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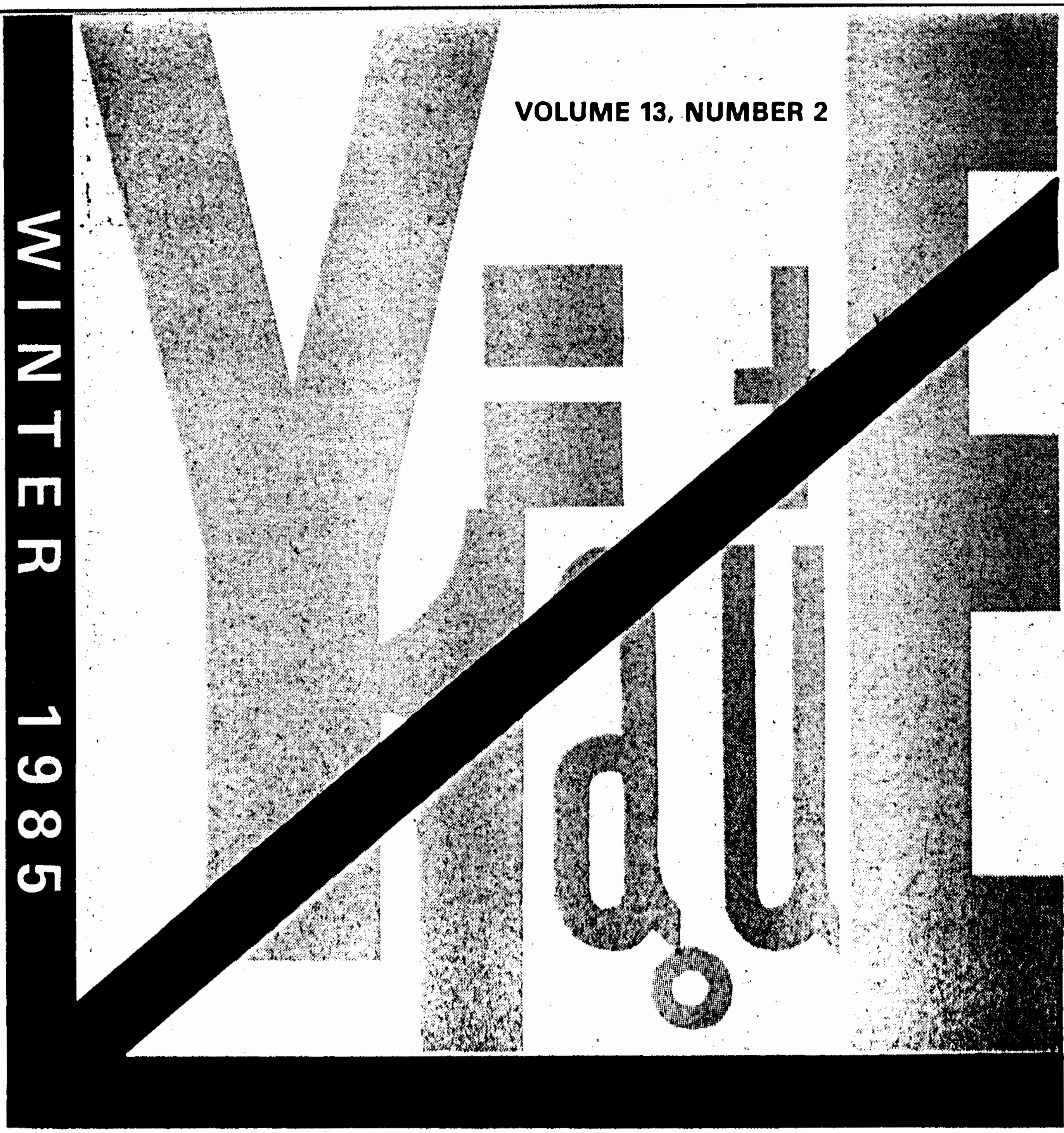

MULTIPLE LINEAR REGRESSION VIEWPOINTS

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MULTIPLE LINEAR REGRESSION VIEWPOINTS

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Testing Hypotheses in a Repeated Measures Design on Employee Attitudes With Large Samples

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Summary - The use of a typical repeated measures design is contrasted with using specific hypotheses which would directly address research questions. The use of imposing side conditions to construct a full model is shown.

