Presidential approval
Many news organizations conduct polls asking adults in the United States if they approve of the job the president is doing. How did President Obama’s approval rating change from August 2009 to September 2010? According to a CNN poll of 1024 randomly selected U.S. adults on September 1-2, 2010, 50% approved of Obama’s job performance. A CNN poll of 1010 randomly selected U.S. adults on August 28-30, 2009 showed that 53% approved of Obama’s job performance.

Problem:

(a) Use the results of these polls to construct and interpret a 90% confidence interval for the change in Obama’s approval rating among all US adults.

(b) Based on your interval, is there convincing evidence that Obama’s job approval rating has changed?
**Hearing loss**
Are teenagers going deaf? In a study of 3000 randomly selected teenagers in 1988-1994, 15% showed some hearing loss. In a similar study of 1800 teenagers in 2005-2006, 19.5% showed some hearing loss.
(Source: *Arizona Daily Star*, 8-18-2010).

**Problem:**

(a) Does these data give convincing evidence that the proportion of all teens with hearing loss has increased?

(b) Between the two studies, Apple introduced the iPod. If the results of the test are statistically significant, can we blame iPods for the increased hearing loss in teenagers?
Potato chips
A potato chip manufacturer buys potatoes from two different suppliers, Riderwood Farms and Camberley, Inc. The weights of potatoes from Riderwood Farms are approximately Normally distributed with a mean of 175 grams and a standard deviation of 25 grams. The weights of potatoes from Camberley, Inc. are approximately Normally distributed with a mean of 180 grams and a standard deviation of 30 grams. When shipments arrive at the factory, inspectors randomly select a sample of 20 potatoes from each shipment and weigh them. They are surprised when the average weight of the potatoes in the sample from Riderwood Farms \( \bar{x}_r \) was higher than the average weight of the potatoes in the sample from Camberley, Inc. \( \bar{x}_c \).

Problem:

(a) Describe the shape, center, and spread of the sampling distribution of \( \bar{x}_c - \bar{x}_r \).

(b) Find the probability that the mean weight of the Riderwood sample is larger than the mean weight of the Camberley sample. Should the inspectors have been surprised?
Plastic Grocery Bags
Do plastic bags from Target or plastic bags from Bashas hold more weight? A group of AP Statistic students decided to investigate by filling a random sample of 5 bags from each store with common grocery items until the bags ripped. Then they weighed the contents of items in each bag to determine its capacity. Here are their results, in grams:

| Target: | 12,572 | 13,999 | 11,215 | 15,447 | 10,896 |
| Bashas: | 9552   | 10,896 | 6983   | 8767   | 9972   |

Problem:

(a) Construct and interpret a 99% confidence interval for the difference in mean capacity of plastic grocery bags from Target and Bashas.

(b) Does your interval provide convincing evidence that there is a difference in the mean capacity among the two stores?
The stronger picker-upper?

In commercials for Bounty paper towels, the manufacturer claims that they are the “quicker picker-upper.” But are they also the stronger picker upper? Two AP Statistics students, Wesley and Maverick, decided to find out. They selected a random sample of 30 Bounty paper towels and a random sample of 30 generic paper towels and measured their strength when wet. To do this, they uniformly soaked each paper towel with 4 ounces of water, held two opposite edges of the paper towel, and counted how many quarters each paper towel could hold until ripping, alternating brands. Here are their results:

Bounty: 106, 111, 106, 120, 103, 112, 115, 125, 116, 120, 126, 125, 116, 117, 114
118, 126, 120, 115, 116, 121, 113, 128, 124, 125, 127, 123, 115, 114

Generic: 77, 103, 89, 79, 88, 86, 100, 90, 81, 84, 84, 96, 87, 79, 90
86, 88, 81, 91, 94, 90, 89, 85, 83, 89, 84, 90, 100, 94, 87

Problem:

(a) Display these distributions using parallel boxplots and briefly compare these distributions. Based only on the boxplots, discuss whether or not you think the mean for Bounty is significantly higher than the mean for generic.

(b) Use a significance test to determine if there is convincing evidence that wet Bounty paper towels can hold more weight, on average, than wet generic paper towels.

