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CONTRAST ANALYSIS ON SINGLE FACTOR STUDIES AND SOLUTION WITH SPSS

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Abstract

Contrast analysis is a method for comparing sets of means using specific coefficients for weighting the means. In this study, contrast analysis as a planned comparison method and its use in one-factor trial designs are examined. For this purpose, a hypothetical data set is used to analyze the data related to the amount of dry matter determined by three different methods. The steps of the contrast analysis are explained using the SPSS.18 package program. In conclusion, contrast analysis results showed that a great part of the difference between the methods is due to the difference between method 3 and the others (P <0.01) according to F test detailed with 1 degree of freedom.

Keywords: ANOVA, Contrast, Mean comparison, Trial plans, Planned comparisons

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1. Introduction

The purpose of many research studies is to examine the mean differences between groups. While t test is commonly used to compare two averages, variance analysis (ANOVA) is used to analyze two or more averages (Bek et al., 1988, Shavelson, 2016). A detailed examination of the differences between the averages is done by multiple comparison tests (Özdamar, 1999, Efe et al., 2000, Üçkardeş, 2006, Darlington and Hayes, 2016; Genç and Soysal, 2018). In this case, unplanned (post-hoc or posteriori) tests or planned (priori) tests are used.

There are numerous unplanned (post-hoc or posteriori) multiple comparison tests involving Duncan, Scheffe, Tukey LSD tests. Recently, some researchers (Benton, 1989; Durapau, 1988; Keppel, 1982; Kuehne, 1993; Thompson, 1988; Tucker, 1991) recently proposed

planned comparisons as an important alternative to unplanned comparisons or post-hoc comparisons following the ANOVA test.

The effect of the independent variable is analyzed in detail by the use of contrast, which is a planned comparison (Kwon, 1996; Abdi, 2010). These comparatively few comparisons are based on personal knowledge and theoretical work in the field of researchers (Zieffler, 2011). Contrast analysis, then, will question the specific hypotheses given for researchers and compare the results with predictions made on the basis of theory, hypothesis or intuition (Rosenthal and Rosnow, 1985, Kwon, 1996, Çanga and Efe, 2017).

The aim of this study is to provide the presentation and use of contrast analysis. Contrast estimates based on the research hypothesis have been made with the data set used to accomplish this. The detailed construction of the generated contrast coefficients and contrast analysis was demonstrated using a one-way ANOVA. With the demonstration of the research in the SPSS analysis, it is expected that the use of contrast analysis, which allows the researcher to ask questions of interest related to the researcher, is expected to increase.

2. Material and Method

2.1. Material

In this study, a data set taken from Bek and Efe (1988) was used in order to understand the use of contrast analysis in one-way studies. The dry matter quantities determined by three different methods are given in Table 1.

Table 1. Dry matter quantities determined by three different methods (%)

Methods	Method 1	Method 2	Method 3
Replicates	3	4	6
	5	4	7
	2	3	8
	4	8	6
	8	7	7
	4	4	9
	3	2	10
	9	5	9
Means	4.75	4.62	7.75
Std Dev	0.87	0.69	0.60
n	8	8	8

2.2. Method

For the one-way ANOVA design, the model has only two components;

$$y_{ij} = \mu + \alpha_i + \varepsilon_{ij} \quad (1)$$

where μ is general mean, α_i is j-th group effect and ε_{ij} is random error (Karpinski, 2006).

2.2.1. Estimate value of a contrast

$$\hat{\psi} = \sum_{a=1}^{A} M_{a.} C_a = \sum_{a=1}^{A} M_{a.} c_{a,i} = M_{1.} c_{1,i} + M_{2.} c_{2,i} + \ldots + M_{k.} c_{k,i} \quad (2)$$

Where, n is number of observations in each group, M_a is means of conditions (or groups), $C_a : c_{a,i}$ is i[th] contrast coefficient in a[th] group. Hypothesis-based contrast coefficient (a: group index, i: contrast estimate index) and $\hat{\psi}$ is contrasted (weighted) sum of the means (Rosethal and Rosnow, 1985; Rosnow et al., 2000; Abdi ve ark., 2009; Çanga and Efe, 2017).