The following design using the notation of Campbell and Stanley (1963), was used to test the effect of moving into superior facilities on employees in an institution for the developmentally disabled:

Group One	0_1	X	0_2		0_3
Group Two	0_1		0_2	X	0_3
Group Three	0_1		0_2		0_3

While this design is relatively simple to conceptualize, computational difficulties can occur in practice; if large N's are encountered with unequal N's, typical texts will often do little more than suggest a solution. If the researcher wishes to address specific hypotheses, traditional multiple comparison procedures do not serve as a handy guide. Using our example, but changing the notation yields:

Group One	$\bar{Y}_1$	X	$\bar{Y}_2$		$\bar{Y}_3$
Group Two	$\bar{Y}_4$		$\bar{Y}_5$	X	$\bar{Y}_6$
Group Three	$\bar{Y}_7$		$\bar{Y}_8$		$\bar{Y}_9$

A researcher may want to address the question, "Is the change in $\bar{Y}_1$ to $\bar{Y}_2$ different than the difference in $\bar{Y}_4$ and $\bar{Y}_5$ or $\bar{Y}_8$ and $\bar{Y}_9$ (or a mean of these two differences)?

Is the long term effect ($\overline{Y}_3 - \overline{Y}_2$) different than the corresponding control differences ($\overline{Y}_9 - \overline{Y}_8$)? Are the implementation changes the same (is $\overline{Y}_2 - \overline{Y}_1 = \overline{Y}_6 - \overline{Y}_5$)?

These questions become more difficult to address in the presence of a repeated measures design with large N. The addressing of these questions in a regression format is made somewhat easier using the suggestion regarding coding of Pedhazur (1977), Williams (1977), and more recently, by Fraas and McDougall (1983).

Subjects and Setting

The subjects involved in this study included three groups of employees at Grafton State School, a state institution for the developmentally disabled. Grafton State School is a unitized facility; that is, living units are organized according to the level of resident functioning. Seven of the units are progressively formed in that residents within a unit display a similar level of functioning. An eighth unit is a behavior management unit that exists to help aleviate short term behavioral problems of residents from the other units. Typically, a resident would spend considerably less time in the behavior management unit than in the other units.

A new complex was built that houses 192 residents (the total institution population has in recent years approximated 800). The first scheduled use of the new complex was December 1982, at which time one unit-Unit VIII-the behavior management unit moved into its half of the complex. A second unit-Unit I-the lowest level of functioning unit moved into the other half of the complex upon its completion in March, 1983.

The new complex could be described as highly superior living units to those occupied previously by the residents. Not coincidentally, the new units would also provide markedly improved working conditions for the affected employees.

The three groups of employees involved in this study included Experimental Group One (N = 37); Experimental Group Two (N = 56); and the control group

(N = 92). The number of employees just referenced indicates the number who completed all three attitude scales. All employees of the designated units were asked to participate; a few employees declined. While many of the members of the professional staff of each unit would have received college or university degrees, over 85 percent of the employees were direct care personnel and typically were high school graduates without further education.

Statement of the Problem

The present study attempted to look at relocation effects-more specifically to determine if there was a change in job attitude among employees after the move to the new, superior facilities.

Attitude Scale Construction and Testing

A small core of professional and direct care personnel were involved in the scale construction, directed by the present second author. Items were written to measure relevant job related activities including actual work activities, relationships with other personnel both inside and outside the unit, work with residents and issues related to pay. Two scales were constructed, each with 24 items. The first scale used a format with complete stems, while the second, measuring the same universe of items, used a Likert format. For example, two items from both scales are presented. The following item is from the scale with complete stems.

11. Do you think your ward is a good place for residents to live?
    - A. The ward is much better than most.
    - B. The ward is somewhat better than most.
    - C. The ward is about the same as most.
    - D. The ward is not quite as good as most.
    - E. The ward is much worse than most.

The corresponding item from the Likert type scale is as follows:

11. I think the ward I work on is better than most other places for residents to live.

1 2 3 4 5

Where 1 = I agree completely

2 = I agree mostly

3 = I agree and disagree about equally

4 = I disagree

5 = I disagree completely

For present purposes, only the first scale is considered; the results from the two scales are quite similar (see Williams and Williams, 1983). A complete copy of the first scale is appended.

The first testing occurred in early December 1982, prior to any move to the new buildings. Shortly after the first scale administration, Experimental Group I (Behavior Management Unit) moved to the new facility. A second testing occurred two months later, prior to the move of Experimental Group II (Unit I) to the new facility. The third and final testing was completed in May 1983, after Experimental Group II had moved into the new facility and after both Experimental Groups I and II had become Title XIX certified (federally funded).

In regard to the scaling, items were scored so that the higher the score, the more favorable the attitude. For each person, a mean was used rather than a sum; thus for those respondents who failed to answer a particular item, scores were still possible.

