RELATED SAMPLE DESIGNS

1- Repeated measures design

- A repeated-measures (within-subjects) research study uses a single sample that is measured in all of the different treatment conditions that are being compared.
- In repeated measures design, the data are obtained by literally repeating measurements under different treatment conditions for the same sample.
- The main advantage of a repeated-measures study is that it uses exactly the same individuals in all treatment conditions. That, there is no risk that the participants in one condition are substantially different from the participants from another.

2- Matched-subjects design

- The researchers try to approximate the advantages of a repeated-measures design by using a technique known as ***matched subjects***.
- A matched subjects design involves two separate samples, but each individual in one sample is matched one-to-one with an individual in the other sample. Specifically, the individual are matched on one or more individuals that are considered to be especially important for the study.
- Matched-subjects design at least ensures that two samples are equivalent with respect to some specific variables.
- Both repeated-measures design and matched subjects design are grouped together under the common name ***related sample designs.***

REPEATED-MEASURES VERSUS INDEPENDENT MEASURES DESIGNS

Advantages of Repeated-Measures Designs

- **Number of Subjects**: It requires fewer subjects than an independent measures design.
- **Study changes over time**: It is especially well suited for studying learning, development and other changes that take place over time. A researcher can observe behavior that change or develop over time.
- **Individual differences**: Primary advantage of repeated measures design is that it reduces or eliminates problems caused by individuals differences.
    - Variance is smaller
    - You are more likely to obtain significant results.

Disadvantages of Repeated Measures Design

- **Time Related Factors**: Outside factors that change over time may be responsible for changes in the participants' scores.
  - Progressive Error. Subjects' performance may change consistently over time due to fatigue or practice.
- **Order Effects:** Changes in scores occur due to the participation in an earlier treatment.
  - Carry over effects: The after effects of one treatment that may influence the scores in the following treatment condition.

Counterbalancing

- **Counterbalancing** One way to deal with time-related factors and order effects is to counterbalance the order of presentation of treatments. That is, the participants are randomly divided into two groups, with one group receiving treatment 1 followed by treatment 2, and the other group receiving treatment 2 followed by treatment 1. The goal of counterbalancing is to distribute any outside effects evenly over the two treatments. For example, if practice effects are a problem, then half of the participantsmgain experience in treatment 1, which then helps their performance in treatment 2. However, the other half gain experience in treatment 2, which helps their performance in treatment 1. Thus, prior experience helps the two treatments equally.
- Finally, if there is reason to expect strong time-related effects or strong order effects, your best strategy is not to use a repeated-measures design. Instead, use independent-measures (or a matched-subjects design) so that each individual participates in only one treatment and is measured only one time. The goal is to distribute outside factors evenly over the two treatments.

ASSUMPTIONS OF THE RELATED SAMPLES t TEST

- The observations within each treatment condition must be independent.
- The population of difference scores must be normal. For relatively large samples (n>30), this assumption can be ignored.

Example: A Repeated-Measures t Test

A major oil company would like to improve its tarnished image following a large oil spill. Its marketing department develops a short television commercial and tests it on a sample of $n = 7$ participants. People's attitudes about the company are measured with a short questionnaire, both before and after viewing the commercial. Was there a significant change? The data are as follows:

Person	X_1 (Before)	X_2 (After)	D (Difference)
A	15	15	0
B	11	13	+2
C	10	18	+8
D	11	12	+1
E	14	16	+2
F	10	10	0
G	11	19	+8

$\Sigma D = 21$

$M_D = \frac{21}{7} = 3.00$

$SS = 74$

State the hypotheses, and select an alpha level. The null hypothesis states that the commercial has no effect on people's attitude, or, in symbols,

H_0: $\mu_D = 0$ (The mean difference is zero.)

The alternative hypothesis states that the commercial does alter attitudes about the company, or

H_1: $\mu_D \neq 0$ (There is a mean change in attitudes.)

For this demonstration, we use an alpha level of .05 for a two-tailed test.

Locate the critical region. Degrees of freedom for the repeated-measures t test are obtained by the formula

$$df = n - 1$$

For these data, degrees of freedom equal

$$df = 7 - 1 = 6$$

The t distribution table is consulted for a two-tailed test with $\alpha = .05$ for $df = 6$. The critical t values for the critical region are $t = \pm 2.447$.

Compute the test statistic. Once again, we suggest that the calculation of the t statistic be divided into a three-part process.

Variance for the D scores: The variance for the sample of D scores is

$$s^2 = \frac{SS}{n-1} = \frac{74}{6} = 12.33$$

Estimated standard error for M_D: The estimated standard error for the sample mean difference is computed as follows:

$$s_{M_D} = \sqrt{\frac{s^2}{n}} = \sqrt{\frac{12.33}{7}} = \sqrt{1.76} = 1.33$$

Make a decision about H_0, and state the conclusion. The obtained t value is not extreme enough to fall in the critical region. Therefore, we fail to reject the null hypothesis. We conclude that there is not enough evidence to conclude that the commercial changes people's attitudes, $t(6) = 2.26$, $p > .05$, two-tailed. (Note that we state that p is *greater than* .05 because we failed to reject H_0.)

EFFECT SIZE FOR THE REPEATED-MEASURES *t*

We estimate Cohen's d and calculate r^2 for the data in Demonstration 11.1. The data produced a sample mean difference of $M_D = 3.00$ with a sample variance of $s^2 = 12.33$. Based on these values, Cohen's d is

$$\text{estimated } d = \frac{\text{mean difference}}{\text{standard deviation}} = \frac{M_D}{s} = \frac{3.00}{\sqrt{12.33}} = \frac{3.00}{3.51} = 0.86$$

The hypothesis test produced $t = 2.26$ with $df = 6$. Based on these values,

$$r^2 = \frac{t^2}{t^2 + df} = \frac{(2.26)^2}{(2.26)^2 + 6} = \frac{5.11}{11.11} = 0.46 \quad \text{(or 46\%)}$$

EXERCISES

1-Participants enter a research study with unique characteristics that produce different scores from one person to another. For an independent-measures study, these individual differences can cause problems. Identify the problems and briefly explain how they are eliminated or reduced with a repeated-measures study.

2-Explain the difference between a matched-subjects design and a repeated-measures design.

3- A researcher conducts an experiment comparing two treatment conditions with 20 scores in each treatment condition.

a. If an independent-measures design is used, how many subjects are needed for the experiment?

b. If a repeated-measures design is used, how many subjects are needed for the experiment?

c. If a matched-subjects design is used, how many subjects are needed for the experiment?

4-A researcher studies the effect of a drug on the number of nightmares occurring in veterans with post-traumatic stress disorder. A sample of PTSD clients records each incident of a nightmare for 1 month before treatment. Participants are then given the medication for 1 month and they continue to report each occurrence of a nightmare.

a. Do the data indicate a significant change in the number of nightmares? A=.05.

b. Estimate Cohen's d and compute r^2 for the test.

Person	1 month before treatment	1 month during treatment
A	6	1
B	10	2
C	3	0
D	5	5
E	7	2

5- A consumer protection agency is testing the effectiveness of a new gasoline addictive that claims to improve gas mileage. A sample of 10 cars is obtained, and each car is driven over a standard 100-mile course with or without the addictive. The researchers carefully record the miles per gallon for each test drive. The cars in this test averaged M_D=2.7 miles per gallon higher with the addictive than without, with s=14.

a. Are the data sufficient to conclude that the addictive significantly increases gas mileage? α=.05

b. Estimate Cohen's d and compute r^2 for the test.

6-Briefly explain the advantages and disadvantages of using a repeated-measures design as opposed to an independent measures design.