Got a Second?

The time unit of 1 second is defined to be "the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom." That definition redefines time to be based on the behavior of atoms instead of the earth's motion. It results in accuracy of ±1 second in 10,000,000 years, which is the most accurate measurement we use. Because it is so accurate, the second is being used to define other quantities, such as the meter. The meter was once defined as 1/10,000,000 of the distance along the surface of the earth between the North Pole and the equator (passing through Paris). The meter is now defined as the length of the distance traveled by light in a vacuum during a time interval of 1/299,792,458 sec.

When dealing with time measurement devices, the traditional standard deviation has been found to be poor because of a trend in which the mean changes over time. Instead, other special measures of variation are used, such as Allan variance, total variance, and TheoH.

Unrelated to statistics but nonetheless interesting is the fact that ads for watches usually show a watch with a time close to 10:10. That time allows the brand name to be visible, and it creates a subliminal image of a happy face. The time of 10:10 has been the industry standard since the 1940s.

3-3 Measures of Variation

Key Concept The topic of variation discussed in this section is the single most important topic in statistics. This section presents three important measures of variation: *range, standard deviation,* and *variance.* Being measures of variation, these statistics result in numbers, but it is essential to know that our focus is not only finding numerical values but developing the ability to *interpret* and *understand* the numbers that we get. This section is not really about arithmetic; it is about conceptual understanding, and the concept is one of paramount importance.

Study Hint: Part 1 of this section presents basic concepts of variation and Part 2 presents additional concepts related to the standard deviation. Although both parts contain several formulas for computation, do not spend too much time memorizing those formulas and doing arithmetic calculations. Instead, make it a priority to *understand* and *interpret* values of standard deviation.

Part 1: Basic Concepts of Variation

To visualize the effect of variation, see Figure 3-2 and verify this important observation: The numbers of chocolate chips in Chips Ahoy cookies (top dotplot) have more *variation* than those in the Triola cookies (bottom dotplot). The top dotplot shows more spread than the bottom dotplot. Although both brands have the same mean (24.0), the Chips Ahoy cookies vary from 19 chocolate chips to 30, but the Triola cookies only vary from 23 chocolate chips to 25. This characteristic of spread, or variation, or dispersion, is so important that we measure it with numbers. (*Note:* The Chips Ahoy data are real and they are listed in Table 3-1, but the Triola cookie data are fabricated. The author doesn't actually produce chocolate chip cookies, but if the writing job doesn't work out, you never know.)

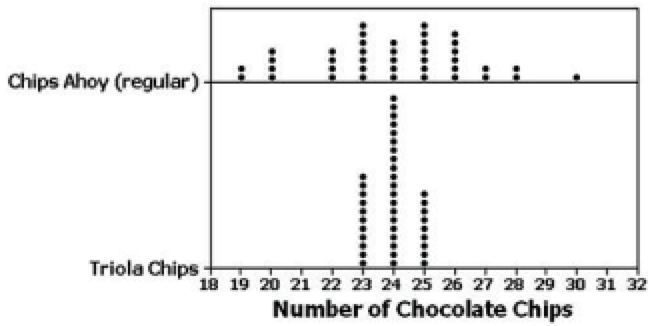

Figure 3-2 Dotplots of Numbers of Chocolate Chips in Cookies

Range

We noted that this section includes these measures of variation: (1) range; (2) standard deviation; (3) variance. We begin with the range because it is so easy to compute, even though it is not as important as the other measures of variation.

> **DEFINITION** The **range** of a set of data values is the difference between the maximum data value and the minimum data value.
>
> **Range = (maximum data value) − (minimum data value)**

Because the range uses only the maximum and the minimum data values, it is very sensitive to extreme values and isn't as useful as other measures of variation that