Completing an Analysis of Variance with Large N

Perhaps the most novel aspect of the analysis of variance, from the point of view of users of linear models, is the coding of the subjects effect. With $N = 185$, building 184 linearly independent person vectors would be wasteful of time and energy, and perhaps beyond the capacity of many computer systems. Rather, the use of the <u>sum</u> of the subjects scores is used as a single variable to serve as a proxy for the $N - 1$ binary coded person vectors.

Results and Interpretation for the Analysis of Variance

From Table 1, it can be seen that significance is found for time (both linear and second degree) and the time X groups interaction; the main effects for groups is non-significant. Experimental Group One appears to have had a slight increase in job satisfaction upon moving into the superior quarters, followed by a decrease at testing time 3. Experimental Group Two appears to have suffered a precipituous drop in job satisfaction upon moving into superior quarters. The control group appears to have had a drop in job satisfaction approximately equal to that of Experimental Group One at testing time 3. Indeed, if Experimental Group One is compared to the control group, the intervention (moving) might be seen as being perhaps slightly beneficial in employee attitude. On the other hand, Experimental Group Two has outcomes that are markedly different from the other two groups. These employees initially had the highest job attitude scores, but by testing time 3 these same employees had the lowest job attitude scores. It would appear that the effect of moving into superior quarters on employee attitude might well be negative.

In the sense of Campbell and Stanley (1963), <u>history</u> yields two clues to the outcomes described here. Because Title XIX (Public Law 92-223) certification was sought for both experimental units, concerns and pressures associated with certification might well have dissipated any positive impact of the move on employee attitudes. Initially, the unit whose employees were in Experimental Group One failed to receive certification. This failure occurred directly before the second administration of the attitude instrument. While certification was received shortly thereafter, this certification was not achieved without considerable disruption <u>after</u> moving into the new facilities. The employees in Experimental Group Two were in a situation made more tense by a "push" to receive certification upon the first inspection. The inspection occurred in April 1983; that inspection occurred prior to the final testing.

A second variable that affected the outcome of the study in the same sense of history could be sought to explain the overall drop. The most significant outcomes are in relation to time. It can be seen that all three groups of employees show a major drop in job satisfaction at testing time 3. See Figure 1. While it can only be conjectured, these outcomes might be closely related to political activity in the state legislature. Perhaps it might be simpler to discuss what happened to employees' raises in the state legislature. The governor was expected to restore 4% increases for employees allowed by the previous legislative session on January 1, 1983, with raises of 8% each year, beginning in July. After testing time 1 (in January, 1983) the 4% that was withheld temporarily became withheld permanently. Also by testing time 2, the raises had dropped to 4% for each year. By testing time 3 the legislature had adjourned. There were to be no salary increases. Thus, dissatisfaction with salary might be one explanation for the overall drop in each of the groups.

<u>Direct Hypotheses Testing</u>

Several different ways using linear models can be incorporated into addressing hypotheses of interest. For example, consider the hypotheses regarding "Is the change in $\bar{Y}_1$ to $\bar{Y}_2$ different than the difference in $\bar{Y}_4$ and $\bar{Y}_5$ or $\bar{Y}_8$ and $\bar{Y}_9$ (or a mean of these differences)?" The question just posed actually can be seen to be three questions: Is $\bar{Y}_1 - \bar{Y}_2 = \bar{Y}_4 - \bar{Y}_5$, is $\bar{Y}_1 - \bar{Y}_2 = \bar{Y}_8 - \bar{Y}_9$ and is $\bar{Y}_1 - \bar{Y}_2 = ½(\bar{Y}_4 - \bar{Y}_5) + ½(\bar{Y}_8 - \bar{Y}_9)$?

The first approach to be used is similar to that shown in Williams (1980). First, the criterion is reconstructed as $Y = Y^* + Y^{**}$ where $Y^* = \hat{Y}$ where the $\hat{Y}$ values are the predicted values from using the equation

$$\hat{Y} = b_0 + b_p P . \qquad [1]$$

For the present data,

$$\hat{Y} = 1/3P$$

Then, $Y^{**} = Y - Y^*$. It is the Y^{**} criterion that will allow tests on certain (but not all) cell means. The full model can be written as:

$$Y^{**} = b_1X_1 + b_2X_2 + \ldots + b_9X_9 + e_1; \qquad [2]$$

where the $X_i = 1$ if from the corresponding cell and 0 otherwise. Reparameterizations that would be useful for this full model include:

$$Y^{**} = b_0 + b_1X_1 + b_2X_2 + \ldots + b_8X_8 + e_1, \qquad [3]$$

and

$$Y^{**} = b_0 + b_1X_1 + b_2X_2 + \ldots + b_7X_7 + b_9X_9 + e_1 . \qquad [4]$$

In fact, nine such reparameterizations could be completed, each time leaving out a single b_iX_i.

