Applied Statistical Analysis

EDUC 6050

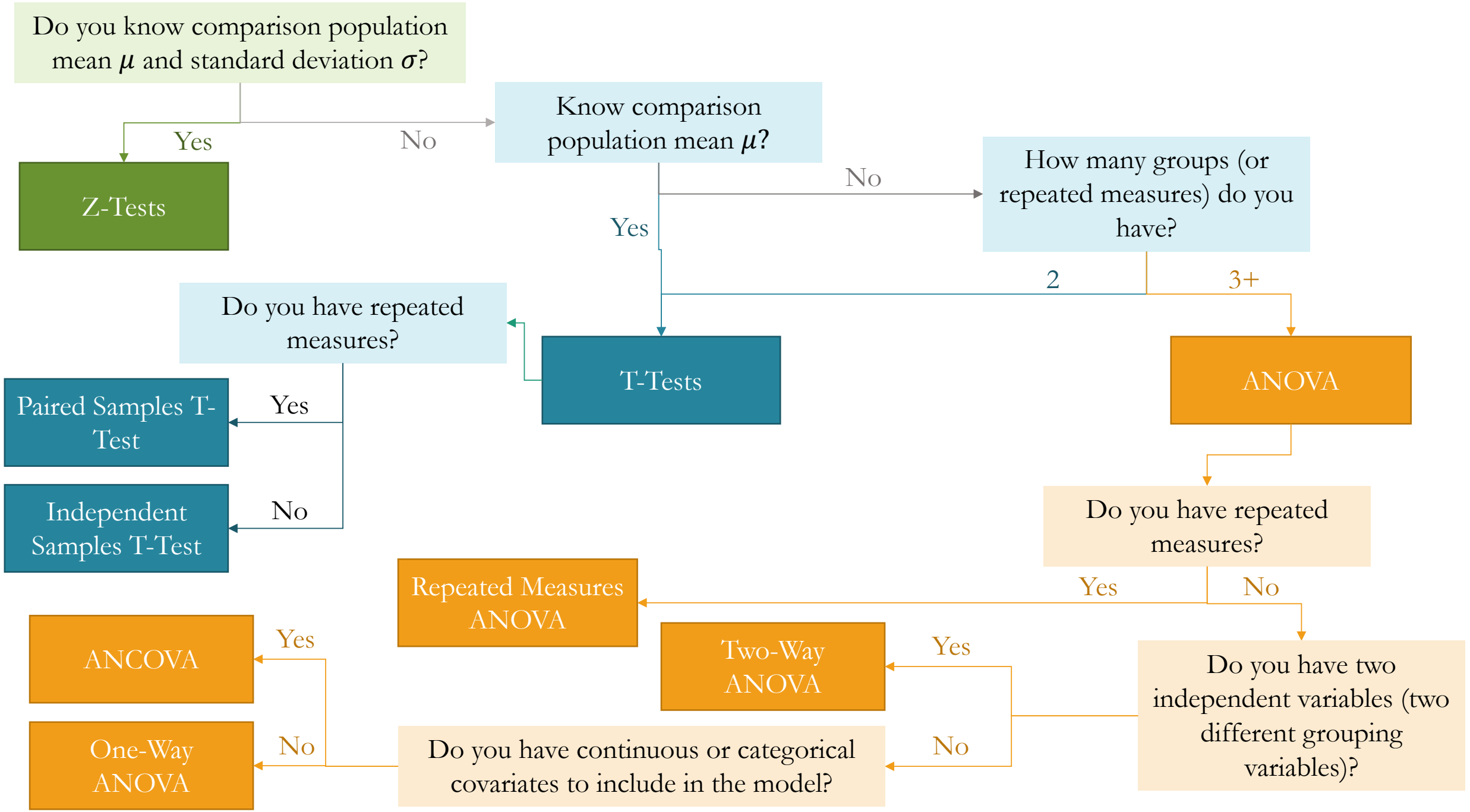
Week 7

Finding clarity using data

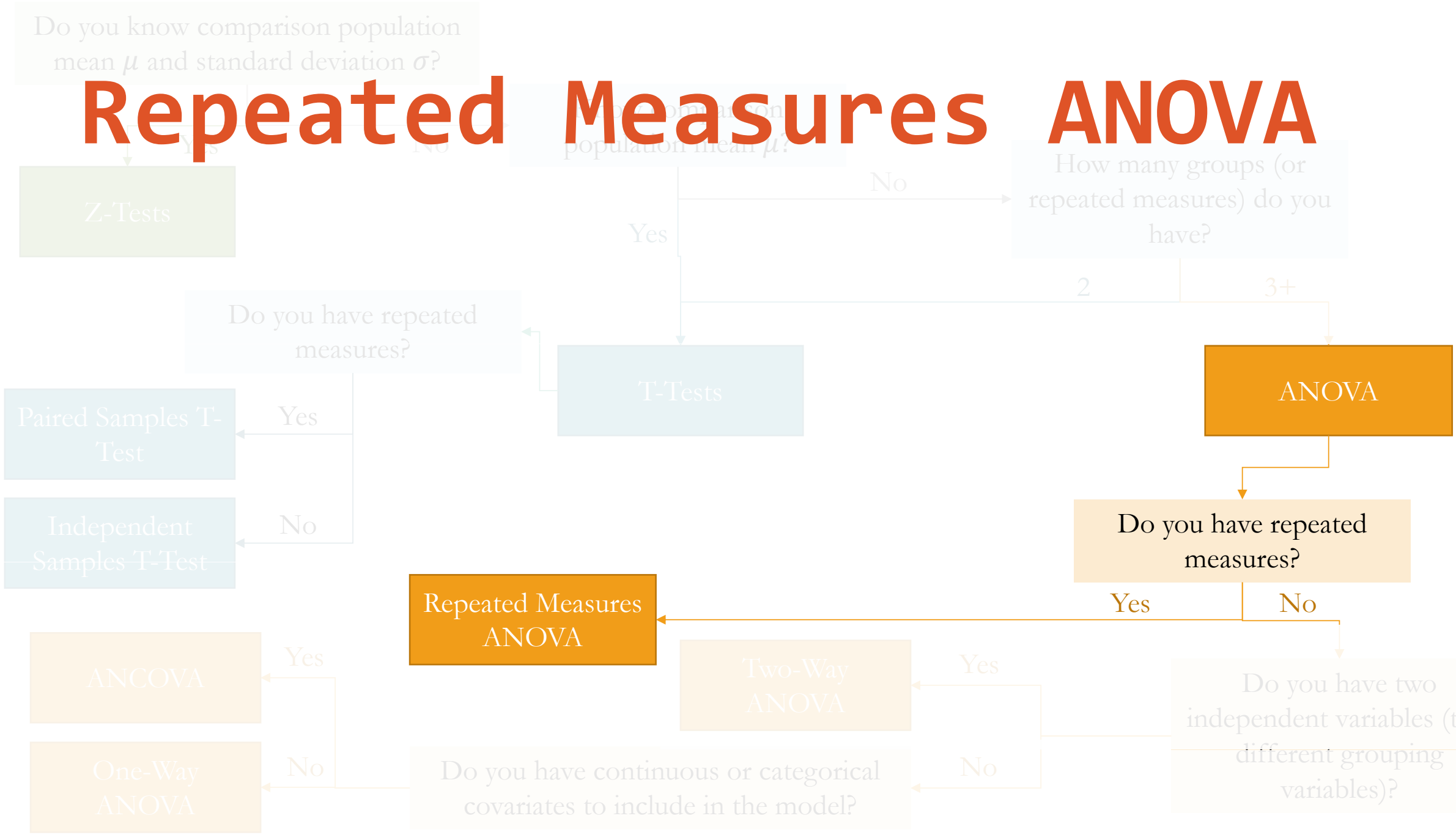
Today

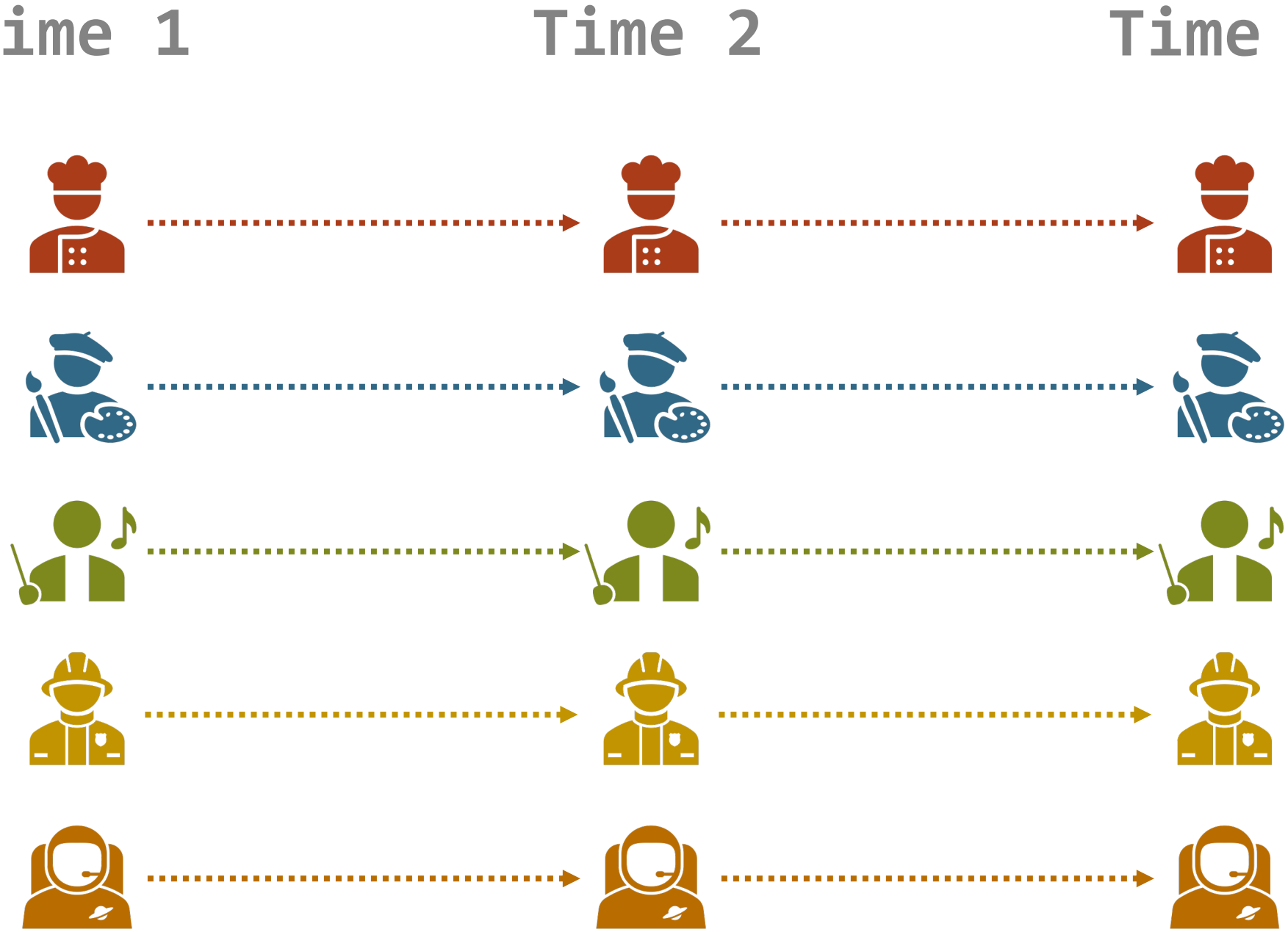
Hypothesis Testing with ANOVA

- Repeated Measures ANOVA
- Mixed ANOVA


Do you know comparison population mean μ and standard deviation σ?
Yes
No
Z-Tests
Know comparison population mean μ?
No
How many groups (or repeated measures) do you have?
Yes
2
3+
Do you have repeated measures?
T-Tests
ANOVA
Paired Samples T-Test
Yes
Independent Samples T-Test
No
Do you have repeated measures?
Yes
No
Repeated Measures ANOVA
Two-Way ANOVA
Yes
Do you have two independent variables (two different grouping variables)?
ANCOVA
Yes
One-Way ANOVA
No
Do you have continuous or categorical covariates to include in the model?
No

