Factorial Analysis

Given the prevalence of soft drink machines on campus a researcher was interesting in finding out if consumption of these drinks had an impact on learning. The research examined three variables related to the drinks: carbonation, caffeine, and sweetener. The researcher was interested in whether different combinations of these factors had an influence on memory tasks. The researcher varied carbonation (present, absent), amount of caffeine (none, moderate, heavy), and type of sweetener used (sugar, ½ sugar ½ artificial, artificial). The researcher gave a group of students a novel text to read and remember while consuming the drinks. Later these students were given a recall test and the number of recall errors was recorded.

- Run a between groups factorial analysis on these data and interpret the results of the analysis.

Tests of Between-Subjects Effects

Dependent Variable: Learning

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1066.250[a]	17	62.721	4.694	.001	.816
Intercept	6006.250	1	6006.250	449.532	.000	.961
Carbonation	14.694	1	14.694	1.100	.308	.058
Caffeine	668.167	2	334.083	25.004	.000	.735
Sweetener	12.167	2	6.083	.455	.641	.048
Carbonation * Caffeine	43.056	2	21.528	1.611	.227	.152
Carbonation * Sweetener	.389	2	.194	.015	.986	.002
Caffeine * Sweetener	326.167	4	81.542	6.103	.003	.576
Carbonation * Caffeine * Sweetener	1.611	4	.403	.030	.998	.007
Error	240.500	18	13.361			
Total	7313.000	36				
Corrected Total	1306.750	35				

a. R Squared = .816 (Adjusted R Squared = .642)

6. Carbonation * Caffeine * Sweetener

Dependent Variable: Learning

Carbonation	Caffeine	Sweetener	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Present	None	Sugar	11.000	2.585	5.570	16.430
		1/2Sugar+1/2Artificial	4.500	2.585	-.930	9.930
		Artifificial	13.500	2.585	8.070	18.930
	Moderate	Sugar	9.500	2.585	4.070	14.930
		1/2Sugar+1/2Artificial	13.000	2.585	7.570	18.430
		Artifificial	7.000	2.585	1.570	12.430
	Heavy	Sugar	20.000	2.585	14.570	25.430
		1/2Sugar+1/2Artificial	25.000	2.585	19.570	30.430
		Artifificial	18.500	2.585	13.070	23.930
Absent	None	Sugar	11.500	2.585	6.070	16.930
		1/2Sugar+1/2Artificial	4.500	2.585	-.930	9.930
		Artifificial	12.500	2.585	7.070	17.930
	Moderate	Sugar	10.000	2.585	4.570	15.430
		1/2Sugar+1/2Artificial	14.000	2.585	8.570	19.430
		Artifificial	7.500	2.585	2.070	12.930
	Heavy	Sugar	15.000	2.585	9.570	20.430
		1/2Sugar+1/2Artificial	21.000	2.585	15.570	26.430
		Artifificial	14.500	2.585	9.070	19.930

Multiple Comparisons

Dependent Variable: Learning

	(I) Caffeine	(J) Caffeine	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	None	Moderate	-.5833	1.49226	.920	-4.3918	3.2252
		Heavy	-9.4167*	1.49226	.000	-13.2252	-5.6082
	Moderate	None	.5833	1.49226	.920	-3.2252	4.3918
		Heavy	-8.8333*	1.49226	.000	-12.6418	-5.0248
	Heavy	None	9.4167*	1.49226	.000	5.6082	13.2252
		Moderate	8.8333*	1.49226	.000	5.0248	12.6418

Based on observed means.
The error term is Mean Square(Error) = 13.361.

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

Multiple Comparisons

Dependent Variable: Learning

	(I) Sweetener	(J) Sweetener	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Sugar	1/2Sugar+1/2Artificial	-.8333	1.49226	.844	-4.6418	2.9752
		Artifificial	.5833	1.49226	.920	-3.2252	4.3918
	1/2Sugar+1/2Artificial	Sugar	.8333	1.49226	.844	-2.9752	4.6418
		Artifificial	1.4167	1.49226	.617	-2.3918	5.2252
	Artifificial	Sugar	-.5833	1.49226	.920	-4.3918	3.2252
		1/2Sugar+1/2Artificial	-1.4167	1.49226	.617	-5.2252	2.3918

Based on observed means.
The error term is Mean Square(Error) = 13.361.

