MA206 Lesson 8 - Generalization

What is μ?

What is $\bar{x}$ and how do we calculate it using R?

What is σ?

What is s and how do we calculate it using R?

Given sufficiently large samples of a population, what does the Central Limit Theorem state the standard deviation of the mean ($\bar{x}$) will converge to?

Review: How is the standardized statistic for a **single proportion** calculated?
z =

How is the standardized statistic for a **single mean** calculated?
t =

What are the validity conditions for a single mean quantitative variable to use a theory-based approach for strength of evidence?

What is an alternative measure for centrality if a distribution is heavily skewed?

What is the R code to calculate a p-value from a t-distribution for a single mean quantitative variable?

Load the provided ACFT1.csv Dataset. This constitutes data collected on or about 2019 (pre-Covid) from randomly selected cadets in 1st Regiment on physical fitness and includes APFT, IOCT, and ACFT performance. Researchers were curious to know how cadets performed physically on various tests, specifically if they were above average. We will conduct analysis on all three tests.

library(tidyverse)
ACFT <- read_csv("ACFT1.csv")

(Alternatively, as this dataset is loaded online as a .csv file, we can run the following line of code).

```
ACFT <- read_csv("https://raw.githubusercontent.com/rslasater82/MA206Datasets/main/ACFT.csv")
```

We can begin exploring our available data to see what variables are captured.

head(ACFT)
colnames(ACFT)

1. What are the observational units in this study?

2. What are some categorical and quantitative variables of interest? List and classify some of interest.

APFT

The APFT is scored with 3 events on a 100 point scale, where 60 is passing in each of the three events (pushup, situp, and 2 mile run). If a Soldier scores at least 100 points on each event, they can push past 300 to an "extended scale," but if any event falls beneath the 100 point threshold then the "additional" points are lost. It has been suggested that the Corps of Cadets had an average APFT score of 270, and we want to assess if this is true.

Step 1: Ask a Research Question

A.3) What is the research question?

A.4) Based on these questions, what is the population of interest?

Step 2: Design a Study and Collect Data

A.5) What is our null and alternate hypothesis, stated in both words and symbols?

A.6) What is our variable of interest? Is it categorical or quantitative?

A.7) Based on the classification in **6**, what theory-based test will we conduct? (hint: z or t)

Step 3: Explore the Data

(Helpful R code, courtesy of the TidyVerse Tutorial. Know where to find this for your own reference.)

```
ACFT %>%
  ggplot(aes(x = APFT_score)) +
  geom_histogram()+
```

```
  labs(x = "Overall Score", y="Count", title="Cadet APFT Scores")

ACFT %>%
    summarize(
        median = median(APFT_score),
        mean = mean(APFT_score),
        s = sd(APFT_score),
        n = n()
    )
```

A.8) Use R to create a histogram of the APFT scores and describe the shape, center, variability, and any unusual observations.

A.9) Calculate the mean, median, standard deviation, and sample size of the APFT scores. Include the proper notation as appropriate.

Step 4: Draw Inferences Beyond the Data

A.10) Have we met our validity conditions to use theoretical methods? Why or why not?

A.11) Assume we met our validity conditions. Using theory, calculate the appropriate standardized statistic.

A.12) Calculate the appropriate p-value using the theoretical method and standardized statistic from **11**.

A.13) Comment on the strength of evidence as it applies to our null and alternate hypotheses.

Step 5: Formulate Conclusions

A.14) Do you feel comfortable generalizing the results of your analysis to all Army cadets (USMA, ROTC, G2G)? Explain your reasoning.

A.15) Do you feel comfortable generalizing the results of your analysis to the Corps of Cadets? Explain your reasoning.

A.16) What population could you generalize your results to? Explain your reasoning.

A.17) How confident are you to say that we have proven the alternate hypothesis?

Step 6: Look Back and Ahead

A.18) Suggest how you might redesign the experiment to allow you to draw a more broad conclusion.

A.19) Suppose your research question had an alternate hypothesis for a one-sided test. That is, do USMA cadets, on average, perform better than 270? Report your new alternate hypothesis, p-value and the significance of your findings. Is this surprising?

A.20) Suppose you wanted to assess the data for only males or only females. Repeat your original ($\neq$) analysis with the proper subsets and report on your findings.