Repeated Measures ANOVA

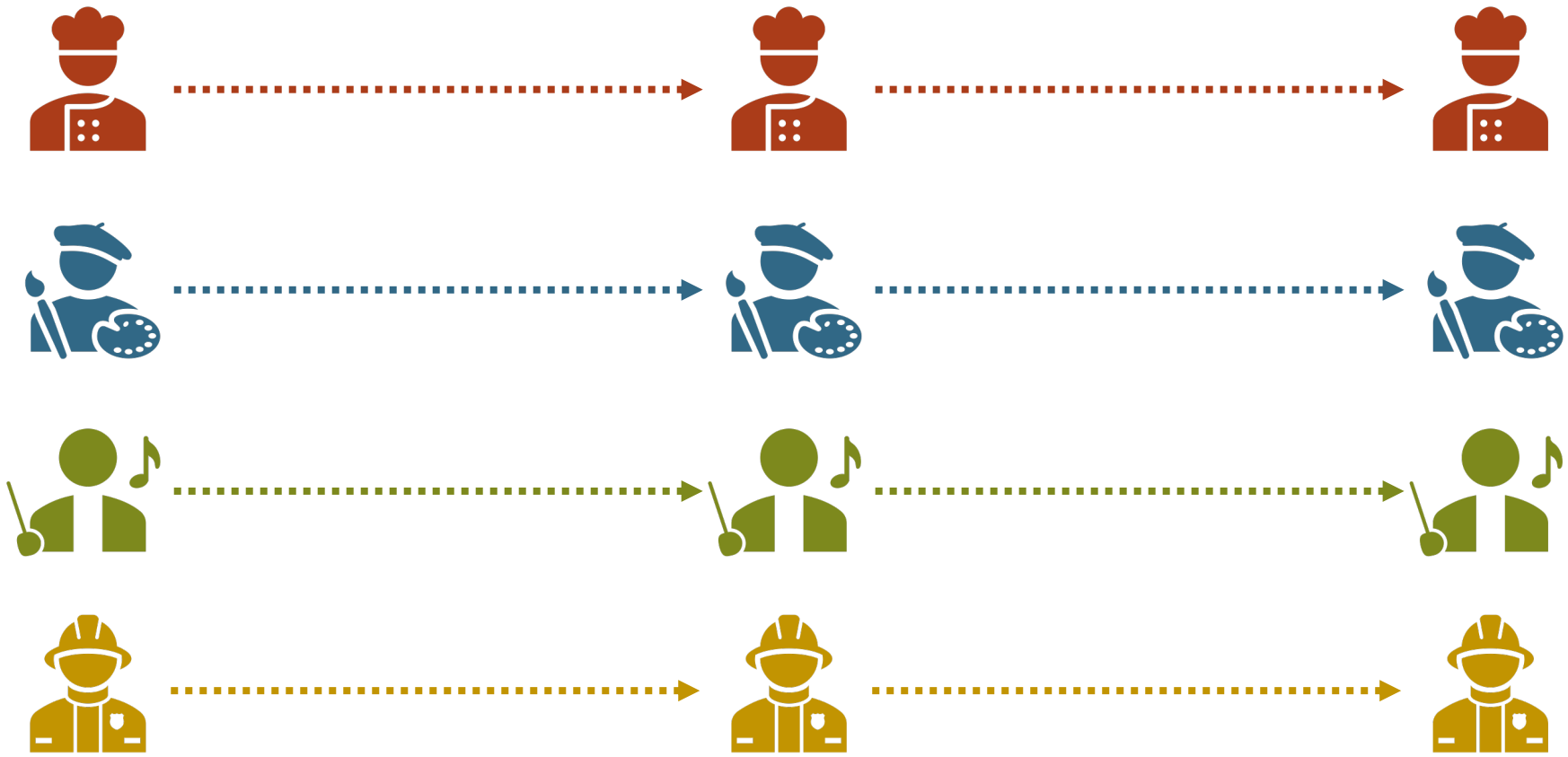




Same people at each time point with same dependent variable at each time point

Difference Score 1

Time 2 – Time 1



Difference Score 2

Time 3 – Time 2

General Requirements

1. Need a DV on an interval/ratio scale measured at 2+ time points
2. The participants need to be present at each time point

ID	Time 1	Time 2
1	8	7
2	8	8
3	9	6
4	7	6
5	7	8
6	9	5
7	5	3
8	5	3

Hypothesis Testing with RM-ANOVA

The same 6 step approach!

1. Examine Variables to Assess Statistical Assumptions
2. State the Null and Research Hypotheses (symbolically and verbally)
3. Define Critical Regions
4. Compute the Test Statistic
5. Compute an Effect Size and Describe it
6. Interpreting the results

1 Examine Variables to Assess Statistical Assumptions

Basic Assumptions

1. Independence of data
2. Appropriate measurement of variables for the analysis
3. Normality of distributions
4. Sphericity (difference scores must have equal variances)

1 Examine Variables to Assess Statistical Assumptions

Basic Assumptions

1. **Independence** of data
2. Appropriat
   for the al
3. Normality
4. Sphericity (difference scores must have equal variances)

Individuals are independent of each other (one person's scores does not affect another's)

1 Examine Variables to Assess Statistical Assumptions

Basic Assumptions

1. Independence of data
2. **Appropriate measurement** of variables for the analysis
3. Normality of distributions
4. Sphericity (or homogeneity of variances, i.e., have equal variances)

