



# Analysis of Psychological Data

## Lab 8. Hey Means, Don't Be Mean To Us: Related-Sample T-Test and One-Way ANOVA

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# Reminders

Homework 3 is **on now** and due October 29 (50 points)

Homework 4 is **on now** and due October 29 (7 points)

Difficulties in homework? Join office hours. I am happy to help you!

Exam 2 is on November 2



# What are we going to do?

Recap to give you a big picture

Related-sample t-test

One-way ANOVA

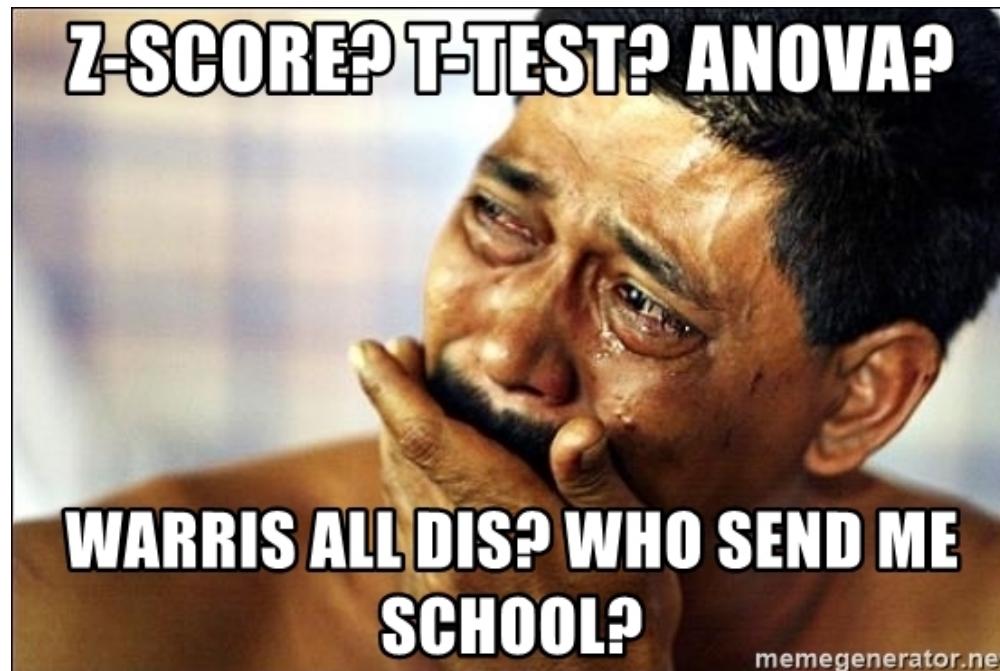
Do it together



# Are you ready?

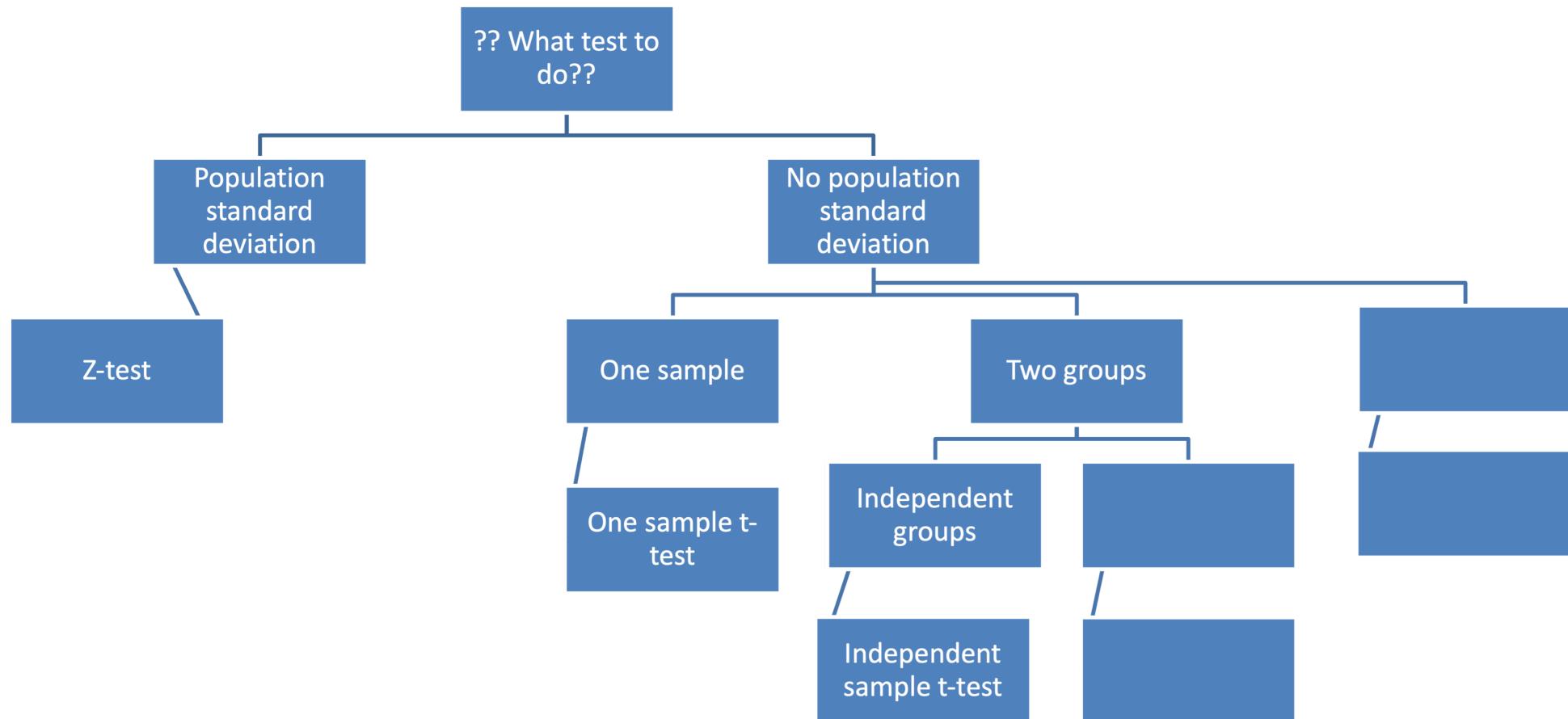
## z-test, t-test, ANOVA, ANCOVA, MANOVA, MANCOVA, RM-ANCOVA... WHAT?!

Playing the game of statistical inference about population 'means'





# Big picture





# Related-sample t-test

When do we use it?

Participants included in one sample are dependent on the other sample

Degrees of freedom

$$df = n_{dif} - 1$$

Test-statistic (**t-statistic**)

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{\bar{dif}}} \text{ where } s_{\bar{dif}} = \frac{s_{dif}}{\sqrt{n_{dif}}}$$



# Related-sample t-test

## Effect size

Remember the practical significance! Let's quantify the size of effect (if significant)

Means the magnitude of the mean difference in the number of standard deviation units

Rule of thumb: 0.2 (small), 0.5 (medium), 0.8 (large)

In related-sample t-test, the effect size is

$$d = \frac{\bar{X}_1 - \bar{X}_2}{s_{dif}}$$



# Effect size

z-test

$$d = \frac{\bar{X} - \mu_0}{\sigma_X}$$

one-sample t-test

$$d = \frac{\bar{X} - \mu_0}{s_X}$$

independent-sample t-test

$$d = \frac{\bar{X}_1 - \bar{X}_2}{s_p}$$

related-sample t-test

$$d = \frac{\bar{X}_1 - \bar{X}_2}{s_{dif}}$$



# Do it together

## Example 1 from Youtube

[https://www.youtube.com/watch?v=Ko\\_WlL1oF1o](https://www.youtube.com/watch?v=Ko_WlL1oF1o)

