**Confidence Intervals for Dependent Samples**

$$\bar{d} - E < \mu_d < \bar{d} + E$$

where

$$E = t_{\alpha/2}\frac{s_d}{\sqrt{n}}$$

**Critical values of $t_{\alpha/2}$:** Use Table A-3 ($t$ distribution) with degrees of freedom df $= n - 1$.

If we compare the components of the preceding box to those used in Part 1 of Section 8-4 for inferences about the mean of a population (with $\sigma$ not known), we can see that they are very similar. The methods of this section are actually the same as those in Section 8-4, except that here we use the differences.

**Procedures for Inferences with Dependent Samples**

1. Verify that the sample data consist of dependent samples (or matched pairs), and verify that the preceding requirements are satisfied.
2. Find the difference $d$ for each pair of sample values. (*Caution:* Be sure to subtract in a consistent manner.)
3. Find the mean of the differences (denoted by $\bar{d}$), and find the standard deviation of the differences (denoted by $s_d$).
4. For hypothesis tests and confidence intervals, use the same $t$ test procedures described in Part 1 of Section 8-5.

**Equivalent Methods** Because the hypothesis test and confidence interval use the same distribution and standard error, they are *equivalent* in the sense that they result in the same conclusions. Consequently, the null hypothesis that the mean difference equals 0 can be tested by determining whether the confidence interval includes 0.

**Example 1** **Are Presidents Taller Than Their Main Campaign Opponents?**

Data Set 12 in Appendix B lists heights of U.S. presidents and their main opponents in the presidential campaigns. We will use only the sample data included in Table 9-1. (We use only a small random selection of the available data so that we can better illustrate the method of hypothesis testing.) Use the sample data in Table 9-1 with a 0.05 significance level to test the claim that for the population of heights of presidents and their main opponents, the differences have a mean greater than 0 cm (so presidents tend to be taller than their opponents).

**Table 9-1** Heights (cm) of Presidents and Their Main Opponents

| Height (cm) of President | 189 | 173 | 183 | 180 | 179 |
|---|---|---|---|---|---|
| Height (cm) of Main Opponent | 170 | 185 | 175 | 180 | 178 |
| Difference $d$ | 19 | −12 | 8 | 0 | 1 |

**Crest and Dependent Samples**

In the late 1950s, Procter & Gamble introduced Crest toothpaste as the first such product with fluoride. To test the effectiveness of Crest in reducing cavities, researchers conducted experiments with several sets of twins. One of the twins in each set was given Crest with fluoride, while the other twin continued to use ordinary toothpaste without fluoride. It was believed that each pair of twins would have similar eating, brushing, and genetic characteristics. Results showed that the twins who used Crest had significantly fewer cavities than those who did not. This use of twins as dependent samples allowed the researchers to control many of the different variables affecting cavities.