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.

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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.