

STA130H1S TUT0109

W5: Hypothesis Testing and Errors

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Announcements

- SSU Social Night! (Today 5-7pm)
 - BBT first come, first serve (need to fill [this](#) out)
- Mentorship program,
a way to earn 1%
Career Exploration requirement

We've teamed up with the Career Exploration and Education Centre to offer a session to learn about programs, services, and resources available to you at Career Exploration & Education. In the second half of the session you will explore the ways in which your future career possibilities could be influenced by your choice of Subject POST.

Registration is required, the session is offered twice, you only need to attend once.

Feb 25th <https://clnx.utoronto.ca/publicEventsController.htm?eventId=14937>

Mar 1st <https://clnx.utoronto.ca/publicEventsController.htm?eventId=14938>

What you need to know:

* REGISTER! *

- Arrive on time (or early). Events start at 10 after the hour and you may be denied entry after the event start time.
- If you can't come - cancel. Please cancel your registration to allow others a chance to attend.
- Waitlisted students. If there are available spaces at the event start time, waitlisted students will be able to attend on a first come, first serve basis.

If you require disability-related accommodations for an event or workshop, please email us at careercentre@mail.careers.utoronto.ca

Overview

- Questions from last week
- Vocabulary for this week
- How to give oral presentations
- Small group discussion
- Group presentation
- Any questions for today?

Questions (from last week)

- Brief questions
 - Can you show us the conclusion (after discussion) on board?
 - Quick review on all materials and key definitions?
- Questions related to R
- Questions related to course material

Is there a way to write subscripts in R?

E.g. Null hypothesis, H_0

- Yes
- In RMarkdown you can use `$$` to write equations (including subscripts)
 - For subscripts, use an underscore (`_`)
 - E.g. `H_0`
 - For superscripts, use a caret (`^`)
 - E.g. p-value is `< $2.2 * 10^{-16}$`

$$2.2 * 10^{-16}$$

QUESTIONS

Is there a way to write subscripts in R?

CODE:

ii. Null and Alternative Hypotheses

```
\begin{itemize}
  \item[]  $H_0$ : There is no difference between the mean heights of males and females.
  \item[]  $H_1$ : There is a difference between the mean heights of males and females.
\newline
\end{itemize}
```

```
\pagebreak
```

iii. A test statistic and its distribution

```
\begin{itemize}
  \item[--] Test statistic (under  $H_0$ ):  $t = 12.076$ 
  \item[--] Distribution:  $t \sim t_{164}$ 
  \item[--] *Refer to Appendix D for R code.
\newline
\end{itemize}
```

OUTPUT:

ii. Null and Alternative Hypotheses

H_0 : There is no difference between the mean heights of males and females.

H_1 : There is a difference between the mean heights of males and females.

2

iii. A test statistic and its distribution

– Test statistic (under H_0): $t = 12.076$

– Distribution: $t \sim t_{164}$

– *Refer to Appendix D for R code.

Is there a list of codes I should be able to use by now?

- Understanding and knowing how to use the code/functions from lecture
- *Some* of the functions are listed here:

Summary of Functions (Week 3)

FUNCTION	DESCRIPTION	WHEN USED TOGETHER
<code>select()</code>	Select variables/columns	
<code>filter()</code>	Choose observations/rows	
<code>mutate()</code>	Create new variables from existing variables	Logical test on vector; Populates cells of new variable depending on test results
<code>ifelse()</code>	Evaluates test to get a logical vector	
<code>rename()</code>	Rename variables	
<code>arrange()</code>	Sort data frame	
<code>summarise()</code>	Summarise data frame	Data frame groups that contains summary information for each group
<code>group_by()</code>	Group one or more variables	

