Sociology 592 - Research Statistics I
Exam 2 Answer Key
November 8, 1996

1. (10 points each, 30 points total, up to 10 points extra credit). You have been asked to serve as a statistical consultant for several proposed projects. For *three* of the following, your employers want you to tell them:

(i) Which of the cases we have studied their problem falls under (e.g. one sample tests, case I, σ known; nonparametric tests, case II, tests of association). Briefly explain why.
(ii) the null and alternative hypotheses
(iii) whether a Z, T, chi-square, or F test is appropriate; where applicable, also tell what the degrees of freedom for the test are. You DO NOT have to give the formula for the test statistic, nor do you need to specify the acceptance region.

If values for population parameters are not specified (e.g. σ) assume they are unknown; and if two or more unknown σ's are involved, assume they are equal. You will get up to 5 points extra credit for each additional problem you do.

a. Al Gore wants to make sure he is ready for his year 2000 presidential campaign. He first wants to see whether his popularity varies across different economic groups. Twenty wealthy voters, twenty middle-class voters, and twenty low-income voters are asked to rate, on a scale ranging from 1 to 100, how much they like Al Gore.

Solution. One-way ANOVA. The dependent variable, popularity, is interval-level, while the IV, Economic group, is categorical.

The null and alternative hypotheses are
H0: $\mu_1 = \mu_2 = \mu_3 = 0$
HA: The means are not all equal

An F test, with df = 2,57 is appropriate.

b. Now that South Bend Mayor Joe Kernan has been elected lieutenant governor, the city needs a new top administrator. Democratic party leaders will officially make the choice, but Kernan's endorsement of a successor will be very influential. Kernan has three people in mind, whom he believes are equally popular with Democratic leaders. To test his theory, a random sample of 30 party leaders will be asked which of the three candidates they like best.

Solution. Nonparametric tests, Case I. More specifically, we want to test the equiprobability model, since Kernan thinks all 3 have equal levels of support.

The null and alternative hypotheses are
H0: P(E1) = P(E2) = P(E3), i.e. all 3 candidates are equally popular
HA: The candidates are not all equally popular.

A chi-square test, with 2 d.f., is appropriate.

c. O.J. Simpson's lawyers are worried that recent charges of sexual harassment against their client will further turn public opinion against him. Before the charges, a random sample of 200 people showed that 60% thought Simpson was guilty. Another random sample of 200 people will now be asked what they think.

Solution. 2 sample tests, case V, test of P1 = P2. Two samples have been collected, one before the charges of sexual harassment, one after. (Note that the figure of 60% is a sample estimate, there is no claim that it is the population parameter.) We want to see whether the proportion of people who think Simpson is guilty differs in the two samples.

The null and alternative are
H0: $P_1 = P_2$

HA: $P_1 < P_2$

i.e. It is feared that more people now think Simpson is guilty than was the case earlier.

A Z statistic is appropriate.

d. A researcher believes that individuals want fewer children after they have been married for a while than they do when they are first married. Twelve newlyweds are asked how many children they want to have. Twelve individuals who have been married for five years are also asked how many children they want.

Solution. 2 sample tests, case II, sigmas unknown but assumed equal. The DV, # of children desired, is interval. Two samples have been collected, one of newlyweds, one of couples who have been married 5 years.

The null and alternative are
H0: $\mu_1 = \mu_2$
HA: $\mu_1 > \mu_2$
The alternative is one-tailed because it is believed that desires for children decline across length of marriage.

A T-test with 22 d.f. is appropriate.

e. Management claims that 2/3 of workers are at least somewhat satisfied with company policies. Union leaders disagree. A random sample of 240 employees is drawn. Employees are asked to rank their satisfaction with company policies on a seven point scale, where 1 = very dissatisfied, 2 = dissatisfied, 3 = somewhat dissatisfied, 4 = neutral, 5 = somewhat satisfied, 6 = satisfied, 7 = very satisfied.

Solution. Single sample tests, case II, binomial parameter p. Management is claiming that 2/3 of employees will give a response of 5 or higher on the satisfaction scale.

The null and alternative are

H0: $p = 2/3$
HA: $p < 2/3$
where p is the probability of an employee giving a response of 5, 6 or 7. The alternative is one-tailed because union leaders feel satisfaction is lower than that.

A Z statistic is appropriate.

2. (5 points each, 20 points total). For <u>each</u> of the following, indicate whether the statement is true or false. If you think the statement is false, indicate how the statement could be corrected.
NOTE: These are all pretty easy, but you could waste a great deal of time on some of them or make stupid mistakes if you don't happen to see what the easiest way to approach each problem is.

a. A researcher is interested in the relationship between race (2 categories), father's occupation (4 categories), and son's occupation (4 categories), where son's occupation is the dependent variable. She estimates the model of conditional independence. If she is using the .01 level of significance and her test statistic equals 35, she should reject the null hypothesis.

False. r = 2, c = 4, l = 4. So, the d.f. are rcl - 1 - (rc - 1) - (l - 1) = 32 - 1 - 7 - 3 = 21. For d.f. = 21 at the .01 level of significance, the critical value is 38.9. Since 35 is less than this, do not reject the null.

b. A Notre Dame finance professor believes that faculty in the College of Business (Group 1) are more intelligent than faculty in the College of Arts and Letters (Group 2). The IQ's of 15 faculty in each College are measured (where the higher the IQ score, the more intelligent the person is). She finds that

$$\hat{\mu}_1 = 119,\ \hat{\mu}_2 = 139,\ s_1 = 6,\ s_2 = 5$$

The null hypothesis should not be rejected.