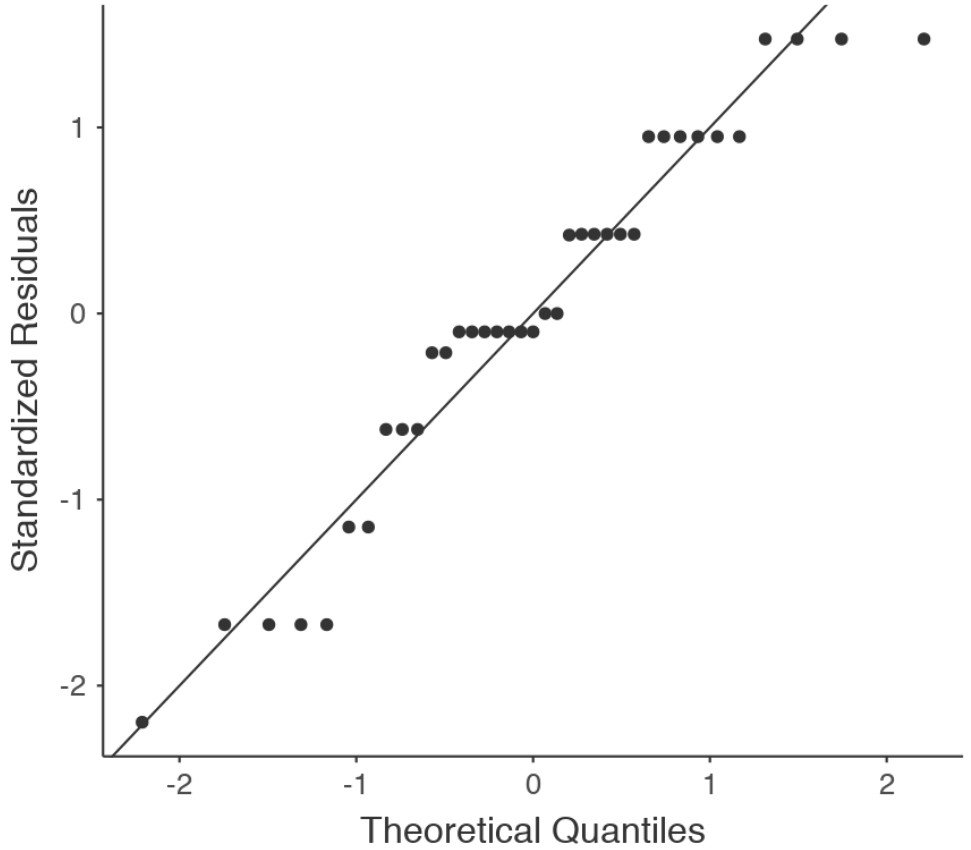
Here we need interval/ratio DV

1 Examine Variables to Assess Statistical Assumptions

Basic Assumptions

1. Inde[illegible]
2. Appr[illegible]pria[illegible]
   for [illegible]he analysis
3. Normality of distributio
4. Sphericity (difference s
   have equal variances)

Normality of the residuals



1 Examine Variables to Assess Statistical Assumptions

Basic Assumptions

1. Independence of data
2. Appropriate measurement of variables for the
3. Normality of distributions
4. Sphericity (difference scores must have equal variances)

The variances of the *difference scores* should be equal

1 Examine Variables to Assess Statistical Assumptions

Examining the Basic Assumptions

1. Independence: random sample
2. Appropriate measurement: know what your variables are
3. Normality: Histograms, Q-Q, skew and kurtosis
4. Sphericity: Mauchly's test

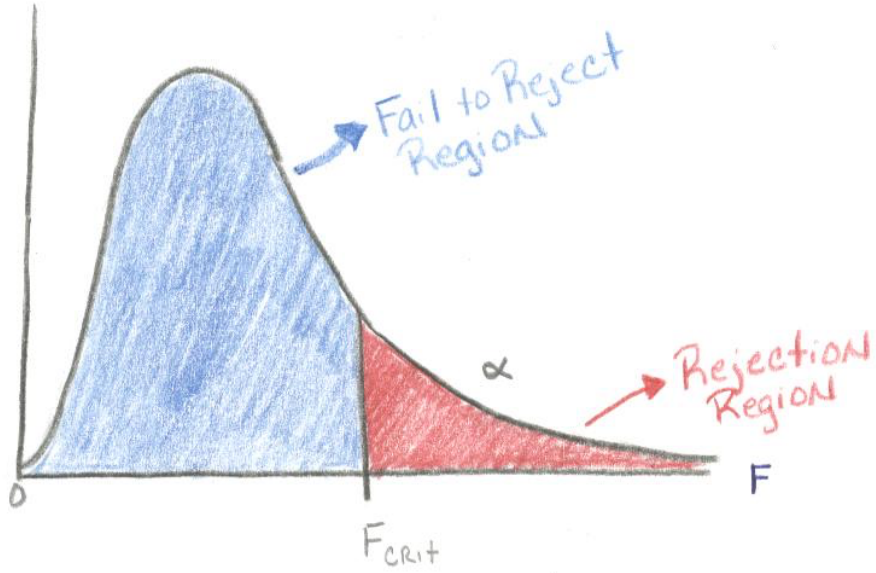
2 State the Null and Research Hypotheses (symbolically and verbally)

Hypothesis Type	Symbolic	Verbal	Difference between means created by:
Research Hypothesis	At least one μ is different than the others	One of the time points' means is different than the others	True differences
Null Hypothesis	All μ's are the same	There is no *real* difference between the time points	Random chance (sampling error)

3 Define Critical Regions

How much evidence is enough to believe the null is not true?