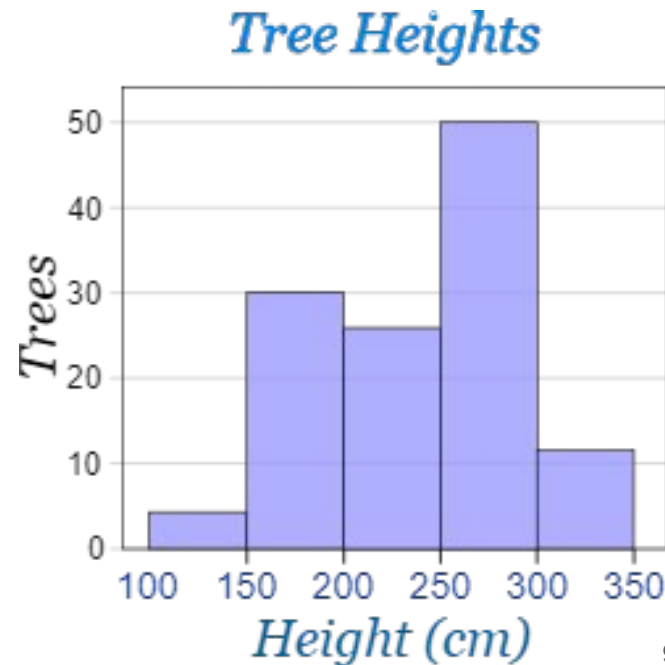
Helpful R Resources

- Includes explanations for functions (some have visuals too!)
- [R Markdown Aid Sheet](#)
- [Basic R Commands](#)
- [Data Wrangling \(with dplyr\)](#)
- [Data Visualization \(with ggplot2\)](#)
- [Data Importing](#)

What's the relationship between probability and the dotplot/histogram?

- Normalize bin counts so sum = 1
 - I.e. $P = \text{\# of counts in bin} / \text{Total \# counts in histogram}$
 - Data is between 0 and 1
- Each bin count represents the probability that an observation falls within that bin

* $N = 120$

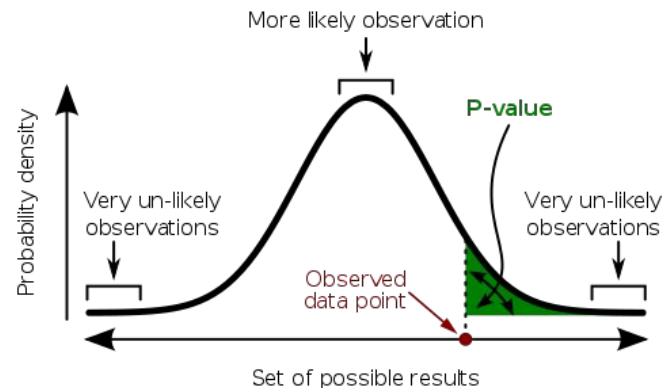


How do you interpret the strength of evidence using p-value?

P-value	Evidence
$p\text{-value} > 0.10$	no evidence against H_0
$0.05 < p\text{-value} < 0.10$	weak evidence against H_0
$0.01 < p\text{-value} < 0.05$	moderate evidence against H_0
$0.001 < p\text{-value} < 0.01$	strong evidence against H_0
$p\text{-value} < 0.001$	very strong evidence against H_0

Why does smaller p-value (<0.05) mean stronger evidence against H_0 ?

- **P-value:** Probability (under H_0) of obtaining a result that is equal to or more extreme than what's actually observed
- **Rejection region:** Area in sampling distribution that contains all the values that allow you to reject the null hypothesis
- If $p < 0.05$, then the chance of observing your outcome due to chance alone was less than 5% (5 times in 100 or less)
 - I.e. Unlikely to occur
- Smaller the p-value, higher significance
 - Tells us the hypothesis under consideration may not adequately explain the observation



A **p-value** (shaded green area) is the probability of an observed 1 (or more extreme) result assuming that the null hypothesis is true.

Is it possible to calculate p-value of bimodal graph?

- Yes
 - Would have to perform tests for bimodality (outside scope of this course)
- STA130: Using simulations (and simplified data)

In a small sample size is p-value near zero [...]

- Small sample size is not sufficient to get a good estimate of sampling distribution

Vocabulary for this Week

- Type I and II errors
- Comparing two group means/proportions

* Refer to last week's vocabulary for additional terms

Type I and II Errors

- Type I Error: Incorrect rejection of true null hypothesis
 - False alarm!
 - Probability of type I error is α
 - α is usually chosen to be 5% (95% confidence intervals)
- Type II Error: Data seems to be consistent with H_0 but H_0 is actually not true
 - Missed opportunity!

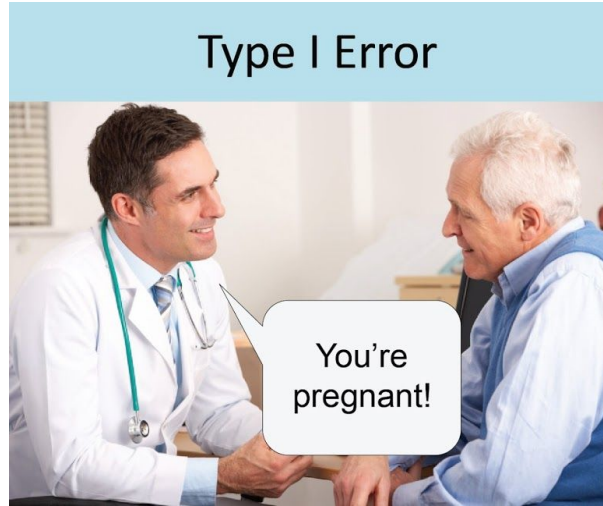
	H_0 is True	H_0 is False
Reject H_0	Type I Error (Probability of <i>false positive</i> = α)	Correct outcome! (True positive)
Fail to reject H_0	Correct outcome! (True negative)	Type II Error (Probability of <i>false negative</i> = β)