## Example 2

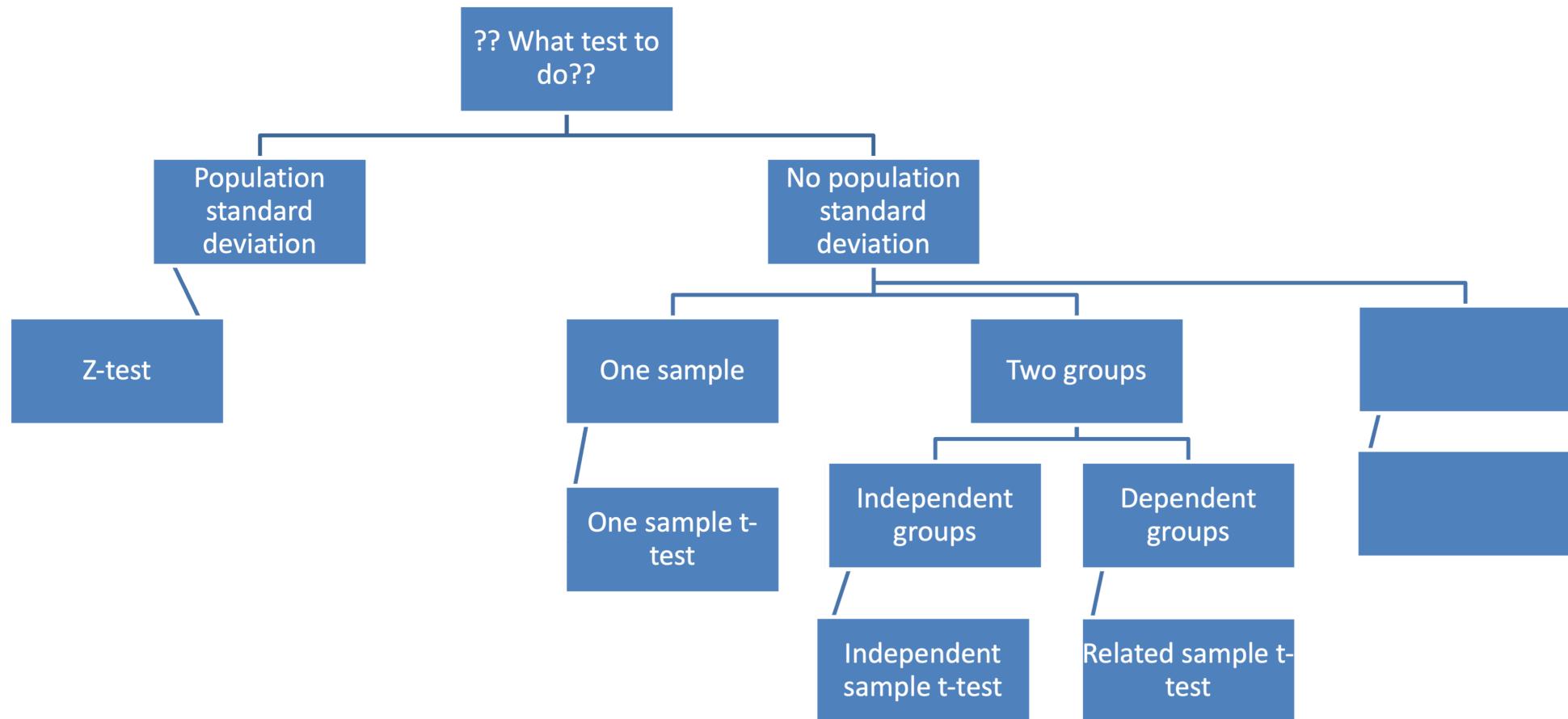
Does medication lower cholesterol levels? A group of 24 patients received medication to reduce their cholesterol. Patient cholesterol was measured before and after the medication.  $\alpha = .05$ .

## Example 3

Is your current happiness level significantly different from the happiness level in August?



# Big picture





# One-way ANOVA

So far, we've only compared two groups (e.g., Lakers vs. Clippers supporters)

z-test, one-sample t-test, independent-sample t-test, related-sample t-test

What if we have three groups? (e.g., Lakers, Clippers, and Sacramento Kings supporters)

ANOVA (= Analysis of Variance)



# One-way ANOVA

## Variables

So far, we think of our variables as different groups

For ANOVA, think of our variables as multiple levels of the same variable

That is,

Instead of comparing Lakers vs. Clippers vs. Sacramento Kings

We have 'basketball supporters' as the independent variable (*aka.* factor in ANOVA context)

