I. One Factor Designs

1. There are many experimental designs that can be employed in doing studies of one factor.

2. For example, **pretest-posttest designs**, **randomized two-groups design**, **randomized multigroups design**, and **related groups design**.

3. What do all of these designs have in common? Only one independent variable. But there may be more than two levels of the independent variable.

II. Pre-Post Design

1. Some researchers pretest subjects on the dependent variable prior to the introduction of the independent variable. Pretesting is an additional control procedure that can be incorporated into an experimental design.

2. Generally, we refer to designs with a pretest as **pre-post**, or **before-after**, designs and to those without a pretest as **posttest-only** or **after-only**, designs.

3. The decision to use a pretest-posttest design procedure depends upon the nature of the research problem. Sometimes researchers use pretesting to equalize performances of subjects on the dependent variable by letting all subjects practice the appropriate response until they reach some criterion level of performance before introduction of the independent variable.

4. This technique, which is often called **training to criterion**, is helpful when the task is
A. For example, the double blind slide test and the chimpanzees naming pictured objects.

B. The executive monkey study where monkeys were trained to press a lever to avoid a shock.

5. Pretesting may also be used to check on the effects of the subject assignment procedure. As you remember, the purpose of all subject assignment procedures is to create groups of equivalent subjects.

6. If differences do exist, the researcher can use the pretest score of each subject as a baseline measure. Instead of using posttest measures of the dependent variable to evaluate the effect of the treatment, researcher could derive some kind of change score, or difference score, that reflected the difference between subject's pretest score and posttest score.

7. The simplest pretest-posttest design would be the one group pretest-posttest design involving three steps.

\[
\begin{align*}
O &= \text{Observation} \\
X &= \text{Treatment} \\
O \rightarrow X \rightarrow O
\end{align*}
\]

8. The first step is the administration of a pretest measuring the dependent variable. The second step is the application of the experimental treatment (independent variable) to the
subjects, and the final step is the administration of a posttest measuring the dependent variable again.

9. F. T. Smith's (1943) study of changes in college students' attitudes toward black people provides a good example of a study that employed this design.

10. In this study Smith administered his pretest, an attitude scale measuring attitudes toward blacks, to a sample of 345 college students at Columbia University. Of this sample he selected 46 students who were representative of the larger group tested.

11. These students were then exposed to the experimental treatment, that is, a series of favorable contacts with blacks, such as having dinner with a black family, visiting a black church, meeting leaders of the black community of Harlem. These contacts extended over a four-day period.

12. Ten days after the last planned contact with blacks, Smith posttested his group using the same attitude measure and found that the mean attitude had changed significantly in favor of blacks.

13. Then, after waiting ten months, Smith administered still another posttest to determine how much of the favorable attitude change had persisted.

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14. The major limitation of the single-group design is that, as no control group is used, the experimenter must assume that changes between the pretest and posttest were brought about by the experimental treatment.

15. There is always some chance, however, that one or more extraneous variables brought about all or part of the change noted between the pretest and the posttest scores.

16. The research worker should use the one-group pretest-posttest design only when the dependent variable is reasonably stable, when the interval between the pretest and the posttest can be kept short, and when it is impossible to obtain a control group.

17. The statistical analysis of data obtained using this design is fairly simple. Usually the pretest and posttest means are compared for statistical significance using the \( t \) test for correlated means. If the scores on either the pretest or posttest show marked deviation from the normal distribution, a nonparametric statistic should be used. Most likely the research worker would select the Wilcoxon signed-rank test.

18. Nearly any study that can be conducted using a single-group design can be carried out more satisfactorily using one of the control group designs.

19. The essential difference between the single-group design and the control-group design is that the latter employs at least two groups of subjects, one of which is called the control group and is included primarily to make it possible to measure the effect of extraneous factors upon the posttest.

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20. The experience of the experimental and control groups are generally kept as identical as possible with the exception that the experimental group is exposed to the experimental treatment.

21. If extraneous variables have brought about changes between the pretest and posttest, these will be reflected in the scores of the control group. Thus, only the posttest change of the experimental group that is over and above the change that occurred in the control group can be attributed to the experimental treatment.

22. The pretest-posttest control-group design is one of the most commonly used experimental designs by educational researchers.

23. It involves the following steps: (1) random assignment of subjects to experimental and control groups, (2) administration of a pretest to both groups, (3) administration of the treatment to the experimental group but not to the control group, and (4) administration of a posttest to both groups.

24. It should be noted that these steps apply to a special case of the pretest-posttest control-group design. This is the case where the control group receives no treatment from the experimenter except a pretest and a posttest.

25. In certain situations the experimenter may want to administer an alternative experimental treatment to the control group.

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26. Analysis is done on the change score (change score = Posttest score - Pretest score) or the difference score.

