Introducing ANOVA and APA Style

Session 08

Lecture Outline

- Introducing ANOVA
- The *F* ratio
- Assumptions of ANOVA
- Post Hoc Tests
- One-Way ANOVA Example
- Introduction to APA Style
  - APA Report Structure
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Introducing ANOVA

Sometimes we want to know whether the mean level on one variable (such as pain), differs between three or more groups (e.g. Treatment A, Treatment B, and Placebo Treatment).

ANalysis Of Variance (ANOVA): the statistical procedure for testing variation among the means of three or more groups.

Introducing ANOVA

We could use descriptive statistics (mean pain levels) to compare the groups, however, we usually want to use a sample to determine whether groups are different in the population.

If you had only two groups to compare, ANOVA would give the same answer as an independent samples *t*-test.

Introducing ANOVA

We could use multiple independent *t*-tests, however, conducting all of these tests would increase the likelihood we would observe significant results by chance.

For example, if we work on an alpha level of 5%, and conduct enough *t*-tests to cover all possible combinations of the three treatment groups (3 possible comparisons), there would be a 15% chance of at least one of the comparisons being incorrectly significant.

When working with more than three groups this probability would be even greater.

Introducing ANOVA

Using ANOVA protects the researcher against **error inflation** by first asking if there are differences at all among means of the groups.

Introducing ANOVA

The main statistical question is: Do the means of the dependent variables depend on which group the individual is in?

If categorical variable has only 2 values, you would use an independent means *t*-test

ANOVA allows for 3 or more groups.

Introducing ANOVA

One-way ANOVA: involves analysing only one dimension over three or more groups.

Introducing ANOVA

The null and research hypothesis

H_o: The null hypothesis in ANOVA is that the three or more populations being compared all have the same mean.

H_1: The research hypothesis is that the means of the three or more groups differ.

Basic question: do the means of the samples differ more than you would expect if the null hypothesis were true.

The *F* ratio

Analysis of Variance measures the different types of variance (variability in scores) that appear in the data and then explains the source of each variance.

Two types of variance:

1. **Between-treatments variance** - Variance due to differences between the group means.
2. **Within-treatment variance** - Variance due to differences within the groups (i.e., between the individuals).

The *F* ratio

Sources of Variance:

Three types:

1. **Individual differences**: Variability between all participants (gender, age, education level, mood). People bring different experiences to your study.
2. **Experimental error**: Inaccurate measurement of the DV, poor planning of the study. Maybe measured weight w/ a broken scale, or I measured intelligence poorly.

The *F* ratio

Three types: (cont.)

3. **Treatment effect**: What was manipulated between the groups.
   - Always different between groups.
   - Cannot influence within-treatment variance since all the subjects in a group are given the same treatment. This is a between treatment variance.

So, the treatment effect is the only source of variance that can influence between-treatment variance that doesn't influence within-treatment variance.

The *F* ratio

ANOVA measures two sources of variation in the data and compares their relative sizes

variation **between** groups
for each data value look at the difference between its group mean and the overall mean

variation **within** groups
for each data value we look at the difference between that value and the mean of its group

The *F* ratio

$$F = \frac{\text{Between-subjects variability}}{\text{Within-subjects variability}}$$

$$F = \frac{\text{Treatment effect + Indiv. Diff. + Exper. Error}}{\text{Indiv. Diff. + Exper. Error}}$$

The *F* ratio

The ANOVA *F-ratio* is a ratio of the Between Group Variation divided by the Within Group Variation.

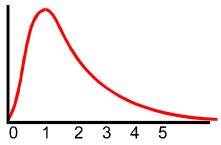
A large *F* is evidence **against** H_o, since it indicates that there is more difference between groups than within groups.

The *F* ratio

From a practical point of view the bigger the *F* value, the larger the chance of significance, the bigger the difference in the groups

The *F* ratio

- ***F* ratio**: the crucial ratio of the between-group to the within-group variance estimate.
- ***F* distribution**: a distribution of *F* ratios.



The *F* ratio

Essentially, ANOVA uses your sample to tell you whether, in the population, you have overlapping group distributions (no significant difference between groups) or fairly distinct group distributions (significant differences between groups).

Assumptions of ANOVA

Assumptions: randomness, an interval/ratio scale of measurement and normality.

Normality: Use Levene's test of variance. If significance value is less than .05 then there is a significant difference in the variance of the groups. Also called homogeneity of variance. If significant, lower the alpha level.

