organisation, you cannot measure the same customer pre-post. Instead you measure customer satisfaction in each organisation at one point in time, then implement your program and then once again measure customer satisfaction in the organisation at another point in time after the program. Here the customers will be different within each organisation for the pre-test and post-test. Here we cannot match the individual participant responses from pre to post. We can only look at the change in average customer satisfaction. Here non equivalence exists not only between the organisations but that is within organisation the pre and post groups are non-equivalent.

3.4.4 The Double Pre-Test Design

This is a very strong quasi experimental design with respect to internal validity. Because in pre-post non-equivalent group design the non-equivalent groups may be different in some way before the program is given and we may incorrectly attribute post-test differences to the program. Although the pre-test helps to assess the degree of pre-program similarity, it does not tell us if the groups are changing at similar rates prior to the program.

The double pre-test design includes two measures prior to the program. Consequently if the program and comparison group are maturing at different rates we can detect this as a change from pretest 1 to pretest 2. Therefore this design explicitly controls for selection maturation threats.

3.4.5 The Switching Replications Design

The Switching Replications quasi-experimental design is also very strong with respect to internal validity. And, because it allows for two independent implementations of the program, it may enhance external validity or generalisability. The design has two groups and three phases of measurement.

In the first phase of the design, both groups are pretested, one is given the program and both are post-tested.

In the second phase of the design, the original comparison group is given the program while the original program group serves as the “control”. This design is identical in structure to its randomised experimental version, but lacks the random assignment to group. It is certainly superior to the simple pre-post non-equivalent groups design.

3.4.6 Mixed Factorial Design with one Non-Manipulated Variable

This design can be explained by an experiment. In an experiment Edmund Keogh and Gerke Witt (2001) hypothesise that caffeine intake might influence the perception of pain and that the effect may be different in men and women. 25 men and 25 women took part in two sessions separated by a week. In one session the participants drank a cup of coffee that contained caffeine and in the other session, they drank decaffeinated coffee. In both the sessions the participants put their non dominant hand in ice water bath and to indicate the point of just noticeable pair.

Design of the Study		
	Coffee Beverage	
Gender	Decaffeinated	Caffeinated
Women	S_1	S_1
	S_2	S_2
	S_{25}	S_{25}
Men	S_{26}	S_{26}
	S_{27}	S_{27}
	S_{50}	S_{50}

The above is a mixed factorial design because it has one between subject variable (gender) and one within subject variable (caffeine).

3.4.7 Interrupted Time-Series Designs

These are the research designs that allow the same group to be compared over time by considering the trend of the data before and after experimental manipulation. (Mcburney & White, 2007).

In this design pre-testing and post-testing of one group of subject is done at different intervals. In the time series design, the purpose might be to determine the long term effect of treatment and therefore the number of pre-test and post-test can vary from one each to many. Sometimes there is an interruption between tests in order to assess the strength of treatment over an extended time period. This design can be diagrammed as below :

$$0_1 \ 0_2 \ 0_3 \ 0_4 \ X \ 0_5 \ 0_6 \ 0_7 \ 0_8$$

The above diagram shows that a series of pre-tests are given to a group. Then treatment (X) is given and a series of post-tests are given to the same subject. This design is different from single group pretest posttest design. In this we give the series of pretests and posttests to a subject, where as in the pre test post test design we give only single pretest and posttest.

3.4.8 Multiple Time Series Design

In this design we have two groups, one group receives treatment and the other group does not receive the treatment and this group acts as the control group.

This design can be presented as given in the diagram below :

Pre response measure	Treatment	Post response measure
G_1 0_1 0_2 0_3 0_4 0_5	X	0_6 0_7 0_8 0_9 0_{10}
G_2 0_1 0_2 0_3 0_4 0_5		0_6 0_7 0_8 0_9 0_{10}

It is usually a complex setting with many events and trends that might affect the behaviour in question. The addition of a comparison group for which the same series of measures is available, but which is not exposed to the treatment whose effects are being studied, can be useful in clarifying the relationship between the treatment and any change in the series of behavioural measures being used.

