Psych 5741, Fall 1994 9 Dec 1994
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Final Exam (Fall Semester)

I. In acknowledgment to the biologists in the class who have suffered through the many psychology examples, this problem is based on a biological study. The following questions are loosely based on:

Sinervo, B. (1990). The evolution of maternal investment in lizards: An experimental and comparative analysis of egg size and its effects on offspring performance. *Evolution*, *44*, 279-294.

One of the issues in this study concerns factors related to the mean egg mass produced by the lizard *Sceloporus occidentalis*. The following variables are available for a total of 166 female lizards.

- MASS: The average mass (in grams) of the eggs laid by each lizard
- SIZE: The snout-vent length was used as an index of the mother's size.
- CLUTCH: The total number of eggs laid at one time.
- ELEV: The elevation (in meters) of the site where the mother was collected
- LAT: The latitude (in degrees north of the Equator) of the site where the mother was collected.

Using these variables, specify for each question below the MODEL C and MODEL A one would use to answer the question. Also, specify PA-PC and n-PA.

A. Do larger lizards lay eggs with greater average mass?

B. Controlling for size of mother, is it the case that the eggs in larger clutches are on average smaller? That is, is there a trade-off between egg mass and number of eggs. [This addresses the first sentence in Sinervo's paper which reads: "The presumed trade-off between the number and the size of offspring a female can produce is a fundamental tenet of life-history theory."]

C. Sinervo did not use CLUTCH as defined here. Rather, in the model for the previous question he used

> "residual clutch size, a measure of the number of eggs in a clutch with female-size effects removed (residuals from the regression of clutch size and snout-vent length. Females laying large clutches for a given body size have large residuals relative to females laying small clutches." p. 281

Why was it unnecessary for him to regress average egg MASS on SIZE and "RESIDUAL CLUTCH SIZE"?

D. When these lizards are housed in ideal laboratory conditions, the average egg mass is known to be 0.75g. Assuming that size of mother and clutch size are useful predictors of egg mass, specify the most powerful test of whether the egg mass from the lizards collected in the field differ from the laboratory mean.

E. In more adverse conditions (i.e., either further north and/or higher elevations), lizards are supposedly less able to devote resources to reproduction. As a consequence, controlling for mother size and size of clutch, the average egg mass should be lower. What are the models for addressing this question.

F. A rule-of-thumb in biology is that increasing elevation by 1000m is like going north by 20 degrees. In the context of the previous question, is there any reason to reject this rule-of-thumb for the model of egg mass? [Note: there is some rule-of-thumb like this, but I just made up the particular numbers for this problem! The answer is easy, but clever. Be sure not to waste to much time on this problem if the clever solution doesn't appear quickly.]

G. A researcher believes that increasing elevation isn't quite like going north because not only is there a difference in average temperature [remember, cold-blooded lizards like it hot] but also there is a difference in the amount of oxygen available. This researcher thus argues that, controlling for latitude, mother size, and clutch size, higher and higher elevations should have increasingly adverse effects on average egg mass. That is, controlling for other factors is it the case that the adverse effects of increasing altitude are even greater at higher altitudes? What are the models to address this researcher's hypothesis?

H. Another researcher wonders whether the relationship between clutch size and egg mass depends on the adversity of the environmental conditions. In particular, when controlling for mother size, does the relationship between clutch size and egg mass depend on the latitude and the elevation?

I. In the context of the previous question, is there an especially adverse effect for sites that are both far north and very high?

J. In the article, the author reports a regression for egg mass with n = 1344. What mistake has he probably made. [The variables used above were defined so as to avoid this mistake.]

II. A clinical researcher is interested in the effects of divorce on children. She collects data from 150 children whose parents are divorced. These children range in age from 7 to 15, and their parents divorced anywhere from 0 years ago to 12 years ago. She is interested in how the divorce, its recency, and the child's age affect the number of psychological and health problems currently experienced by the child. Additionally, she has a measure of how bitter the divorce was (presence of custody battles, etc.) and she is interested in this variable as well. Thus, she has the following four variables in her dataset:

AGE	Current age of child (range 7 - 15)
YRSAGO	How many years ago the divorce took place (range 0 - 12)
BITTER	Rating of bitterness of divorce (range 1 - 6)
PROB	Number of current psychological and health problems of child (range 0 - 17)

She estimates a series of models that predict PROB as a function of the other variables. She is both interested in how the three other variables predict as well as in some interactions among them. To capture these, she computes three product terms and includes them in some of her regression models as predictors. The three product terms are defined as follows:

YRSAGO2:	YRSAGO * YRSAGO
AGEB:	AGE * BITTER
YRSAGOB:	YRSAGO * BITTER

The models she estimates are given by the SAS code on the following page and the resulting output follows. Use these results to answer the following questions.