Post Hoc Tests

Overall, any type of ANOVA will simply tell you if at least one of the groups is different from the rest.

So after every significant ANOVA, you need to run post hoc tests to tell you which of the groups are significantly different.

Post Hoc Tests

Post Hoc Tests

- Because of the likelihood of multiple comparison errors, statisticians have created ways to reduce the multiple comparison error rate.
- They are similar to running a bunch of T-tests (i.e. group 1 vs 2, 1 vs 3 and 2 vs 3). In this way they tell you specifically which group is different, whilst keeping the alpha level low.
- SPSS has many types of post hoc tests which are calculated in different ways, you only need to pick one.

Post Hoc Tests

Commonly used examples:

- Scheffe's Test
- Tukey's HSD (honestly significant difference).

One-Way ANOVA Example

Blister Treatment Study

Participants: 25 patients with skin grazes.

Treatments: Treatment A (wound bandaged 1 hour a day), Treatment B (wound elevated 1 hour a day), Placebo (participant listens to music 1 hour a day).

Measurement: number of days until skin graze heals.

One-Way ANOVA Example

Data [and means]:

A: 5,6,6,7,7,8,9,10	[7.25]
B: 7,7,8,9,9,10,10,11	[8.875]
P: 7,9,9,10,10,10,11,12,13	[10.11]

Are these differences significant?

One-Way ANOVA Example

Whether the differences between the groups are significant depends on:

- the difference in the means
- the standard deviations of each group
- the sample sizes

All of these potential sources of difference are included in an ANOVA.

One-Way ANOVA Example

Descriptive statistics:

Descriptives

Days Healing

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Treatment A	8	8.8750	1.4577	.5154	7.6563	10.0937	7.00	11.00
Treatment B	8	7.2500	1.6690	.5901	5.8546	8.6454	5.00	10.00
Treatment C	8	10.1250	1.8851	.6665	8.5490	11.7010	7.00	13.00
Total	24	8.7500	2.0054	.4094	7.9032	9.5968	5.00	13.00

One-Way ANOVA Example

Test of homogeneity (for assumptions):

Test of Homogeneity of Variances

Days Healing

Levene Statistic	df1	df2	Sig.
.141	2	21	.869

One-Way ANOVA Example

ANOVA Table

ANOVA

Days Healing

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.250	2	16.625	5.892	.009
Within Groups	59.250	21	2.821		
Total	92.500	23			

One-Way ANOVA Example

Post Hoc comparisons

Multiple Comparisons

Dependent Variable: Days Healing

Tukey HSD

(I) Treatment Condition	(J) Treatment Condition	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Treatment A	Treatment B	1.6250	.8399	.154	-.4919	3.7419
	Treatment C	-1.2500	.8399	.316	-3.3669	.8669
Treatment B	Treatment A	-1.6250	.8399	.154	-3.7419	.4919
	Treatment C	-2.8750*	.8399	.007	-4.9919	-.7581
Treatment C	Treatment A	1.2500	.8399	.316	-.8669	3.3669
	Treatment B	2.8750*	.8399	.007	.7581	4.9919

*. The mean difference is significant at the .05 level.

One-Way ANOVA Example

Experimental Outcome:

The wounds of participants in Treatment Group B (elevation) healed significantly faster than Treatment Group A (bandaging), when compared to the control group

Introduction to APA Style

APA style: the literary style used in most scientific writing.

It embodies:

- How to effectively organise information,
- Acknowledge sources,
- Structure an argument,
- Deal with data honestly and economically,
- Communicate persuasively, and . . .
- Write clearly.

APA Report Structure

The Title Page:

Full Title of the Study Here

A Research and Investigation Assignment

Student Name
Student ID
Date due
Subject

APA Report Structure

The Abstract:

Abstract

Self-contained summary of the report. Approximately 200 words. One non-indented paragraph only. Usually written last.

APA Report Structure

The Literature Review:

Full Title of the Study Here

Introduce the general area and review literature relevant to the topic in a logical and coherent way, gradually becoming more and more specific.

Try to cite as often as possible, however only quote when absolutely necessary.

This section may amount to approximately 1000 words.

APA Report Structure

The Method:

Page numbering starts on the second page of the literature review as page 2. Conclude this section of the report with the general aim of the study, and any hypotheses/objectives you have formulated.