27. The statistical analysis can be done in several ways. The easiest way is a t-test on the difference scores. A second way and a better analysis would be the analysis of covariance (ANCOVA), in which the posttest means are compared using the pretest means as the covariate. A third way would be to use Multiple Regression Correlation with the posttest scores regressing on the pretest scores.

28. Example, Marijuana and driving errors. Pretest - Posttest design two groups of subjects. Both getting the test in advance and after the treatment. The analysis is base on difference score.

<table>
<thead>
<tr>
<th>Table 8-1. Scores from Hypothetical THC Experiment</th>
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</thead>
<tbody>
<tr>
<td>Performance on Dependent Measure</td>
</tr>
<tr>
<td>Control Group</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>24</td>
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<td>18</td>
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<tr>
<td>29</td>
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<tr>
<td>19</td>
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<tr>
<td>Mean 23</td>
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III. Randomized Two-Groups Design

1. A randomized two-groups design is used when the research hypothesis or problem involves the comparison of two treatment conditions.

2. When using this design, you randomly assign subjects to one of two treatment conditions, manipulate the independent variables, control all possible extraneous variables (secondary variables), and measure the response of subjects in both groups.

3. If these scores are significantly different (based upon the appropriate statistical test), you would attribute the obtained difference in performance to the independent variable. This design may be summarized in the following way:

   \[ X \rightarrow O \quad \text{experimental group} \]
   \[ \quad \rightarrow O \quad \text{control group} \]
   or
   \[ X_1 \rightarrow O \quad \text{experimental group 1} \]
   \[ X_2 \rightarrow O \quad \text{experimental group 2} \]

4. Example, would cockroaches run through a maze faster if other cockroaches were present? Zajonc, Heingartner and Herman (1969)\(^2\) tested the hypothesis that cockroaches would run faster through a simple maze when other roaches were present than when they had to run alone.


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5. The hypothesis is based on the principle of social facilitation: In the presence of an audience, the performance of some behaviors improves. Cockroaches should do better in some mazes when other roaches are present.

6. We can test this hypothesis using two independent groups. One group, the experimental group, runs through the maze in the presence of an audience. The control group runs with no one watching.

7. The dependent variable is the average time it takes each group to run the maze. The subjects must be assigned at random to each condition.

8. The statistical test appropriate for any experimental design with a single independent variable depends upon three basic factors:
   
   A. the level of measurement of the dependent variable
   
   B. the number of levels of treatment
   
   C. and the nature of the relationship between subjects assigned to various treatment.

9. If the scales of measurements are nominal or ordinal use chi-square or the Mann-Whitney U. If the scales of measurements are interval or ration use the t-test between means or the analysis of variance.

10. Randomized two-group designs use random assignment to control the potential influence

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of organismic variables (individual differences).

11. The assumption behind this strategy is that subjects with different organismic characteristics will be randomly distributed among the various treatment conditions.

12. Another example is the Brady\(^3\) study of ulcers in "executive" monkeys. In this study monkeys were divided into two groups. An "executive" group was given control of a button connected to an apparatus that produced electric shock.

13. The "executive's" task was to prevent a painful electric shock by hitting the control button at least once every 20 seconds. Each "nonexecutive" was coupled (or \textit{yoked}) with an executive. If the executive failed to hit the button in time, the nonexecutive would also receive a shock. The nonexecutives had no control over the shock; only the executives could prevent it.

14. The independent variable in Brady's experiment was control over the shock. The executives had control; the nonexecutives had none. The dependent variable was the development of gastrointestinal ulcers.

15. Brady hypothesized that monkeys that had the responsibility of remaining vigilant and preventing the shock would be more apt to develop ulcers. In other words, their "executive" responsibilities in the experiment would be stressful; they would develop ulcers just as a hard-driving human executive might.

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16. After the experimental phase of the experiment ended, Brady sacrificed the monkeys and studied their tissues for signs of ulcers. As predicted, the "executives" had many ulcers; the "nonexecutives" did not.

17. On the face of it, his experimental procedure appears sound. Brady devised a controlled task that would presumably be more stressful to one treatment group than the other. Executives and nonexecutives were coupled together so that both received the same total number of shocks. The only difference was the degree of control the monkeys had over the shock.

18. The problem with this design is that Brady had used a pretest to determine which monkeys in each pair could learn to avoid the shock more quickly, and this monkey was then made the executive. The subjects were not randomly assign to treatment conditions. These two groups may not have been equal.

IV. Randomized Multigroups Design.

1. The randomized multigroups design differs from the randomized two-group design in the number of groups or levels of the independent variable.

