

One-Way Independent ANOVA: Exam Practice Sheet

Questions

Question 1

Students were given different drug treatments before revising for their exams. Some were given a memory drug, some a placebo drug and some no treatment. The exam scores (%) are shown below for the three different groups:

	Memory Drug	Placebo	No Treatment
	70	37	3
	77	43	10
	83	50	17
	90	57	23
	97	63	30
Mean	83.40	50.00	16.60
Variance	112.30	109.00	112.30
Grand Mean		50.00	
Grand Variance		892.14	

- Carry out a one-way ANOVA by hand to test the hypothesis that the treatments will have different effects.
- Can you suggest some follow-up comparisons (with weights)?

Question 2

A neuropsychologist was interested in how Monkeys learn to perform a task. The task was to retrieve a coconut from the opposite side of a river. 15 wild monkeys were assigned to one of three conditions: observing a monkey (they watched another monkey retrieve the coconut by building a bridge across the stream), observing a human (they watched a human solve the task), banana reward (they were allowed to do what they wanted but every time they engaged in behaviour that facilitated solving the task they were rewarded with a banana. After learning the monkeys were required to solve the problem again and the time taken to solve the problem was measured.

	Banana Reward	Observing Monkey	Observing Human
	1	7	15
	1	15	8
	7	1	13
	13	8	13
	13	9	6
Mean	7.00	8.00	11.00
Variance	36.00	25.00	14.50
Grand Mean	8.67		
Grand Variance	24.67		

- Carry out a one-way ANOVA by hand to test the hypothesis that some forms of learning are more successful than others.
- Can you suggest some follow-up comparisons (with weights)?

Question 3

The experimenter in question 2 repeated the experiment above but with different Monkeys who had been lab-reared (and so had identical learning experiences prior to the experiment).

	Banana Reward	Observing Monkey	Observing Human
	6	7	8
	7	8	6
	7	8	15
	7	8	13
	8	9	13
Mean	7.00	8.00	11.00
Variance	0.50	0.50	14.50
Grand Mean	8.67		
Grand Variance	7.52		

- Carry out a one-way ANOVA by hand to test the hypothesis that some forms of learning are more successful than others.
- Note that the means of the groups are the same as Experiment 1. Can you explain any differences in the results between this experiment and the one in question 2?

Question 4

A psychologist was interested in whether different TV shows lead to a more positive outlook on life. People were split into 4 groups and then taken to a room to view a program. The four groups saw: The Muppet Show, Futurama, The News, No program. After the program a blood sample was taken and serotonin levels measured (remember more serotonin means more happy!

	The Muppet Show	Futurama	BBC News	No Program
	11	4	4	7
	7	8	3	7
	8	6	2	5
	14	11	2	4
	11	9	3	3
	10	8	6	4
	5			4
				4
Mean	9.43	7.67	3.33	4.75
Variance	8.95	5.87	2.27	2.21
Grand Mean	6.30			
Grand Variance	10.06			

- Carry out a one-way ANOVA by hand to test the hypothesis that some TV shows make people happier than others.
 - Can you suggest some follow-up comparisons (with weights)?
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Answers

Answer to Question 1

Descriptives

Exam Score (%)								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Memory Drug	5	83.4000	10.5972	4.7392	70.2419	96.5581	70.00	97.00
Placebo	5	50.0000	10.4403	4.6690	37.0366	62.9634	37.00	63.00
No Treatment	5	16.6000	10.5972	4.7392	3.4419	29.7581	3.00	30.00
Total	15	50.0000	29.8688	7.7121	33.4592	66.5408	3.00	97.00

ANOVA

Exam Score (%)						
	Sum of Squares	df	Mean Square	F	Sig.	
Between Groups	11155.600	2	5577.800	50.160	.000	
Within Groups	1334.400	12	111.200			
Total	12490.000	14				

Contrasts would be (weights in brackets):

