1. Suppose that the mean of a population of normally distributed raw scores is 50. As we consider larger and larger samples drawn at random from this population increases, what happens to the probability of obtaining a sample mean of 60 or larger? Assuming that the standard deviation of the population of raw scores ($\sigma$) is 10, what proportion of all possible samples of size 20 would have a mean ($M$) equal to or greater than 54?

2. For a normally distributed population, with $\mu = 20$ and $\sigma = 4$, what is the probability that a randomly drawn sample with $n = 10$ will have $M \geq 22$? What is the probability if sample size is 30?

3. What is the difference between a rejection criterion and a region of rejection? Specify the rejection criterion and region of rejection for the following example involving a one-sample $z$ test. A researcher tests the null hypothesis that a population has a mean of 50 (i.e., $H_0: \mu = 50$). Suppose that $\sigma = 10$. The researcher uses a directional alternative hypothesis that claims the true value of $\mu$ for this population is less than 50 and tests this claim by drawing a random sample of 30 subjects from the population. Assume that the researcher applies a one-sample $z$ test with $\alpha = .05$.
   (a) What is the rejection criterion and what is the region of rejection for this study?
   (b) Suppose that a nondirectional test had been used instead. What would be the rejection criteria and regions of rejection?

4. Working with the scenario in question 3, suppose the researcher does not know the value of $\sigma$, and instead plans to compute a $t$ test based on a sample of 30 subjects. The data for a random sample of 30 subjects is listed below. Copy and paste these scores (separated by ,) into R and use the t.test function to compute the $t$ test. Keep in mind that in this case we have a directional alternative hypothesis that expects the real value of $\mu$ to be less than 50 (so the alternative parameter in the t.test function should be set equal to \textit{"less"}). Consult the posted instructions on using R for details regarding the t.test function (see Section 7 on the one-sample $t$ test). When copying and pasting the data below into R, start by setting up the following command in R:

\[
\begin{align*}
s^2 &= \frac{\sum(X - M)^2}{N - 1} = \frac{SS}{df} \\
\sigma_M &= \frac{\sigma}{\sqrt{n}} \\
M &= \mu + \sigma_M(z) \\
s_M &= \frac{s}{\sqrt{n}} \\
t &= \frac{M - \mu}{s_M} \\
s_{M_0} &= \frac{s_D}{\sqrt{N}} \\
t &= \frac{M_D - 0}{s_{M_0}}
\end{align*}
\]
With the cursor situated between the parentheses in this command line, paste the numeric values below.

48, 45, 51, 41, 46, 48, 41, 58, 52, 51, 53, 54, 55, 48, 57, 45, 47, 43, 48, 56, 52, 45, 51, 48, 32, 41, 50, 48, 51

What is the \( t \) ratio produced by R and does it allow rejection of the null hypothesis with \( \alpha = .05 \)?

Now that you have these data in R, you can use some of the functions in R to help you compute this \( t \) test by hand. Use the `mean` command to obtain the mean of this sample, and the `sd` command to compute its standard deviation, like this:

```r
> mean(data)
> sd(data)
```

Use the sample mean and standard deviation to compute the \( t \) ratio by hand, assuming the value of \( \mu \) is 50, as per the null hypothesis.

5. To test whether a naturopathic agent is effective at relieving stress, a researcher obtains a sample of eight subjects who report relatively high stress levels. Each subject reports stress by providing a rating on a 10-point scale. This ratings are used as pre-test scores. Then all eight subjects are given the naturopathic agent in its recommended dose for two weeks. After that, a post-test is given in which the subjects again provide a stress rating on the 10-point scale. The data for the eight subjects on the pre- and post-test are shown below. Compute a related-samples \( t \) test by hand to determine whether the post-test scores are lower than the pre-test scores. Use a nondirectional test in this case. Do these data allow rejection of the null hypothesis with \( \alpha = .05 \)? Assuming the null hypothesis is rejected and considering the means for the pre- and post-test conditions, is it reasonable to conclude that the naturopathic agent was responsible for reducing stress? Why or why not?

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6. In a test of memory ability in human infants, a researcher makes use of the fact that when given a choice between two simultaneously presented visual displays, infants will tend to look longer at the novel display. The researcher created two similar visual
patterns, A and B. A sample of 24 infants was presented with one of these patterns for 5 seconds of viewing in the first part of the experiment (half were shown A and half were shown B). The next day, each infant was presented with both patterns simultaneously for 10 seconds. The researcher recorded how much time each infant spent looking at the pattern he or she had seen in the first phase of the experiment (old pattern) and how much time was spent looking at the new pattern. (Note that some of the 10 seconds would be spent looking at neither pattern.) The looking time data, measured in 10ths of a second, are shown in the data file called infant.txt. Read this data file into R and compute a related-samples \( t \) test to determine whether there is a difference in mean looking time for the old and new patterns. Use a nondirectional test with \( \alpha = .05 \). Does this study show that infants spend significantly more time looking at the new pattern? You will want to use the describe command (from the psych library) to look at the means for the two conditions.