PH 142: Review of Part III

December 3rd, 2023

Instructor: Tomer Altman

Course Evaluation Assignment!

- Screenshot and submitted to Gradescope
- Due Dec 5th at 11:59 PM
- This assignment contributes 5% to your participation grade
- This is **NOT** extra credit. You will *lower* your grade if you skip this!
- See pinned message on Ed for more details

Part III of the course

- Heavily focused on conducting hypothesis tests and calculating confidence intervals
- We covered many tests one by one. Your task is to be able to know which test applies when you read a question.

Hypothesis testing: four steps

TESTS OF SIGNIFICANCE: THE FOUR-STEP PROCESS

STATE: What is the practical question that requires a statistical test?

PLAN: Identify the parameter, state null and alternative hypotheses, and choose the type of test that fits your situation.

SOLVE: Carry out the test in three phases:

1. **Check the conditions** for the test you plan to use.
2. Calculate the **test statistic.**
3. Find the ***P*-value** using a table of Normal probabilities or technology.

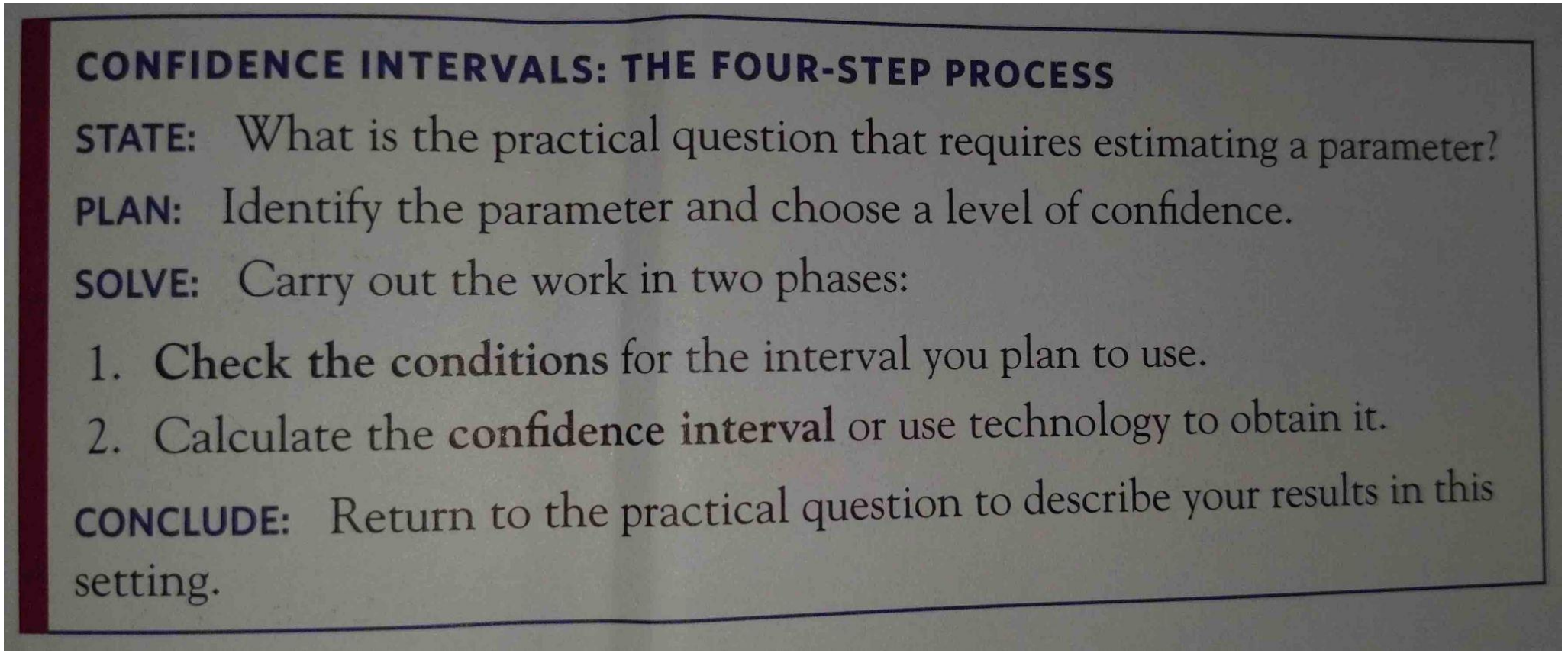
CONCLUDE: Return to the practical question to describe your results in this setting.