3.4.9 Repeated Treatment Design

Repeated treatment design is one in which a treatment is withdrawn and then presented the second time (McBurney and White, 2007).

In this design the treatment is presented more than once. The subject's response is measured before and after the introduction of a treatment, then the treatment is withdrawn and the whole process is began again. The design is shown in following table

Table : A Repeated treatment design

$Pretest_1$	Treatment	$Posttest_1$	Withdraw	Treatment	$Pretest_1$	$Posttest_2$

Repeated treatment design can be explained with the help of a study of the effect of a ban on alcohol consumption in a small community , let us say the Toda Community in Tamil Nadu. Let us assume that the government has put a ban on alcohol consumption as it is detrimental to the health of the workers in that area. To assess the impact of alcohol policy changes on the productivity of the workers, medical problems related to alcohol consumption etc., were studied. The results indicated that the productivity improved as a result of this ban amongst the community persons.

3.4.10 Counter Balanced Design

Such designs are also called cross-over design (Cochran & Cox, 1957). The name counter balance was given by Underwood (1949). In this design the experimental control is achieved by randomly applying experimental treatment. Here each treatment appears once and only once in each column and in each row. A counter balance design in which four treatment have been randomly given to four groups on four different occasion is given below :

Group-A	X_1	X_2	X_3	X_4	0
Group-B	X_2	X_4	X_1	X_3	0
Group-C	X_3	X_1	X_4	X_2	0
Group-D	X_4	X_3	X_2	X_1	0

Variables like maturation, selection and experimental mortality posing threats to internal validity are well controlled by the counter balance design.

3.5 ADVANTAGES AND DISADVANTAGES OF QUASI EXPERIMENTAL DESIGN

Advantages

In social science, where pre selection and randomisation of groups is often difficult, they can be very useful in generating results for general trends.

E.g. if we study the effect of maternal alcohol use when the mother is pregnant, we know that alcohol does harm embryos. A strict experimental design would include that mothers were randomly assigned to drink alcohol. This would be highly illegal because of the possible harm the study might do to the embryos.

So what researchers does is to ask people how much alcohol they used in their pregnancy and then assign them to groups.

Quasi-experimental design is often integrated with individual case studies; the figures and results generated often reinforce the findings in a case study, and allow some sort of statistical analysis to take place.

In addition, without extensive pre-screening and randomisation needing to be undertaken, they do reduce the time and resources needed for experimentation.

Since quasi-experimental designs are used when randomisation is impossible and/or impractical, they are typically easier to set up than true experimental designs.

Utilising quasi-experimental designs minimises threats to external validity as natural environments do not suffer the same problems of artificially as compared to a well-controlled laboratory setting.

Since quasi-experiments are natural experiments, findings in one may be applied to other subjects and settings, allowing for some generalisations to be made about population.

This experimentation method is efficient in longitudinal research that involves longer time periods which can be followed up in difference environments.

Quasi-experimental design is often integrated with individual case studied; the figures and results generated often reinforce the findings in a case study, and allow some sort of statistical analysis to take place.

In addition, without extensive pre-screening and randomisation needing to be undertaken, they do reduce the time and resources needed for experimentation.

Disadvantages

Without proper randomisation, statistical tests can be meaningless.

A quasi experiment constructed to analyse the effects of different educational programs on two groups of children, for example, might generate results that show that one program is more effective than the other. These results will not stand up to rigorous statistical scrutiny because the researcher also needs to control other factors that may have affected the results.

The lack of random assignment in the quasi experimental design method may allow studies to be more feasible, but this also poses many challenges for the investigator in terms of internal validity. This deficiency in randomisation makes it harder to rule out confounding variables and introduces new threats to internal validity.

Because randomisation is absent, some knowledge about the data can be approximated, but conclusions of causal relationships are difficult to determine due to a variety of extraneous and confounding variables that exist in a social environment.