(c) Interpret the P-value from (b) in the context of this question.
**Presidential approval**

**Solution:**

(a) **State:** We want to estimate $p_{2010} - p_{2009}$ at the 90% confidence level where $p_{2010}$ = the true proportion of all U.S. adults who approved of President Obama’s job performance in September 2010 and $p_{2009}$ = the true proportion of all U.S. adults who approved of President Obama’s job performance in August 2009.

**Plan:** We should use a two-sample z interval for $p_{2010} - p_{2009}$ if the conditions are satisfied.

- Random: The data came from separate random samples.
- Normal: $n_{2010} \hat{p}_{2010} = 512$, $n_{2010} (1 - \hat{p}_{2010}) = 512$, $n_{2009} \hat{p}_{2009} = 535$, $n_{2009} (1 - \hat{p}_{2009}) = 475$ are all at least 10.
- Independent: The samples were taken independently and there are more than $10(1024) = 10,240$ U.S. adults in 2010 and $10(1010) = 10,100$ U.S. adults in 2009.

**Do:**

\[
0.50 - 0.53 \pm 1.645 \sqrt{\frac{0.50(1 - 0.50)}{1024} + \frac{0.53(1 - 0.53)}{1010}} = -0.03 \pm 0.036 = (-0.066, 0.006)
\]

**Conclude:** We are 95% confident that the interval from $-0.066$ to $0.006$ captures the true change in the proportion of U.S. adults who approve of President Obama’s job performance from August 2009 to September 2010. That is, it is plausible that his job approval has fallen by up to 6.6 percentage points or increased by up to 0.6 percentage points.

(b) Since 0 is included in the interval, it is plausible that there has been no change in President Obama’s approval rating. Thus, we do not have convincing evidence that his approval rating has changed.

**Hearing loss**

**Solution:**

(a) **State:** We will test $H_0 : p_1 - p_2 = 0$ versus $H_a : p_1 - p_2 > 0$ at the 0.05 significance level where $p_1$ = the proportion of all teenagers with hearing loss in 2005-2006 and $p_2$ = the proportion of all teenagers with hearing loss in 1988-1994.

**Plan:** We should use a two-sample z test for $p_1 - p_2$ if the conditions are satisfied.

- Random: The data came from separate random samples.
- Normal: $n_1 \hat{p}_1 = 351$, $n_1 (1 - \hat{p}_1) = 1449$, $n_2 \hat{p}_2 = 450$, $n_2 (1 - \hat{p}_2) = 2550$ are all at least 10.
- Independent: The samples were taken independently and there were more than $10(1800) = 18,000$ teenagers in 2005-2006 and $10(3000) = 30,000$ teenagers in 1988-1994.
Do: \[ \hat{p}_c = \frac{450 + 351}{3000 + 1800} = 0.167, \quad z = \frac{0.195 - 0.15 - 0}{\sqrt{\frac{0.167}{1800} + \frac{0.167}{3000}}} = 4.05, \quad P\text{-value} \approx 0 \]

**Conclude:** Since the $P$-value is less than 0.05, we reject $H_0$. We have convincing evidence that the proportion of all teens with hearing loss has increased from 1988-1994 to 2005-2006.

(b) No. Since we didn’t do an experiment where we randomly assigned some teens to listen to iPods and other teens to avoid listening to iPods, we cannot conclude that iPods are the cause. It is possible that teens who listen to iPods also like to listen to music in their cars and perhaps the car stereos are causing the hearing loss.

**Potato chips**

**Solution:**

(a) The shape of the sampling distribution of $\bar{x}_c - \bar{x}_r$ is approximately Normal since both population distributions are approximately Normal. The mean of the sampling distribution is $180 - 175 = 5$ grams and its standard deviation is $\sqrt{\frac{25^2}{20} + \frac{30^2}{20}} = 8.73$.

(b) If the mean of the Riderwood sample is larger, then $\bar{x}_c - \bar{x}_r$ must be negative. The graph below shows the sampling distribution with the desired probability shaded. $P(\bar{x}_c - \bar{x}_r < 0) = P\left( z < \frac{0 - 5}{8.73} \right) = P(z < -0.57) = 0.28$. The inspectors shouldn’t be surprised since the Riderwood sample with have a higher mean over one-fourth of the time.
Plastic Grocery Bags
Solution:

(a) State: We want to estimate $\mu_T - \mu_B$ at the 99% confidence level where $\mu_T$ = the mean capacity of plastic bags from Target (in grams) and $\mu_B$ = the mean capacity of plastic bags from Bashas (in grams).

