Jumping into Statistics: Introduction to Study Design and Statistical Analysis for Medical Research Using JMP Pro Statistical Software

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Course Objectives

- Review fundamentals of study design and research methodology
- Understand how to choose best statistical test for your research question
- Practice basic statistical analysis use JMP Pro Software

Course Topics

- Asking a Good Research Question
- Life Cycle of Research and Scientific Method
- Study Design
- Data types and Database Construction
- Descriptive Statistics
- Data Visualization
- Population and Sample, Probability, Statistical Inference
- How to Chose Correct Statistical Method and Run Some Analyses
  - T-tests, ANOVA, Non-Parametric
  - Chi-square, odds ratio, relative risk
  - Regression and Correlation
  - Survival Analysis
  - Test Diagnostics (e.g. sensitivity, specificity, etc.)
- Comparing Statistical Modeling and Machine Learning

Choosing right statistical test

COMPARING GROUPS

Which test to choose?

For group comparisons your independent variable will be categorical

Dependent variable dictates type of test that will be used:

- Continuous→ T-tests, ANOVA
- Discrete→ Mann-Whitney-Wilcoxon, Kruskal Wallis
- Nominal/Ordinal→ Chi-square, Fisher's exact, Z test
  - Next lecture

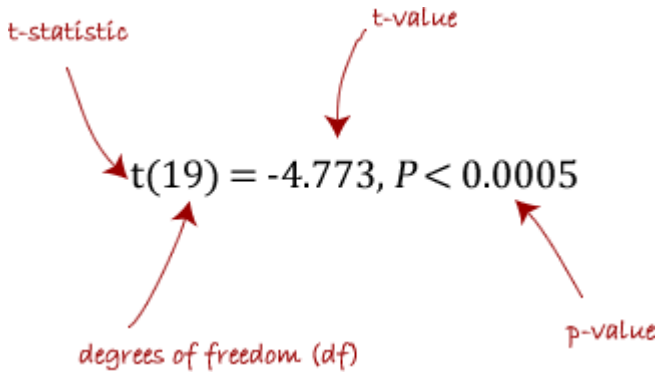
Compare two independent groups

For continuous, normally distributed data:

Student's t-test (unpaired, independent samples)

$H_{0:}$ group 1 mean = group 2 mean

$H_{A:}$ group 1 mean ≠ group 2 mean



Report results:

t statistic (df) = XXXX, p value

Df→ degrees of freedom, related to sample size

Assumptions of t-test

Continuous, normally distributed data

- Caveat→ can be robust to some deviations from normal

Independent observations (if not, must use paired t-test)

SD are equal (very important)

- Equal variances
- Could cause inaccurate results
- If not, must used alternative t-test that takes this into account
- Welch's t-test
- Tests for unequal variances: F-ratio, Levene, Brown-Forsythe

Student’s t-test

William Sealy Gosset

Used to test for differences between batches of beer. While working at Guinness, Gosset was not allowed to publish academic research, so he used a pseudonym.

Compare two paired groups

For continuous, normally distributed data:

Paired t-test (dependent)

- Repeated measurements (before/after)

$H_{0:}$ time 1 mean = time 2 mean

$H_{A:}$ time 1 mean ≠ time 2 mean

- Patients are own control (receive two treatments)

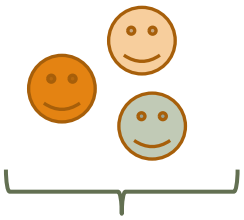
$H_{0:}$ treatment 1 mean = treatment 2 mean

$H_{A:}$ treatment 1 mean ≠ treatment 2 mean

Unpaired vs. Paired T-Tests

UNPAIRED

2 levels (conditions) compared between different groups



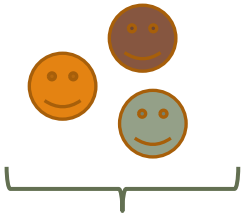
Treatment 1

Treatment 2

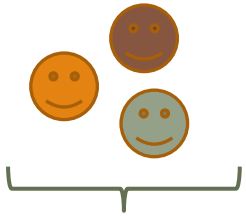
PAIRED

Pre-post designs (same individuals before and after treatment)

2 levels (conditions) experienced by the same subjects (*crossover*)