Moreover, even if these threats to internal validity are assessed, causation still cannot be fully established because the experimenter does not have total control over extraneous variables.

Thus one may conclude that disadvantages aside, as long as the shortcomings of the quasi experimental design are recognised, these studies can be a very powerful tool, especially in situations where 'true' experiments are not possible.

These are very useful to obtain a general overview and then follow up with a case study or quantitative experiment so as to focus on the underlying reasons for the results generated. They are very useful methods for measuring social variables.

3.6 LET US SUM UP

Quasi experiments may be performed when a true experiment is not possible. The main difference between true experimental design and quasi experimental design is random assignment of subject in groups. In quasi experimental design researcher does not have control over the assignment of subject to condition. There are different types of quasi experimental design. Some design involve two groups and other have single group. Some commonly used quasi experimental designs are non equivalent control group design, the separate pretest protest design, the double pretest design, mixed factorial design, interrupted time series design, multiple time series, design etc., repeated treatment design etc. The main advantage of quasi experimental design is that these can be used when randomisation of the group is impossible and or impractical. Because of the lack of random assignment the internal validity of quasi experimental design is very low. In these design there are possibility of selection bias because the participant are not randomly assigned.

3.7 UNIT END QUESTIONS

1) Define and describe the quasi experimental design.

2) Differentiate between true experimental design and quasi experimental design.

3) Discuss with example the non equivalent control group design.

4) What are the various types of quasi experimental designs.

3.8 GLOSSARY

Quasi experiment : Research procedure in which the scientist must select subjects for different conditions from preexisting groups.

Non-equivalent control group design : Research design having both an experimental and a control group wherein subjects are not randomly assigned to group.

Counter balance design : The design in which each treatment appeare once and only once in each column and row.

Interrupted time series design : Research design that allows the same group to be compared over time by considering the trend of the data before and after experimental manipulation.

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UNIT 4 OTHER DESIGNS (CORRELATIONAL DESIGN AND COMPARATIVE DESIGN)

Structure

4.0 INTRODUCTION

The experimental designs which we discussed in first two units provide the most powerful means of studying the behaviour. As you know the important features of experimental design is manipulation of independent variable and control over the experiment. The researcher has enough control over the situation to decide which participant receives which condition at which time. Sometimes the researchers are interested in some variables which cannot be manipulated by the experimenter, where researcher does not have control over the who, what, when, where and how. For example if we are interested to study:

a) Whether scholastic achievement depended upon the general intelligence of a child?

b) Does there exist gender difference in aggression?

c) Is there any relationship between the sise of the skull and the general intelligence of the individual?

Many such questions may arise from time to time for which we may try to find answers through research. To answer such research questions we have to use

non-experimental research design. The most commonly used non-experimental research designs are correlational research design and causal comparative research design. Correlational research design involves correlation between two variables and causal comparative research design involves comparing two groups in order to explain existing differences between them on some variable or variables of interest. In this unit we will learn about correlational research design and causal comparative research design.

4.1 OBJECTIVES

After studying this unit, you will be able to:

- Define correlational design;
- Enumerate the types of correlational design;
- Describe the advantages and limitations of correlational design;
- Define causal comparative design;
- Differentiate between causal and correlation designs; and
- Enumerate the advantages and limitations of causal comparative design.

4.2 DEFINITION OF CORRELATIONAL RESEARCH DESIGN

Correlational research designs are founded on the assumption that reality is best described as a network of interacting and mutually causal relationship. Everything affects and is affected by everything else. This web of relationship is not linear. Thus, the dynamics of a system, that is how each part of the whole system affects each other part is more important than causality. The correlational investigations attempt to compare the level of one variable with those of another to see if a relationship exists between the two. The correlational design is a quantitative design.

According to Singh, (1998), Correlational design is one in which the researcher collects two or more sets of data from the same group of subjects so that the relationship between the two subsequent sets of data can be determined.

Correlational research design is one which studies relationship among variables, none of which may be the actual cause of the other (Mcburney & White, 2007).