Part 2: Question 1: Interpretation

A factorial analysis was conducted to evaluate the impact of drinks carbonation, sweeteners and caffein on learning (recall). The means and standard deviations for the learning recall are presented in Table 2.1 below. The result of the analysis indicated a significant main effect for only caffeine, $F(2,18) = 25.004$, $p(0.000) < 0.05$, partial $\eta^2 = 0.735$, whereas, there were nonsignificant main effect for carbonation $p(0.308) > 0.05$ and sweetener $p(0.641) > 0.05$. In terms of interactions, there was significant interaction effect between caffeine and sweetener, $F(4,18) = 6.103$, $p(0.003) < 0.05$, partial $\eta^2 = 0.576$., but there were nonsignificant interaction effects between carbonation and caffeine, $p(0.227) > 0.05$, between carbonation and sweetener, $p(0.986) > 0.05$ and between carbonation caffeine and sweetener, $p(0.998) > 0.05$.

Table 2.1. Mean and Standard Deviation for Question 1

Carbonation	Caffeine	Sweetener	M	SD
Present	None	Sugar	11.0000	1.41421
		1/2Sugar+1/2Artificial	4.5000	2.12132
		Artifificial	13.5000	2.12132
	Moderate	Sugar	9.5000	3.53553
		1/2Sugar+1/2Artificial	13.0000	4.24264
		Artifificial	7.0000	1.41421
	Heavy	Sugar	20.0000	1.41421
		1/2Sugar+1/2Artificial	25.0000	5.65685
		Artifificial	18.5000	7.77817
Absent	None	Sugar	11.5000	2.12132
		1/2Sugar+1/2Artificial	4.5000	.70711
		Artifificial	12.5000	3.53553
	Moderate	Sugar	10.0000	1.41421
		1/2Sugar+1/2Artificial	14.0000	2.82843
		Artifificial	7.5000	3.53553
	Heavy	Sugar	15.0000	2.82843
		1/2Sugar+1/2Artificial	21.0000	7.07107
		Artifificial	14.5000	2.12132

- Run these data as a mixed factorial design with carbonation as the repeated (within) variable.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
CarbonationPA	Pillai's Trace	.068	.659[b]	1.000	9.000	.438	.068
	Wilks' Lambda	.932	.659[b]	1.000	9.000	.438	.068
	Hotelling's Trace	.073	.659[b]	1.000	9.000	.438	.068
	Roy's Largest Root	.073	.659[b]	1.000	9.000	.438	.068
CarbonationPA * Sweetner2	Pillai's Trace	.002	.009[b]	2.000	9.000	.991	.002
	Wilks' Lambda	.998	.009[b]	2.000	9.000	.991	.002
	Hotelling's Trace	.002	.009[b]	2.000	9.000	.991	.002
	Roy's Largest Root	.002	.009[b]	2.000	9.000	.991	.002
CarbonationPA * Caffeine2	Pillai's Trace	.177	.965[b]	2.000	9.000	.417	.177
	Wilks' Lambda	.823	.965[b]	2.000	9.000	.417	.177
	Hotelling's Trace	.214	.965[b]	2.000	9.000	.417	.177
	Roy's Largest Root	.214	.965[b]	2.000	9.000	.417	.177
CarbonationPA * Sweetner2 * Caffeine2	Pillai's Trace	.008	.018[b]	4.000	9.000	.999	.008
	Wilks' Lambda	.992	.018[b]	4.000	9.000	.999	.008
	Hotelling's Trace	.008	.018[b]	4.000	9.000	.999	.008
	Roy's Largest Root	.008	.018[b]	4.000	9.000	.999	.008

a. Design: Intercept + Sweetner2 + Caffeine2 + Sweetner2 * Caffeine2
Within Subjects Design: CarbonationPA

b. Exact statistic

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
CarbonationPA	Sphericity Assumed	14.694	1	14.694	.659	.438	.068
	Greenhouse-Geisser	14.694	1.000	14.694	.659	.438	.068
	Huynh-Feldt	14.694	1.000	14.694	.659	.438	.068
	Lower-bound	14.694	1.000	14.694	.659	.438	.068
CarbonationPA * Sweetner2	Sphericity Assumed	.389	2	.194	.009	.991	.002
	Greenhouse-Geisser	.389	2.000	.194	.009	.991	.002
	Huynh-Feldt	.389	2.000	.194	.009	.991	.002
	Lower-bound	.389	2.000	.194	.009	.991	.002
CarbonationPA * Caffeine2	Sphericity Assumed	43.056	2	21.528	.965	.417	.177
	Greenhouse-Geisser	43.056	2.000	21.528	.965	.417	.177
	Huynh-Feldt	43.056	2.000	21.528	.965	.417	.177
	Lower-bound	43.056	2.000	21.528	.965	.417	.177
CarbonationPA * Sweetner2 * Caffeine2	Sphericity Assumed	1.611	4	.403	.018	.999	.008
	Greenhouse-Geisser	1.611	4.000	.403	.018	.999	.008
	Huynh-Feldt	1.611	4.000	.403	.018	.999	.008
	Lower-bound	1.611	4.000	.403	.018	.999	.008
Error(CarbonationPA)	Sphericity Assumed	200.750	9	22.306			
	Greenhouse-Geisser	200.750	9.000	22.306			
	Huynh-Feldt	200.750	9.000	22.306			
	Lower-bound	200.750	9.000	22.306			

