Matched Pairs Design: Compare two treatment groups (such as treatment and placebo) by using subjects matched in pairs that are somehow related or have similar characteristics, as in the following cases.

- Before/After: Matched pairs might consist of measurements from subjects before and after some treatment, as illustrated in Figure 1-5(d). Each subject yields a "before" measurement and an "after" measurement, and each before/after pair of measurements is a matched pair.
- Twins: A test of Crest toothpaste used matched pairs of twins, where one twin used Crest and the other used another toothpaste.

Rigorously Controlled Design: Carefully assign subjects to different treatment groups, so that those given each treatment are similar in the ways that are important to the experiment. In an experiment testing the effectiveness of aspirin on heart disease, if the placebo group includes a 27-year-old male smoker who drinks heavily and consumes an abundance of salt and fat, the treatment group should also include a person with these characteristics (such a person would be easy to find). This approach can be extremely difficult to implement, and often we can never be sure that we have accounted for all of the relevant factors.

Sampling Errors In an algebra course, you will get the correct result if you use the correct methods and apply them correctly. In statistics, you could use a good sampling method and do everything correctly, and yet it is possible for the result to be wrong. No matter how well you plan and execute the sample collection process, there is likely to be some error in the results. Suppose that you randomly select 1000 adults, ask them whether they use a cell phone while driving, and record the sample percentage of "yes" responses. If you randomly select another sample of 1000 adults, it is likely that you will obtain a *different* sample percentage. The different types of sampling errors are described here.

DEFINITIONS

A **sampling error** (or **random sampling error**) occurs when the sample has been selected with a random method, but there is a discrepancy between a sample result and the true population result; such an error results from chance sample fluctuations.

A **nonsampling error** is the result of human error, including such factors as wrong data entries, computing errors, questions with biased wording, false data provided by respondents, forming biased conclusions, or applying statistical methods that are not appropriate for the circumstances.

A **nonrandom sampling error** is the result of using a sampling method that is not random, such as using a convenience sample or a voluntary response sample.

If we carefully collect a random sample so that it is representative of the population, we can use methods in this book to analyze the sampling error, but we must exercise great care to minimize nonsampling error.

Experimental design requires much more thought and care than we can describe in this relatively brief section. Taking a complete course in the design of experiments is a good start in learning so much more about this important topic.

Misleading Statistics in Journalism

New York Times reporter Daniel Okrant wrote that although every sentence in his newspaper is copyedited for clarity and good writing, "numbers, so alien to so many, don't get nearly this respect. The paper requires no specific training to enhance numeracy and [employs] no specialists whose sole job is to foster it." He cites an example of the *New York Times* reporting about an estimate of more than \$23 billion that New Yorkers spend for counterfeit goods each year. Okrant writes that "quick arithmetic would have demonstrated that \$23 billion would work out to roughly \$8000 per city household, a number ludicrous on its face."