Plan: If the conditions are met, we will calculate a two-sample $t$ interval for $\mu_T - \mu_B$.

- Random: The students selected a random sample of bags from each store.
- Normal: Since the sample sizes are small, we must graph the data to see if it is reasonable to assume that the population distributions are approximately Normal.

\[
\text{Weight (thousands)}
\]

\[
\begin{array}{ccc}
\text{Store} & \text{Bashas} & \text{Target} \\
8 & \circ & \circ \\
9 & \circ & \circ \\
10 & \circ & \circ \\
11 & \circ & \circ \\
12 & \circ & \circ \\
13 & \circ & \circ \\
14 & \circ & \circ \\
15 & \circ & \circ \\
16 & \circ & \circ \\
\end{array}
\]

Since there is no obvious skewness or outliers, it is safe to use $t$ procedures.

- Independent: The samples were selected independently and it is reasonable to assume that there are more than $10(5) = 50$ plastic grocery bags at each store.

Do: For these data, $\bar{x}_T = 12825.8$, $s_T = 1912.5$, $\bar{x}_B = 9234$, $s_B = 1474.2$. Using the conservative df of 5 – 1 = 4, the critical value for 99% confidence is $t^* = 4.604$. Thus, the confidence interval is:

\[
12826 - 9234 \pm 4.604 \sqrt{\frac{1474.2^2}{5} + \frac{1912.5^2}{5}} = 3592 \pm 4972 = (-1380, 8564). \text{ With technology and df } = 7.5, CI = (-101, 7285). \text{ Notice how much narrower this interval is.}
\]

Conclude: We are 99% confident that the interval from –1380 to 8564 grams captures the true difference in the mean capacity for plastic grocery bags from Target and from Bashas.

(b) Since the interval includes 0, it is plausible that there is no difference in the two means. Thus, we do not have convincing evidence that there is a difference in mean capacity. However, if we increased the sample size we would likely find a convincing difference since it seems pretty clear that Target bags have a bigger capacity.
The stronger picker-upper?
Solution:

(a) The five-number summary for the Bounty paper towels is (103, 114, 116.5, 124, 128) and the five-number summary for the generic paper towels is (77, 84, 88, 90, 103). Here are the boxplots:

![Boxplots of Bounty and Generic paper towels](image)

Both distributions are roughly symmetric, but the generic brand has two high outliers. The center of the Bounty distribution is much higher than the center of the generic distribution. Although the range of each distribution is roughly the same, the interquartile range of the Bounty distribution is larger.

Since the centers are so far apart and there is almost no overlap in the two distributions, the Bounty mean is almost certain to be significantly higher than the generic mean. If the means were really the same, it would be virtually impossible to get so little overlap.

(b) State: We want to perform a test of $H_0: \mu_B - \mu_G = 0$ versus $H_a: \mu_B - \mu_G > 0$ at the 5% level of significance where $\mu_B$ = the mean number of quarters a wet Bounty paper towel can hold and $\mu_G$ = the mean number of quarters a wet generic paper towel can hold.

Plan: If the conditions are met, we will conduct a two-sample $t$ test for $\mu_B - \mu_G$.

- Random: The students used a random sample of paper towels from each brand.
- Normal: Even though there were two outliers in the generic distribution, both distributions were reasonably symmetric and the sample sizes are both at least 30, so it is safe to use $t$ procedures.
- Independent: The samples were selected independently and it is reasonable to assume there are more than 10(30) = 300 paper towels of each brand.

Do: For these data, $\bar{x}_B = 117.6$, $s_B = 6.64$, $\bar{x}_G = 88.1$, and $s_G = 6.30$.

Test statistic: $t = \frac{117.6 - 88.1 - 0}{\sqrt{\frac{6.64^2}{30} + \frac{6.30^2}{30}}} = 17.64$

$P$-value: Using either the conservative df = 30 – 1 = 29 or from technology (df = 57.8), the $P$-value is approximately 0.
Conclude: Since the $P$-value is less than 0.05, we reject $H_0$. There is very convincing evidence that wet Bounty paper towels can hold more weight, on average, than wet generic paper towels.

(c) Since the $P$-value is approximately 0, it is almost impossible to get a difference in means of at least 29.5 quarters by random chance, assuming that the two brands of paper towels can hold the same amount of weight when wet.