Baldi & Moore

Parts of a hypothesis test

- What are the assumptions?
- State the null and alternative hypotheses. Are they one or two-sided?
- Calculate the test statistic
- Calculate the p-value (or write/identify the code to do so)
- Interpret the p-value with respect to consistency with the null hypothesis

Confidence Intervals: Four Steps



CONFIDENCE INTERVALS: THE FOUR-STEP PROCESS

STATE: What is the practical question that requires estimating a parameter?

PLAN: Identify the parameter and choose a level of confidence.

SOLVE: Carry out the work in two phases:

1. **Check the conditions** for the interval you plan to use.
2. Calculate the **confidence interval** or use technology to obtain it.

CONCLUDE: Return to the practical question to describe your results in this setting.

Baldi & Moore

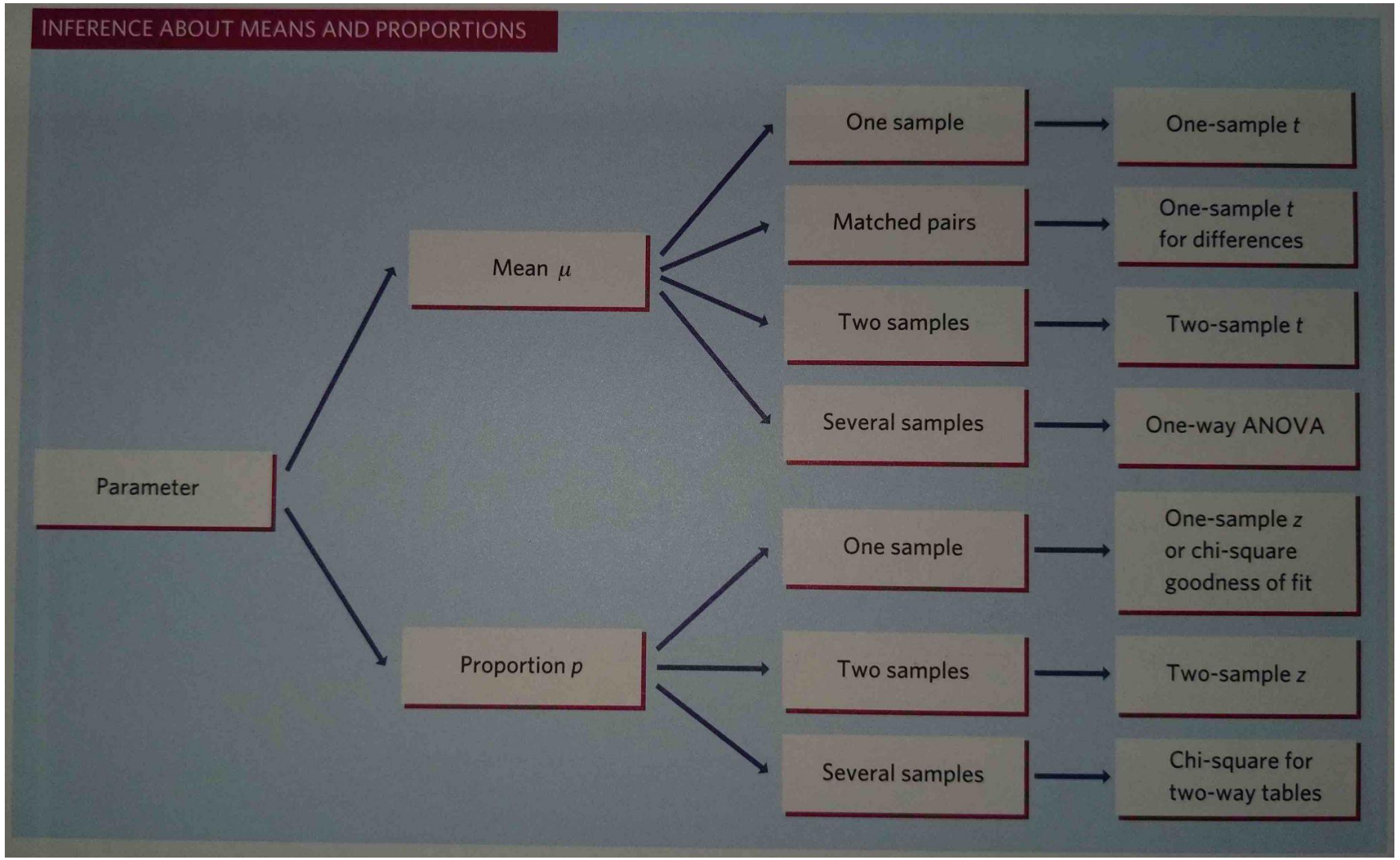
Confidence interval analysis

- Form: estimate +/- (critical value x standard error)
- Estimate is what you calculate from your data