If simple comparisons of cell means are of interest, the set of nine reparameterizations would yield psuedo-Dunnett solutions (Williams, 1971) that would allow all possible comparisons of means such as would be accomplished by Tukey's test (Williams, 1974). The resulting computed t values would have to be adjusted by multiplying by $\sqrt{\frac{\text{correct df}}{\text{incorrect df}}}$ since the df for the MS_w would be 364 rather than 546 which would routinely appear on the printout (Fraas & McDougall, 1983; Williams, 1980). However, these values are only accurate for within subjects effects (i.e., comparisons among Group One at Times 1, 2 or 3, or comparisons among Group Two at Times 1, 2 or 3 or among the control group at Times 1, 2 or 3). For comparisons among cross group cell differences, the situations is the same as any two way layout for multiple comparisons (see Williams, 1980, Chapter Four). A reparameterization of equation 4 would be:

$$Y^{**} = b_0 + b_2X_2 + b_3X_3 + \ldots + b_9X_9 + e_2. \qquad [5]$$

Using equation 5, the computed t value, .474, would be multiplied by $\sqrt{\frac{364}{546}}$ or .8165; t = .387.

Of course, this value could have also been found by placing appropriate restrictions on the full model (equation 3) and solving the equation:

$$t = \sqrt{F} = \sqrt{\frac{(R_F^2 - R_R^2)/1}{(1 - R_F^2)/364}}\ .$$

The appropriate restriction is $b_1 = b_2$. Then

$$Y^{**} = b_2X_1 + b_2X_2 + b_3X_3 + \ldots + b_9X_9 + e_3$$

or

$$Y^{**} = b_2(X_1 + X_2) + b_3X_3 + \ldots + b_9X_9 + e_3, \text{ and}$$

reparameterizing,

$$Y^{**} = b_0 + b_2(X_1 + X_2) + b_3X_3 + \ldots + b_8X_8 + e_3. \qquad [6]$$

Testing the restricted model against the full model yields:

$$t = \sqrt{\frac{.16043 - .16008}{(.83957)/364}} = .389$$ (approximately the same as the earlier value).

This comparison could also have been accomplished by:

$$t = \frac{\bar{Y}_2 - \bar{Y}_1}{\sqrt{\left(\frac{1}{37} + \frac{1}{37}\right)(.094)}}\ .$$

To address the question:

is $\overline{Y}_1 - \overline{Y}_2 = \overline{Y}_4 - \overline{Y}_5$, the restriction $b_1 - b_2 = b_4 - b_5$ can be placed on equation 3. First, $b_1 = b_4 - b_5 + b_2$. Then:

$Y^{**} = (b_4 - b_5 + b_2)X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e_5.$

$$Y^{**} = b_2(X_2 + X_1) + b_3X_3 + b_4(X_4 + X_1) + b_5(X_5 - X_1) + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e_4. \quad [7]$$

Then, arbitrarily choosing any b_i between b_2 and b_9 to equal zero (thereby reintroducing b_0), yields (choosing $b_9 = 0$)

$$Y^{**} = b_0 + b_2(X_2 + X_1) + b_3X_3 + b_4(X_4 + X_1) + b_5(X_5 - X_1) + b_6X_6 + b_7X_7 + b_8X_8 + e_4. \quad [8]$$

Then, $t = \sqrt{F} = \sqrt{\dfrac{(R_F^2 - R_R^2)/1}{(1 - R_F^2)/364}}$ or $\sqrt{\dfrac{.16043 - .15576}{.83957/364}}$,

$t = 1.423$,

which should be tested using an appropriate multiple comparison procedure, depending upon the number and type of comparisons to be completed. In any event, this t value is unlikely to be convincing evidence that the change for Group One is significantly better than Group Two at Time 2.

A similar process could be used to test $\overline{Y}_1 - \overline{Y}_2 = \overline{Y}_8 - \overline{Y}_9$.

This test yields

$t = \sqrt{F} = \sqrt{\dfrac{.16043 - .15516}{.83957/364}} = 1.512.$

Also, testing $\overline{Y}_1 - \overline{Y}_2 = \frac{1}{2}(\overline{Y}_4 - \overline{Y}_5) + \frac{1}{2}(\overline{Y}_8 - \overline{Y}_9)$ yields

$t = \sqrt{F} = \sqrt{\dfrac{.16043 - .15443}{.83957/364}} = 1.613.$

Testing the second set of implied questions, "Is the long term effect, that is, $\overline{Y}_3 - \overline{Y}_2$ different than the corresponding control differences $(\overline{Y}_9 - \overline{Y}_8)$? Here, $t = \sqrt{F} = \sqrt{\dfrac{.16043 - .15878}{.83957/364}} = .846$, indicating little long term effect.