A. Do children in families where the divorce was relatively bitter experience more problems than children where the divorce was less bitter? (Answer this in the context of the simplest model possible; report PRE, F*, and interpret the relevant parameter estimate if you reject the null hypothesis.)

B. Once we control for the child's age and how many years ago the divorce took place, does bitterness of the divorce make a difference? (Report PRE, F*, and interpret the relevant parameter estimate if you reject the null hypothesis.)

C. Examine the effects of AGE on PROB in Models 1, 4 (where YRSAGO is controlled), and 5 (where YRSAGO and BITTER are controlled). Write a few sentences that discusses the role that AGE seems to play in the problems experienced by these children.

D. If a model was estimated in which BITTER was regressed on AGE and YRSAGO, what would be the value of the resulting R-square?

E. The researcher hypothesized that bitter divorces are particularly likely to lead to problems for the child if they occurred recently. On the other hand, the bitterness of divorces that occurred a long time ago should not make as much difference. Do the present data support this hypothesis? (Report PRE, F*, and interpret the relevant parameter estimate if you reject the null hypothesis.)

F. She has two predictions about the recency of the divorce (controlling for AGE and BITTER):

1. The child experiences fewer problems currently, the longer ago the divorce took place.

2. The decline in problems as the divorce recedes in time (i.e., becomes less recent) is greater at first and then begins to asymptote.

Do the present data support each of these hypotheses? (For each one, report PRE, F*, and interpret the relevant parameter estimate if you reject the null hypothesis.)

G. 1. What is our best estimate of the expected decline in problems as time passes immediately after the parents are divorced?

2. What is our best estimate ten years later?

3. What models C and A would you compare to test whether the estimate ten years later (in question G. 2. just above) is different from zero?

H. In model 5, the slope for YRSAGO is -.34 and it is reliably different from zero. In model 7, the slope for YRSAGO is larger (in absolute value: -.41), yet it is no longer reliable.

1. Provide 95% confidence intervals for these two slopes.

2. Why do you think the confidence interval for this slope in model 7 is so much wider than for the one in model 5?

3. Regardless of the width of these confidence intervals, why are these slopes different from each other?

4. Provide an interpretation for the slope in model 7.

I. If we reëstimated Model 8 with all variables in mean deviation form. What would be the slope for BITTER?

```
libname stat '';
options ps=60 ls=80;
proc corr data=stat.div;
 var age yrsago bitter prob;
data stat.div;
set stat.div;
 yrsago2=yrsago*yrsago;
 ageb=age*bitter;
 yrsagob=yrsago*bitter;
run;
proc reg;
 model prob=age;
 model prob=bitter;
 model prob=yrsago;
 model prob=age yrsago/pcorr2 ss2 tol;
 model prob=age yrsago bitter/pcorr2 ss2 tol;
 model prob=age yrsago bitter ageb/pcorr2 ss2 tol;
 model prob=age yrsago bitter yrsagob/pcorr2 ss2 tol;
 model prob=age yrsago bitter yrsago2/pcorr2 ss2 tol;
run;
```

Correlation Analysis

4 'VAR' Variables: AGE YRSAGO BITTER PROB

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
AGE	150	11.29333	2.44276	1694	7.00000	15.00000
YRSAGO	150	5.34000	2.89834	801.00000	0	12.00000
BITTER	150	3.96667	1.22292	595.00000	1.00000	6.00000
PROB	150	7.00000	3.08710	1050	0	17.00000

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 150

	AGE	YRSAGO	BITTER	PROB
AGE	1.00000	0.82475	0.32007	-0.27590
	0.0	0.0001	0.0001	0.0006
YRSAGO	0.82475	1.00000	0.38192	-0.30529
	0.0001	0.0	0.0001	0.0001
BITTER	0.32007	0.38192	1.00000	0.05867
	0.0001	0.0001	0.0	0.4758
PROB	-0.27590	-0.30529	0.05867	1.00000
	0.0006	0.0001	0.4758	0.0

Model: MODEL1
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	108.08764	108.08764	12.194	0.0006
Error	148	1311.91236	8.86427		
C Total	149	1420.00000			

Root MSE	2.97729	R-square	0.0761
Dep Mean	7.00000	Adj R-sq	0.0699
C.V.	42.53275		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	10.937644	1.15354432	9.482	0.0001
AGE	1	-0.348670	0.09984996	-3.492	0.0006

Model: MODEL2
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	4.88706	4.88706	0.511	0.4758
Error	148	1415.11294	9.56157		
C Total	149	1420.00000			

Root MSE	3.09218	R-square	0.0034
Dep Mean	7.00000	Adj R-sq	-0.0033
C.V.	44.17399		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	6.412565	0.85958967	7.460	0.0001
BITTER	1	0.148093	0.20714508	0.715	0.4758

