

Application of Multivariate Analysis of Variance (MANOVA)

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Abstract

Multivariate analysis of variance (MANOVA) is the most commonly used multivariate statistical procedure in a clinical psychology. Statistical procedures in psychological research have found MANOVA to be the most popular multivariate statistical method. in spite of the popularity of MANOVA, the method is steadily misunderstood, and researchers are particularly unfamiliar with the proper statistical procedures after rejecting a multivariate null hypothesis. This paper is to explain the ideology of MANOVA and how to properly perform and interpret a MANOVA and its join together post hoc procedure.

1.Introduction

MANOVA

MANOVA is a member of the General Linear Model-families of statistical procedures that are often used to quantify the strength between variables .Many of the procedures in the General Linear Model are hierarchically organized i.e., more specific procedures are often special cases of general procedures. MANOVA explicitly, is an analysis of variance (ANOVA) that has two or more dependent variables. In an ANOVA the independent variable is a nominal variable that has two or more values, and the dependent variable is interval or ratio scaled.

1 The null hypothesis is that the mean score on the dependent variable will be statistically equal for every group. As with any null hypothesis statistical significance testing procedure, an observed statistic is calculated and then compared to a sampling distribution. If the observed statistic is found to be a more extreme value in the sampling distribution than the critical value., then the null hypothesis will be rejected; otherwise, the null hypothesis is retained. Afterwards, an effect size usually η^2 in an ANOVA quantifies the

relationship between the independent and dependent variables . MANOVA is merely an ANOVA that has been mathematically extended to apply to situations where there are two or more dependent variables.

Why Use MANOVA?

Given MANOVA's more complicated nature, some researchers may question whether it is worth the added complexity. The alternative to using MANOVA is to conduct an ANOVA for each dependent variable. However, this approach is not advantageous because (a) conducting multiple ANOVAs increases the likelihood of committing a Type I error, and (b) multiple ANOVAs cannot determine whether independent variables are correlated to combinations of dependent variables, which is more helpful information for behavioral scientists who study correlated dependent variables.

2.Post Hoc Procedures

Post hoc procedures are often necessary after the null hypothesis is rejected in an ANOVA. This is because the null hypotheses for these procedures often do not provide researchers with all the information that they desire. For example, if the null hypothesis is rejected in an ANOVA with three or more groups, then the researcher knows that at least one group mean statistically differs from at least one other group mean. However, most researchers will be interested in learning which mean(s) differ from which other group mean(s). Many ANOVA post hoc tests have been invented to provide this information, although Tukey's test is by far the most common test reported in the psychological literature .

Just like ANOVA, MANOVA has posthoc procedures to determine why the null hypothesis was rejected.

3.Multi-variate ANOVA (MANOVA):

Awaiting now, we were making conclusions on the performance of students based on just one test. May possibly there be a the music treatment helped improve the results of a subject like mathematics but would affect the results adversely for a theoretical subject like history?

We cannot say that test is unbiased .As a result again, we take two groups of randomly selected students from a class and subject each group to one kind of music environment, i.e., constant music and no music. Now we thinking of conducting two tests mathematics and history, in its

place of just one. In this way we can be sure about how the treatment would work for different kind of subjects.

We can say that one IDV/factor (music) will be affecting two dependent variables (maths scores and history scores) now. This kind of a problem comes under a multivariate case and the technique we will use to solve it is known as MANOVA. Will see a specific case i.e. one factor MANOVA. Now see how our data looks like :

Table 1

	History	Maths
Group A	7	3
Group A	9	1
Group A	5	6
Group A	8	7
Group A	6	8
Group A	8	3
Group A	6	6
Group A	10	5
Group A	7	9
Group A	4	6
Group B	4	8
Group B	3	5
Group B	6	1
Group B	2	8
Group B	7	1
Group B	5	3
Group B	5	5
Group B	4	6
Group B	1	4
Group B	3	7

We have one factor, music, with 2 levels. This factor is going to affect two dependent variables, i.e., the test scores of mathematics and history. Denote this information in form of variables, we can say that we have $L = 2$ (2 different music treatment groups) and $P = 2$ (maths and history scores).

The MANOVA test also takes into concern a null hypothesis and an alternate hypothesis.:

$H_0 : \mu_1 = \mu_2 = \dots = \mu_L$	<i>Null hypothesis</i>
$H_1 : \mu_l \neq \mu_m$	<i>Alternate hypothesis</i>

The calculation of MANOVA are complex. We will implement MANOVA in MS-Excel using the ‘RealStats’ Add-ins.

