Laboratory for Two-Factor Repeated Measures Designs (Completely Within and Mixed)

1. First of all, let's try to gain a sense of the source of the error terms in a two-factor repeated measures design. As you know, the error term for the *A* effect is the *AxS* interaction and the error term for the *B* effect is the *BxS* interaction. For the *AxB* interaction, the error term is the *AxBxS* interaction (which is a 3-way interaction). What would it mean to have small or large error terms?

For simplicity's sake, let's deal with a simple 2x2 design. For each of the data sets below, can you decide which of the source tables would emerge from an analysis of the data? Can you see why the *S* line remains the same?

Set 1.

	a_1		a_2	
	b_1	b_2	b_1	b_2
s_1	3	4	4	5
s_2	6	7	7	8
s_3	2	3	3	4
s_4	4	5	5	6

Set 2.

	a_1		a_2	
	b_1	b_2	b_1	b_2
s_1	3	4	5	4
s_2	6	7	7	8
s_3	2	3	4	3
s_4	4	5	5	6

Set 3.

	a_1		a_2	
	b_1	b_2	b_1	b_2
s_1	3	5	4	4
s_2	6	7	7	8
s_3	2	4	3	3
s_4	4	5	5	6

Set 4.

	a_1		a_2	
	b_1	b_2	b_1	b_2
s_1	3	5	4	4
s_2	7	8	7	6
s_3	2	4	3	3
s_4	6	5	5	4

Source Table A

Source	SS	df	MS	F
S	35	3	11.7	
A	1	1	1	3
AxS	1	3	.33	
B	.25	1	.25	.273
BxS	2.75	3	.917	
AxB	2.25	1	2.25	9
AxBxS	.75	3	.25	

Source Table B

Source	SS	df	MS	F
S	35	3	11.7	
A	4	1	4	*
AxS	0	3	0	
B	4	1	4	*
BxS	0	3	0	
AxB	0	1	0	*
AxBxS	0	3	0	

Source Table C

Source	SS	df	MS	F
S	35	3	11.7	
A	1	1	1	3
AxS	1	3	.33	
B	4	1	4	*
BxS	0	3	0	
AxB	1	1	1	3
AxBxS	1	3	.33	

Source Table D

Source	SS	df	MS	F
S	35	3	11.7	
A	4	1	4	*
AxS	0	3	0	
B	1	1	1	3
BxS	1	3	.33	
AxB	1	1	1	3
AxBxS	1	3	.33	

2. In a two-factor completely within design participants are exposed to lists of concrete words that vary in frequency of occurrence in the language (Low, Medium, and High Frequency). In addition, for some words, participants are told to repeat the word over and over (Repetition) for other words, participants are told to make an image of the word (Imagery), and for other words, participants are given no instructions about what they should do with the words (No Instructions). The DV is the percentage of words recalled.

a. First, compute the overall ANOVA for the data (Two-Way.Rep.sav). You should obtain a source table like the one below:

Descriptive Statistics

	Mean	Std. Deviation	N
LOWREP	36.7778	8.01143	18
MEDREP	45.9444	7.95186	18
HIREP	48.2778	6.66691	18
LOWIMAG	35.2222	7.44039	18
MEDIMAG	55.0000	4.35215	18
HIIMAG	70.7222	7.27450	18
LOWNO	35.1667	6.94728	18
MEDNO	45.4444	4.32805	18
HIGHNO	50.4444	4.94942	18

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
INST	Sphericity Assumed	3580.037	2	1790.019	31.898	.000	63.796	1.000
	Greenhouse-Geisser	3580.037	1.410	2538.390	31.898	.000	44.988	1.000
	Huynh-Feldt	3580.037	1.500	2386.490	31.898	.000	47.851	1.000
	Lower-bound	3580.037	1.000	3580.037	31.898	.000	31.898	1.000
Error(INST)	Sphericity Assumed	1907.963	34	56.117				
	Greenhouse-Geisser	1907.963	23.976	79.578				
	Huynh-Feldt	1907.963	25.502	74.816				
	Lower-bound	1907.963	17.000	112.233				
FREQ	Sphericity Assumed	11896.926	2	5948.463	139.828	.000	279.655	1.000
	Greenhouse-Geisser	11896.926	1.696	7015.339	139.828	.000	237.126	1.000
	Huynh-Feldt	11896.926	1.864	6382.860	139.828	.000	260.623	1.000
	Lower-bound	11896.926	1.000	11896.926	139.828	.000	139.828	1.000
Error(FREQ)	Sphericity Assumed	1446.407	34	42.541				
	Greenhouse-Geisser	1446.407	28.829	50.171				
	Huynh-Feldt	1446.407	31.686	45.648				
	Lower-bound	1446.407	17.000	85.083				
INST * FREQ	Sphericity Assumed	3009.259	4	752.315	21.962	.000	87.846	1.000
	Greenhouse-Geisser	3009.259	2.850	1055.895	21.962	.000	62.590	1.000
	Huynh-Feldt	3009.259	3.484	863.727	21.962	.000	76.515	1.000
	Lower-bound	3009.259	1.000	3009.259	21.962	.000	21.962	.993
Error(INST*FREQ)	Sphericity Assumed	2329.407	68	34.256				
	Greenhouse-Geisser	2329.407	48.449	48.079				
	Huynh-Feldt	2329.407	59.229	39.329				
	Lower-bound	2329.407	17.000	137.024				

a. Computed using alpha = .05

b. Of course, given the significant interaction, that’s where you will focus your analyses. However, just to be sure that you can compute post-hoc analyses on the main effects, do so on the data from this study. Remember, to compute the simple comparisons (or complex comparisons for that matter), you would need to compute repeated measures ANOVAs on the two levels that you want to compare. So, for Instruction, you want to compare Repetition, Imagery, and No Instruction. For the main effect of Frequency, you want to compare Low, Medium, and High. First, write the means in the boxes below, then determine which means are significantly different and interpret the main effect for instruction.