On the basis of above definitions it can be stated that correlational design is one which have two or more quantitative variables from the same group of subjects and which shows the relationship between the two variable.

The correlational design may be diagrammed as follows :

X1	X2
O1	P1
O2	P2
O3	P3
.	.
.	.
.On	Pn

The relationship indicated by the symbol r will be the relationship between the observations (O1 ….On) of X1 and (P1….Pn) of X2

4.3 TYPES OF CORRELATIONAL RESEARCH DESIGN

Correlational designs can be broadly categorised in two broad divisions:

1) Those that measure the degree of association between variables and (2) Those that are used to Predict the score on one variable using knowledge about the one or more variables.

   Within the former, that is those that measure the degree of association between variables, we have (a) Association between two variables and (b) Association amongst more than 2 variables. These are being presented below.

   For example let us say a researcher wants to study the relationship between academic stress and academic achievement of college students. For this let us say that the researcher randomly selects 100 college students and administers the measure of academic stress and subsequently a test of academic achievement. Thus the researcher will have two sets of data.

   a) **Association between two variables**

   A correlation coefficient can be calculated from those 100 pairs of numbers. Theoretically it could take a positive or negative absolute value between -1.00 to 0.00 to +1.00. The larger the coefficient, whether positive or negative, the more consistent the relationship between the two variables.

   If the coefficient takes a positive value it means the individual who is higher on one variable (X1) will higher on second variable (X2). This is sometimes referred to as a *direct relationship*. If the coefficient takes a negative value between 0 and -1.00, it would indicate that those who have obtained higher scores on X1 will have lower scores on X2. In our above example if the correlation is negative it means that those who scored high on academic stress will have low academic achievement. This is some time referred to as an *inverse relationship.*

   b) **Association between more than two variables**

   So what if academic stress and academic achievement have significant correlation ? And what if study habits, intelligence and other factors were also associated with academic achievement. We could measure the association between all these variables in the same group of children. We administer tests for the measurement of study habit and intelligence and obtain scores on the same group of subjects and find out the multiple correlation.

2) Those that are used to pedict the score on one variable using knowledge about the one or more variables.

If there is a correlation between two variables, and we know the score on one, the second score can be predicted. In this type of situation there are two variables, one variable that is used to make a forecast about an outcome is known as *predictor variable* and the other variable, is what we are trying to predict is known as *criterion variable.*

By way of regression analysis we can make this prediction. For example there is a relationship between stress and health. If we know the stress score, by way of regression analysis we can predict the future health status score.

Some time the researchers have more than one predictor variable and one criterion variable. The combination gives us more power to make accurate predictions. for example if we have stress scores as well as health behaviour score and past health score then one can make more accurate prediction of health status. Here we have three predictors, stress, health behaviour and previous health status and one criterion variable future health.

4.4 EVALUATION OF CORRELATIONAL DESIGN

The advantages and disadvantages of the correlational designs are presented in the following section. First we deal with advantage and then the disadvantages.

4.4.1 Advantages

The correlational designs are used in many cases because available data makes it easy to use. Some more careful researchers use the result of correlational studies to formulate new hypothesis which they can test later using more rigorous research design rather than test hypothesis about cause and effect directly.

Correlational design is used as the foundation for other designs that permit more certain causal inferences to be drawn from results.

It usually does not involve repeated administration of a behavioural measure, thus avoiding pretest sensitisation.

It usually uses very realistic measurements of behaviour and its possible causes as well.

Correlational research thus avoids the problem of non-representative research context. It also permits the use of large carefully chosen sample thus avoiding the threat of non representative sample of participant.

4.4.2 Disadvantages

The major disadvantage of correlational designs is that they leave the actual reason for the association found quite unclear. For example there is a positive correlation between exposure to violent program on television and violence on the playground. If we find the correlation rather positive and high, we may be tempted to conclude that exposure to violent television causes children to be aggressive and violent. But such a conclusion is completely unwarranted.