Are the implementation changes the same (is $\bar{Y}_2 - \bar{Y}_1 = \bar{Y}_6 - \bar{Y}_5$) yields $t = \sqrt{F} = \sqrt{\frac{.16043 - .13265}{.839577/364}} = 3.470$.

This last difference would show that the implementation changes were different for the two experimental units. Clearly, other questions could be posed on the data as well.

Using Side Conditions

Another approach to the repeated measures design is to employ side conditions. Since the group effect is nested in the subjects effect, the full model $Y = b_pP + b_1X_1 + b_1X_2 + \ldots + b_9X_9 + e_5$ [9]

can be turned into a full model with the group effects removed by imposing side conditions.

The group effects hypotheses can be given as:

$$\frac{n_1b_1 + n_2b_2 + n_3b_3}{n_1 + n_2 + n_3} = \frac{n_4b_4 + n_5b_5 + n_6b_6}{n_4 + n_5 + n_6} = \frac{n_7b_7 + n_8b_8 + n_9b_9}{n_7 + n_8 + n_9}. \quad [10]$$

Since $n_1 = n_2 = n_3$, $n_4 = n_5 = n_6$, $n_7 = n_8 = n_9$, equation 10 can be rewritten as:

$$\frac{n_1(b_1 + b_2 + b_3)}{3n_1} = \frac{n_4(b_4 + b_5 + b_6}{3n_4} = \frac{n_7(b_7 + b_8 + b_9)}{3n_7}.$$

or more simply as $b_1 + b_2 + b_3 = b_4 + b_5 + b_6 = b_7 + b_8 + b_9$. Any two of several restrictions could be made. The following two could be chosen:

$b_3 = b_7 + b_8 + b_9 - b_1 - b_2$ and

$b_6 = b_7 + b_8 + b_9 - b_4 - b_5$.

Imposing these two restrictions (actually, side conditions) yields:

$$Y = b_pP + b_1X_1 + b_2X_2 + (b_7 + b_8 + b_9 - b_1 - b_2)X_3 + b_4X_4 + b_5X_5 + (b_7 + b_8 + b_9 - b_4 - b_5)X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e_6; \quad [11]$$

or

$$Y = b_pP + b_1(X_1 - X_3) + b_2(X_2 - X_3) + b_4(X_4 - X_6) + b_5(X_5 - X_6) + b_7(X_7 + X_3 + X_6) + b_8(X_8X_3 + X_6) + b_9(X_9 + X_3 + X_6) + e_6. \quad [12]$$

Equation 12 (or reparameterizations of it, using different restrictions expressing the side conditions) then serves as a full model for testing against restricted models; $R^2 = .79869$.

Now, direct hypotheses can be tested by placing appropriate restrictions simultaneously with the side conditions. For example, testing $\bar{Y}_1 - \bar{Y}_2 = \bar{Y}_4 - \bar{Y}_5$ is done using the restriction $b_1 - b_2 = b_4 - b_5$ or $b_1 = b_4 - b_5 + b_2$, as before.

Then $Y = b_pP+(b_4 - b_5 + b_2)X_1 + b_2X_2 + (b_7 + b_8 + b_9 - b_4 + b_5 - 2b_2)X_3 + b_4X_4 + b_5X_5 + (b_7 + b_8 + b_9 - b_4 - b_5)X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e_7;$ [13]

$$Y = b_pP + b_2(X_2 + X_1 - 2X_3) + b_4(X_4 + X_1 - X_6 - X_3) + b_5(X_5 - X_1 - X_6 + X_3) + b_7(X_7 + X_3 + X_6) + b_8(X_8 + X_3 + X_6) + b_9(X_9 + X_3 + X_6) + e_7. \quad [14]$$

Note that the restrictions are made simultaneously with the side conditions on the full model (equation 9). Were the restrictions placed on equation 12, a different hypothesis would be tested; b_1 in equations 13 and 14 is different from b_1 in equation 12. Placing the restriction $b_1 - b_2 = b_4 - b_5$ on equation 12 tests the hypothesis $2(\bar{Y}_2 - \bar{Y}_5) = \bar{Y}_6 - \bar{Y}_3$, clearly a very different hypothesis than $\bar{Y}_1 - \bar{Y}_2 = \bar{Y}_4 - \bar{Y}_5$.

The constant term could be reintroduced by arbitrarily setting equal to zero any one of the remaining b_i. Doing this yields $R^2 = .79757$. Therefore $t = \sqrt{F} = \sqrt{\dfrac{.79869 - .79757}{.20131/364}} = 1.423$, the same result given earlier for this contrast following equation 8.