Treatment 1



Treatment 2

Compare two groups: Non-parametric tests

For discrete data (count) OR continuous, non-normally distributed data or some ordinal data (numeric format):

Mann-Whitney-Wilcoxon test

- Based on ranking of means in each group (distribution)

Wilcoxon Signed Rank Test

- For paired observations

Compare three or more independent groups

For continuous, normally distributed data

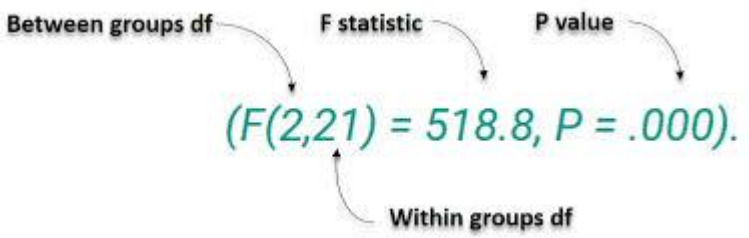
Equal variance assumption (look at SD)

- Programs can test this for you
- Welch's ANOVA for unequal variances

One-Way ANOVA (1 grouping factor)- F statistic

$H_{0:}$ group means equal

$H_{A:}$ at least one group mean not equal



If you have 3 or more groups, **DO NOT** run multiple t-tests.

Post-hoc tests

Compare pairs of means

Take into account type 1 error

Common types:

- **Tukey-Kramer**
- **LSD**
- **Scheffe**

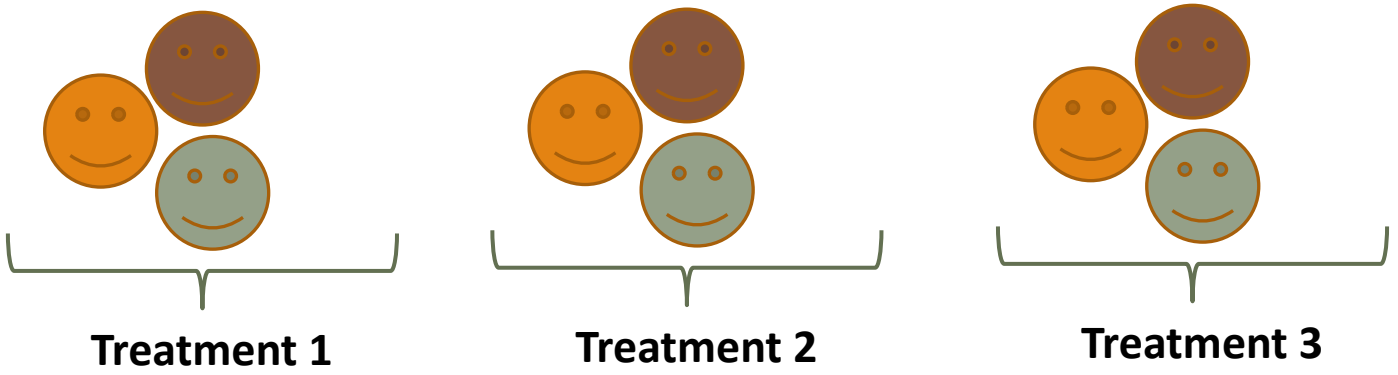
- Do not run posthoc analysis if ANOVA/F-test is not statistically singifcant

Repeated Measures ANOVA

More than 2 timepoints

BP at baseline → BP at 1 month → BP at 3 months

More than 2 levels (conditions) experienced by the same subjects



-measurements in SAME people

Compare three or more groups: Non-parametric

For discrete data OR continuous, non-normally distributed data or some ordinal data (numeric format):

Kruskal-Wallis (ANOVA on ranks)

- Dunn's posthoc test

Repeated measures test: **Friedman test**

Review: Continuous outcome/ Categorical predictor

Groupings	Test
Only 2 groups that are distinct	Unpaired t-test/Mann-Whitney-Wilcoxon
Only 2 groups (same people) before and after or 2 conditions tested in same people	Paired t-test/Wilcoxon Signed Rank
3 or more groups	ANOVA/ANOVA on Ranks
3 or more timepoints (same people) or 3 or more conditions tested in same people	Repeated Measures ANOVA Friedman

JMP Demo