For each of the comparisons below, write the two means, the df_{Error} and the F for the comparison. Then, determine which Fs are significant using some post hoc procedure.

Comparison	**Mean 1**	**Mean 2**	**df_{Error}**	**F**
Rep vs. Imag				
Rep vs. NoInst				
Imag vs. NoInst				
Low vs. Med				
Low vs. High				
Med vs. High				

Of course, you could also compute complex comparisons (and you should be able to articulate how to do so in SPSS). However, I think that you have sufficient information now to discuss the source of the two main effects.

Interpretation of Main Effect for Instruction

Interpretation of Main Effect for Word Frequency

c. OK, now it's time to interpret the interaction. First get SPSS to plot your data. Next determine how you will approach interpreting the interaction. Keep in mind that looking at simple effects will involve both interactions and main effects, so you may also want to examine interaction comparisons. Once you have a plan, compute the post hoc comparisons you need to interpret the interaction effect and write out your interpretation.

Two-Factor Mixed Designs

3. Next, conduct an analysis of the data from K&W's Problem 19.2 (K&W.448.2.sav). In this problem, participants are given a vigilance task, looking at one of three types of displays (black-on-white, white-on-black, or amber-on-black), which is the independent groups factor. The participants are tested on three different days, which serves as the repeated factor. The dependent variable is the number of targets detected, so higher numbers are better.

	Black-on-White				White-on-Black				Amber-on-Black		
	Day1	Day 2	Day 3		Day 1	Day 2	Day 3		Day 1	Day 2	Day 3
s_1	23	24	27	s_5	15	20	27	s_9	23	34	38
s_2	20	21	25	s_6	18	25	32	s_{10}	19	32	32
s_3	23	29	28	s_7	24	26	33	s_{11}	24	32	38
s_4	14	22	24	s_8	22	31	36	s_{12}	18	28	37

Source	**SS**	**df**	**MS**	**F**
A				
Subject(Group)				
B				
AxB				
B * Subject(Group)				

You could compute a Brown-Forsythe analysis on these data, right? But you wouldn't necessarily need to, given that the interaction is significant. You should also note that you would not be able to remove the position effects from these data. Why not?

Begin to interpret the interaction by computing the simple effects of Display at Day 1, then at Day 2, then at Day 3. When your simple effect is significant, conduct the appropriate simple comparisons.

Comparison	$F_{Comparison}$	F_{Crit}	Interpretation
Display at Day 1			
Display at Day 2			
Display at Day 3			

You could also have approached the interaction by computing the simple effects of Day for each of the Displays. Do so now, and if the simple effect is significant, conduct the appropriate simple comparisons.

Comparison	$F_{Comparison}$	F_{Crit}	Interpretation
Day at Black-on-White			
Day at White-on-Black			
Day at Amber-on-Black			

Next, to give you a sense of where the SS_{Error} for the repeated factor comes from, compute separate repeated measures ANOVAs on Day for each of the types of display. (You'll need to use Data->Select Cases to get each analysis.)

Analysis	SS_{Error}
Day @ B-o-W	
Day @ W-o-B	
Day @ A-o-B	
Sum	
SSError from Overall ANOVA	

4. [Problem from Howell, 2002]

The data set (King.sav) is from a study by King (1986). King investigated motor activity in rats following injection of the drug midazolam. The first time this drug is injected, it typically leads to a distinct decrease in motor activity. Like morphine, however, a tolerance for midazolam develops rapidly. King wished to know whether that acquired tolerance could be explained on the basis of a conditioned tolerance related to the physical context in which the drug was administered.

He used three groups, collecting the crucial data on only the last day, which was the test day. During pretesting, two groups of animals were repeatedly injected with midazolam over several days, whereas the Control group was injected with physiological saline. On the test day, one group — the "Same" group — was injected with midazolam in the *same* environment in which it had earlier been injected. The "Different" group was also injected with midazolam, but in a *different* environment. Finally, the Control group was injected with midazolam for the first time. This Control group should thus show the typical initial response to the drug (decreased ambulatory behavior), whereas the Same group should show the normal tolerance effect — that is, they should decrease their activity little or not at all in response to the drug. If King is correct, however, the Different group should respond similarly to the Control group, because although they had several exposures to the drug, they are receiving it in a novel context and any conditioned tolerance that might have developed will not have the necessary cues required for its elicitation.

The dependent variable is a measure of ambulatory behavior, in arbitrary units. Because the drug is known to be metabolized over a period of approximately 1 hour, King recorded his data in 5-minute blocks, or Intervals. We would expect to see the effect of the drug increase for the first few intervals and then slowly taper off.

a. Again, start by computing the overall ANOVA.
b. Next, just to get a sense of how you would do so, compute the analyses of the main effects. For the between factor (Group) you can actually use the critical mean difference approach. However, for the repeated factor (Interval) you cannot. As a result, you'd have to compute a whole bunch of pair-wise comparisons. To make your life simpler, simply compute a couple of the comparisons (Interval 1 vs. Interval 2 and Interval 2 vs. Interval 3).
c. Finally, compute the analyses necessary to interpret the interaction. Write your interpretation below.