  - The sample mean
  - The sample proportion
  - The difference in means (or proportions)
- The critical value is found using one of the R `q` functions like `qnorm()` or `qt()`. You are asking R for the value such that 95% (or 99%, say) of the area of the distribution is between +/- that value.
- The standard error is calculated using a formula, such as s/sqrt(n). The standard error decreases as the sample size n increases
- No parametric formula for the sampling distribution of an estimator? No problem, just use the Bootstrap!

Meta Questions:
What to ask yourself when you read a question

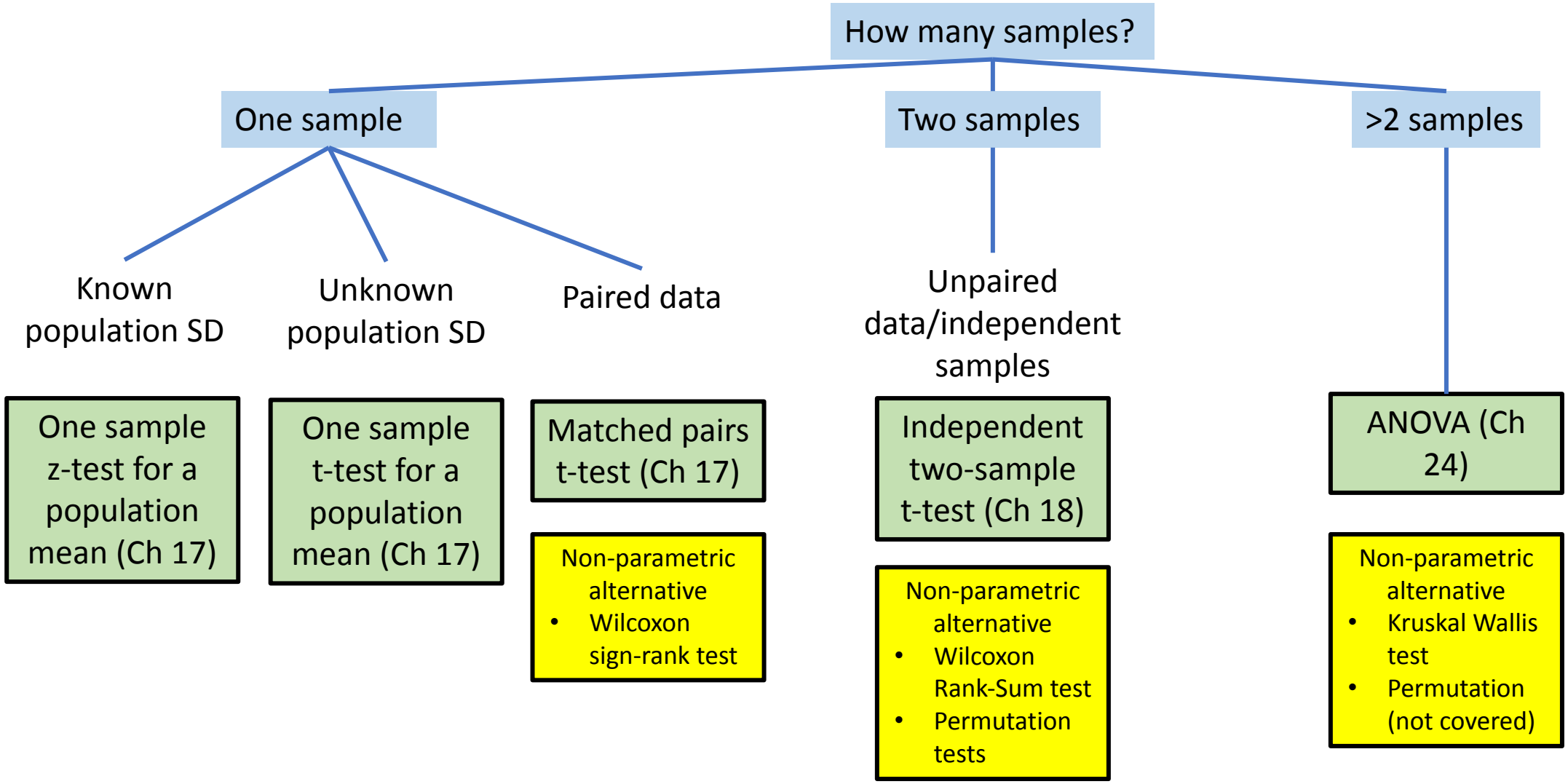
- What type of data is represented?
  - Quantitative
    - Discrete
    - Continuous
  - Categorical
    - Binary
    - Categorical with >2 levels
      - Ordinal
      - Nominal
- How many samples are there?
  - One sample
  - Two samples
  - > Two samples
- How many relevant variables are there in the data to test?
- ***What is the problem really asking for?***