Rarely does a correlational study allow inferences about cause and effect. In this case, there are many other possible explanations for the relationship. For example, perhaps children with parents who neglect and physically abuse them just pop them in front of the TV at night, when the violent shows tend to be on. These children may have learned from the parent's abuse and neglect, that aggression and violence are acceptable ways of relating to others, and so they do it on their own around their classmates. In such a case, the obtained association between exposure to violent television and actual violent behaviour may be spurious. That is, a third variable parental neglect and abuse cause them both.

Another possible explanation is that children who tend to be violent, for whatever reason, tend to prefer watching violent television shows. It is not that the violent television causes the violent behaviour. Instead, some children are dispositionally violent (that is, due to personality or genetics also other variables) and it is this that determines both the preference for violent TV shows and the playground aggressiveness.

Correlational designs have directional problem. The causation is reversed from the expected direction. The designation of one of the variables as the independent variable and one as the dependent variable is arbitrary, compared to a true experiment, in which the independent variable is manipulated by the researcher. Children may watch violent television program because they behave aggressively rather than the other way round. Television program may validate their choice of activities by showing others who do the same, or children may watch to learn more about how to behave violently.

Hence, the internal validity of the correlational design is very low.

4.5 WHAT ARE THE STANDARD OF QUALITY USED WHEN ASSESSING CORRELATIONAL DESIGN

Researchers must choose the variables to use within a correlational analysis with great care. A sound theory that takes alternative explanations into account should be used to determine which variables are of immediate interest.

Correlation is based on the assumption that the variables in question are related linearly and do not suffer from multicollinearity.

Care must be taken to ensure that artificially restricted distributions, missing data, and deviant cases or outliers are addressed.

Correlational studies can be made more powerful by using statistical techniques that themselves allow for the partial control of third variables, when those variables can be measured. Correlational statistics such as hierarchical multiple regression, path analysis, and structural equation modeling all fall into this category. These statistics, in essence, allow the correlation between two variables to be recalculated after the influence of other key variables are removed. Thus these types of correlational statistics and designs help to rule out certain causal hypotheses, even if they cannot demonstrate the true causal relation definitely.

The most important thing to look for in a correlational study, when determining its validity, is the controls that the researcher puts into place to control the extraneous variables influence.

4.6 CAUSAL COMPARATIVE RESEARCH DESIGN

There are many occasions while conducting research in psychology, where the researcher is unable to control the independent variable. Or it may be that the researcher finds it rather unethical to control the independent variable, or it could also be that it is too difficult to control the independent variable. To cite an example, let us say that the researcher wants to study “the effect of gender on aggression”, here the independent variable is gender and dependent variable is

aggression. Researcher cannot manipulate independent variable i.e. gender. Another example is that if the researcher is interested in studying the effect of diet (vegetarian V/s. non-vegetarian) on mental health, here again the independent variable which is cannot be manipulated, as it is unethical to manipulate the diet from vegetarian to non vegetarian as there are people who are purely vegetarians. In these types of situation the researcher uses a causal comparative research design rather than an experimental design for the research.

The basic design of a causal-comparative research study is to select a group that has the independent variable (the experimental group) and then select another group of subjects that does not have the independent variable (the control or comparison group). The two groups are then compared on the dependent variable. For example, in school, some of the seventh grade math classes use hand held calculators. We want to find the effect of calculator use on mathematics grades at the end of the year. So we select a group of students from the classes which use calculators and then select another group of the same sise from the classes who do not use calculators and then compare the two groups at the end of the year on their final math grades. Another variant of this study would be to take the students from one class that uses calculators and compare them with another class that does not use calculators. Both these studies would be causal comparative research studies.