True. As you would expect, this absurd contention has no merit whatsoever. Those in Arts and Letters actually have higher IQs than those in Business, which is exactly the opposite of what the Alternative hypothesis claims. Ergo, do not reject the null.

c. A researcher believes that younger people are more likely to support welfare reform than are older people. She therefore collects data on age (2 categories) and support for welfare reform (also 2 categories). To test her hypothesis, she can either use Nonparametric tests, case II, tests of association, or else 2 sample tests, case V, test of $p_1 = p_2$.

False. The alternative hypothesis is one-tailed, which makes the nonparametric test inappropriate. The statement would be true if it merely claimed that younger people and older people differed in their support of welfare.

d. A researcher has collected data from 36 respondents on their race (white, black, other), region of country (North, South, East, West) and the number of hours they spend watching TV every day. She computes

$$F_{J+K-2,N-JK} = \frac{SS\ Main/(J + K - 2)}{SS\ Error/(N - JK)} = 140$$

She should therefore conclude that both race and region significantly affect the amount of TV watched.

False. This F test merely tells you that one variable and/or the other has a significant effect. While both race and region could have effects, it could also be the case that race alone or region alone account for all of the observed effect.

3. (25 points) Lou Holtz thinks his football players need to be in better shape. Sixty players are combined into 30 pairs of "near-twins." In each pair, one person takes part in an experimental conditioning program (A) while the other person continues under the old program (B). Holtz is unsure which program will be more effective. The individual percentage increases in strength are recorded. For each pair, the researcher computes $D_i = X_{Ai} - X_{Bi}$. The researcher finds that $\Sigma D_i = 120$ and $\Sigma D_i^2 = 3960$.

a. Compute the mean and standard deviation for D.

Solution. Mean = $\Sigma D_i/N = 120/30 = 4$. Sample variance = $(\Sigma D_i^2 - N\bar{x}^2)/(N - 1) = (3960 - 30*4^2)/29 = 3480/29 = 120$, sample s.d. = $\sqrt{120}$.

b. Using our 5-step hypothesis testing procedure, determine whether the two approaches significantly differ in their effectiveness. Use $\alpha = .05$.

Step I:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 <> \mu_2$

Step II: Appropriate test statistic is

$$t_{29} = \frac{\bar{d} - \mu_{D_0}}{\sqrt{\frac{s_D^2}{N}}} = \frac{\bar{d}}{\sqrt{\frac{120}{30}}} = \frac{\bar{d}}{2}$$

Step III: Do not reject if $-2.045 \le t \le 2.045$

Step IV: The computed value of the test statistic is

$$t_{29} = \frac{\bar{d} - \mu_{D_0}}{\sqrt{\frac{s_D^2}{N}}} = \frac{\bar{d}}{\sqrt{\frac{120}{30}}} = \frac{\bar{d}}{2} = \frac{4}{2} = 2$$

Step V: Do not reject the null. The two programs do not significantly. (Note, however, that if you chose a one-tailed alternative — which could be quite reasonable if you suspected the new program was better — you would reject.)

c. Construct the 95% confidence interval for μ_D. According to the confidence interval, do the two approaches significantly differ in their effectiveness?

Solution. The 95% c.i. is

$$\bar{d} \pm 2.045 * \sqrt{\frac{120}{30}}, \; i.e.$$

$$4 - 4.086 = -0.09 \le \mu_D \le 4 + 4.09 = 8.09$$

Since 0 falls within the c.i., do not reject the null.

4. (25 points) The NRA (National Rifle Association) is concerned about public opinion on gun control laws. Subjects were asked (on a scale ranging from 1 to 100) whether they supported stronger gun control laws. They were also asked whether they owned a gun (yes or no) and their party affiliation (Republican, Democrat, Reform Party, Other). For each combination of gun ownership and party affiliation, 12 subjects were interviewed. The NRA finds that the mean score is 70 with a standard deviation of 5. Complete the following ANOVA table. You do NOT need to indicate whether or not the F values are statistically significant.

Source	SS	D.F.	M. S.	F
A + B (or Main Effects)				
A (Gun Ownership)	485			
B (Party)				
AB (or 2-way interaction)				2.0
A + B + AB (or explained)	1055			
Error (or residual)				
Total				

Solution. Note that MST = s^2, J = 2, K = 4. N = 96 (8 combos of gun and party, each with 12 respondents). Once you fill in the d.f. and the known info, the calculations are pretty straightforward.

Source	SS	D.F.	M. S.	F
A + B (or Main Effects)	965	J+K-2 = 4	SSMain/DFMain = 241.25	MSMain/MSE = 16.08
A (Gun Ownership)	485	J - 1 = 1	SSA/DFA = 485	MSA/MSE = 32.33
B (Party)	480	K - 1 = 3	SSB/DFB = 160	MSB/MSE = 10.67
AB (or 2-way interaction)	90	(J-1)(K-1) = 3	SSAB/DFAB = 30	MSAB/MSE = 2.0
A + B + AB (or explained)	1055	JK - 1 = 7	SSCells/DFCells = 150.71	MSCells/MSE = 10.47
Error (or residual)	1320	N - JK = 88	15	
Total	2375	N – 1 = 95	25	