Exam 2, PS306, Spring 1999

1a. Suppose that you are interested in conducting an experiment on the effects of sleep deprivation and task difficulty on performance. You operationally define performance as the time it takes a participant to complete the task correctly (better performance = faster time to complete the task). You decide that you want to use 5 levels of sleep deprivation. You also decide to use 3 levels of difficulty: easy tasks, moderate tasks, and difficult tasks. (You pre-test the tasks with a group of participants to determine the level of task difficulty.) You decide to use a mixed design with task difficulty repeated and sleep deprivation a between (independent groups) factor. Because of power considerations, you want to have a minimum of 30 scores in each cell. Describe the study you would conduct in sufficient detail that I can tell that you know how to conduct such a study. Flesh out the details of the experiment, including (at minimum) the following: (1) the exact levels of sleep deprivation you would use; (2) how many people you would need to complete your study; (3) how you would run them through the study;

Lots of designs would work. Here's just one. I would have people go through two days of sleep deprivation and then test them on the tasks. One group (control) would get no sleep deprivation (get 8 hrs of sleep/night), another group would get a little sleep deprivation (get 6 hrs of sleep/night), another group would get a moderate amount of sleep deprivation (get 4 hrs of sleep/night), another group would get lots of sleep deprivation (get 2 hrs of sleep a night), and a final group would be totally sleep deprived (get 0 hrs of sleep/night). [Including the control group was crucial!] Thus, a schematic design would be:

	8 hrs a night	6 hrs a night	4 hrs a night	2 hrs a night	0 hrs a night
Easy Tasks	Min n = 30				
Mod Tasks					
Diff Tasks					

Because the tasks are repeated, I would need to counterbalance. With only three levels, I could counterbalance with 6 orders: EMD, EDM, MED, MDE, DEM, and DME. Thus, to achieve a minimum of 30 scores per cell, I would need to run 30 participants (with each order used 5 times) in each of the five levels of sleep deprivation. Thus, I would need a total of 150 participants. Those 150 participants would generate 450 pieces of data. Obviously, this study is a major undertaking.

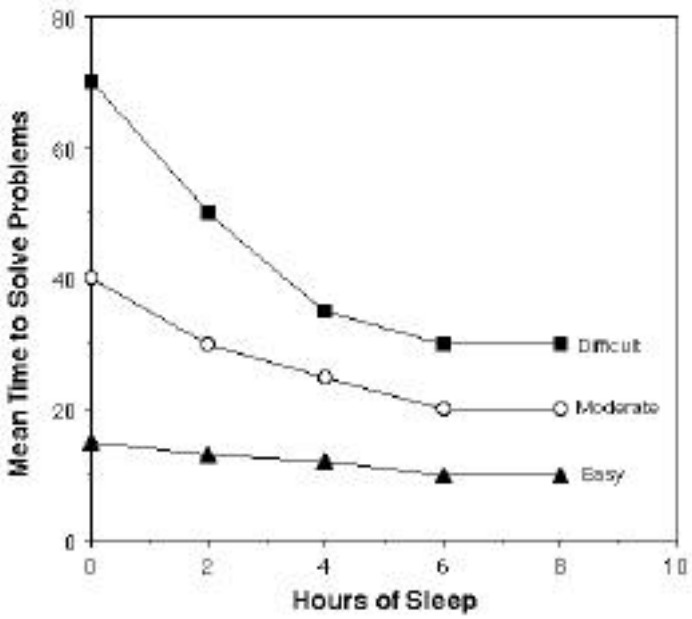
For the tasks, I would use mathematical problems. I would have a group of people complete a large number of mathematical problems and then use their ratings as well as time-to-solve data to group the problems into Easy, Moderate, and Difficult sets. These problems could then be placed on individual sheets of paper. Thus, I would have one sheet of Easy problems, one sheet of Moderate problems, and one sheet of Difficult problems.

I might run 5 participants at a time. I would have each of them undergo one of the 5 levels of sleep deprivation for the prior two evenings. Then, at 10AM on the

morning after the second night of sleep deprivation I would have each of the 5 participants come into a room. I would have arranged a packet of arithmetic tasks such that these participants would receive one of the six orders of tasks (EMD, EDM, etc.), though the order wouldn't be the same for all 5 participants. I would measure the time for each participant to complete each page, then would later score the problems on the page to see how many the participant completed correctly.