Steps to perform MANOVA in Excel:

Step 1: Download the ‘RealStats’ add-in.

Step 2: Press “control+m” to open RealStats window

Step 3: Select “Analysis of variance”

Step 4: Select “MANOVA: single factor”

Step 5: One can type the Input Range into the Input Range box. Our data is in cells A1 to A25, type “A1:A25” into the Input Range box. Make sure that we have include all of our data, including headers and group names.

Step 6: Choose ‘Significance of analysis’ then “Group Means” and then click on “Multiple Anova”.

Step 7: Select the Output Range.

Step 8: Select level of significance(α). In most cases, an alpha level of 0.05 (5 percent) works for most tests.

Step 9: Click “OK” to run. The data will be returned in our specified output range.

Step 10: Read the results. To figure out if you are going to reject the null hypothesis or not, we’ll basically be looking at two factors:

1. If F-value (F) is larger than the F critical value (F critical)
2. If the p-value is smaller than your chosen alpha level(α).

Table 2

MANOVA						
	<i>stat</i>	<i>F</i>	<i>df1</i>	<i>df2</i>	<i>p-value</i>	<i>eta-sq</i>
Pillai Trace	0.55149076	10.4516721	2	17	0.00109662	0.55149076
Wilk's Lambda	0.44850924	10.4516721	2	17	0.00109662	0.55149076
Hotelling Trace	1.22960848	10.4516721	2	17	0.00109662	0.55149076
Roy's Lg Root	1.22960848					

RealStats shows us the results by different methods. Each of them denotes the same p-value. The p-value is less than the α alpha value, we will reject the null hypothesis, means that the music treatment have a significant effect on the test results of student

Still we cannot say which subject was affected by the treatment and which was not affected. This is one limitation of MANOVA; even if it tells us whether the effect of a factor on a population was significant or not, it does not give us idea, which dependent variable was actually affected by the concern factor introduced.

Now we will see the “Multiple ANOVA” table to generate summary. The result will look like this as shown below:

Table 3

Multiple ANOVA									
ANOVA: Single Factor					History				
DESCRIPTION					Alpha 0.025				
Groups	Count	Sum	Mean	Variance	SS	Std Err	Lower	Upper	
Group A	10	70	7	3.33333333	30	0.57735027	5.44980826	8.55019174	
Group B	10	40	4	3.33333333	30	0.57735027	2.44980826	5.55019174	
ANOVA									
Sources	SS	df	MS	F	P value	F crit	RMSSE	Omega Sq	
Between Groups	45	1	45	13.5	0.00173543	5.97805246	1.161895	0.38461538	
Within Groups	60	18	3.33333333						
Total	105	19	5.52631579						
ANOVA: Single Factor					Maths				
DESCRIPTION					Alpha 0.025				
Groups	Count	Sum	Mean	Variance	SS	Std Err	Lower	Upper	
Group A	10	54	5.4	6.04444444	54.4	0.79582243	3.26320815	7.53679185	
Group B	10	48	4.8	6.62222222	59.6	0.79582243	2.66320815	6.93679185	
ANOVA									
Sources	SS	df	MS	F	P value	F crit	RMSSE	Omega Sq	
Between Groups	1.8	1	1.8	0.28421053	0.60047575	5.97805246	0.16858545	-0.0371179	
Within Groups	114	18	6.33333333						
Total	115.8	19	6.09473684						

4. Conclusion

We observed that the 'P' value for history lies in significant region as P value less than 0.025. While for maths it does not. This means that the music treatment had a significant effect in improving the performance of students in history but did not have any significant effect in improving their performance in maths. Based on this, we might consider picking and choosing subjects where this music approach can be used.

Although this MANOVA and its accompanying were simple, analyses with additional independent or dependent variables would not be much more complex. Statistical package SPSS often produces interesting figures that can show researchers the degree of overlap among groups and how different their average members are from one another. This paper on MANOVA was designed to help researchers better use and understand one of the most common multivariate statistical methods in the published literature. I hope that researchers will use the information in this paper to (a) understand the nature of MANOVA (b) serve as a guide to correctly performing their own MANOVA and post hoc analyses, and (c) aid in the interpretation of their own data and of other studies that use these methods. Researchers in the behavioral sciences should use this powerful multivariate analysis method more often in order to take advantage of its benefits. However, other methods are more complex and difficult to perform, and many researchers may not find the advantages worth the extra time and expertise needed to use them. Therefore, I believe that this paper is often an expedient choice for researchers who wish to understand their multivariate analyses. Regardless of the choice of post hoc method, researchers should completely avoid using univariate methods after rejecting a multivariate null hypothesis.

References

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