This process could be repeated for any of the other hypotheses, imposing the restriction implied by the hypothesis simultaneously with the side conditions. Care must be taken to be sure that hypotheses tested on this model are appropriate; such hypotheses must be some combination of within group contrasts.

Directly Using the Full Model

Had equation 9 been used directly, it can be seen that the outcome is comparable to using the side conditions:

$$Y = b_pP + b_1X_1 + b_2X_2 + \ldots b_9X_9 + e_5; \qquad [9]$$

testing $\overline{Y}_1 - \overline{Y}_2 = \overline{Y}_4 - \overline{Y}_5$ is done using the restriction $b_1 - b_2 = b_4 - b_5$ or $b_1 = b_4 - b_5 + b_2$, as before.

Then,

$$Y = b_pP + (b_4 - b_5 + b_2)X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e_8;$$

$$Y = b_pP + b_2(X_2 + X_1) + b_3X_3 + b_4(X_4 + X_1) + b_5\ (X_5 - X_1) + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e_8.$$

Reparameterizing by choosing $b_9 = 0$,

$$Y = b_0 + b_pP + b_2(X_2 + X_1) + b_3X_3 + b_4(X_4 + X_1) + b_5(X_5 - X_1) + b_6X_6 + b_7X_7 + b_8X_8 + e_8. \qquad [15]$$

Note the similarity between equation 15 and equation 9.

Equation 9 yields $R^2 = .79869$; equation 15 yields $R^2 = .79757$. Therefore, $t = \sqrt{F} = \sqrt{\dfrac{.79869 - .79757}{.20131/364}} = 1.423$, identically the same result as found using side conditions.

It can be seen that several different approaches can be used to test hypotheses in a repeated measures designs. The use of the criterion Y^{**} where $Y^{**} = Y - Y^*$ when $Y^* = 1/3P$, as was shown in Williams (1980) allows an appropriate testing procedure. The use of side conditions (which uses a model removing the nesting effect) or a model containing the group membership variables and the person-score vector yield identical results. Perhaps the latter approach would be conceptually easier to understand. The direct use of equation 9 can be completed despite the nesting of the group effects. Had person vectors been included rather than the summed P variable, the nesting problem becomes more apparent. In any event, the relationship of these three solutions should be noted.

Table 1

Analysis of Variance for the Stem Attitude Scale
with Three Groups of Employees (N = 185)

Source of Variation	df	SS	MS	F
Among Subjects	184	128.84		
Groups	2	.64	.32	.46
error (a)	182	128.20	.70	
Within Subjects	370	40.63		
Time	2	5.23	2.62	29.11c
Linear	1	4.83	4.83	53.67c
Second	1	.40	.40	4.44a
Time X Groups	4	1.29	.32	3.56b
error (w)	364	34.11	.09	
Total	554	169.47		

a, $p < .05$
b, $p < .01$
c, $p < .001$

Table 2

Table of Means for the Stem Attitude Scale
with Three Groups of Employees (N=185)

	Time 1	Time 2	Time 3	Total
Group One (N=37)	2.68	2.71	2.54	2.64
Group Two (N=56)	2.90	2.79	2.50	2.73
Control (N=92)	2.80	2.73	2.63	2.75
Total (N=185)	2.80	2.75	2.57	2.71