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	CarbonationPA	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
CarbonationPA	Linear	14.694	1	14.694	.659	.438	.068
CarbonationPA * Sweetner2	Linear	.389	2	.194	.009	.991	.002
CarbonationPA * Caffeine2	Linear	43.056	2	21.528	.965	.417	.177
CarbonationPA * Sweetner2 * Caffeine2	Linear	1.611	4	.403	.018	.999	.008
Error(CarbonationPA)	Linear	200.750	9	22.306			

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	6006.250	1	6006.250	1359.906	.000	.993
Sweetner2	12.167	2	6.083	1.377	.301	.234
Caffeine2	668.167	2	334.083	75.642	.000	.944
Sweetner2 * Caffeine2	326.167	4	81.542	18.462	.000	.891
Error	39.750	9	4.417			

8. Sweetner2 * Caffeine2 * CarbonationPA

Measure: MEASURE_1

Sweetner2	Caffeine2	CarbonationPA	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Sugar	None	1	11.000	2.769	4.736	17.264
		2	11.500	2.386	6.102	16.898
	Moderate	1	9.500	2.769	3.236	15.764
		2	10.000	2.386	4.602	15.398
	Heavy	1	20.000	2.769	13.736	26.264
		2	15.000	2.386	9.602	20.398
1/2Sugar1/2Artificial	None	1	4.500	2.769	-1.764	10.764
		2	4.500	2.386	-.898	9.898
	Moderate	1	13.000	2.769	6.736	19.264
		2	14.000	2.386	8.602	19.398
	Heavy	1	25.000	2.769	18.736	31.264
		2	21.000	2.386	15.602	26.398
Artificial	None	1	13.500	2.769	7.236	19.764
		2	12.500	2.386	7.102	17.898
	Moderate	1	7.000	2.769	.736	13.264
		2	7.500	2.386	2.102	12.898
	Heavy	1	18.500	2.769	12.236	24.764
		2	14.500	2.386	9.102	19.898

Multiple Comparisons

Measure: MEASURE_1

	(I) Sweetner2	(J) Sweetner2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Sugar	1/2Sugar1/2Artificial	-.8333	.85797	.612	-3.2288	1.5621
		Artificial	.5833	.85797	.781	-1.8121	2.9788
	1/2Sugar1/2Artificial	Sugar	.8333	.85797	.612	-1.5621	3.2288
		Artificial	1.4167	.85797	.275	-.9788	3.8121
	Artificial	Sugar	-.5833	.85797	.781	-2.9788	1.8121
		1/2Sugar1/2Artificial	-1.4167	.85797	.275	-3.8121	.9788

Based on observed means.
The error term is Mean Square(Error) = 2.208.

Multiple Comparisons

Measure: MEASURE_1

	(I) Caffeine2	(J) Caffeine2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	None	Moderate	-.5833	.85797	.781	-2.9788	1.8121
		Heavy	-9.4167*	.85797	.000	-11.8121	-7.0212
	Moderate	None	.5833	.85797	.781	-1.8121	2.9788
		Heavy	-8.8333*	.85797	.000	-11.2288	-6.4379
	Heavy	None	9.4167*	.85797	.000	7.0212	11.8121
		Moderate	8.8333*	.85797	.000	6.4379	11.2288

Based on observed means.
The error term is Mean Square(Error) = 2.208.

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

How does the analysis change?

The analysis changes because test of within subject effect was generated, test of within subject contrast was generated in addition to the test of between subject effects. However, in the test of between subject effect, only caffeine and interaction between caffeine and sweetener was significant as earlier reported.

Does your interpretation change?

No, my interpretation remains the same. Because there was no any level of significance form within subject effects that could change my earlier interpretations.