**Hypothesis Testing of One Mean (One Sample t-Test): M&Ms’ Weight**

**As a result of completing this exercise you should be able to:**

* Understand the concept of hypothesis testing
* Understand P-Value, alpha level , and test statistic t
* Construct the null hypothesis and alternative hypothesis
* Conduct hypothesis for one mean by hand
* Test hypothesis in R using t.test function
* Verifying the output of hypothesis testing with diverse approaches (using confidence interval and R functions)

**Instructions**

**Section I: Introduction of hypothesis testing**

Before we start to test any hypothesis, let’s review some basic ideas.

1. What are the two hypothesis you need to make to conduct a hypothesis testing? (Please write or type down the name and proper symbol for each one)

**Alternative hypothesis: the alternative claim we should conclude when we reject the null hypothesis**

**Null hypothesis: the claim that states. “no changes”, “no effect”, “no difference”, “no relationship”**

1. What is a P-Value?

**P-value is the probability that the sample you collected actually come from the population that the null hypothesis describes, if the null hypothesis is true.**

1. What is , the alpha level or significant level?

**Alpha level is used for the threshold value of a hypothesis test. When we reject the null hypothesis, the test is significant at the alpha level.**

1. When can you reject a null hypothesis, using P-Value and alpha level?

**If the p-value is smaller than the alpha level, we reject the null hypothesis**

1. When can you use R/RStudio to solve hypothesis testing problems? When can you do that?

**You can use RStudio to draw t-distributions, find p-values, and double check in R. These are the couple of last steps in the process of hypothesis testing. `1**

**Section II: Conducting one-sample t-test**

We are wondering whether M&M’s has good quality control that keep all the bags of chocolates they produce with the same weights as 47.9 grams, the weight they marked as their net weight on the package. We used the cumulative data (at bag level) based on the M&M’s data collected the ISAT 251 students in previous semesters.

Some background information of the data:

The data contain three columns:

student: the unique id (eid) of student who exanimated a M&M’s bag

total.number: the total number of M&M’s chocolates in the bag the student exanimated

weight: the weight of the bag of M&M’s (with the bag) in grams

1. Get the data ready
   1. Download the M&M’s bag data (“ISAT251\_MMsBags.csv”) from the Canvas.
   2. Bring the data into R

> myfile <- file.choose()

> mms.bags <- read.csv(myfile,header=TRUE)

*Type or paste the full path to your file here:*

**/Users/zshindc/Downloads/ISAT251\_MMsBags.csv**

* 1. Check and overview the data. (*Snapshot and paste the summary outcome below*)

> summary(mms.bags)

A screenshot of text

Description automatically generated

1. Find the information (i.e., the mean, sample size, and the standard deviation) you need to construct standard error for test statistic using proper R functions (i.e., mean, sd, and dim or length). Type or write down those statistics with *both the symbols and values*.

## sample size as the row number in the dimension

> n <- dim(mms.bags)[1]

mean (use R to get the value): = 49.41963

standard deviation (use R to get the value): = 1.615026

sample size: = 64

1. The Eight Steps for Hypothesis Testing
2. Check the assumptions or conditions. What are those assumption and conditions? Also, explain why those assumptions can be true and use a plot to check whether the distribution seems nearly normal.

* **Dependent variable should be measured at the interval or ratio level with the variable of weight meeting this criteria.**
* **Data are independent which there is no relationship between the observation**
* **No significant outliers that are unusual with the usual data pattern**
* **Dependent variable should be approximately normally distributed that the assumption can be a little violated and still provide valid results.**

Plot a histogram to display the distribution of the weight of M&M’s (paste the plot below), does it look like a normal (in which case, the sample size can be smaller)?

* **This looks like a normal distribution.**

Chart, histogram

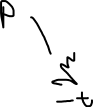
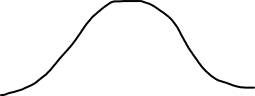
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1. Set the null hypothesis and alternative hypothesis. Write or type down your hypotheses with *proper symbols, values, and formula*.
2. Set the alpha level (the significance level), . Let’s set the alpha level as 0.01 this time (no work to be done here
3. Find the test statistic t. Please write or type down the equations with proper symbols, plug in the values associate with each variable, and calculate the t. Show your work and outcome below. If you do the work on paper, please paste the photo of your work below. (You should *do the calculation manually* rather than using the function in step 7.)

A picture containing graphical user interface

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1. Draw a picture of the normal distribution and *mark where the t is and where (the area) the P-Value you want to find in next step*. Paste your drawing below. If you draw the picture by hand, please take a photo of it and paste the photo below. Pay attention on whether you should use one-tailed (which tail, lower or higher tail) or two-tailed?



1. Find P-Value using R. Please using proper R function with proper arguments to find the P-Value given the test statistic you found in step 3. Snapshot your codes and output in R below and, if you don’t show the output in the snapshot, type out your p-value. (You should *use the function with test statistic t you found in step 3 to get the p-value rather* than using the p-value from the function in step 7.)
2. �" µ ≠ �!: 2\*pt(q=t, df = \_\_\_\_)





1. Make your conclusion. Based on the P-Value you found in step 5 the we decided to use in step 2, can you reject the null hypothesis and at which level your test is statically significant? (State your answer and explain how you reach the conclusion.)

**We cannot reject the null hypothesis because the p-value (about 2) is bigger than the alpha level (0.01).**

1. Double Check your findings with a 99% confidence interval and t.test function in R.

Step 7.1 Construct a 99% confidence interval using the sample and see whether your garget value is included or excluded by the confidence interval. *Show your work and explain whether the finding of your confidence interval aligned with the outcome of your one-sample t test. (Please calculate the CI by hand like you learned in previous lesson rather than use the outcome from the function in step 7.2.)*



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**The finding of the confidence interval did not align with the outcome of the one-sample.**

Step 7.2 Using t.test in R (snapshot and paste your codes and output below.) Does the output from R aligned with your finding and conclusion in step5 and step 6? Explain how and why.

t.test(\_\_\_\_, alternative = \_\_\_\_\_\_, mu = \_\_\_\_, conf.level = \_\_\_\_)

t.test(mms.bags$weight,alternative=c("two.sided", "less", "greater"),mu=47.9,conf.level = 0.995)

Text

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1. Interpret the outcome of your hypothesis testing and the recommendation you would make base on that. (For example, how’s the weight of M&M’s per bag compare to the standard value statistically? Does M&M’s company need to worry or do anything about their quality control?)

**The weight of M&M’s per bag (49.41953 g) are heavier compared to the standard value statistically (47.9 g).**

1. [Bonus] In our previous exercise (CI for one mean), we noticed that all the confidence intervals do not contain the true average weight (the standard value) because we included the weight of the empty package. Given that the weight of an empty M&M’s bag is 1.5 grams, please redo the one-sample t test with a proper standard value (the net weight plus bag weight = 47.9 + 1.5 grams). Show your work and conclusion. (Running the test in R only is sufficient for this bonus question.)

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