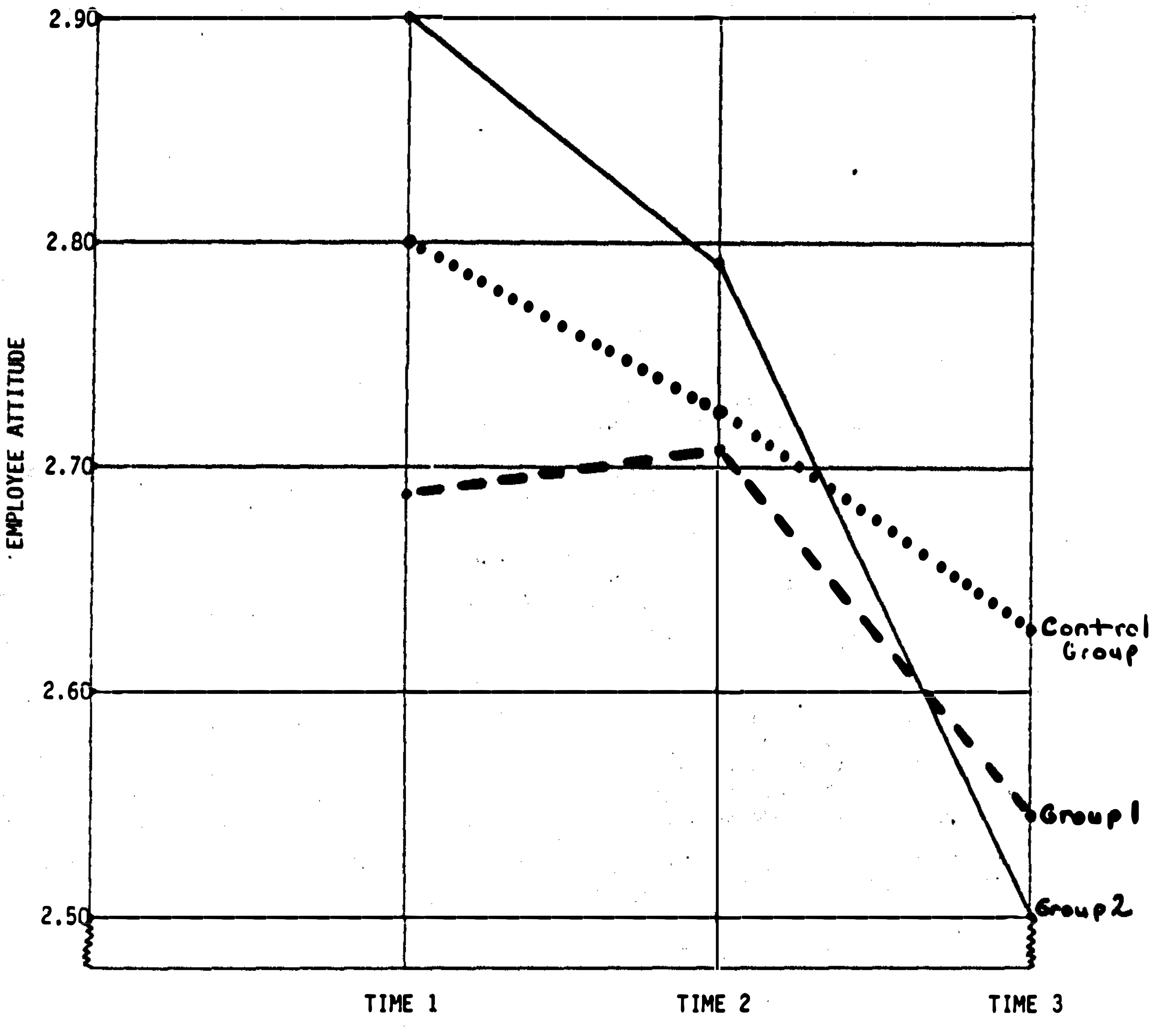

FIGURE 1. MEANS FOR THE STEM ATTITUDE SCALE WITH THREE GROUPS OF EMPLOYEES

JOB ATTITUDE QUESTIONNAIRE

Please choose the letter that best represents your answer to the question asked and put it in the blank provided next to the question number.

_____ 1. How do you like the work that you do?

A. It's the kind of work that I like best.
B. It is close to the type of work I like to do.
C. I like it, but there are other kinds of work I like just as much.
D. It's all right, but there are other kinds of work I like better.
E. I don't like it very much; I would prefer some other kind of work.

_____ 2. What do you think about the Unit you work in as a place to work?

A. The best possible place to work.
B. Good place to work.
C. About average.
D. Somewhat below average.
E. Among the poorest places to work.

_____ 3. What do you think about your ward as a place to work?

A. The best possible place to work.
B. Good place to work.
C. About average.
D. Somewhat below average.
E. Among the poorest places to work.

_____ 4. When it comes to accomplishing results, how do you think your Unit would compare with other units at the School?

A. Much better than most.
B. Somewhat better than most.
C. About the same as most.
D. Not quite as good as most.
E. Much worse than most.

_____ 5. All in all, how do you feel about your own pay?

A. Very satisfied.
B. Satisfied.
C. Fairly satisfied.
D. Rather dissatisfied.
E. Very dissatisfied.

_____ 6. If you had a chance to do the same kind of work, for the same salary, in another unit of the School, what would you rather do?

A. Definitely want to stay where I am.
B. Rather stay where I am.
C. It wouldn't matter to me.
D. Rather move than stay.
E. Want very much to move to another section.

7. How would you describe the morale of employees in positions similar to yours in your Unit?

   A. Most employees have high morale.
   B. More employees have high morale than have low morale.
   C. Employees who have high morale and employees that have low morale are about the same in number.
   D. More employees have low morale than have high morale.
   E. Most employees have low morale.

8. Do you feel you are working as part of a team?

   A. I almost always feel I am part of a team.
   B. I usually feel I am part of a team.
   C. I feel I am part of a team about half of the time.
   D. I rarely feel I am part of a team.
   E. I almost never feel I am part of a team.