EXAMPLE:

“Pregnancy”

H_0 : Person is not pregnant

H_A : Person is pregnant



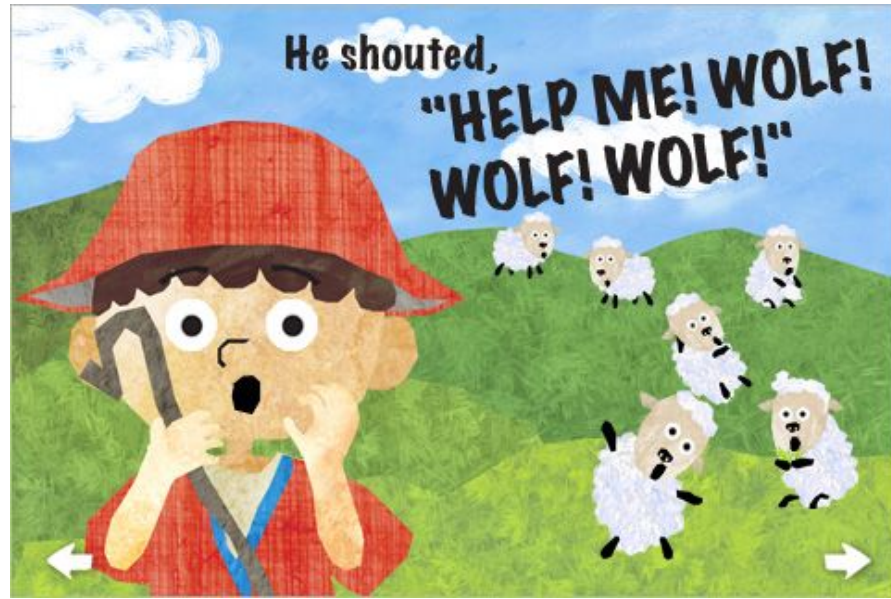
	H_0 is True	H_0 is False
Reject H_0	Type I Error (Probability of <i>false positive</i> = α)	Correct outcome! (True positive)
Fail to reject H_0	Correct outcome! (True negative)	Type II Error (Probability of <i>false negative</i> = β)

EXAMPLE:

“The boy who cried wolf”

H_0 : ?

H_A : ?



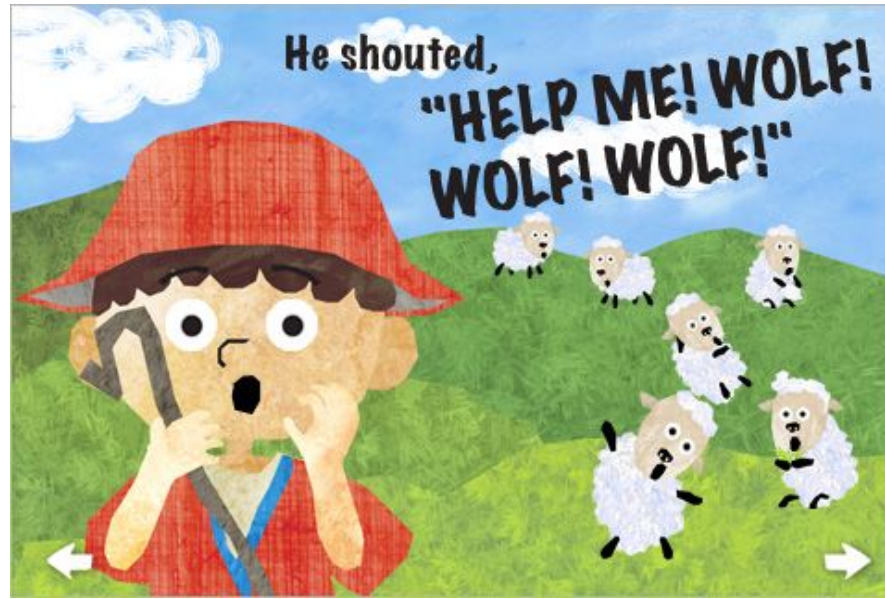
	H_0 is True	H_0 is False
Reject H_0	Type I Error (Probability of <i>false positive</i> = α)	Correct outcome! (True positive)
Fail to reject H_0	Correct outcome! (True negative)	Type II Error (Probability of <i>false negative</i> = β)

EXAMPLE:

“The boy who cried wolf”

H_0 : There is no wolf

H_A : There is a wolf



Question:

If the boy cried “wolf” when there was no wolf, is this a Type I or Type II error?