If I had started the next group of 5 participants on their sleep deprivation process properly, then the following morning at 10AM I would see another group of 5 participants. Within each level of deprivation, the participant would be given a different order of problems than had been used for participants the preceding day. Thus, over the course of 6 days I would have used all 6 orders for all 5 groups.

and, (4) produce a figure or table to illustrate a set of results that you think you might obtain from this study and what the implications of the results would be in terms of the effects found in an ANOVA (i.e., main effects and interaction). [25 pts]



The graph illustrates a significant interaction, a significant main effect for Task Difficulty (Easier tasks are solved more quickly, duh!), and a significant main effect for Sleep Deprivation (generally, less sleep = poorer performance). Keep in mind, however, that the significant interaction is where you should focus your attention. In this case, it appears that Easy tasks are not much affected by sleep deprivation, as the time to solve doesn't increase substantially with increasing sleep deprivation. However, for Moderate and (especially for) Difficult tasks, as

people have fewer hours sleep (beyond 6 hours/night, which seems to be the same as 8 hours), performance on the problems takes much longer.

2. Suppose that you have conducted a completely between (independent groups) 5 [Factor A] X 6 [Factor B] design with 10 scores per cell. Complete the following source table, and answer the following related questions. [10 pts]

Source	SS	Df	MS	F
Factor A	16.	**4.**	**4.**	**1.0**
Factor B	100.	**5.**	**20.**	**5.0**
A x B	400.	**20.**	**20.**	**5.0**
Error	1080.	**270.**	**4.**	
Total	1596.	**299.**		

a. What would be your best estimate of the population variance (σ^2)? **4.0, MS_{Error}**

b. If the design were modified to be a completely within design, what impact would you expect on the Mean Square error?

I would expect that the MS_{Error} would decrease, as a byproduct of the power typically found in repeated measures designs.

3. Several researchers have investigated the encoding specificity effect. The general finding is that people remember best when the testing situation is as similar as possible to the learning situation. (Thus, because the typical testing situation is a relatively quiet classroom, you'd best study/learn under conditions as similar to the testing situation as possible.) Dr. Julie Ard was interested in the effects of music on studying, as well as the encoding specificity effect. That is, she was interested in the extent to which the similarity of the study and test situations affected performance. To test her hypotheses, she used five acquisition conditions (studying while listening to: heavy metal, rock, classical, jazz, or blues). People in these groups studied material while listening to a particular type of music. After a brief delay, half of the people in each condition were tested under identical music (same) and half of the people were tested with no music (different). The dependent variable was the percentage score on the test (100 = perfect performance). Complete the analysis and interpret the results below as completely as possible. [25 pts.]

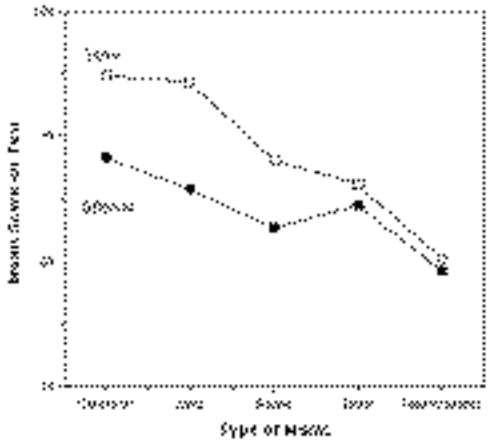
ANOVA Table for Score

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Music	4	1738.900	434.725	80.671	<.0001	322.682	1.000
Test	1	529.000	529.000	98.165	<.0001	98.165	1.000
Music * Test	4	207.100	51.775	9.608	<.0001	38.431	1.000
Residual	90	485.000	5.389				

Means Table for Score
Effect: Music * Test

	Count	Mean	Std. Dev.	Std. Err.
Blues, Different	10	82.700	1.252	.396
Blues, Same	10	88.100	2.132	.674
Classical, Different	10	88.300	3.529	1.116
Classical, Same	10	94.800	2.150	.680
Heavy Metal, Different	10	79.200	3.011	.952
Heavy Metal, Same	10	80.200	2.394	.757
Jazz, Different	10	85.800	3.048	.964
Jazz, Same	10	94.300	1.889	.597
Rock, Different	10	84.500	1.179	.373
Rock, Same	10	86.100	1.287	.407

Given the significant interaction, that's where I would focus my attention. My first step would be to create a graph to see what happened in the study. I've produced just such a graph below:



To my eyes, here's what happened. Performance was better when the test conditions matched the learning conditions (Same) compared to situations when they differed (Different) for Classical, Jazz, and Blues, but not for Rock and Heavy Metal. To gain some statistical confidence in what my eyes are telling me, I would compute Tukey's HSD. In this case, with 10 treatment conditions and 90 df_{Error}, I would get q = 4.6 and HSD = 3.38. Thus, if two means differ by 3.38 or more, they would be significant. Now I can see that my analyses support what my eyes had told me. That is, Same produced better performance than Different for Classical, Jazz, and Blues. However, for Rock and Heavy Metal keeping the conditions the Same from Learning to Test did not lead to better performance than changing the conditions at test.

You may want to comment on the fact that the "Different" condition was no music at all. Thus, for all conditions you have Music/Music for the Same condition and Music/No Music for the Different condition. Thus, it's hard to know if the effects observed in the Different condition are due to a difference between Learning and Test or are due to having No Music at test. However, if you had music at test for the Different condition, it's hard to know what kind of different music you would use. That could be worked out, however.

4. Dr. Mai Ayes was interested in studying the effects of task difficulty and sleep deprivation on performance, as you did in the first question, but she's decided to use a completely between (independent groups) design. The amounts of sleep deprivation that she decided to use are: 24, 36, 48, 60, and 72 hours. That is, participants were awake without sleep for one of those periods before being tested (on either an easy, a moderate, or a difficult task). She measured performance on a 9-point scale (1 = lousy performance <-> 9 = excellent performance). Analyze these data as completely as you can. [20 pts]

ANOVA Table for Score

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Hours Deprived	4	65.813	16.453	43.298	<.0001	173.193	1.000
Task Difficulty	2	120.027	60.013	157.930	<.0001	315.860	1.000
Hours Deprived * Task Difficulty	8	.107	.013	.035	>.9999	.281	.058
Residual	60	22.800	.380				

Means Table for Score
Effect: Hours Deprived * Task Difficulty

	Count	Mean	Std. Dev.	Std. Err.
24 Hours, Difficult	5	4.000	.707	.316
24 Hours, Easy	5	7.200	.447	.200
24 Hours, Moderate	5	6.200	.447	.200
36 Hours, Difficult	5	2.600	.548	.245
36 Hours, Easy	5	5.600	.548	.245
36 Hours, Moderate	5	4.600	.548	.245
48 Hours, Difficult	5	2.600	.548	.245
48 Hours, Easy	5	5.600	.548	.245
48 Hours, Moderate	5	4.600	.548	.245
60 Hours, Difficult	5	1.800	.837	.374
60 Hours, Easy	5	4.800	.837	.374
60 Hours, Moderate	5	3.800	.837	.374
72 Hours, Difficult	5	1.400	.548	.245
72 Hours, Easy	5	4.400	.548	.245
72 Hours, Moderate	5	3.400	.548	.245

Again, I would look at the interaction first. In this case, it is not significant. Thus, I would focus on the two main effects.

For Hours of Sleep deprivation the means would be:

24 Hours	36 Hours	48 Hours	60 Hours	72 Hours
5.8	4.3	4.3	3.5	3.1

When testing for the effects of sleep deprivation, I would be comparing 5 means, thus I would use q = 3.98. My HSD would be .633. Note that the n I would use in this case would be 15 because each of the 5 means came from 15 people. Thus, performance was significantly better when people were deprived of sleep for 24 hours compared to 36 or more hours of sleep deprivation. People who were sleep deprived for 36 or 48 hours didn't differ, but both groups performed better than people deprived of sleep for 60 or 72 hours. There was no difference between people deprived of sleep for 60 or 72 hours.

For Task Difficulty, the means would be:

Easy	Moderate	Difficult
5.5	4.5	2.5

When testing for the effects of task difficulty, I would be comparing 3 means, thus I would use q = 3.4. My HSD would be .42. Note that the n I would use in this case would be 25 because each of the 3 means came from 25 people. Thus, the world of psychology is amazed to learn that performance was significantly better on Easy compared to Moderate or Difficult tasks. Moderate tasks led to better performance than Difficult tasks. Whooooppeeeee!

For this study, it appears that Dr. Ayes did not have a No deprivation control group. Such a group would have been very useful. On the other hand, she might argue that being awake for 24 hours without sleep isn't really sleep deprivation.