

Question A

This question is loosely based on Jessica's research. I've taken some liberties; I hope she still recognizes the general research area!

People are given a hearing test in which their task is to detect when a vowel sound is being presented at two frequencies, about a semi-tone apart. Of particular interest is performance at a high frequency of 3000 cycles/sec, because that is in the range that tends to be lost first. The dependent variable is the proportion of times a subject correctly detects the two vowel sounds when the base frequency is 3000 cycles/sec. As a possible baseline condition, proportion correct detections is also available for a base frequency of 500 cycles/sec.

Of interest is whether there are differences in right and left ears. Half the participants are randomly assigned to have their right ears tested and the other half their left ears. In case performance in the right or left ear may depend on which side of the brain is dominant, the handedness of participants is assessed as being either right or left handed.

Suppose the following variables are available to Jessica and her colleagues in Speech Language and Hearing Sciences (SLHS):

P3000 proportion (between 0 and 1) correct detection for base frequency 3000

P500 proportion (between 0 and 1) correct detection for base frequency 500

EAR categorical variable with levels RIGHT and LEFT

HANDED categorical variable with levels RIGHT and LEFT

Answer the following questions about this study. If models are requested, provide MODELS C and A that the folks in SLHS could use to answer the question. As usual, define any variables you create.

1. Why is it important that each participant's hearing was tested in only one ear instead of both ears? That is, what statistical assumption would have been violated had both ears been tested for each person? [Not a MODEL question.]
2. The dependent variable P3000 is a proportion. What statistical assumption may be violated? (We will assume not, for the remainder of the questions.) [Not a MODEL question and we barely discussed this a long time ago so this question may be difficult.]
3. Using a complete model using both categorical predictors (EAR and HANDED), is there a difference in the mean detection proportion at 3000 cycles/sec for right versus left ears? Specify the MODELS C and A to answer this question.

4. In the context of a complete two-way ANOVA, specify the MODEL C/A comparison to ask the key question of whether detection performance at 3000 c/s is better in the ear that corresponds to one's dominant hand (right versus left).
5. There are obviously a lot more people who are right-handed than left-handed.
 - a. If we randomly sample from the population, we will therefore have many more observations in the right-handed group than in left-handed group. **Briefly** describe how this will affect the analysis. [Not a MODEL question.]
 - b. If we sample selectively to achieve equal number of participants who are right- and left-handed, rather than random sampling from the population, how will this affect statistical power for finding a difference between the MODELS for #4? [Not a MODEL question]
6. Suppose we did detect that the ear difference depended on handedness. Would this difference hold up if we statistically equated participants based on their performance at 500 cycles/sec? Specify the MODELS C and A.
7. Would there be differences among any of four means (determined by EAR and HANDED) at 3000 c/s when controlling for performance at 500 c/s? Specify the MODELS C and A.
8. Does the relationship between detection performance at 500 c/s and 3000 c/s depend in any way on EAR and HANDED?

Question B

Given recent events concerning the judging of figure skating at the Winter Olympics, a study is conducted to examine whether there are rating biases as a function of the nationalities of the judges and of the skaters whose routines are judged. Twenty four judges are recruited, 12 of these are Russian and 12 are American. They each watch one of two videotaped performances, either of a Russian skater or of an American skater. They then judge the performance of the skater whom they have watched on the usual 6.0 rating scales, with higher numbers indicating more expert performance.

The researcher also collects data on how experienced each judge is, recording the number of years that have done ice skating judging at the international level.

The following variables are collected:

JNAT	Judge's nationality (R if Russian; A if American)
SNAT	Skater's nationality (R if Russian; A if American)
RATING	Rating of the skater's performance
EXP	Judge's years of experience.

From these variables, the following additional variables are computed:

```
J=-1*(JNAT='A')+1*(JNAT='R');  
S=-1*(SNAT='A')+1*(SNAT='R');  
JS=J*S;  
EXPJ=EXP*J;  
EXPS=EXP*S;  
EXPJS=EXP*JS;
```

On the following pages are the output from the following SAS commands:

```
PROC MEANS ; BY JNAT SNAT;VAR RATING EXP;  
PROC REG;  
MODEL RATING=J S JS/PCORR2 SS2 TOL;  
MODEL RATING=J S JS EXP/PCORR2 SS2 TOL;  
MODEL RATING=J S JS EXP EXPJ EXPS EXPJS/PCORR2 SS2 TOL;
```

In light of this output, answer the following questions:

1. Is there evidence in the mean ratings that judges are biased in favor of skater's of their own nationalities? (Give PRE, F*, p-a-pc, n-pa, and interpret the relevant parameter estimate(s).)

2. Test whether there is significant nationality bias among the Russian judges. That is, are the Russian judges giving higher ratings to the Russian skater than to the American skater?

