The ANOVA for Dependent Groups — Analysis of k-Within-Group Data with a Quantitative DV

Application: To compare the means of two or more quantitative variables obtained from dependent samples (repeated measures or matched groups). The two or more scores might be the same variable measured at different times or under different conditions, comparable variables measured at the same time, or some combination.

Research Hypothesis: The data come from the Pet shop database. The researcher hypothesized that stores would tend to display more fish than other types of animals, fewer reptiles, and an intermediate number of mammals.

H0: for this analysis: Pet stores display the same mean number of reptiles, fish and mammals.

Research Design: The IV is Pet Type, with the conditions Reptiles, Fish & Mammals The DV is the number animals of each type.

(fishnum,

	Type of Pet	
Reptiles	Fish	Mammals

Analyze → General Linear Model → Repeated Measures

- In the **Repeated Measures Definition Window** enter your name for the IV in the "Within-subject Factor Name" box (pettype)
- enter the number of conditions of the IV in the "Number of levels" window (2)
- click the "Add" button
- click the "Define" button
- In the **Repeated Measures** window highlight the variables that are the DV score for each condition and click the arrow
- click the "Options" button -- in the Repeated Measures: Options window check the "Descriptives" box

Repeated Measures Defin 🔀					
\underline{W} ithin-Subject Factor Name:	pettype	De <u>f</u> ine			
Number of <u>L</u> evels:	3	<u>R</u> eset			
Add pettype(3)	_	Cancel			
Change		Help			
Remove		Mea <u>s</u> ure >>			

Repeated Me	asures	×
 	Within Subjects Variables (pettype) ishum(1) replnum(2) manufmum(3) Between Subjects Factor(s): Covariates: i	OK Pasta <u>R</u> ecet Cancel Helµ
OdelContrasts.	No <u>ts</u> Post <u>11</u> 5c <u></u>]

Variables in the Analysis: In a WG design the variables in the analysis are the

reptnum & mamlnum)

variables holding the DV scores for each IV condition

aciot(s, and Factor Interactions)	Lushay <u>M</u> eans the
(UVL A⊥) pet:ype	
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 Descriptive statistics 	🔲 ans on ration rights
Estimates of effect size	Herngenety tests
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Descriptive Statistics

	Mean	Std. Deviation	Ν
number of fish at store	23.92	9.605	12
number of mammals	21.50	12.866	12
number of reptiles at store	9.25	4.267	12

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sia.	
PETTYPE <	Sphericity Assumed	1484.056	2	742.028	22,222	.000	\searrow
	Greenhouse-Geisser	1484.056	1.672	887.492	22.222	.000	
	Huynh-Feldt	1484.056	1.937	766.233	22.222	.000	
	Lower-bound	1484.056	1.000	1484.056	22.222	.001	
Error(PETTYPE	Sphericity Assumed	734.611	22	33.391	\bigwedge	/	
	Greenhouse-Geisser	734.611	18.394	39.937			
	Huynh-Feldt	734.611	21.305	34.481			
	Lower-bound	734.611	11.000	66.783			l ¦

SPSS provides different "versions" of the ANOVA output. We will focus on the "traditional" analysis, which SPSS labels as "Sphericity Assumed"

df, F & p-value to use

There is a significant difference among the means of the three different munbers of animals displayed in the stores.

df(error) & Mean Square Error term for this analysis

Steps for computing and interpreting LSD minimum mean difference

 Dermine df(error) for th Use the t-table to determine 	e analysis (nine the critio	df(error) = 22 cal value of t (at p	0 = .05) for this df(error)	with df=22 t-	critical = 2.07	
3. Determine the MSerror 4. Determine the number	for the analy of participant	sis MSerror = 3 ts in the analysis	3.39 n = 12		•	t-ta
5. Apply the LSD formula $d_{LSD} = \frac{t * \sqrt{2}}{\sqrt{2}}$ 6. Compare the minimum if the pairwise conditio if the pairwise conditio For this analysis compare There were about the same mean difference between reptiles (M=9.25), and sig	to obtain the $\sqrt{(2 * MS_{Err})}$ mean differe mean differe mean differe mean differe ns have mea mean have mea are the minim these two co nificantly mo	minimum mean $\left(\frac{1}{2.07}\right)^{-1} = \frac{2.07}{2.07}$ ence (4.89) with ence is larger than no that are "signing ince is smaller that are "statistic mum mean different ber of mammals that re mammals that that the mammals th	difference $x + \sqrt{(2 + 33.39)}$ $\sqrt{12}$ each pairwise mean dif in the minimum mean dif- ficantly different" an the minimum mean stically equivalent" ence of 4.89 with each of is (M=21.50) and fish (M han 4.89). There were in reptiles (both mean d	= 4.89 ference fference, then t difference, ther of the pairwise of I=23.92) in thes significantly me lifferences were	hose two hose two lifferences. e stores (the ore fish than larger than	
Reporting the Results Table 1 summ There was a significant (F(2,22) = 22.22, p < .0 mean difference = 4.98 reptiles were displayed average. However, cor between the average n	arizes the da difference a 5, Mse = 33.3) revealed th on average trary to the re umber of fish	ta for the numbe nong the distribu 39). Pairwise col at, consistent wi and also more m esearch hypothes	ers of animals displayed utions of the three types mparisons using LSD (th the research hypothe nammals than reptiles v sis, there was not a sigr displayed	d at the stores. s of animals with a minimum esis, more fish t were displayed nificant difference	han on ce	
Table 1. Summary of the numbe	r of animals	of each type disp	layed in the pet stores.			
		Type of Animal				
	Fish	Mammals	Reptiles			
Mean	23.92	21.50	9.25			
Standard Deviation	9.61	12.87	4.27			