2.2.2. Standard error of a contrast estimate

If it is recalled that the standard deviation of the standard error is the standard deviation; standard error is calculated for contrast estimation;

$$Std\ Error(\hat{\psi}) = \sqrt{MSE \sum \frac{c_{a,i}^2}{n_i}} \quad (3)$$

Where, $c_{a,i}^2$ is the squared weight for each group, n_i is sample size of each group and MSE: Mean Square Error.

2.2.3. Significance test for estimating a contrast

For a contrast estimation, the t value is calculated using the following formula:

$$t = \frac{\sum c_{a,i} \bar{X}_{a.}}{\sqrt{MSE \sum \frac{c_{a,i}^2}{n_i}}} \quad (4)$$

Where, α is the significance of the test (Karpinski, 2006).

2.2.4. Determination of research questions

Since there are 3 groups of research questions, (3-1) hypothesis can be established. In general, if n groups are present, (n-1) contrast estimates (hypothesis) can be generated.

If you want to compare two contrasts firstly; The hypothesis $H_{0,1}$ for hypothesis 1 is constructed as follows:

Hypothesis 1: The null hypothesis "There is no difference between the mean of the first method and the mean of the second method" has been transformed into a symbolic hypothesis in equation 5;

$$H_{0,1} : \mu_{method1} - \mu_{Method2} = 0 \quad (5)$$

For the contrast estimate ($\hat{\psi}_1$) to be formed by this hypothesis, the contrast coefficient values are determined as $c_{1,1} = 1$, $c_{2,1} = -1$, $c_{3,1} = 0$.

Hypothesis 2: The null hypothesis of "there is no difference between the averages of the third method and

the averages of the other two methods" is transformed into a symbolic hypothesis in equation 6;

$$H_{0,2}:\left(\frac{\mu_{Method1}+\mu_{Mehthod2}}{2}\right)-\mu_{Method3}=0 \qquad (6)$$

The same hypothesis as another demonstration saved from fractions can also be written as;

$$H_{0,2}:\psi_2:\mu_{Method1}+\mu_{Method2}-2\mu_{Method3} \qquad (7)$$

For the contrast estimate ($\hat{\psi}_2$) to be formed by this hypothesis, the contrast coefficient values are determined as $c_{1,1}$ = 1, $c_{2,1}$ = 1, $c_{3,1}$ = -2 (Abdi, 2009; Çanga, 2018).

Analysis of the data in the study was made using the "Windows SPSS 18.0 software" statistical package program (SPSS Inc., Chicago, IL, USA).

3. Results and Discussion

The results of the analysis of classical variance depending on the data in Table 1 are given in Table 2.

Table 2. ANOVA results based on the dry substance used in the three methods specified

SV	DF	SS	MS	F
Between methods	2	50.083	25.041	6.053*
Within methods (Error)	21	86.875	0.065	
Total	23	136.958		

*: p<0.05

Contrast estimation coefficients C_1 = {1, -1, 0},

C2 = {1, 1, -2}; the standard error due to these values when written in Equation 3; standard error for two predictions made respectively;

$$Std\ Error(\hat{\psi}_1)=\sqrt{4.14*\left(\frac{1}{8}+\frac{1}{8}+\frac{0}{8}\right)}=1.01734$$

$$Std\ Error(\hat{\psi}_2)=\sqrt{4.14*\left(\frac{1}{8}+\frac{1}{8}+\frac{4}{8}\right)}=1.76210$$

The t values for the first contrast estimate and the second contrast estimate, respectively, are written as follows in Equation 4:

$$t(\hat{\psi}_1)=\frac{\hat{\psi}_1}{Std\ \ Error(\hat{\psi}_1)}$$
$$=\frac{1*4.75-1*4.62+0*7.75}{1.01734}$$
$$=\frac{0.13}{1.76210}=0.12$$

$$t(\hat{\psi}_2)=\frac{\hat{\psi}_2}{Std\ Error(\hat{\psi}_1)}$$
$$=\frac{1*4.75+1*4.62-2*7.75}{1.76210}$$
$$=\frac{-6.1}{1.76210}=-3.46$$

(Karpinski, 2006; Gonzalez, 2016).