Single Variable Methods

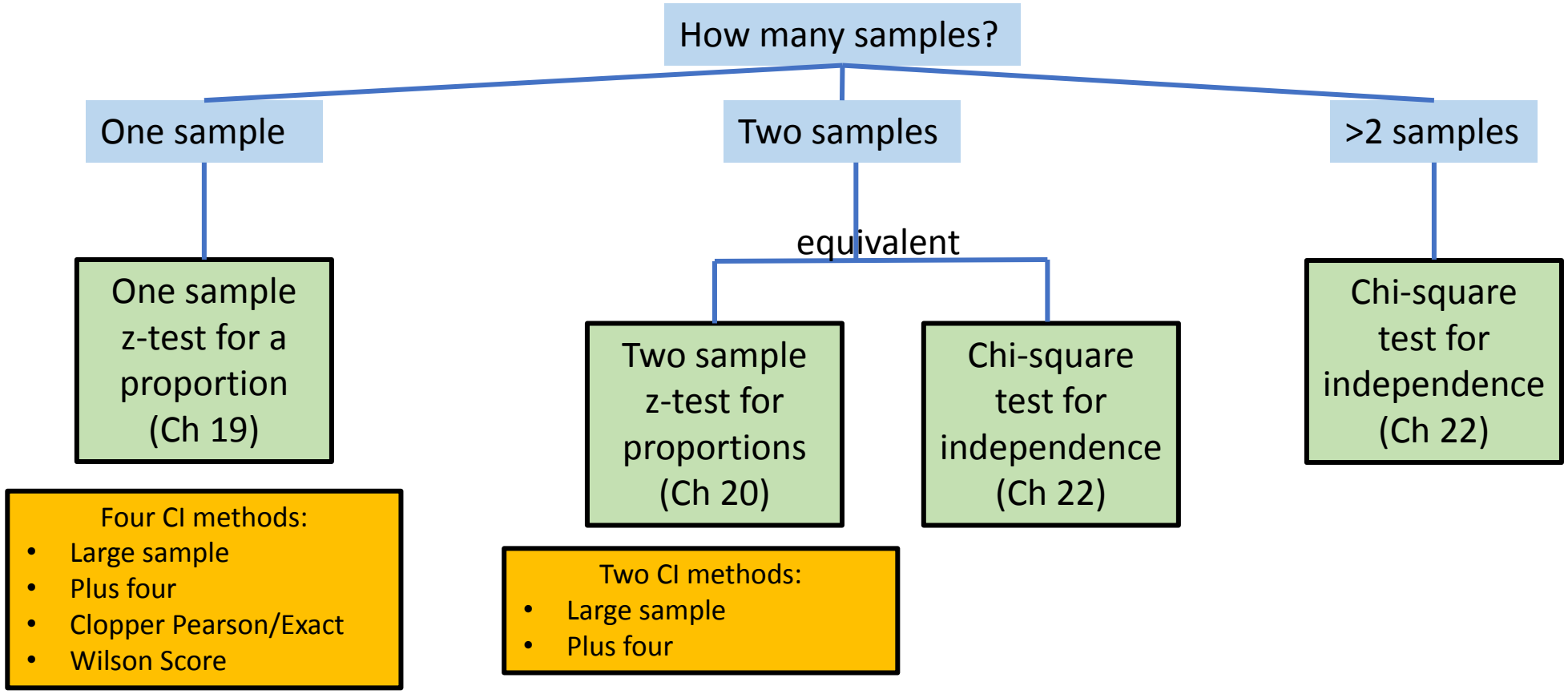


Baldi & Moore

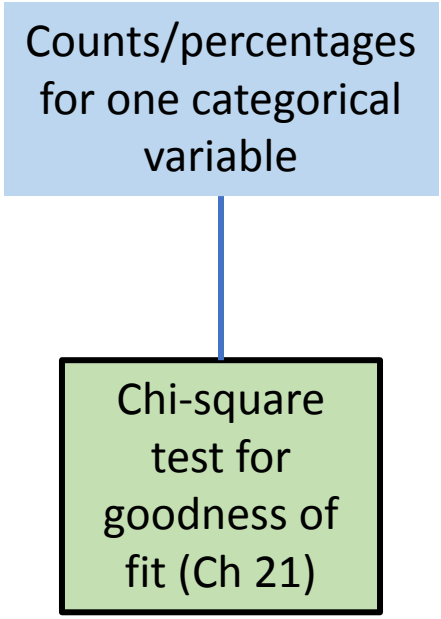
If you have continuous data, single variable:



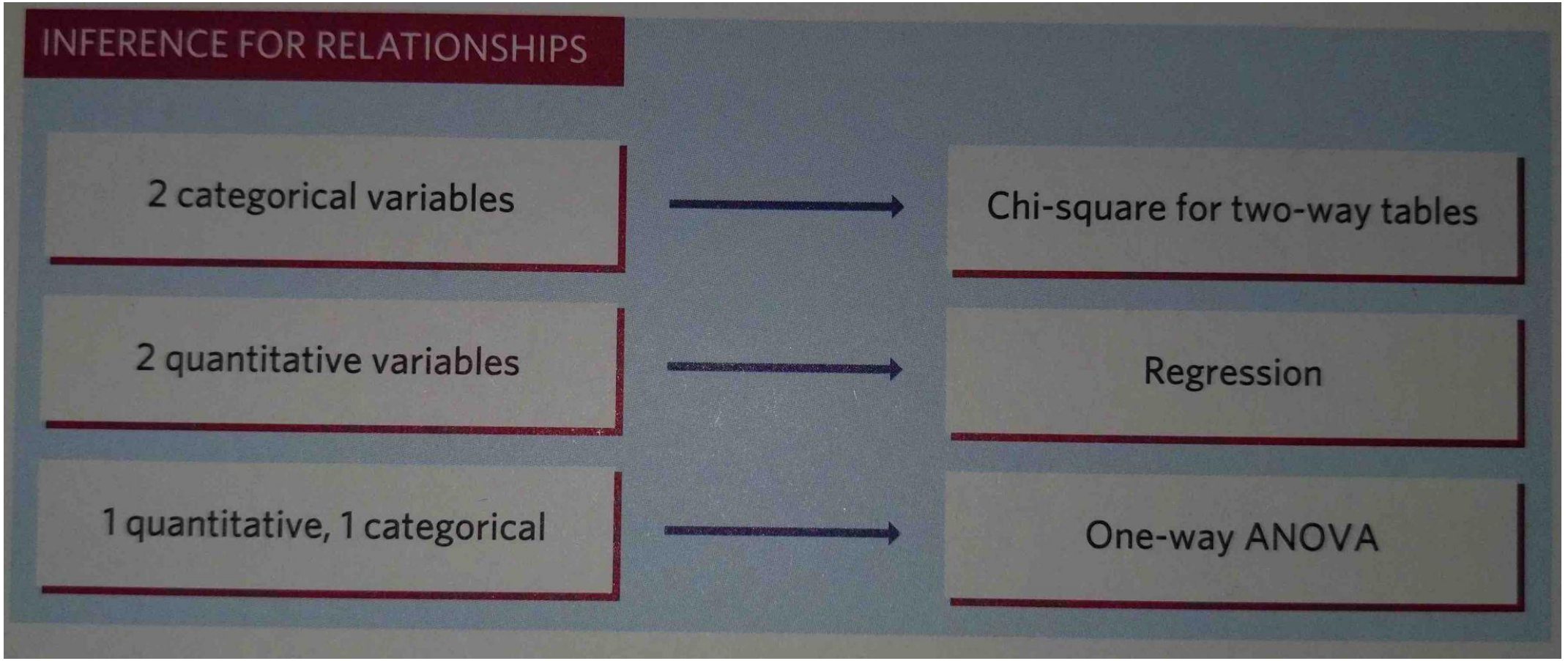
If you have binary data, single variable:



If you have categorical data (>2 levels), single variable:

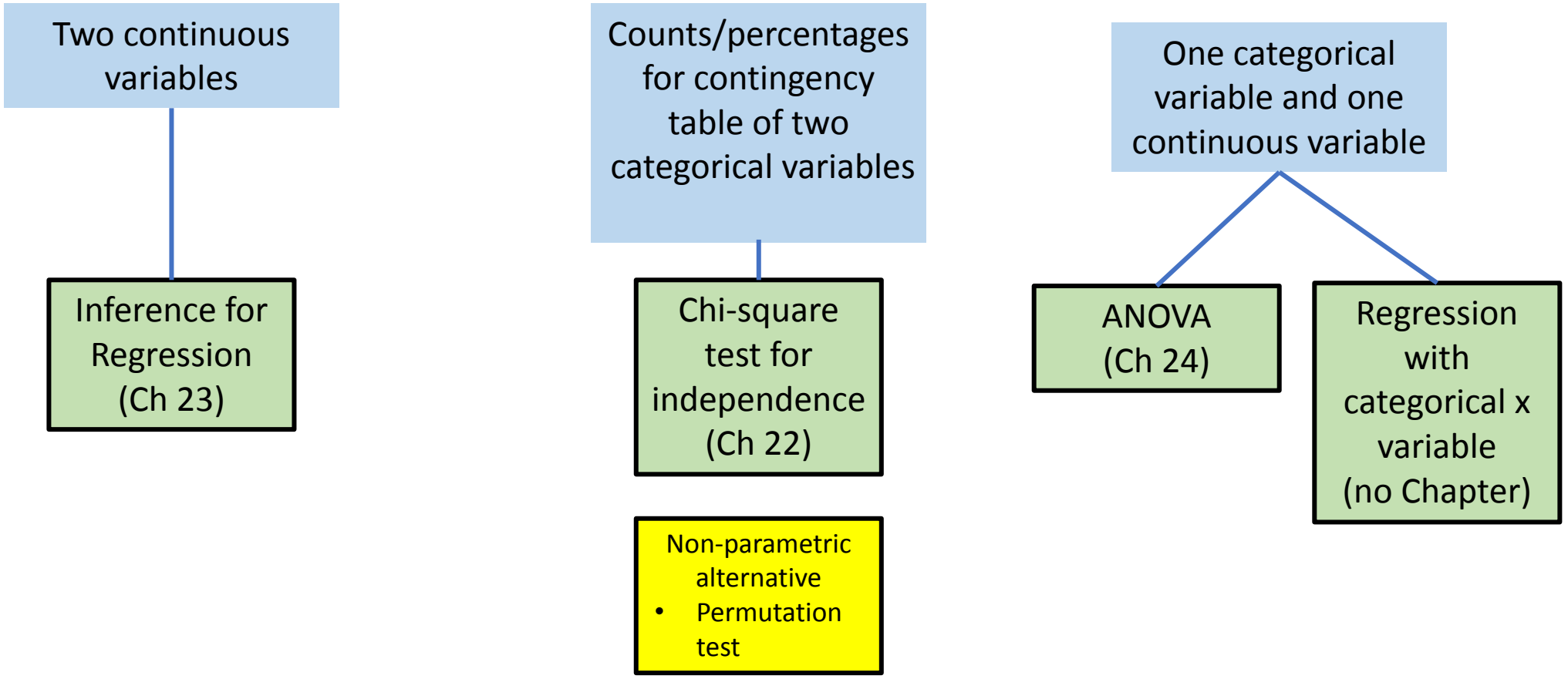


Two Variable Methods



Baldi & Moore

What if you have two variables?



Two variable analysis table

		Explanatory Variable	
		Quantitative	Categorical
Response Variable	Quantitative	**Regression**	**One-Way ANOVA** **Regression with Categorical Explanatory Variable**
	Categorical	(not covered)	**Two-Way Chi Square Test of Independence**

More about inference for regression

- Continuous data
- One sample
- Two continuous variables: an explanatory variable x and a response variable y

t-test for the regression slope (Ch 23)

t-test for correlation (Ch 23)

We didn't cover this because it is redundant to the test for slope

Example 1: Which test to perform?

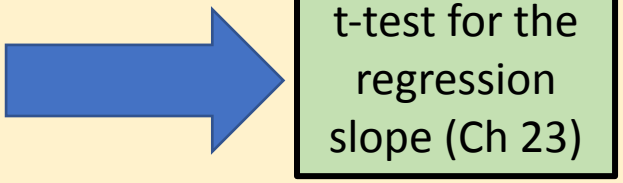
- The amygdala is a brain structure involved in the processing of memory of emotional reactions. Ten subjects were shown emotional video clips. They had their brains scanned and their memory of the clips assessed. The first three rows of the data frame looks like this:

Relative activity	Memory score
-0.417	31
-0.258	29
-0.234	29

- What type of data do you have?
- How many samples?
- How many variables?

Example 1: Which test to perform? (From Ch 23)

- Continuous data
- One sample (on ten participants)
- Two variables



While it isn't yet apparent (because a question wasn't asked), this should signal linear regression because that is what we try when we have two continuous variables on one sample

Questions that could be asked (if you had all the data):

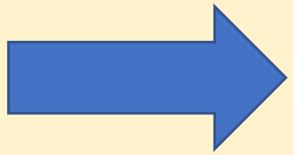
- Make a scatter plot. Does it appear linear?
- Interpret the provided r or r^2 values.
- Write code to test the slope coefficient. Write the null and alternative hypotheses for the corresponding test. Interpret the output from the test (including the p-value).
- Assess the provided diagnostic plots. Does the data meet the assumptions?

Example 2: Which test to perform?

- A study investigated ways to prevent staph infections in surgery patients. In a first step, the researchers examined the nasal secretions of a random sample of 6771 patients admitted to various hospitals for surgery. They found that 1251 tested positive for *Staphylococcus aureus*, the bacterium responsible for most staph infections.
  - What type of data do you have?
  - How many samples?
  - How many variables?