Instead of using an experimental group and a control group as in the study considered above, we could have a causal comparative research study in which two or more groups differ in some variable that constitutes the independent variable for the study. For example in a study researcher might wish to compare students at four different age levels (or grade levels) on their amount of participating in extra-curricular activities. The researcher could look at the number of extra-curricular activities participated in by four groups of students. The first group would be students in grades 1-3, the second group students in grades 4-6, the third group students in grades 7-9, and the fourth group students in grades 10-12. The independent variable in this study would be grade placement and the dependent variable would be participating in extra-curricular activities. Thus the research would focus on the effect of grade levels on participation in extra-curricular activities for public school students grades 1-12.

Causal comparative research attempts to identify a causative relationship between an independent variable and a dependent variable. However this relationship is more suggestive than proven as the researcher does not have complete control over independent variable.

Causal comparative design compares two or more groups on one variable. Causal comparative design is used to determine the cause for or consequences of existing differences in groups of individuals. For example the researcher may be interested in finding out the differences in performances of students taught by inquiry teaching method and by lecture teaching method.

Self Assessment Questions

1) Given below are statements, state whether statement are true or false :

   i) Correlational design is a quantitative design of research.

   ii) Causal comparative research design is an experimental design.

iii) Correlational design avoids the threat of non-representative sample of participation.

iv) Causal comparative research design attempt to identify a causative relationship between an independent variable and dependent variable.

v) In causal comparative design researcher manipulate the independent variable.

2) Fill in the blanks :

i) Correlational design studies the ..... between the variables.

ii) Coefficient of correlation expresses the ..... and ..... of relationship between the variables.

iii) Causal comparative research looks at ..... between the groups.

iv) Correlational design and causal comparative design both are ..... research design.

v) When it is possible to manipulate the independent variable then we use ..... design.

Answers:

1) i) T ii) F iii) T iv) T v) F

2) i) relationship ii) degree, direction
iii) comparison iv) non-experimental
v) experimental

4.7 COMPARISON BETWEEN CAUSAL-COMPARATIVE AND CORRELATIONAL DESIGNS

4.7.1 Similarity

Both are non-experimental methods because they lack manipulation of an independent variable which is under the control of the experimenter and hence in both the cases, random assignment of participants is not possible. This means among other things the variable must be observed as they occur in the natural setting.

In both the designs, techniques used for controlling confounding variables is the same. In both the methods matching or quota sampling techniques are used to control confounding extraneous variables.

In both the research the most common type of independent variable used are called attribute variable (Kerlinger, 1986). They cannot be manipulated by the researcher, they represent characteristics or attributes of different persons.

Like correlational research, causal comparative research is sometimes treated as a type of descriptive research since it too describes conditions that already exist.

4.7.2 Differences

Causal comparative research involves comparing two groups in order to explain existing differences between them on some variables of interest. In causal comprehensive research the groups being compared have already been formed and if any treatment (if there was a treatment), it also has already been applied.

Correlational research on the other hand does not look at differences between groups. Rather it looks for relationship within a single group.

Causal comparative research compares groups but the correlational research looks at one group having nothing to do with establishing evidence of causality.

In correlational research some, independent variable is labelled as predictor variable but not in causal comparative research.

Both designs differ on the scaling of the independent and/or dependent variables. Causal comparative researches include at least one categorical variable. The correlational research includes only quantitative variables. i.e. intelligence, attitude, age, income, job satisfaction etc.

4.8 COMPARISON BETWEEN CAUSAL COMPARATIVE AND EXPERIMENTAL DESIGN

Causal comparative and experimental research both attempt to establish cause effect relationship and both involve comparison. But there are difference between two methods.

In experimental design researcher select a random sample and then randomly divide the sample into two or more groups. Groups are assigned to the treatment and the study is carried out.

In causal comparative design individuals are not randomly assigned to treatment groups because they already were assigned into groups before the research began.

In experimental research the independent variable is manipulated by the researcher whereas in causal comparative research the groups are already firmed and already different on the independent variable. Independent variable in causal comparative cannot be manipulated by the researcher.

4.9 DATA ANALYSIS FOR CAUSAL COMPARATIVE RESEARCH DESIGN

An inferential statistic used in both causal comparative and experimental research designs is the t-test. Where the subjects in the two groups are independent of one another, that is no matching of subjects or other control procedures were used, the independent t-test is used to test the significance of a difference between the means of the two groups in the study.

