1. A researcher sets out to test the claim that frequency of phobic reactions among clients suffering from phobias can be reduced through relaxation training. A group of 26 volunteers who suffer some sort of phobia were recruited through newspaper ads. Eleven of the subjects were randomly assigned to receive relaxation training and the other 15 were given no such training. At the completion of training all subjects recorded the number of phobic reactions experienced during a one-month period. Descriptive statistics for each group are shown below.

(a) Assume that the researcher plans to use a t test to analyze the data. State the null and alternative hypotheses using symbols (i.e., $H_0$, $H_1$, etc.).
(b) Apply the appropriate t test using $\alpha = .05$. Provide the obtained t ratio and state your decision regarding the null hypothesis.
(c) What conclusion should be reached regarding relaxation training and frequency of phobic reactions?

<table>
<thead>
<tr>
<th></th>
<th>Relaxation</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M$</td>
<td>8.30</td>
<td>12.40</td>
</tr>
<tr>
<td>$s$</td>
<td>3.72</td>
<td>4.58</td>
</tr>
<tr>
<td>$n$</td>
<td>11</td>
<td>15</td>
</tr>
</tbody>
</table>

2. In a distribution of differences between sample means (of the sort on which a typical independent-samples t test is based), assume that the null hypothesis is true ($\mu_1 = \mu_2$) and that the populations have equal variance. How many of the values in the distribution of differences would be negative? Pick one answer.
(a) none
(b) all
(c) nearly all
(d) very few
(e) about half
(f) it depends on how many negative raw scores are in the populations

3. A researcher randomly assigns a sample of 40 children into two groups of 20. One group plays a violent video game for 2 hours and the other group plays a non-violent video game for 2 hours. Then, each subject is observed playing with other children in a room stocked
with toys and the level of aggressiveness in each child is assessed. The mean aggressiveness score (higher score indicates more aggression) and standard deviation for each group is shown below.

<table>
<thead>
<tr>
<th></th>
<th>Violent game</th>
<th>Non-violent game</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M</strong></td>
<td>14.5</td>
<td>11.5</td>
</tr>
<tr>
<td><strong>s</strong></td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

(a) Draw a distribution representing the hypothetical distribution of differences between means for this study based on the assumption that the null hypothesis is true and that distributions of raw scores are normal.

(b) Use the sample standard deviations to compute an estimate for the standard deviation of this distribution.

(c) Compute the observed difference between means and, keeping in mind the size of the standard deviation of the distribution of differences between means found in (b), plot the approximate location of the observed difference between means in the distribution of differences.

(d) Does the observed difference appear to be an unlikely result assuming the two population means are equal?

4. Suppose you use R to compute an independent samples t test with a nondirectional alternative hypothesis and the output that is generated includes this line:

\[ t = 1.905, \text{ df } = 14, \text{ p-value } = 0.0780 \]

Does this result allow you to reject the null hypothesis with \( \alpha = 0.05 \) assuming a nondirectional alternative hypothesis? What about with \( \alpha = 0.01 \)? What would be your answers if a directional alternative hypothesis were used and we assumed that the observed difference between means went in the direction expected by \( H_1 \)?

5. A researcher tests the effectiveness of a treatment program for gambling addiction. A sample of 36 problem gamblers is obtained, and each one is randomly assigned to a control group or a treatment group. The groups are not of equal size because the researcher thinks it is unethical to withhold treatment from more of these subjects than necessary, so the control sample size is smaller than the size of the treatment group. Following the treatment period, all subjects are measured on a self-report scale that assesses level of desire to engage in gambling. Higher scores mean higher desire and the treatment is expected to reduce the level of desire to gamble.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M</strong></td>
<td>22.0</td>
<td>19.5</td>
</tr>
<tr>
<td><strong>s</strong></td>
<td>2.3</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

Compute an independent samples t test to determine whether the treatment is effective. Watch out for the difference in sample variances and take the necessary precaution when
computing the $t$ test. Even though the researcher has a directional prediction, use a nondirectional test with $\alpha = .05$. What might have caused the variance in the two groups to be different (consider which of the two groups is the one with the larger variance when thinking about this question)?

6. Here is an opportunity for you to simulate the theoretical distributions involved in the independent samples $t$ test and to learn about the implications of relying on sample-based estimates of population variance. Our basic population will be a normal distribution with $\mu = 10$ and $\sigma = 3$. You can easily obtain a random sample from such a population using R. Use the `rnorm` function with this command line:

```r
> round(rnorm(5, mean = 10, sd = 3))
```

This command will produce 5 values randomly drawn from the population. Because the scores in this population are "real" values from a continuous range, we apply the `round` function to round each value to the nearest whole number. Your task is to draw two random samples from this population, with each sample containing 5 scores, so repeat this R command a second time to get the second set of 5 scores.

