NOTE TO INSTRUCTORS

This chapter is devoted to the paired-samples $t$ test, the second out of three chapters about the $t$ test. Because several chapters are devoted to different $t$ tests, students may find this somewhat confusing and intimidating; however, to help ease any anxiety, emphasize to students the similarities between the paired-samples $t$ test and the single-sample $t$ test. A number of hands-on activities are proposed to give students more practice working with the paired-samples $t$ test. Further, an examination of $t$ tests in the literature will help students become more comfortable with how $t$ tests are used in psychology research.

OUTLINE OF RESOURCES

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CHAPTER GUIDE

I. The Paired-Samples $t$ Test
   1. A paired-samples $t$ test (or dependent-samples $t$ test) is used to compare two means for a within-groups design, a situation in which every participant is in both samples.

> Discussion Question 10-1

What is a paired-samples $t$ test? What would be an example of an experimental design that would use a paired-samples $t$ test?

Your students’ answers should include:
- A paired-samples $t$ test is a method used to compare two means for a within-groups design, a situation in which every participant is in both samples.
- An example of a paired-samples $t$ test experimental design would be how a sample of people will perform a mental test both on an empty stomach and immediately after lunch.

Classroom Activity 10-1
Make It Your Own: The Stroop Test—Dependent-Sample $t$ Test

In Chapter 1, you may have had your students collect their Stroop data. You can have your students now retake the same test and run a correlated $t$ test using SPSS (Statistical Package for the Social Sciences) on the data. The Web site again is:
http://www.snre.umich.edu/eplab/demos/st0/stroopdesc.html
(Note: This experiment requires that your computers are running Shockwave.)

Transparency Master 10-1 provides the outline for the six steps of hypothesis testing for a dependent-sample $t$ test discussed in the textbook. Follow those steps for this demonstration. (The transparency can be found at the end of this chapter. You may display the transparency on an overhead projector by photocopying it onto acetate, or you may use PowerPoint by scanning the transparency master into your computer.)
- Have your students collect their individual time data for each of the three tasks: word, color, color not word. Have your students note their errors for each of these measures.
- If you did not keep this data from earlier, you can have your students do the Stroop twice in one class and look at fatigue effects—have them complete the Stroop at the beginning of the class and again at the end of the class.

2. We use the same six steps as any of our previous hypothesis tests.
3. In this case, we will want to create difference scores and use these difference scores for our dependent variable. We will find the mean differ-
ence score and calculate our standard deviation using these difference scores.

4. Aside from the use of difference scores, the calculations are the same as for a single-sample $t$ test.

**Classroom Activity 10-2**

**The Candy Test**

In this activity, students will engage in a hands-on activity which will then allow them to calculate a paired-samples $t$ test. Specifically, they will reproduce the positive-affect induction technique of using a small gift of candy that has been repeatedly demonstrated by Alice Isen and her colleagues. [See Isen, A. M., Daubman, K. A., & Nowicki, G. P. (1987). Positive affect facilitates creative problem solving. *Journal of Personality and Social Psychology, 52*(6), 1122–1131; and Isen, A. M., Labroo, A. A., & Durlach, P. (2004). An influence of product and brand name on positive affect: Implicit and explicit measures. *Motivation and Emotion, 28*(1), 43–63. (To view or purchase these articles, go to your local library or visit, respectively, the American Psychological Association at http://www.apa.org and Springer at http://www.springer.com.)]

To do this demonstration:

- Students will rate their positive mood on a scale from 1 (not at all positive) to 7 (very positive) both before receiving a gift of candy and after receiving a gift of candy (you can decide to have them rate a specific mood instead—such as ratings of happiness—if you prefer).
- Then, students will take the class positive mood ratings and calculate a paired-samples $t$ test using Handout 10-1, found at the end of this chapter.

**II. Beyond Hypothesis Testing**

1. There are five steps to calculate the confidence interval for a paired-samples $t$ test. First, we draw a picture of a $t$ distribution that includes the confidence interval. Second, we indicate the bounds of the confidence interval on the drawing. Next we add the $t$ statistic to the curve and convert the $t$ statistic back into raw mean differences using the same formula as for the single-sample $t$ test. Lastly, we check that the confidence interval makes sense.

2. We use the same formula for Cohen’s $d$ for a single-sample $t$ test when using a paired-samples $t$ test.

**Classroom Activity 10-3**

**Using Confidence Intervals and Cohen’s $d$**

Using the data from Classroom Activity 10-2: The Candy Test, calculate the confidence interval and Cohen’s $d$. Use Handout 10-1 to aid in this activity.
III. Next Steps: Order Effects and Counterbalancing

1. Order effects refer to how a participant’s behavior changes when the dependent variable is presented for a second time.

2. Order effects can be minimized by using counterbalancing or a technique that varies the order of presentation of different levels of the independent variable from one participant to the next.

> Discussion Question 10-2

*What is counterbalancing? What would be an example of an experimental design that would use counterbalancing?*

Your students’ answers should include:

- Counterbalancing minimizes order effects by varying the order of presentation of different levels of the independent variable from one participant to the next.

- For example, researchers test the effects of a new drug to improve memory by administering a memory test to participants after they have taken the drug and a placebo. In counterbalancing, half of the participants would receive the new drug first followed by the placebo, whereas the other half of participants would receive the placebo first followed by the new drug.

Additional Readings


This paper compares the properties of $t$ and $z$ in simulation runs. The differences in the results are attributed to the fluctuations in the $t$ test sample variance.


The $t$ test, like all parametric tests, has as an underlying assumption that the data are normally distributed. What happens when our data are not normally distributed? Should we still use the $t$ test? Rasch and Volker argue yes.

Online Resources

This online psychology lab outlines numerous in-class experiments from which you can choose: http://opl.apa.org/Main.aspx. See their First Impressions experiment, which can be analyzed using a one-sample $t$ test.
HANDOUT 10-1: THE CANDY TEST

Directions: This demonstration is designed to give you more practice calculating paired-samples \( t \) tests. Follow the instructions from your instructor, and answer each of the questions below.

1. What was your initial mood rating?

2. What was your final mood rating?

3. With the data provided from your instructor, calculate the paired-samples \( t \) test in the space below.

4. Interpret the findings of the \( t \) test. Based on the findings from the class, did the candy impact the class’ mood ratings?
The Six Steps of Hypothesis Testing for a Dependent-Sample $t$ Test

Step 1. Populations, distributions, and assumptions.
   - The population is our class.
   - The comparison is the distribution of mean difference scores.
   - The hypothesis test is the $t$ test for dependent samples.

Step 2. State the null and research hypotheses.
   - $H_0$ There will be no difference sessions.
   - $H_1$ There will be a difference session.

Step 3. Determine the characteristics of the comparison distributions.

Step 4. Determine the critical values, or cutoffs.
   - By behavioral science convention, $p < 0.05$. The degrees of freedom are the number of difference scores minus 1.

Step 5. Calculate the test statistics.
   \[
   t = \frac{(M_{\text{diff}}) - 0}{s_M}
   \]

Step 6. Make a decision.