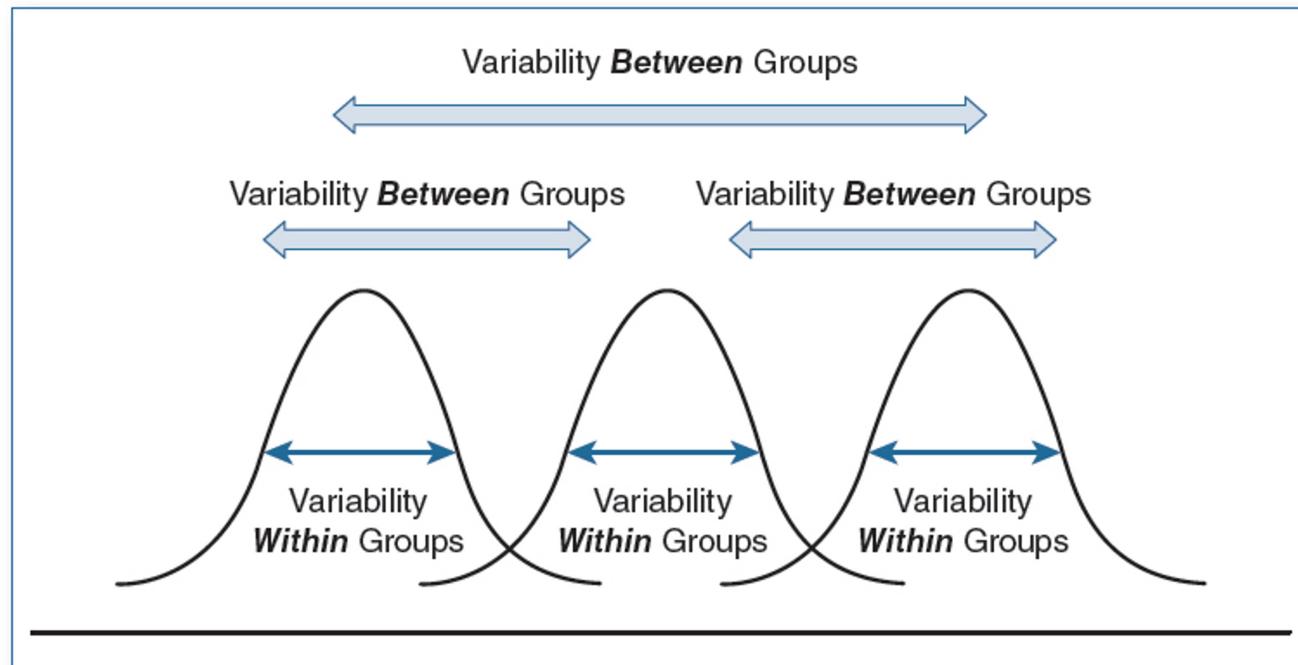
The 'basketball supporters' has 3 levels: Lakers, Clippers, and Sacramento Kings



# One-way ANOVA

'N-Way': N = the number of IV (or factor)

One-way ANOVA: ANOVA using one IV; factorial ANOVA: 2 or more IV





# One-way ANOVA

## F-ratio

test-statistic for ANOVA

The ratio between the between group-variability and within-group variability

Larger F-ratio → larger portion of between-group variability compared to within-group variability

$$F = \frac{MS_{between}}{MS_{within}}$$



# One-way ANOVA

'Variance' is the key, and do you remember that SS plays a role in variance?

Remember?

$$\sigma^2 = \frac{\sum_{i=1}^N (X_i - \bar{X})^2}{N} \text{ and } s^2 = \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}$$

