

STT 3850 Midterm Study Guide

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Statistics

Characterizing a set of data (3 S's)

Shape: how the data is distributed

- Low outliers make a dataset skewed to the Right
- High outliers make a dataset skewed to the Left
- Normal distributions have fairly even outliers on either side

Center: Where the data is centered around

- Normal: If the dataset has a normal distribution (shape) this can be calculated using the `mean($data)` function.
- Skewed (left or right): The mean will be misrepresent the center. Calculate a skewed center using `median($data)`.

Spread: How far the data differs from the center

- Normal: If the dataset has a normal distribution, then the standard deviation applies to both sides of the data and so it represents the spread.
- Skewed (left or right): If the dataset is skewed on either side, the deviation above and below the center will not be the same, so you must calculate it using `IQR($data)` for the interquartile range.

Hypothesis testing (5 step procedure)

- Z-Score: The number of Standard deviations an element is from the mean.
- P-Score:
- $\bar{X} = \text{mean}$

1. Specify the Null and Alternative hypothesis

- Null hypothesis notated as $H_0 : M = \text{value}$ or $\bar{M}_1 - \bar{M}_2 = 0$
- Alternative hypothesis notated as $H_A : M \neq 0$

2. Test your statistic using the Z-test or T-test

- `t.test(variable~categoricalVariable, data=DF)` will perform the t-test on a set of data. If the data is not tidy you might want to use `dplyr` to tidy it up first.
- Alternatively, if we have an expected mean, and our data has the experimental mean, we can call the `t.test` function as such: `t.test(experimental_data, mu = <expected_mean>)` Example:

```
DF <- ChickWeight %>%                                # Imports data frame
  filter(Diet %in% c(3:4))                             # Then removes all collums except for 3 and 4
                                                         # Weight~Diet means the weight across Diets value.
t.test(weight~Diet, data=DF)                          # Quickly gives us what we need to know
```

3. Determine rejection region

- Rejection region is the percent of data points on either end of a data set.
- Percentile is represented by alpha (α) (probability of a type 1 error)
- Unless otherwise specified, assume rejection region to be 5% (0.05).

4. Statistical conclusion.

You can either

- Reject the null hypothesis H_0 if $P < \alpha$

or

- Fail to reject the null hypothesis H_0 if $P \geq \alpha$

Based on the output from the previous example pictured below, $P = 0.45$, and we assume $\alpha = 0.05$. P is far greater than α , so we **fail to reject the null hypothesis H_0** .

```
##
## Welch Two Sample t-test
##
## data: weight by Diet
## t = 0.75908, df = 226.16, p-value = 0.4486
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -12.26840 27.64298
## sample estimates:
## mean in group 3 mean in group 4
##      142.9500      135.2627
```

5. English conclusion (or Spanish, if that's your thing)

- The statistical conclusion deals with the null hypothesis H_0 , but the English conclusion only deals with things in terms of the Alternative Hypothesis H_A (written out)

In the case of our example from above, we failed to reject the null hypothesis, so we **failed to find evidence supporting a weight difference in chicks between Diets 3 and 4**.

- The English hypothesis must ALWAYS be written this way. You either find evidence to support H_A or you fail to find evidence to support H_A .
- There is a chance for error:
- type 1 error: Assuming the Alternative hypothesis when the Null hypothesis is true.
- type 2 error: Assuming the Null hypothesis when the Alternative hypothesis is true.

Cohens'd (effect size) Not really used in this class

- The difference between a control group's mean, and an experiment group's mean, measured in standard deviations.
- Measured using the following formula: $d = \frac{|M_0 - M_1|}{SD}$
- How large is the effect size?
 - small if $|d| < 0.20$
 - medium if $|d| < 0.5$
 - large if $|d| > 0.5$
- Compute using R with `cohensD(post_data, pre_data, method = "paired")`

```
Diet_3 <- filter(ChickWeight, Diet == 3)
Diet_4 <- filter(ChickWeight, Diet == 4)
#method should normally be "paired", but the sample size was different
cohensD(Diet_4$weight, Diet_3$weight, method = "unequal")
```

Analysing a DataSet

- An analysis consists of
 - t-value

- p-value
- effect size (Cohen's D)

```
DF <- ChickWeight %>%
  filter(Diet %in% c(3:4))
t.test(weight ~ Diet, data = DF)

Diet_3 <- filter(DF, Diet == 3)
Diet4 <- filter(DF, Diet == 4)
cohensD(Diet_3$weight, Diet_4$weight, method = "unequal")
```

From this we can gather the effect size is roughly 10% and, with a t-value of 75% and a p-value of 45%.
 TODO: ask about reading these statistics.

Probability

- Binomial probability: The probability of a binary outcome (not always 50%)
 - Written $X \sim \text{Bin}(\#,)$
 - Programmed into R with `sum(dbinom(low#:high#, <number_of_trials>, <probability>))`

```
#Probability of making at LEAST 7 shots out of 10, with a 70% success rate (statistically)
prob <- 0.7
shots <- 7
trials <- 10
sum(dbinom(shots:trials, trials, prob))
```

```
## [1] 0.6496107
```

Probability in R (by Corrinne)

- $X \sim \text{Binomial}(\text{number of random draws}, \text{probability})$
- `rbinom()` function can be used to simulate N independent binomial random variables.
- `rbinom(number of random draws, number of coins we are flipping on each draw, probability)`

```
# Generate 20 occurrences of flipping 10 coins, each with 30% probability
flips <- rbinom(200, 10, 0.3)
# Find the probability of 5 of the coins being heads
mean(flips == 5)
```

```
## [1] 0.1
```

```
# Or
dbinom(5, 10, 0.3)
```

```
## [1] 0.1029193
```

- `dbinom()` function is used to calculate *exact probability density* (binomial distribution)
- probability density of a specific outcome (5 heads)
- `dbinom(mean, number of coins flipping, probability)`
- probability density of outcomes up to a point (4 or fewer heads)
- `pbinom()` function is used to calculate *exact cumulative density* of the binomial