Example 2: Which test to perform? (Ch 19)

- Binary data (staph or not)
- One sample
- One variable



One sample z-test for a proportion (Ch 19)

Four CI methods:
- Large sample
- Plus four
- Clopper Pearson/Exact
- Wilson Score

Questions that could be asked:

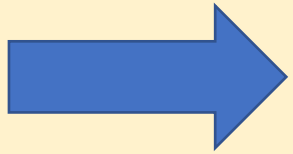
- Perform the test (write your hypotheses, evaluate the assumptions, calculate the test statistic, write code to find the p-value, interpret the p-value
- Calculate the confidence interval by hand using large sample or plus four method (when to use plus four method?). Write code for the other two methods
- Evaluate the assumptions for using the method

Example 3: Which test to perform

- A study on the effects of vaping classifies people as “never vapers”, “occasional vapers”, “frequent vapers”. You interview a sample of 150 people in each group and ask a questionnaire to derive a quantitative score (between 0 and 100) on stress levels.
  - What type of data do you have?
  - How many samples?
  - How many variables?

Example 3: Which test to perform (Ch 24)

- You have one categorical variable (level of vaping), and one continuous variable (stress level)
- The categorical variable corresponds to three samples – one for each level of the category
- Two variables: one categorical and one continuous



Either is appropriate:

ANOVA (Ch 24)

Regression with categorical x variable (no Chapter)

Example 3: Which test to perform (Ch 24)

Questions that could be asked:

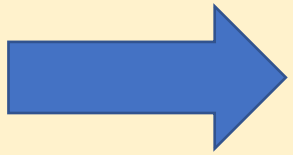
- State the null and alternative hypotheses for an ANOVA test
- With more information, you could perform the ANOVA calculation, write code to perform the calculation or interpret the ANOVA R output
- Write a model to perform regression with x as a categorical variable.
- Interpret the output from a regression model performed on these data

Example 4: Which test to perform?

- Essential tremor is a neurological movement disorder characterized by involuntary rhythmic movement that typically interferes with the full use of the arms and hands. A pilot experiment examining the effectiveness of a noninvasive handheld device using active cancellation of tremor technology to stabilize tremor-induced motion in patients diagnosed with essential tremor. Tremor amplitude was measured (in centimeters) for each of 11 subjects when performing a spoon-use tasks with the ACT device turned, in random order, once on and once off.
  - What type of data do you have?
  - How many samples?
  - How many variables?

Example 4: Which test to perform? (Ch 17)

- Tremor amplitude is a continuous variable
- One sample, but paired data (before and after)
- If helpful, can think of “on” and “off” as a second, categorical variable.



Matched pairs t-test (Ch 17)

Questions that could be asked:

- (If you had the data or some statistics): Perform the appropriate test. Write code for the p-value.
- What is the key feature of these data that determines which test is appropriate?
- How could you plot the data before performing the test to visualize the statistic of interest?
- Define wash out period, and carry over effects.

Example 5: Which test to perform?

- A random sample of 700 births from local records shows this distribution across the days of the week. Do these data give evidence that local births are not equally likely on all days of the week?

Day	Births
Monday	110
Tuesday	124
Wednesday	104
Thursday	94
Friday	112
Saturday	72
Sunday	84

  - What type of data do you have?
  - How many samples?
  - How many variables?

Example 5: Which test to perform? (Ch 21)

- Categorical variable with > 2 levels: Day of the week
- One sample
- Note that you have a table of data where the numeric information is only one column and you're asked if data is evenly distributed across the days
  - This signals that the null is an "even distribution" across the days and should remind you to calculate observed counts (provided) and expected counts (under the null)
- Questions that could be asked:
  - Calculate the expected counts, calculate the test statistic, what are the degrees of freedom, write code to calculate the p-value. What day of the week contributes data that is furthest from the null hypothesis?