Before analyzing the data, we define the critical regions (generally based on an alpha = .05)



3 Define Critical Regions

We decide on an alpha level first

↳ And compare the p-values (in Step 4) to our alpha level

$$df_{num} = k - 1$$

where k is number of time points

$$df_{den} = N - k$$

4 Compute the Test Statistic

Repeated Measures ANOVA

Within Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η^2_G	η^2
Productivity	18.6	1	18.561	42.6	<.001	0.116	0.116
Residual	13.9	32	0.436				

Note. Type 3 Sums of Squares

[3]

Between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η^2_G	η^2
Residual	128	32	3.99				

Note. Type 3 Sums of Squares

4 Compute the Test Statistic

Shows us if at least one time point is different from the others

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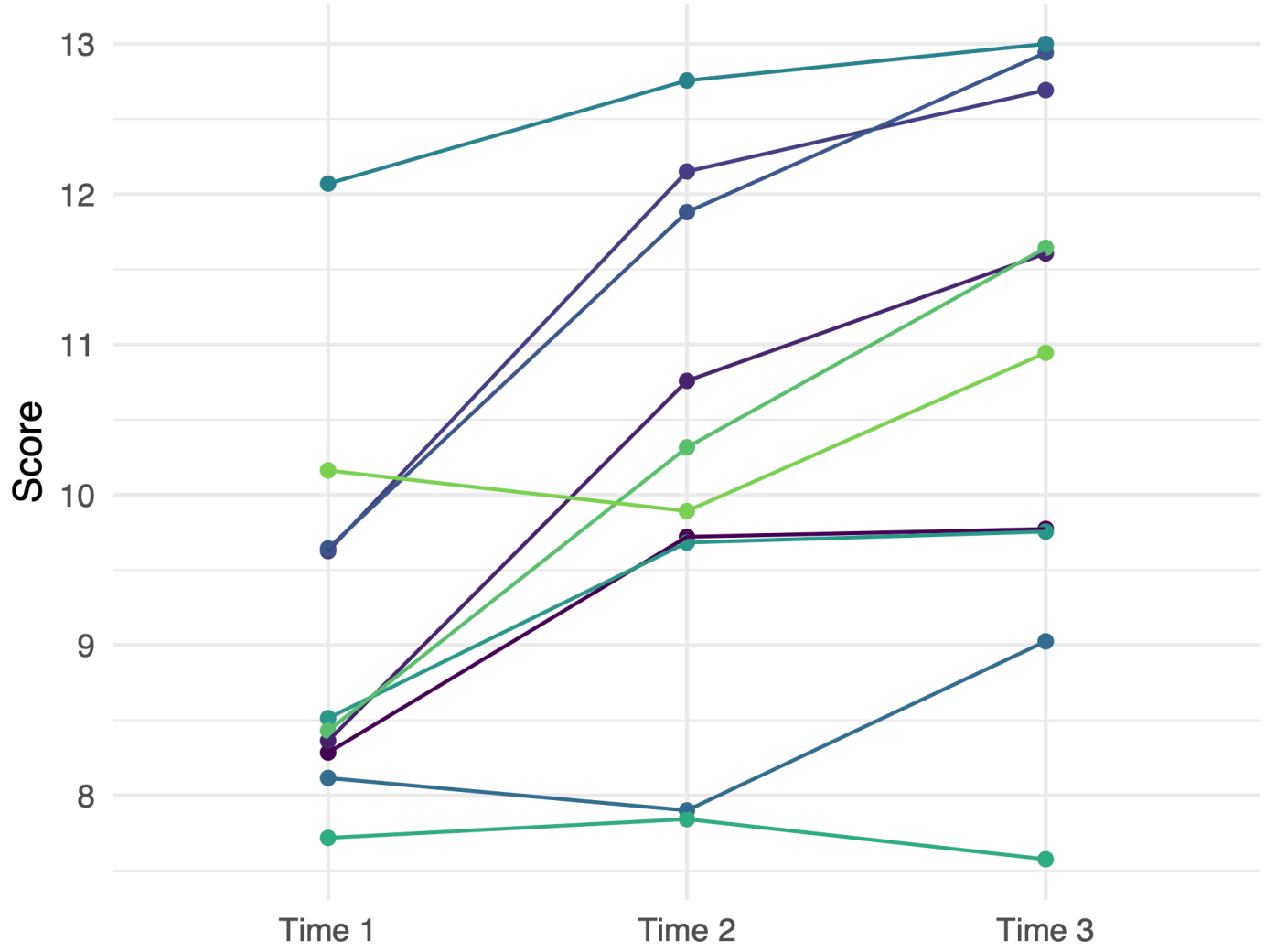


4 Compute the Test Statistic

F-statistic and p-value tell you if one of the times is different than the others

But it doesn't tell you which ones are different if you have 3+ time points...