	H_0 is True	H_0 is False
Reject H_0	Type I Error (Probability of <i>false positive</i> = α)	Correct outcome! (True positive)
Fail to reject H_0	Correct outcome! (True negative)	Type II Error (Probability of <i>false negative</i> = β)

EXAMPLE:

“Somebody is being convicted of murder”

H_0 : ?

H_A : ?



	H_0 is True	H_0 is False
Reject H_0	Type I Error (Probability of <i>false positive</i> = α)	Correct outcome! (True positive)
Fail to reject H_0	Correct outcome! (True negative)	Type II Error (Probability of <i>false negative</i> = β)

* **Convicted:** Judge has evidence to say the person did do the crime

EXAMPLE:

“Somebody is being convicted of murder”

H_0 : This person is innocent

H_A : This person is not innocent



Question:

If a *guilty* person was let go free, is this a Type I or Type II error?

	H_0 is True	H_0 is False
Reject H_0	Type I Error (Probability of <i>false positive</i> = α)	Correct outcome! (True positive)
Fail to reject H_0	Correct outcome! (True negative)	Type II Error (Probability of <i>false negative</i> = β)

* **Convicted:** Judge has evidence to say the person did do the crime

EXAMPLE:

“Somebody is being convicted of murder”

H_0 : This person is innocent

H_A : This person is not innocent



Question:

If an *innocent* person was let go free, is this a true positive or true negative?

	H_0 is True	H_0 is False
Reject H_0	Type I Error (Probability of <i>false positive</i> = α)	Correct outcome! (True positive)
Fail to reject H_0	Correct outcome! (True negative)	Type II Error (Probability of <i>false negative</i> = β)

* **Convicted:** Judge has evidence to say the person did do the crime

Group Discussion

What makes a good/poor oral presentation?

(10 min discussion)

Video

What do you think makes a good/bad presentation?
What do you like/dislike about the presentation?

(10 min)

Tips for giving a great oral presentation: Content

1. What is the main message you want to get across?
2. Create an (organized) outline of your presentation
3. Define terms early
4. Make clear transitions between parts of your presentation
5. Make your data/ figures meaningful
6. Summarize

Tips for giving a great oral presentation: Delivery

1. Be confident, make eye contact and avoid reading
2. Avoid filler words – “ummm”, “like”, “you know”
3. Speak slowly and it’s ok to pause (and breathe!)
4. Remember to enunciate all the parts of each word
5. Practice! Practice! Practice!

Useful Phrases

Providing an outline of your presentation:

"I'd like to give you a brief outline of my presentation...";

"Here is the agenda for the meeting...";

"My presentation consists of the following parts...";

"The presentation is divided into four main sections..."

Making clear transitions:

"I'd like to move on to another part of the presentation...";

"Now I'd like to look at..."; "For instance..."; "In addition...";

"Moreover..."; "This leads me to the next point..."

Summarizing:

"Let's summarize briefly what we've looked at..."; "In conclusion...";

"I'd like to recap..."; "I'd like to sum up the main points..."

Tips for Effectively Designed Posters

1. Use large font and a clean typeface
2. Consistent and clean layout
3. Provide enough information – but avoid the urge to overload each slide with text. Keep it short.
4. Remember you're telling a story. Be brief and to the point: cover the what(s), how(s), and why(s) of the work you did.
5. Figures should stand alone: title, appropriate axis titles, figure caption, etc.
6. Use a catchy title to gain the audience's attention
7. Only provide what is necessary. Unnecessary figures/ data are distracting (and potentially confusing).
8. PROOFREAD! (Spell check is your friend)

Group Presentation

(30 min to prepare, 5 min presentation)

Instructions

- Create a draft outline for your oral presentation (30 min)
 - Upload to Quercus, one per group (include all names)
- Present as a group (5 min)

Like a written summary, the presentation should include:

1. Contextualize the problem
2. Summarize the methods. E.g. State hypotheses; define the test statistic; etc.
3. Summarize their findings
4. Conclusion
5. Limitations (optional, but good practice). E.g. sample size, study design issues, etc.

Questions about today?

- Get a piece of paper (you can just use a small piece) and write down any questions you had about today, I'll address them in the next class!
 - E.g. Something you were confused about, want to go more in depth
- If you don't have any questions you can just draw something like a smiley face ☐