APPENDIX 8.1: DETERMINING *n* FOR A GIVEN δ IN EXCEL

There is no formula that returns the sample size required to achieve the power you want, given δ, α, and H_1. Instead, we have to use a computer to *search* for the required sample size. Fortunately, this can be easily done in Excel. In this appendix, as in Chapter 8, we will consider power for a one-tailed test where H_1: $\mu_1 > \mu_0$. Figure 8.A1.1 shows an Excel workbook that is set up to calculate the sample size required to achieve a specified power. The illustration in this appendix relates to the power-pose example used in Chapter 8.

To conduct this power analysis, we require values for μ_0, δ, σ, *n*, and α. These values are given in cells **B2**, **B3**, **B4**, **B7**, and **B10**, respectively, in Figure 8.A1.1. From these values, we can calculate μ_1 (cell **B5**), σ_m (cell **B8**), z_{critical} (cell **B11**), m_{critical} (cell **B12**), β (cell **B15**), and power (cell **B16**).

We've seen how power and β depend on sample size. If you set up the workbook as in Figure 8.A1.1, you should be able to see how power and β change with *n*. If *n* is set to 32, then power = .30. If *n* is set to 8, then power = .14. Our goal is to find the sample size that produces the power we desire.

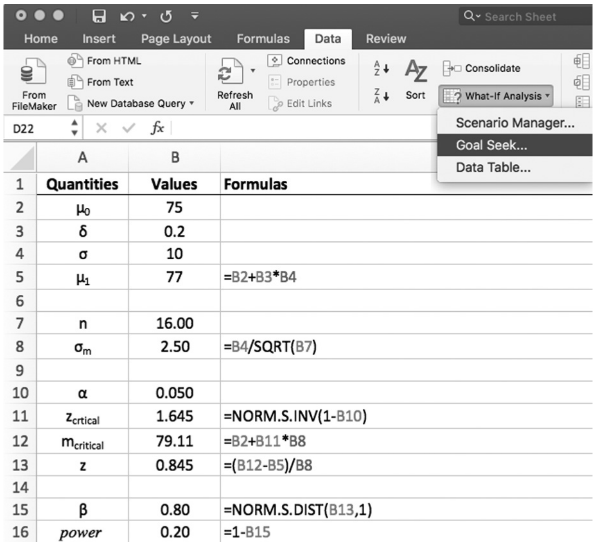
Let's say we would like to achieve power = .8 (cell **B16**). We could change values of *n* by hand until we get the value we want. Or we could have Excel do the searching for us using the **Goal Seek . . .** option, which is reached by clicking on the **What-If Analysis** button in the **Data** tab, as shown in Figure 8.A1.1. (The **What-If Analysis** button is actually farther to the right in the **Data** ribbon than shown in Figure 8.A1.1.)

When we choose **Goal Seek**, the dialog box shown in Figure 8.A1.2 appears. We tell **Goal Seek** to change the number in some cell until the number in another cell reaches a specified value. In our case, we want cell **B16** (power) to have a value of .8, by changing the value in cell **B7** (*n*). When we press the **OK** button, **Goal Seek** searches for a value of *n* that yields power = .8.

Figure 8.A1.3 shows the result of **Goal Seek**'s efforts. It determined that to achieve power = .8, we would need a sample of size 154.46. Of course, our sample size has to be a whole number, so we round 154.46 up to 155. This means we would need a sample of size *n* = 155 to reject H_0 80% of the time when δ = .2. All values in Tables 8.1 and 8.2 were computed essentially this way.

It is worth noting that this analysis can be conducted even if we don't know μ_0 or σ. If we set μ_0 to 0 in cell **B2**,

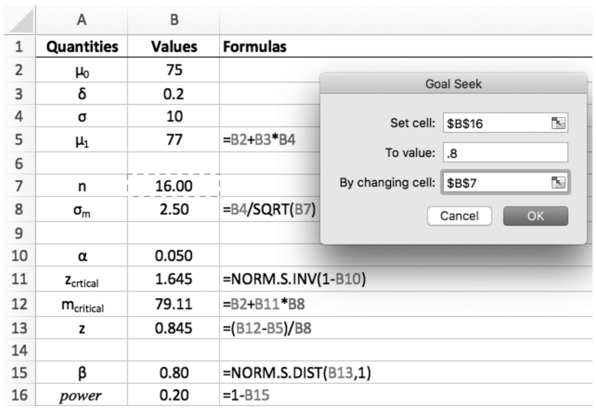
FIGURE 8.A1.1 ■ Accessing Goal Seek . . .