able	Critical valu	ues of t for α =	.05 & α = .01
	df	α = .05	α = .01
	1	12 71	63 66
	2	4 30	9 92
	3	3.18	5.84
	4	2.78	4.60
	5	2.57	4.03
	б	2.45	3.71
	7	2.36	3.50
	8	2.31	3.36
	9	2.26	3.25
	10	2.23	3 17
	11	2.20	3.11
	12	2.18	3.06
	13	2.16	3.01
	14	2.14	2.98
	15	2.13	2.95
	16	2.12	2.92
	17	2.11	2.90
	18	2.10	2.88
	19	2.09	2.86
	20	2.09	2.84
	21	2.08	2.83
	22	2.07	2.82
	23	2.07	2.81
	24	2.06	2.80
	25	2.06	2.79
	26	2.06	2.78
	27	2.05	2.77
	28 20	2.05	2.70
	29	2.04	2.70
	30 40	2.04	2.75
	40 60	2.02	2.70
	120	1 98	2.00
	- 20	1 96	2.52
		1.90	2.00

Steps for computing and interpreting HSD minimum mean difference

- 1. Determine the MSerror for the analysis MSerror = 33.39
- 2. Determine the number of participants in the analysis n = 12
- 3. Determine the number of conditions or means involved in the design k = 3
- 4. Dermine df(error) for the analysis **df(error) = 22**
- 5. Use the table of Q values to determine the value of Q with df=22 and k=3 (with no df = 22, we drop to the row with df = 20) Q = 3.58
- 5. Apply the HSD formula to obtain the minimum mean difference

$$d_{HSD} = \frac{Q * \sqrt{MS_{Error}}}{\sqrt{n}} = \frac{3.58 * \sqrt{33.39}}{\sqrt{12}} = 5.98$$

6. Compare the minimum mean difference (5.98) with each pairwise mean difference

- -- if the pairwise mean difference is larger than the minimum mean difference, then those two conditions have means that are "significantly different"
- -- if the pairwise mean difference is smaller than the minimum mean difference, then those two conditions have means that are "statistically equivalent"

By the Way: Sometimes LSD and HSD analyses will produce different results for one or more of the pairwise comparisons. If so, the difference will always be that you have rejected H0: based on the LSD test (the more sensitive test) and retained H0: based on the HSD test (the more conservative test). When this happens you should consider the general trend among statisticians (and journal editors) towards "statistical conservatism". More importantly, you should remember that rejecting the null for a particular analysis is not a guarantee that the effect is "really there". Replication (finding the effect in several different studies) is a much better indicator of the "reality" of an effect.

Reporting the Results

Table 1 summarizes the data for the numbers of animals displayed at the stores. There was a significant difference among the distributions of the three types of animals (F(2,22) = 22.22, p < .05, Mse = 33.39). Pairwise comparisons using hSD (with a minimum mean difference = 5.98) revealed that, consistent with the research hypothesis, more fish than reptiles were displayed on average and also more mammals than reptiles were displayed on average. However, contrary to the research hypothesis, there was not a significant difference between the average number of fish and mammals displayed.

Table 1.

Summary of the number of animals of each type displayed in the pet stores.

	Type of Animal				
	Fish	Mammals	Reptiles		
Mean	23.92	21.50	9.25		
Standard Deviation	9.61	12.87	4.27		

Studentized Range Statistic Table Values of Q for α = .05

Denomina	ator k	= numb	per of me	eans	
df	2	3	4	5	6
5	3.64	4.60	5.22	5.67	6.03
б	3.46	4.34	4.90	5.30	5.63
7	3.34	4.16	4.68	5.06	5.36
8	3.26	4.04	4.53	4.89	5.17
9	3.20	3.95	4.41	4.76	5.02
10	3.15	3.88	4.33	4.65	4.91
11	3.11	3.82	4.26	4.57	4.82
12	3.08	3.77	4.20	4.51	4.75
13	3.06	3.73	4.15	4.45	4.69
14	3.03	3.70	4.11	4.41	4.64
15	3.01	3.67	4.08	4.37	4.59
16	3.00	3.65	4.05	4.33	4.56
17	2.98	3.63	4.02	4.30	4.52
18	2.97	3.61	4.00	4.28	4.49
19	2.96	3.59	3.98	4.25	4.47
20	2.95	3.58	3.96~	4.23	4.45
24	2.92	3.53	3.90	4.17	4-37
30	2.89	3.49	3.85	4.10	4.30
40	2.86	3.44	3.79	4.04	4.23
60	2.83	3.40	3.74	3.98	4.16
120	2.80	3.36	3.68	3.92	4.10
∞	2.77	3.31	3.63	3.86	4.03