2. Multigroups designs contain three or more groups of subjects receiving different treatment

\[ X_1 \rightarrow O \quad \text{experimental group 1} \]
\[ X_2 \rightarrow O \quad \text{experimental group 2} \]
\[ \rightarrow O \quad \text{control group} \]

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or

\[ X_1 \rightarrow O \quad \text{experimental group 1} \]
\[ X_2 \rightarrow O \quad \text{experimental group 2} \]
\[ X_3 \rightarrow O \quad \text{experimental group 3} \]

3. Example, study of aggressive behavior in siamese fighting fish. The three group design and the five group design.


5. The meaning of the F ratio -- the F ratio is treatment effect plus experimental error divided by experimental error. That is between-group variability divided by within-group variable. The between-group variability is the variability of the treatment level means from the grand mean, whereas, the within-group variability is the individual subjects within treatment levels.

6. When the observed value of F is significant, the researcher can conclude that differences exist among the treatment means. However, the significant F value doesn't tell the researcher which of the three (or more) means are different.

7. In order to obtain this information, the researcher should have to make comparisons between all pairs of means.

8. Randomized multigroups designs have the same general advantages and limitations as the randomized two-group designs. The only difference between the two-groups and the
multigroups designs is the number of levels of the independent variable.

V. Matched Pairs Designs

1. In order to use the matched pairs design, you must identify organismic, or subject, characteristics, that is characteristics related to performance on the dependent variable.

2. Then you select pairs of individuals who have comparable values on these variables, and randomly assign them to the various levels of treatment.

3. Matched two-group designs are more common than multigroups designs because of the difficulty of obtaining three or more subjects with comparable performance on the matching variables.

4. Experimental design would look like this:

   \[
   M -- X -- O \quad \text{experimental group (} M=\text{matched subjects)}
   
   M -- \quad \quad O \quad \text{control group}
   
   \text{or}
   
   M -- X_1 -- O \quad \text{experimental group 1}
   
   M -- X_2 -- O \quad \text{experimental group 2}
   \]

5. Example, studying the effect of teaching methods on academic performance, you may match subjects on Intelligence.

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6. If the dependent variable scores are based upon interval and ratio measurements, you would generally use a correlated (related-sample) t-test to evaluate the significance of the results.

7. The advantage of using a related groups designs is that by matching the subjects you control for organismic variables (individual differences). When the available number of subjects is very small, a related groups design is more effective than a randomized groups design in equating groups prior to the introduction of the independent variable.

8. Another advantage of the related groups designs is that by matching the subjects you reduce the error term in the correlated t test ratio. Thus increasing the chance of obtaining a significant t value.

9. A major limitation of this design is the difficulty involved in identifying a relevant matching variable. If the matching-variable scores are not closely related to the dependent-variable scores, the design will not equate the groups appropriately before the introduction of the treatment.

10. Consequently, the researcher could draw invalid conclusions about the effectiveness of the independent variable.

VI. Within-Subjects Designs

1. Within-Subject designs are single group designs, or repeated measurement designs; that is, each subject is exposed to all treatments. As you imagine, repeated measurements is
a logical extension of matching to control organismic variables.

2. Like the randomized groups designs, within-subjects designs may contain two levels of the independent variable or more than two levels of the independent variable.

3. Even though subjects are not randomly assigned to treatment conditions, within-subjects designs are considered experimental designs as long as the investigator can directly control the appearance of the independent variable and can eliminate or control extraneous variables that may confounded with the effects of the independent variable.

4. Every within-subject design is vulnerable to order effects that may be confounded with the independent variable, you must incorporate into the experimental design a special control known as counterbalancing.

5. This control works by distributing the order effects equally over all treatments. This is accomplished by having each treatment follow every other treatment an equal number of times. Thus order effects that do arise influence each treatment in an equivalent fashion.

6. There are two major approaches to counterbalancing: Intrasubject counterbalancing distributes order effects over the trials for a single subject; Intragroup counterbalancing distributes these effects over the trials for the entire group of subjects.

7. Intrasubject counterbalancing is commonly used when you have two levels of the independent variable and is basically an ABBA design. That is treatment 1 followed by

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treatment 2 and then treatment 2 followed by treatment 1.

8. There are several different approaches to intragroup counterbalancing: complete counterbalancing, incomplete counterbalancing, and random counterbalancing. These approaches are used in studies involving three or more levels of the independent variable.

9. In all three approaches the treatment conditions are presented in different sequences to different subjects. Since subjects receive treatments in different orders, any order effects should be equally distributed over all treatment conditions when the scores of all subjects are averaged.

10. Within-subjects designs control organismic variables by using subjects as their own controls. This approach is even more effective than a matched pairs or matched groups technique in reducing error variability.

11. Another major advantage of the within-subjects design is subject economy: You need fewer subjects because subjects are tested under all conditions.

12. Nevertheless, within-subjects designs do have a major limitation: The effects of the first treatment may dissipate very slowly, or they may never disappear and may still be present when the second treatment is given.

13. If this does occur, the effect of the second treatment on the dependent variable will be confounded by carry-over effects from the first treatment.

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