	A	B	
1	Quantities	Values	Formulas
2	μ_0	75	
3	δ	0.2	
4	σ	10	
5	μ_1	77	=B2+B3*B4
6			
7	n	16.00	
8	σ_m	2.50	=B4/SQRT(B7)
9			
10	α	0.050	
11	z_{critical}	1.645	=NORM.S.INV(1-B10)
12	m_{critical}	79.11	=B2+B11*B8
13	z	0.845	=(B12-B5)/B8
14			
15	β	0.80	=NORM.S.DIST(B13,1)
16	*power*	0.20	=1-B15

This spreadsheet has calculated power based on the quantities μ_0, δ, σ, *n*, and α, presented in cells **B2**, **B3**, **B4**, **B7**, and **B10**, respectively. The formulas in column **B** (and documented in column **C**) calculate μ_1 (cell **B5**), σ_m (cell **B8**), z_{critical} (cell **B11**), m_{critical} (cell **B12**), β (cell **B15**), and power (cell **B16**).

FIGURE 8.A1.2 ■ Using Goal Seek . . .



	A	B	
1	Quantities	Values	Formulas
2	μ_0	75	
3	δ	0.2	
4	σ	10	
5	μ_1	77	=B2+B3*B4
6			
7	n	16.00	
8	σ_m	2.50	=B4/SQRT(B7)
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10	α	0.050	
11	z_{critical}	1.645	=NORM.S.INV(1-B10)
12	m_{critical}	79.11	=B2+B11*B8
13	z	0.845	=(B12-B5)/B8
14			
15	β	0.80	=NORM.S.DIST(B13,1)
16	*power*	0.20	=1-B15

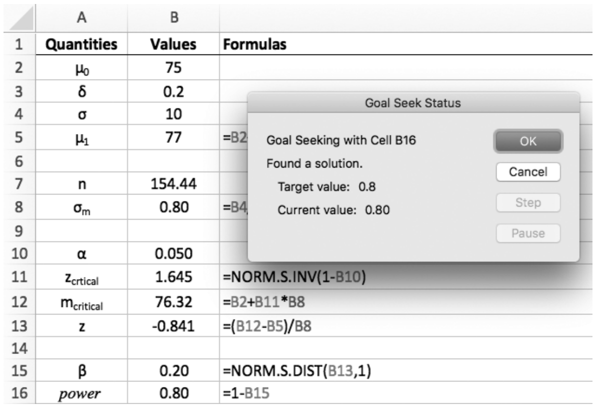
Goal Seek . . . searches for a solution to the goal specified in the dialog box. It is instructed to set cell **B16** (power) to have value .8, by changing the value in cell **B7** (*n*).

and σ to 1 in cell **B4**, we will find that $\mu_1 = \delta$, and power and β do not change. In fact, it doesn't matter what values are in cells **B2** and **B4** because μ_1, σ_m, and $m_{critical}$ are all relative to μ_0 and σ. If you work with this workbook, you should be able to convince yourself that this is true.

In this example, our problem was structured assuming a one-tailed test (H_1: $\mu_1 > \mu_0$) with δ set to .2. If the alternative hypothesis had been H_1: $\mu_1 < \mu_0$, then δ would be a negative number. The workbook, as set up in Figures 8.A1.1 to 8.A1.3, would produce the wrong result if we had entered $\delta = -.2$. We could rewrite our equations to produce the correct answer, but there is no need to do this. The sample size required to achieve the desired power for H_1: $\mu_1 < \mu_0$ and $\delta = -.2$ is exactly the same as that required to achieve the desired power for H_1: $\mu_1 > \mu_0$ and $\delta = .2$. So, there's no need to change the spreadsheet; just enter the absolute value of δ in cell **B3**.

We have focused on directional alternative hypotheses, but we can perform a power analysis for non-directional (two-tailed) tests just as easily. In this case, we are interested in an effect size whose absolute value is $|\delta|$. Although we don't know whether μ_1 is above or below μ_0, our hypothesis says that it has to be one or the other. Because our test is two tailed, there are two values of $z_{critical}$; i.e., $\pm z_{critical}$. $(\alpha)100\%$ of the z-distribution lies outside of $\pm z_{critical}$, and the proportion above $|z_{critical}|$ is $(\alpha/2)100\%$. Therefore, to compute the sample size required to achieve the desired power for given α and δ, we would simply substitute $\alpha/2$ for α in cell **B10**. When we conduct a power analysis for a two-tailed test with $\alpha = .05$ ($\alpha/2 = .025$) and $\delta = .2$, we find that the required sample size is $n = 197$.

FIGURE 8.A1.3 ■ Goal Seek . . . Results



	A	B	
1	Quantities	Values	Formulas
2	μ_0	75	
3	δ	0.2	
4	σ	10	
5	μ_1	77	=B2
6			
7	n	154.44	
8	σ_m	0.80	=B4
9			
10	α	0.050	
11	$z_{crtical}$	1.645	=NORM.S.INV(1-B10)
12	$m_{critical}$	76.32	=B2+B11*B8
13	z	-0.841	=(B12-B5)/B8
14			
15	β	0.20	=NORM.S.DIST(B13,1)
16	*power*	0.80	=1-B15

Goal Seek . . . shows that it has found a solution to the goal we gave it.