IOCT

The IOCT is a timed event and times can be converted to a 1000 point scale for calculation into the Physical Program Score (Cumulative) where 900 points is the cutoff for an A, 800 for a B, and so on with a minimum passing score of 680. It has been suggested that DPE curves their scoring to keep the average at 800, but we want to assess if the current average is different than 800.

Step 1: Ask a Research Question

B.3) What is the research question?

B.4) Based on these questions, what is the population of interest?

Step 2: Design a Study and Collect Data

B.5) What is our null and alternate hypothesis, stated in both words and symbols?

B.6) What is our variable of interest? Is it categorical or quantitative?

B.7) Based on the classification in **6**, what theory-based test will we conduct? (hint: z or t)

Step 3: Explore the Data

(Helpful R code, courtesy of the TidyVerse Tutorial. Know where to find this for your own reference.)

```
ACFT %>%
  ggplot(aes(x = IOCT_Score)) +
  geom_histogram()+
  labs(x = "Overall Score", y="Count", title="Cadet IOCT Scores")

ACFT %>%
    summarize(
        median = median(IOCT_Score),
        mean = mean(IOCT_Score),
        s = sd(IOCT_Score),
        n = n()
    )
```

B.8) Use R to create a histogram of the IOCT scores and describe the shape, center, variability, and any unusual observations.

B.9) Calculate the mean, median, standard deviation, and sample size of the IOCT scores. Include the proper notation as appropriate.

Step 4: Draw Inferences Beyond the Data

B.10) Have we met our validity conditions to use theoretical methods? Why or why not?

B.11) Assume we met our validity conditions. Using theory, calculate the appropriate standardized statistic.

B.12) Calculate the appropriate p-value using the theoretical method and standardized statistic from **11**.

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B.14) Do you feel comfortable generalizing the results of your analysis to the Corps of Cadets? Explain your reasoning.

B.15) What population could you generalize your results to? Explain your reasoning.

B.16) How confident are you to say that we have proven the alternate hypothesis?

Step 6: Look Back and Ahead

B.17) Suggest how you might redesign the experiment to allow you to draw a more broad conclusion.

B.18) Suppose your research question had an alternate hypothesis for a one-sided test. That is, do cadets, on average, perform better than 800? Report your new new alternate hypothesis, p-value and the significance of your findings. Is this surprising?

B.19) Suppose you wanted to assess the data for only males or only females. Repeat your original ($\neq$) analysis with the proper subsets and report on your findings.

ACFT

The ACFT is scored with 6 events on a 100 point scale, where 60 is passing in each of the six events. If the arbitrary "average" score is 80 in each event (480 points), is the Corps of Cadets "average" at the ACFT?

Step 1: Ask a Research Question

C.3) What is the research question?

C.4) Based on these questions, what is the population of interest?

Step 2: Design a Study and Collect Data

C.5) What is our null and alternate hypothesis, stated in both words and symbols?

C.6) What is our variable of interest? Is it categorical or quantitative?

C.7) Based on the classification in **6**, what theory-based test will we conduct? (hint: z or t)

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ACFT %>%
  ggplot(aes(x = ACFT_score)) +
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ACFT %>%
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        median = median(ACFT_score),
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        s = sd(APFT_score),
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C.8) Use R to create a histogram of the ACFT scores and describe the shape, center, variability, and any unusual observations.

C.9) Calculate the mean, median, standard deviation, and sample size of the ACFT scores. Include the proper notation as appropriate.

Step 4: Draw Inferences Beyond the Data

C.10) Have we met our validity conditions to use theoretical methods? Why or why not?

C.11) Assume we met our validity conditions. Using theory, calculate the appropriate standardized statistic.

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C.15) Do you feel comfortable generalizing the results of your analysis to the Corps of Cadets? Explain your reasoning.

C.16) What population could you generalize your results to? Explain your reasoning.

C.17) How confident are you to say that we have proven the alternate hypothesis?

Step 6: Look Back and Ahead

C.18) Suggest how you might redesign the experiment to allow you to draw a more broad conclusion.

C.19) Suppose your research question had an alternate hypothesis for a one-sided test. Report your new new alternate hypothesis, p-value and the significance of your findings. Is this surprising?

C.20) Suppose you wanted to assess the data for only males or only females. Repeat your original ($\neq$) analysis with the proper subsets and report on your findings.

C.21) What do the signs of the t statistic tell you that the p-value alone does not in this case?