SS means the sum of each individual's squared deviation from the mean

$$SS_X = \sum_{i=1}^N (X_i - \bar{X})^2$$



# One-way ANOVA

We 'separate' the between-group variance and within-group variance

$$SS_{total} = SS_{between} + SS_{within}$$

where

$$SS_{total} = \sum_{i=1}^N (X_{ij} - \bar{X})^2 \quad df = N - 1$$

$$SS_{between} = \sum_{i=1}^N (\bar{X}_j - \bar{X})^2 \quad df = J - 1$$

$$SS_{within} = \sum_{i=1}^N (X_{ij} - \bar{X}_j)^2 \quad df = N - J$$



# One-way ANOVA

## Mean squares

$$MS_{between} = \frac{SS_{between}}{df_{between}}$$

$$MS_{within} = \frac{SS_{within}}{df_{within}}$$

Finally, F-ratio

$$F = \frac{MS_{between}}{MS_{within}}$$



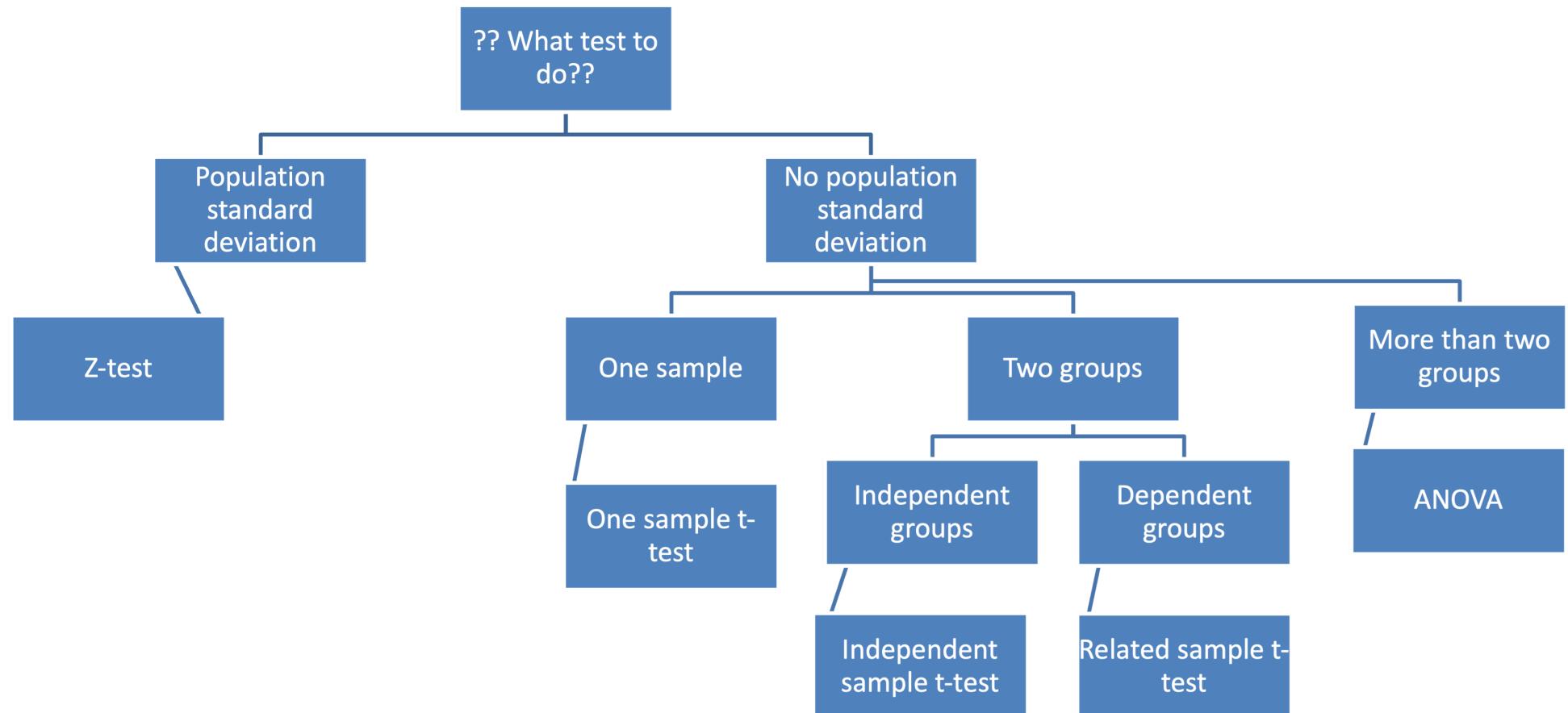
# Do it together

## Example

Some researchers are interested in whether social media use impacts sleep quality



# Big picture





# Summary

## Related-sample t-test

When to compute (when comparing dependent samples, e.g., pre-test & post-test) & how to compute?

## Effect sizes

What it is (magnitude of difference between means)

## One-way ANOVA

When to compute (when you have more than 2 groups)



# Before you go home...

Exam 2 is on November 2

Bring red scantron (large and red one)

Pencil, eraser, pen, calculator, notes, z-table, t-table, F-table

Check everything is working before the exam!



# Before you go home...

## Correct scantron form (otherwise, you will get a score of 0)

The image shows two versions of a scantron test form side-by-side. Both forms are titled "ParScore® STUDENT ENROLLMENT SHEET" and "SCANTRON Test Form No. F-288-PAR-L".

**Left Form (Student Enrollment Sheet):**

- INSTRUCTOR:** Only write your lab section number or TA's name in this area.
- CLASS:** \_\_\_\_\_
- HOUR/DAY:** \_\_\_\_\_
- DIRECTIONS:**
  - MAKE DARK MARKS
  - ERASE COMPLETELY TO CHANGE
  - EX.
  -
- ID NUMBER:** 100098765
- PHONE NUMBER:** LEAVE THIS BLANK
- LAST NAME:** CARLOS
- FIRST NAME:** JOSE
- M.I.:** \_\_\_\_\_
- FEED THIS DIRECTION:** An arrow points upwards along the left edge of the form.

**Right Form (Test Form):**

- ID NUMBER:** 100098765
- TEST FORM:** 001
- DIRECTIONS:**
  - MAKE DARK MARKS
  - ERASE COMPLETELY TO CHANGE
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- TEST QUESTIONS:** A grid of 180 questions, each with four options (A, B, C, D). The first few questions are:
  - 1. You will have 50 multiple choice questions. Answer them here.
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- FEED THIS DIRECTION:** An arrow points downwards along the right edge of the form.



# Thanks! Have a nice weekend!