Model: MODEL3
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	132.34345	132.34345	15.211	0.0001
Error	148	1287.65655	8.70038		
C Total	149	1420.00000			

Root MSE	2.94964	R-square	0.0932
Dep Mean	7.00000	Adj R-sq	0.0871
C.V.	42.13773		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	8.736398	0.50617844	17.260	0.0001
YRSAGO	1	-0.325168	0.08337311	-3.900	0.0001

Model: MODEL4
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	134.92470	67.46235	7.717	0.0007
Error	147	1285.07530	8.74201		
C Total	149	1420.00000			

Root MSE	2.95669	R-square	0.0950
Dep Mean	7.00000	Adj R-sq	0.0827
C.V.	42.23841		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	9.458775	1.42293032	6.647	0.0001
AGE	1	-0.095282	0.17534820	-0.543	0.5877
YRSAGO	1	-0.258937	0.14778549	-1.752	0.0818

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	386.290236	.	.
AGE	1	2.581257	0.00200462	0.31978734
YRSAGO	1	26.837065	0.02045645	0.31978734

Model: MODEL5
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	186.21858	62.07286	7.345	0.0001
Error	146	1233.78142	8.45056		
C Total	149	1420.00000			

Root MSE	2.90698	R-square	0.1311
Dep Mean	7.00000	Adj R-sq	0.1133
C.V.	41.52835		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	7.877524	1.53920620	5.118	0.0001
AGE	1	-0.099415	0.17240860	-0.577	0.5651
YRSAGO	1	-0.339724	0.14895522	-2.281	0.0240
BITTER	1	0.519158	0.21072177	2.464	0.0149

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	221.345794	.	.
AGE	1	2.809751	0.00227217	0.31975707
YRSAGO	1	43.956938	0.03440214	0.30428990
BITTER	1	51.293871	0.03991507	0.85405611

Model: MODEL6
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	186.63926	46.65982	5.486	0.0004
Error	145	1233.36074	8.50594		
C Total	149	1420.00000			

Root MSE	2.91649	R-square	0.1314
Dep Mean	7.00000	Adj R-sq	0.1075
C.V.	41.66420		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	8.670541	3.88587082	2.231	0.0272
AGE	1	-0.172817	0.37263501	-0.464	0.6435
YRSAGO	1	-0.336035	0.15036064	-2.235	0.0270
BITTER	1	0.315613	0.93935246	0.336	0.7374
AGEB	1	0.018004	0.08095657	0.222	0.8243

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	42.348481	.	.
AGE	1	1.829470	0.00148112	0.06889813
YRSAGO	1	42.483667	0.03329847	0.30058506
BITTER	1	0.960229	0.00077794	0.04325983
AGEB	1	0.420688	0.00034097	0.02344585

Model: MODEL7
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	186.88968	46.72242	5.494	0.0004
Error	145	1233.11032	8.50421		
C Total	149	1420.00000			

Root MSE	2.91620	R-square	0.1316
Dep Mean	7.00000	Adj R-sq	0.1077
C.V.	41.65997		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	8.208751	1.94279512	4.225	0.0001
AGE	1	-0.097815	0.17304876	-0.565	0.5728
YRSAGO	1	-0.407890	0.28497247	-1.431	0.1545
BITTER	1	0.422482	0.40388273	1.046	0.2973
YRSAGOB	1	0.017677	0.06292438	0.281	0.7792

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	151.821776	.	.
AGE	1	2.717109	0.00219862	0.31941081
YRSAGO	1	17.422642	0.01393217	0.08366460
BITTER	1	9.305494	0.00748984	0.23396086
YRSAGOB	1	0.671103	0.00054394	0.06102881

Model: MODEL8
Dependent Variable: PROB

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	234.81565	58.70391	7.182	0.0001
Error	145	1185.18435	8.17369		
C Total	149	1420.00000			

Root MSE	2.85897	R-square	0.1654
Dep Mean	7.00000	Adj R-sq	0.1423
C.V.	40.84237		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	8.632582	1.54512844	5.587	0.0001
AGE	1	-0.060090	0.17032594	-0.353	0.7248
YRSAGO	1	-1.035667	0.32081538	-3.228	0.0015
BITTER	1	0.579336	0.20870535	2.776	0.0062
YRSAGO2	1	0.061814	0.02535075	2.438	0.0160

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	255.135054	.	.
AGE	1	1.017336	0.00085764	0.31689032
YRSAGO	1	85.181919	0.06705304	0.06344847
BITTER	1	62.981292	0.05045908	0.84211342
YRSAGO2	1	48.597073	0.03938872	0.08192907