Post Hoc Tests

4 Compute the Test Statistic

Post Hoc Tests (or Contrasts)

Post hoc usually refers to comparing all groups with each other (and making an adjustment for the multiple comparisons)

Contrasts usually refers to comparing some of the groups with each other (or a combination of groups with each other)

5 Compute an Effect Size and Describe it

One of the main effect sizes for ANOVA is "Eta Squared"

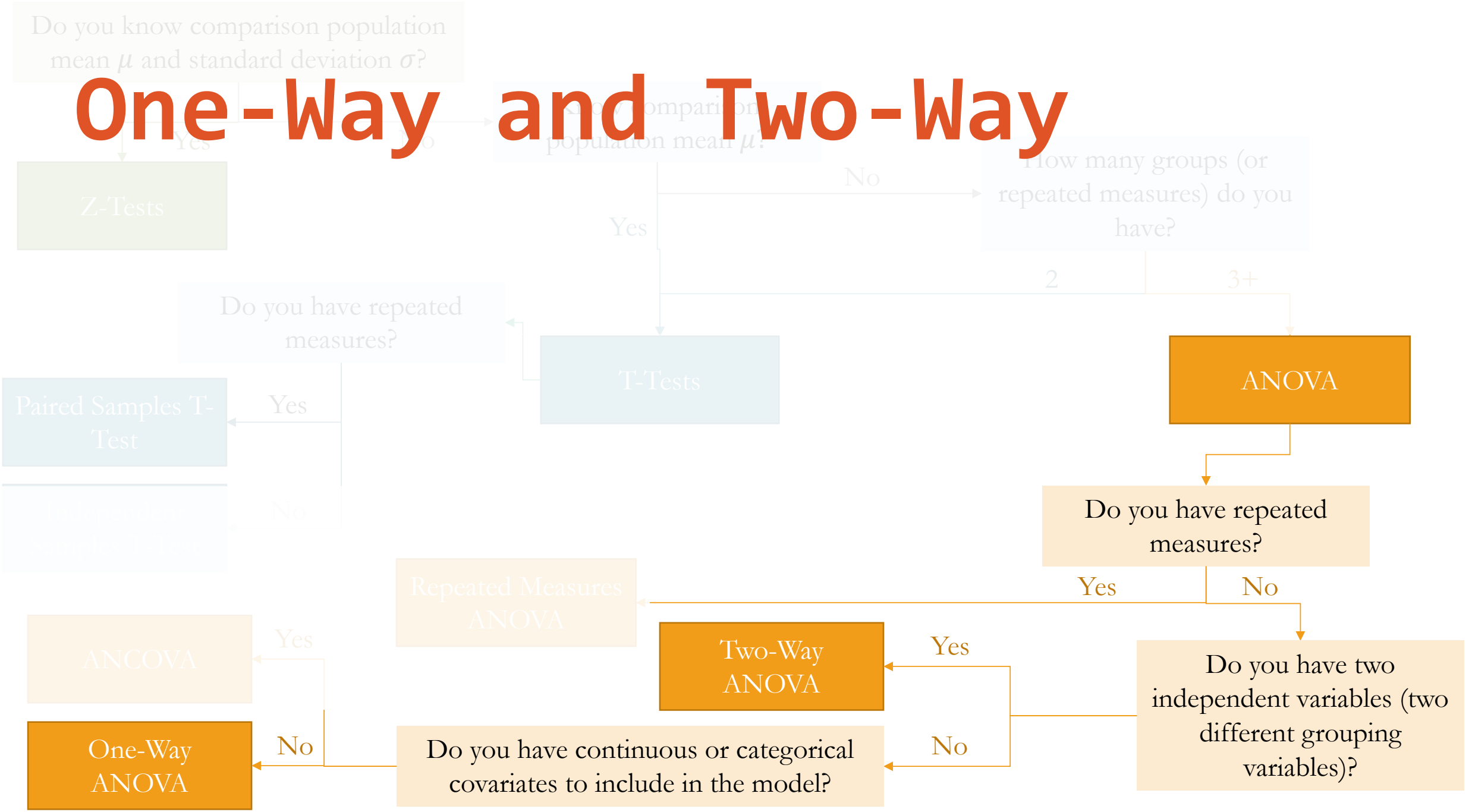
$$\eta^2 = \frac{SS_{Time}}{SS_{Time} + SS_{residual}}$$

η^2	Estimated Size of the Effect
Close to .01	Small
Close to .06	Moderate
Close to .14	Large