(Give PRE, F^* , pa-pc, n-pa, and provide a one sentence conclusion.)

3. In the second model, where J, S, JS and EXP are used as predictors, provide an interpretation of the following parameter estimates:

a. the slope for JS (.072179)

b. the slope for EXP (-.016154)

4. Is there any evidence that judges with more or less experience manifest any greater or lesser nationality bias? (Give PRE, F^* , pa-pc, n-pa, and interpret the relevant parameter estimate(s).)

5. In the third model, where J S, JS, EXP, EXPJ, EXPS, and EXPJS are used as predictors, provide interpretations for the following parameter estimates:

a. the slope for JS (-.169079)

b. the slope for EXP (-.008135)

----- JNAT=A SNAT=A -----

Variable	N	Mean	Std Dev	Minimum	Maximum
RATING	6	5.6166667	0.0752773	5.5000000	5.7000000
EXP	6	5.8333333	1.8348479	4.0000000	8.0000000

----- JNAT=A SNAT=R -----

Variable	N	Mean	Std Dev	Minimum	Maximum
RATING	6	5.4833333	0.1169045	5.4000000	5.7000000
EXP	6	5.3333333	2.0655911	3.0000000	8.0000000

----- JNAT=R SNAT=A -----

Variable	N	Mean	Std Dev	Minimum	Maximum
RATING	6	5.4500000	0.1516575	5.3000000	5.7000000
EXP	6	5.6666667	1.8618987	3.0000000	8.0000000

----- JNAT=R SNAT=R -----

Variable	N	Mean	Std Dev	Minimum	Maximum
RATING	6	5.6000000	0.1414214	5.4000000	5.8000000
EXP	6	5.5000000	1.3784049	4.0000000	7.0000000

Model: MODEL1
 Dependent Variable: RATING

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	0.12458	0.04153	2.665	0.0756
Error	20	0.31167	0.01558		
C Total	23	0.43625			
Root MSE	0.12483	R-square	0.2856		
Dep Mean	5.53750	Adj R-sq	0.1784		
C.V.	2.25432				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T
INTERCEP	1	5.537500	0.02548147	217.315	0.0001
J	1	-0.012500	0.02548147	-0.491	0.6291
S	1	0.004167	0.02548147	0.164	0.8718
JS	1	0.070833	0.02548147	2.780	0.0116

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	735.933750	.	.
J	1	0.003750	0.01188904	1.00000000
S	1	0.000417	0.00133511	1.00000000
JS	1	0.120417	0.27868852	1.00000000

Model: MODEL2
 Dependent Variable: RATING

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	0.14154	0.03539	2.281	0.0983
Error	19	0.29471	0.01551		
C Total	23	0.43625			
Root MSE	0.12454	R-square	0.3245		
Dep Mean	5.53750	Adj R-sq	0.1822		
C.V.	2.24907				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T
INTERCEP	1	5.627692	0.08991756	62.587	0.0001
J	1	-0.012500	0.02542210	-0.492	0.6286
S	1	0.001474	0.02555214	0.058	0.9546
JS	1	0.072179	0.02545467	2.836	0.0106
EXP	1	-0.016154	0.01544758	-1.046	0.3088

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	60.758315	.	.
J	1	0.003750	0.01256470	1.00000000
S	1	0.000051640	0.00017520	0.98984772
JS	1	0.124717	0.29735485	0.99744246
EXP	1	0.016962	0.05442205	0.98734177

Model: MODEL3
 Dependent Variable: RATING

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	7	0.24910	0.03559	3.042	0.0309
Error	16	0.18715	0.01170		
C Total	23	0.43625			

Root MSE	0.10815	R-square	0.5710
Dep Mean	5.53750	Adj R-sq	0.3833
C.V.	1.95309		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > T
INTERCEP	1	5.581328	0.08137631	68.587	0.0001
J	1	0.007690	0.08137631	0.094	0.9259
S	1	-0.059618	0.08137631	-0.733	0.4744
JS	1	-0.160979	0.08137631	-1.978	0.0654
EXP	1	-0.008135	0.01402954	-0.580	0.5701
EXPJ	1	-0.002543	0.01402954	-0.181	0.8584
EXPS	1	0.011219	0.01402954	0.800	0.4356
EXPJS	1	0.041564	0.01402954	2.963	0.0092

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	55.023974	.	.
J	1	0.000104	0.00055779	0.07359792
S	1	0.006278	0.03245694	0.07359792
JS	1	0.045774	0.19651720	0.07359792
EXP	1	0.003933	0.02058310	0.90269358
EXPJ	1	0.000384	0.00204895	0.07300654
EXPS	1	0.007480	0.03843241	0.07306639
EXPJS	1	0.102666	0.35424302	0.07302150