In Figure 1, data entry is given in SPSS (Efe et al., 2000; Field, 2016).

	method	dry_matter
1	1	3
2	1	5
3	1	2
4	1	4
5	1	8
6	1	4
7	1	3
8	1	9
9	2	4
10	2	4
11	2	3
12	2	8
13	2	7
14	2	4
15	2	2
16	2	5
17	3	6
18	3	7
19	3	8
20	3	6
21	3	7
22	3	9
23	3	10
24	3	9

Figure 1. Example data set

The window after the **Analyze/Compare Means/ One Way Anova** key sequence; dependent variable (dry matter) is transferred to **Dependent Variable** and the independent variable (Method) is transferred to **Factor** fields (Figure 2).

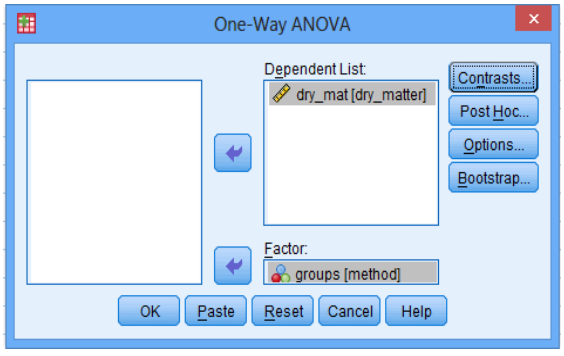

Figure 2. Factor / Variable definitions

In the same window, the window with the **Contrasts...** button will have the contrast definitions. If the trends in the data are to be tested, **Polynomial** option is marked. In this study, trends will not be examined. The **Cofficients** option is for specifying planned comparisons. In order to make planned comparisons, firstly, in SPSS, it is determined which contrast estimation coefficients are assigned to each group. First, coefficients related to the first contrast estimate are entered as {1, -1, 0}, respectively. After each coefficient of the first estimate is entered; to generate another contrast estimate, the **Next** box on the left side is highlighted and the other contrast estimate is passed. Another important point here is that the sum of the coefficients entered must be equal to zero. For this reason, under the contrast coefficients entered, totals are immediately reported by the software. Then, coefficients related to the second contrast estimate are entered {1, 1, -2}, respectively, and **Continue** button on the lower left corner is pressed to return to the **One-Way ANOVA** window (Figure 3a, Figure 3b).

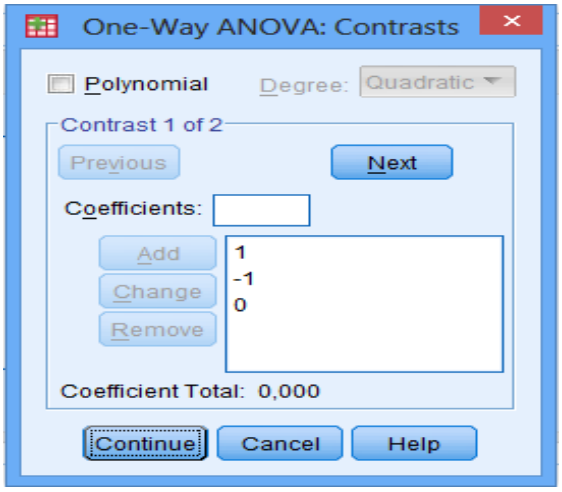

Figure 3a. First contrast estimation coefficients

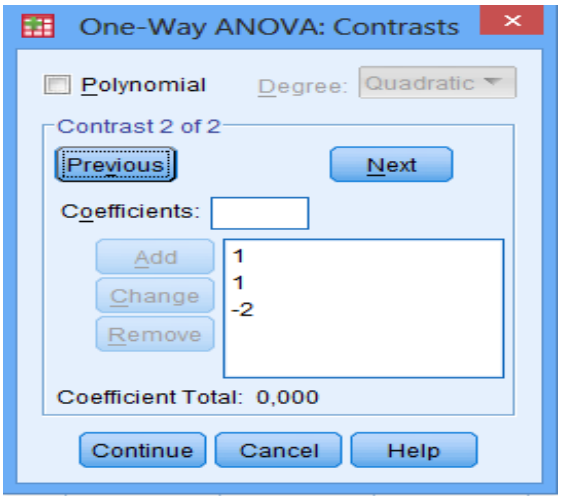

Figure 3b. Second contrast estimation coefficients

Here, the **Homogeneity of variance test** box, which is used to test the homogeneity of the window variances that come with the **Options...** button, should be selected (tick) (Figure 4). From this window, press **Continue** button in the lower left corner and return to the **One-Way ANOVA** window.