6 Interpreting the results

Put your results into words

One-Way and Two-Way



Repeated Measures vs. Mixed

RM ANOVA has one time variable

Tests for any differences across the groups on one time variable

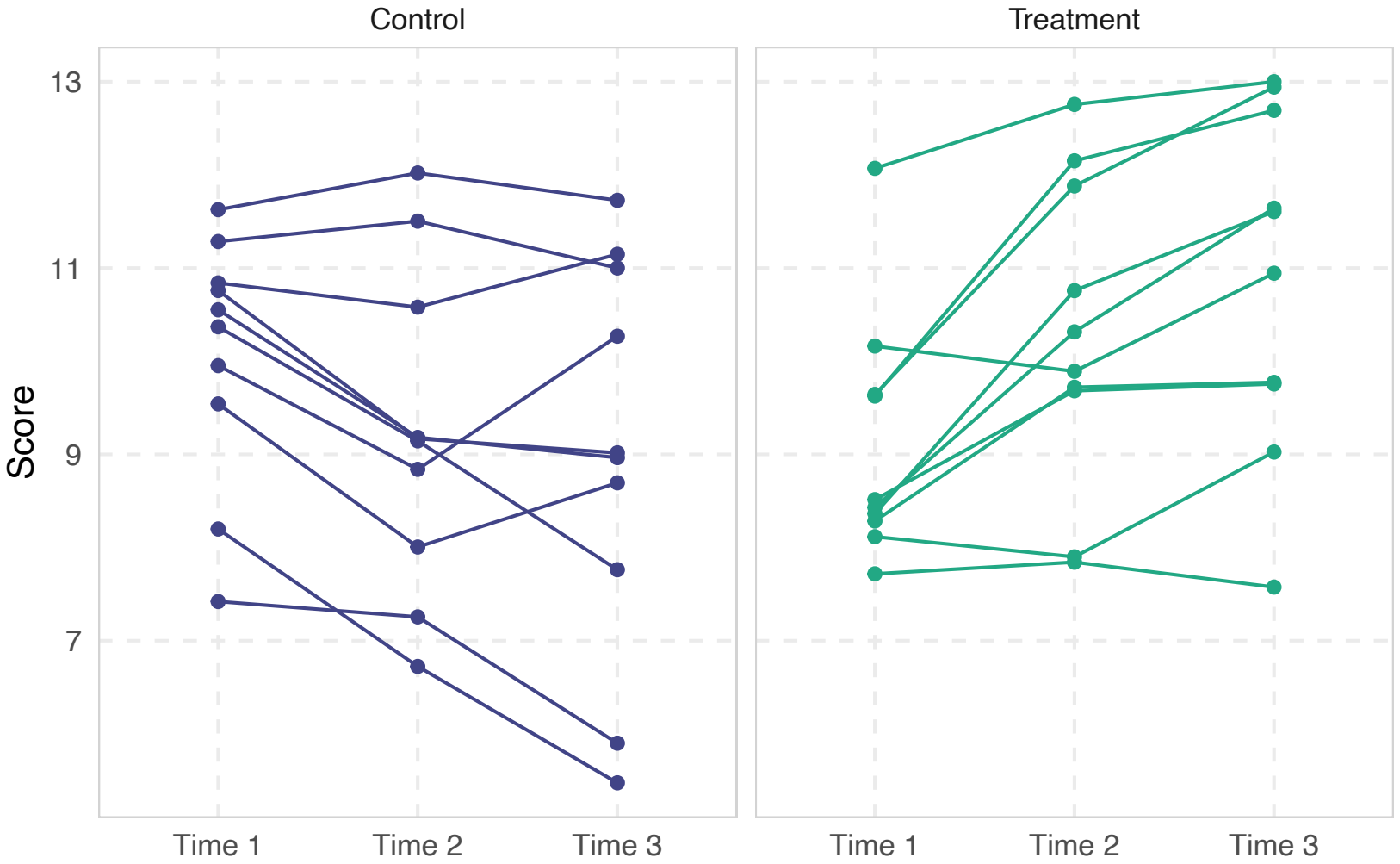
Mixed ANOVA combines One-Way ANOVA and RM ANOVA

Tests for any differences across the times/groups (and their combinations)

"Interaction"

Mixed ANOVA Interaction

When the changes over time depends on another variable



Mixed ANOVA

Repeated Measures ANOVA

Within Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η^2_G	η^2
Time	6.67	1	6.667	18.34	<.001	0.048	0.045
Time ✻ Group	2.67	1	2.667	7.34	0.011	0.020	0.018
Residual	11.27	31	0.364				

Note. Type 3 Sums of Squares

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Between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η^2_G	η^2
Group	8.26	1	8.26	2.14	0.153	0.059	0.056
Residual	119.56	31	3.86				

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Mixed ANOVA

Repeated Measures ANOVA

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Questions?

Please post them to the discussion board before class starts

End of Pre-Recorded Lecture Slides

In-class discussion slides

Application

Example Using
The Office/Parks and Rec Data Set

Hypothesis Test with RM ANOVA
and
Mixed ANOVA