- **Contrast 1:** {Memory Drug (-2)} vs. {Placebo (1) and No Treatment (1)}
- **Contrast 2:** {Placebo (-1)} vs. {No Treatment (1)} — [Memory Drug would have a weight of 0 in this contrast]

Answer to Question 2

Descriptives

Experiment 1								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Banana Reward	5	7.0000	6.0000	2.6833	-.4500	14.4500	1.00	13.00
Observing Monkey	5	8.0000	5.0000	2.2361	1.7917	14.2083	1.00	15.00
Observing Human	5	11.0000	3.8079	1.7029	6.2719	15.7281	6.00	15.00
Total	15	8.6667	4.9666	1.2824	5.9163	11.4171	1.00	15.00

ANOVA

Experiment 1						
	Sum of Squares	df	Mean Square	F	Sig.	
Between Groups	43.333	2	21.667	.861	.447	
Within Groups	302.000	12	25.167			
Total	345.333	14				

There are no control groups, so there is no real correct way to define contrasts. However, you might want to first combine observational learning conditions and compare with the reward learning (weights in brackets):

- **Contrast 1:** {Banana reward (-2)} vs. {Observe Monkey (1) and Observe Human (1)}
- **Contrast 2:** {Observe monkey (-1)} vs. {Observe Human (1)} — [Banana Reward would have a weight of 0 in this contrast]

Answer to Question 3

Descriptives

Experiment 2								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Banana Reward	5	7.0000	.7071	.3162	6.1220	7.8780	6.00	8.00
Observing Monkey	5	8.0000	.7071	.3162	7.1220	8.8780	7.00	9.00
Observing Human	5	11.0000	3.8079	1.7029	6.2719	15.7281	6.00	15.00
Total	15	8.6667	2.7430	.7082	7.1477	10.1857	6.00	15.00

ANOVA

Experiment 2					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	43.333	2	21.667	4.194	.042
Within Groups	62.000	12	5.167		
Total	105.333	14			

- The reason why this ANOVA is significant whereas the one in question 2 is not is because the variance within groups is much smaller (note the standard deviations in each group compared to question 2 in the table of descriptives). By using lab-reared monkeys, thus controlling the prior experiences of the monkeys, the experimenter has reduced the variability in task performance between monkeys within a group. The result is that the error variance is much lower (note in the ANOVA tables that the SSMS (between group SS) are the same but the SSRs (within group SS) are different. Therefore, the error against which the experimental effect is tested is much lower.

Answers to Question 4

Descriptives

Serotonin Level								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
The Muppet Show	7	9.4286	2.9921	1.1309	6.6614	12.1958	5.00	14.00
Futurama	6	7.6667	2.4221	.9888	5.1248	10.2085	4.00	11.00
BBC News	6	3.3333	1.5055	.6146	1.7534	4.9133	2.00	6.00
No Program (Control)	8	4.7500	1.4880	.5261	3.5060	5.9940	3.00	7.00
Total	27	6.2963	3.1722	.6105	5.0414	7.5512	2.00	14.00

ANOVA

Serotonin Level					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	151.749	3	50.583	10.588	.000
Within Groups	109.881	23	4.777		
Total	261.630	26			

Contrasts could be (weights in brackets):

- **Contrast 1 (all TV shows vs. no TV show control):** {Muppets (1), Futurama (1), BBC News (1)} vs. {No Program (-3)}
- **Contrast 2 (cartoons vs. factual):** {Muppets (1), Futurama (1)} vs. {BBC news (-2)} — [No program would have a weight of 0 in this contrast]
- **Contrast 3:** {Muppets (1)} vs. {Futurama (-1)} — [No program and BBC news would have a weights of 0 in this contrast].

Now try it on SPSS!

For extra practice at interpretation, you could try analysing these data in SPSS and selecting contrasts or post hoc tests. This will give you some practice at interpreting one-way ANOVA.