In research designs where the influence of an extraneous variable has been controlled, or in designs utilising a pre-test-post-test procedure, the appropriate t-test to use to compare the two group would be the dependent t-test.

When we have three or more groups to compare, the appropriate inferential statistic to use would be one-way analysis of variance. This statistics shows the significance of differences in the means of three or more groups of subjects.

In cases where we are using frequency counts for the dependent variable, the appropriate inferential statistic to use would be the chi-square test. This statistic tests the significance of differences between two or more groups (independent variable) in frequencies for the dependent variable. For example, a high school social studies teacher wants to see if the major party political affiliation for students is similar to or different from that of the registered voters in the country where the high school is located. The teacher would ask the students (anonymously) to indicate whether they would support the democratic party or the republican party. The proportion of students selecting the democratic or republican parties would be compared with the country's proportions of democratic and republican voters.

4.10 EVALUATION OF CAUSAL COMPARATIVE RESEARCH DESIGN

4.10.1 Advantage

For the behavioural science causal comparative research is more fruitful than experimental study. Because there are number of organismic variables such as age, gender etc. cannot be manipulated by the researcher similarly sometime the nature of the independent variable is such that it may cause physical or mental harm to participants if it is manipulated by the researcher. For such type of variables the causal comparative research design is more fruitful.

Experimental studies are more costly than causal comparative studies. Causal comparative studies help to identify variable worthy of experimental investigation.

Causal comparative research do permit investigation of variables that cannot, or should not be investigated experimentally, facilitate decision making, providing guidance for experimental studies and are less costly on all dimensions.

But despite many key advantages causal comparative research does have serious limitation.

4.10.2 Limitation

Since the independent variable has already occurred the same kind of control cannot be exercised as in experimental study.

In causal comparative research manipulation of independent variable is not done by the researcher, the alleged cause of an observed effect may in fact be the effect itself, or there may be third variable that influence both cause and effect. For example a research hypothesised that self concept is a determinant of reading achievement. For this researcher administered a self concept test on a group of subjects and identify two groups with one group having high self esteem and one group having low self esteem. If the high self esteem group shows high reading achievement, we conclude that self esteem influence reading achievement. Here it is difficult to establish whether self esteem causes achievement or vice versa. Because both the independent variable and dependent variable would have already occurred, it would not to be possible to determine which came first. It

would be possible that some third variable, such as parental attitude might be the main influence on self esteem and achievement. Therefore caution must be exercised in attributing cause effect relationship based on causal comparative research.

In causal comparative research the researcher cannot assign participant to treatment groups because they are already in those groups.

One of the problems with causal comparative research is that since the pupil are not randomly placed in the groups, the groups can differ on other variables that may have an effect on the dependent variable. In experimental research we can assume that these other variables cancel out among the study groups by the process of randomisation.

4.11 LET US SUM UP

The correlational designs are used when we have two or more quantitative variables from the same group of subjects and we are interested to determine if there is a relationship between two variables. Correlation does not show a causal relation, it can be used for prediction.

Causal comparative design compare two or more groups on one variable. This design does permit investigation of variables that cannot or should not be investigated experimentally. Correlational design and causal comparative design both are non-experimental designs. But one studies the relationship between variables and the other studies the difference between variables.

4.12 UNIT END QUESTIONS

1) When to use correlational and causal comparative research design.

2) Write down the advantage and limitation of correlational design.

3) What are the similarities and differences between correlational and causal comparative research.

4) What are the advantage and limitation of causal comparative design.

4.13 GLOSSARY

Correlational design : Correlational research design is one which studied relationship among variables none of which may be the actual cause of other.

Coefficient of correlation : Degree and direction of relationship among variables. The coefficient of correlation usually expressed as number between -1 to +1.

Causal comparative design : Research design compare two or more groups on one variable.

4.14 SUGGESTED READINGS

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