After you have drawn your two samples, compute an independent samples $t$ ratio. If you are fully confident in your ability to compute means and variances, then you can use the following shortcut. When drawing each random sample, put the result into a uniquely named variable, then apply the `mean` and `var` functions to that variable to get the sample mean and sample variance. For example, put the first set of random scores into a variable called `s1`:

```r
> s1 = round(rnorm(5, mean = 10, sd = 3))
> mean(s1)
[1] 9.8
> var(s1)
[1] 5.7
```

You can repeat this for the second sample, using a new variable name, so that both sets of scores are preserved.

Given that the samples came from the same population, we expect the means to be similar and the $t$ ratio to be small, but your case may be an exception (indeed, the chances are 1 in 20 that you will end up rejecting the null hypothesis with $\alpha = .05$). Note (a) the two means, (b) the raw score difference between the means, and (c) the standard error of difference estimated from the sample variances. Now repeat this exercise with a new pair of independently selected samples of 5 scores each (use the R command above to get these new samples). Again, note the means, the difference between means, and the standard error of estimate for this second case. These two cases represent just two instances of the many, many instances that make up the distribution of differences between means. Notice that the difference between means and the standard error of difference found in your first pair of samples are likely different than they are in your second pair of samples.
Now compare the estimated value of the standard error of difference that you found in your two cases to the actual standard error of difference. The actual value can be computed knowing that sample size was 5 and knowing that the population variance is \( 3^2 = 9 \) (recall that \( \sigma = 3 \)). With the actual value of the standard error of difference available, you can convert the difference between means in each of your two sets of samples above to a \( z \) score, so do that. Note the size of the two \( t \) ratios you computed above and then note the size of your two \( z \) scores. You are likely to see that the \( t \) ratios are further from zero than are the \( z \) scores (although this is not guaranteed to happen), and this is part of the process that causes the \( t \) distribution to be flatter with more area in the tails than the normal distribution.

7. A researcher is interested in how being in a romantic relationship is associated with social networking. She obtains a sample of 126 individuals, some of whom are in a romantic relationship (and have been so for at least a year), and some of whom are not and have not been for at least 3 months. As a measure of degree of social networking, she has each person in the sample indicate how many Facebook friends he or she has. The hypothetical data are in a file called social.txt on the course web site. The first column lists the scores for subjects in the Relationship group and the second column lists the scores for subjects in the No-relationship group. The dependent measure is number of Facebook friends. Use R to read in the data file, obtain the descriptive statistics for each group, and to compute the relevant \( t \) test. Determine whether there is evidence from this study, with \( \alpha = .05 \) and a nondirectional test, that being in a relationship is associated with extent of social networking. If there is such evidence, what can you say about the association between these two variables?

8. A researcher plans to compare two randomly assigned groups of subjects (one receiving a treatment and the other a control group) using an independent-samples \( t \) test of a null hypothesis which says the populations from which these samples were drawn have equal means, versus an alternative hypothesis which claims that the population means differ. The data are contained in a file called treat.txt on the course web site. Read in the data file and acquaint yourself with the data by printing the first few lines using the head command, then obtain the descriptive statistics for each group using the describe command (remember to call the psych package from the library if you have not already done so in your current R session). Next, use the t.test command to obtain a test of the null and alternative hypotheses here. Note that the null hypothesis says that the data come from two populations with equal means, whereas the alternative hypothesis claims that the two population means are different. What does this analysis show with respect to rejecting or not rejecting the null hypothesis with \( \alpha = .05 \)? What if \( \alpha = .01 \)? In case the null hypothesis is rejected, should we conclude that the treatment condition has a higher mean than the control condition or vice versa? What if the null hypothesis is not rejected?

9. A company is designing an electronic tablet that allows users to make handwritten notes on it. To compare the effectiveness of this method of notetaking in class with taking notes by typing on a keyboard, a researcher is recruited to carry out the following
experiment. A sample of 70 subjects is obtained and half are randomly assigned to each of two conditions: notetaking in handwriting with the tablet or notetaking with a keyboard on a laptop computer. All subjects watch a TED talk on how a young boy in Kenya developed a device to help ward off lions that were attacking the family livestock. Subjects took notes while watching the talk, then answered from memory a set of questions based on the talk. The dependent measure was number of correctly answered questions. Two different outcomes are shown below. For each one, conduct a nondirectional test of the null hypothesis that method of notetaking makes no difference. Use $\alpha = .05$. In each case, decide whether the data allow rejection of the null hypothesis.

<table>
<thead>
<tr>
<th>Outcome 1</th>
<th>Outcome 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tablet</td>
</tr>
<tr>
<td></td>
<td>$M$ 9.0</td>
</tr>
<tr>
<td></td>
<td>$s$ 2.5</td>
</tr>
<tr>
<td></td>
<td>$n$ 35</td>
</tr>
</tbody>
</table>

You should have found that the null hypothesis was rejected in the first case, but not the second case, despite the fact that the difference between means was the same in both cases. Explain why this happened [hint: notice what is different in the two analyses you computed].