Finally, click **OK** to save the results. Following the analysis performed, the SPSS results of the variance analysis for the data in Table 1 are listed below respectively.

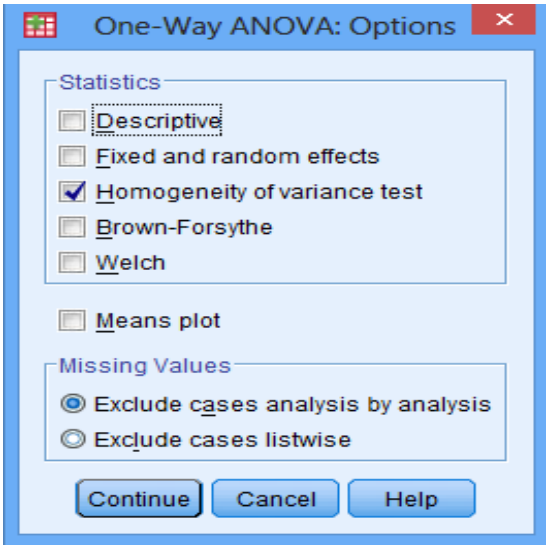

Figure 4. Homogeneity test for One Way Anova

Table 3. Homogeneity test of variances

Test of Homogeneity of Variances			
Dry matter			
Levene Statistic	df1	df2	Sig.
0.784	2	21	0.469

If the end result of the Levene test is meaningful, the variances may differ significantly and the assumption of equality of variances may be violated. When evaluated according to Table 3; Assuming that the Levene test is not significant ($p>0.05$), it is assumed that the variances are equal and the variance analysis the results are believed to be reliable. In Table 4, the results of classical variance analysis in SPSS are given (Karpinski, 2006; Field, 2016).

According to the analysis of classical variance, it is seen that there is a difference between the mean of the methods ($p<0.01$). At this stage, all possible binary mean differences are tested with one of the multiple comparison methods. In this study, however, there are only two comparisons that the investigator is interested in. Depending on this situation, the contrast coefficients are assigned. The assignment of the coefficients determined for the planned comparisons is shown in Table 5.

Table 4. Dry matter classical ANOVA results for the three methods identified

ANOVA					
Dry matter	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50,083	2	25,042	6,053**	.008
Within Groups	86,875	21	4,137		
Total	136,958	23			

**: p<0.01

Table 5. Contrast estimation coefficients for the three methods identified

Contrast Coefficients			
Contrast	Groups		
	Method1	Method2	Method3
1	1	-1	0
2	1	1	-2

Table 6. Contrast tests for the three determined methods

Contrast Tests							
		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Dry matter	Assume equal variances	1	0.13	1.017	0.123	21	0.903
		2	-6.13	1.761	-3.477	21	0.002**
	Does not assume equal variances	1	0.13	1.129	0.111	13.360	0.913
		2	-6.13	1.543	-3.969	19.118	0.001

**: p<0.01

4. Conclusions

In this study, how to use contrast in single-factor experiments was analyzed in Analysis of variance. At the same time, one-way contrast analysis with SPSS statistical software was discussed and presented in the form of analysis.

Numerical examples of dry matter quantities determined by three different methods were used in the study. Two special questions of the researcher were hypothesized. The effect of the differences between the methods with respect to these questions was examined with the contrast estimates, each of which was determined with 1 degree of freedom and based on the estimator of the investigator. For this, contrast analysis was done with the coefficients which are formed according to these estimations.

As a result, the first and second method means were found to be the same (p>0.05). In addition, it shows that the mean dry matter determined by the third method is different from the mean dry matter means determined by the other two methods (p <0.01). In other words, the third method mean is different from the first and second method means.

It is expected that this study will be a guide for the hypothesis that the researcher focuses only on specific questions, to determine the contrast coefficients of these hypotheses, and to test the hypotheses dealing with the results of variance analysis with the aid of contrast estimates.

Conflict of interest

The authors declare that there is no conflict of interest.

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