Method

The method follows on directly from the literature review. It contains three areas:

Participants

Include numbers, sexes, ages, occupations and any other relevant details.

APA Report Structure

The Results:

Materials

Include statistical properties pertaining to the measures used in the report.

Procedure

A detailed chronological account of what happened to participants in the study.

Results

The results follows on directly from the method. Results are presented in the order in which the hypotheses/objectives were stated in the literature review.

APA Report Structure

The Discussion:

For each hypothesis; Restate the hypothesis/objective, provide an illustration that simplifies the findings, and then report any statistical analyses that quantify these findings.

Discussion

The discussion follows on directly from the results. Again, discuss the results in the order in which the hypotheses / objectives were stated in the literature review.

APA Report Structure

The Discussion . . .

In this section review your findings as they relate to the literature cited in your literature review. Make suggestions for any observed differences, consider limitations of the study, and suggest avenues for future research. Make the discussion section interesting and end on a positive note.

Approximate length 1000 words.

APA Report Structure

The References:

References

Starts on a new page. Only list references cited in your text in alphabetical order.

APA Report Structure

The Appendices:

Appendix

Starts on a new page. Includes any additional important material that was not included in the body of the report, but was alluded to in the text. Here you might include blank copies of the questionnaires used in the study.

Each separate Appendix begins on a new page and is titled Appendix A, Appendix B etc...

Figures

Introduce the Figure here.

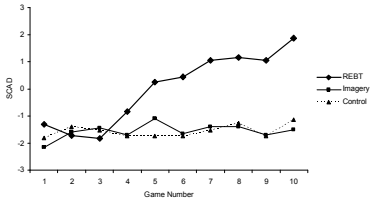


Figure 1. Full Title of the Figure Here in Title Case. Follow-up with a descriptive statement.

Tables

Introduce the Table here.

Table IV
Full Title of the Table Here in Title Case

Scale	Scale M	Scale SD	Cronbach's Alpha
SDS	3.08	2.27	0.49
CTAI-2 (cognitive anxiety intensity)	27.08	5.16	0.89
CTAI-2 (somatic anxiety intensity)	21.98	5.6	0.87
CTAI-2-D (cognitive direction)	-15.67	6.03	0.87
CTAI-2-D (somatic direction)	-11.23	6.64	0.89

Follow-up with a descriptive statement.

Citation

Citation: rephrasing an authors original words into your own.

Include the authors(s) names and year of publication in the text. Report additional details in the reference section.

Single author: Hewitt (1987) initiated these studies by . . .

Two to five authors: Jones and Allen (1979) found . . .

or . . was found (Jones & Allen, 1979).

Multiple citations different authors: Several studies (Jones, 1979; Lorenzo & Masters, 1981; Pope, 1965) have found . . .

Secondary sources: Marx's (1945) study (cited in Johnston, 1956) suggests that . . .

Quotation

Quotation: the use of the original author's own words within the body of your report.

Only quote if rephrasing leads to a loss of meaning.

Brown (1988) defined learning as "any relatively permanent change in behaviour which occurs as a result of experience or practise" (p. 85).

or

Learning has been defined as "any relatively permanent change in behaviour which occurs as a result of experience or practise" (Brown, 1988 , p. 85).

Referencing

Provides the information necessary to retrieve a source.

Single author: Hutchison, M. (1984). *The book of floating*. New York: Morrow.

Two authors: Liebert, R. M., & Spiegler, M. D. (1987). *Personality: Strategies and issues*. The Dorsey Press: Illinois.

Journal article: Martens, R., Burwitz, L., & Zuckerman, J. (1976). Modelling effects on motor performance. *Research Quarterly*, *47*, 277-291.

Website: Bixley, T. S. (1995). *Sentient microfilaments home page.* [On-line]. Available: http://www.something.princeton.edu.au/sentient.htm

Evaluation Criteria

- There is a clear discussion of the limitations and implications of the results.
- The hypothesis/es or objective/s evolve/s logically an clearly from the theoretical and empirical work you cite in the introduction.
- That you give precise specification of the results, including any details of statistical procedures employed.
- That the details of the experimental method are communicated unambiguously.

Evaluation Criteria

- That you reading be sufficient, cited effectively and precisely to support your hypothesis/es/ or objective/s and discussion.
- That you use clear and accurate expression.
- That you adhere to the rules and regulations set down for report writing.