9. In your opinion, what do you think your effect is on the behavior of residents on your ward?

   A. Strong, positive effect.
   B. Most often the effect is positive.
   C. There is little or no effect.
   D. The effect tends to be somewhat negative.
   E. Strong, negative effect.

10. What one word sums up your opinion of your job?

   A. Challenging.
   B. Satisfying.
   C. Acceptable.
   D. Frustrating.
   E. Boring.

11. Do you think your ward is a good place for residents to live?

   A. The ward is much better than most.
   B. The ward is somewhat better than most.
   C. The ward is about the same as most.
   D. The ward is not quite as good as most.
   E. The ward is much worse than most.

12. In your opinion, do you think residents in your Unit have enough privacy and individual space?

   A. Residents have enough privacy and individual space - with no exceptions.
   B. Residents have enough privacy and individual space - with few exceptions.
   C. Residents have enough privacy and individual space - with several exceptions.
   D. Residents do not have enough privacy and individual space - they have not been treated fairly.
   E. Residents do not have enough privacy and individual space - they have been treated quite unfairly.

______ 13. Would your attitude toward your job be different if staff on your ward ha programming and activity supplies to work with the residents?

A. Much more positive attitude.
B. A little better attitude.
C. Neutral attitude.
D. A little poorer attitude.
E. A much more poorer attitude.

______ 14. How closely do your actual work duties match the job description you read applying for your job?

A. Exactly the same.
B. Basically, pretty much the same.
C. Some duties are similar, others are different.
D. Mostly dissimilar.
E. Aren't alike at all.

______ 15. How important to me in my job is feeling useful and being needed?

A. That's the most important thing to me.
B. It's nice to be useful and needed.
C. It's o.k.
D. There are other things that are more important to me.
E. It is unimportant to me.

______ 16. The opportunities for job advancement in your Unit are?

A. Excellent.
B. Good.
C. Average.
D. Fair.
E. Poor.

______ 17. I feel that I am wasting my time on my job.

A. All of the time.
B. Most of the time.
C. Some of the time.
D. Seldom.
E. Never.

______ 18. I think the inservice training is?

A. Appropriate and useful.
B. Useful, but more is needed.
C. Useful some of the time.
D. Only occassionally useful.
E. A waste of time.

19. In regard to working with residents, I think.

A. That this is a type of work that will be very fulfilling to me for most of my working life.
B. The work is enjoyable, but not something I want to spend the rest of my life doing.
C. I see this job in many ways like any other, I don't mind it, it's o.k.
D. If I could get another job with the same or higher pay, I would prefer to switch jobs.
E. If I could get another job even at a lower pay, I would prefer to change jobs.

20. The supervisors that I have on my job are?

A. Both helpful and knowledgeable about my job concerns.
B. Somewhat helpful and knowledgeable about my job concerns.
C. They try to be helpful, but don't always know enough about my specific job to help that much.
D. They don't seem to be available enough.
E. The supervisors tend to be disinterested in my job and the work I do.

21. The professional staff in your Unit:

A. Talk with ward staff regularly and ask for opinions on residents' programs, problems and behaviors.
B. Talk with ward staff occassionally and ask for opinions on residents' programs, problems and behaviors.
C. Talk with ward staff occassionally and now and then ask for opinions on resident's programs, problems and behaviors.
D. Do not talk with ward staff.
E. Appear not to treat the ward staff with respect.

22. Do you feel free to openly discuss concerns with the administrative staff of your Unit?

A. Yes; both personal and business concerns.
B. Yes; but only matters concerning business.
C. Some, but not all of the time.
D. No; it is best not to discuss either personal or business concerns with the unit administrative staff.
E. The less said the better in my unit; you can avoid trouble that way.

23. With regard to the professional staff in your unit, they seem?

A. Readily available for assistance with resident's and staff's concerns.
B. Usually available for assistance with resident's and staff's concerns.
C. Not readily available for assistance.
D. Do not think that they are performing their job duties.
E. Do not know what they do within the Unit.

24. Do you think that the Grafton State School administrative staff is receptive to your concerns or feelings?

A. Always.
B. Usually.
C. Some of the time.
D. Seldom.
E. Never.

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The Use Of Multiple Linear Regression In Predicting Scholarly Productivity Among Counselor Educators

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Abstract

The present study was designed to find a regression equation that would help predict research productivity among counselor educators. Seven variables were found to contribute significantly to the equation, yielding an R^2 of .455. The authors present several ways in which this information can be utilized.

Research activity is very important for college and university faculty members. In addition to teaching, advising students, and other related duties, faculty are expected to engage in research activity within their particular disciplines. The "publish or perish" phenomenon is well known in academic circles, even though it may be argued that a college educator's worth cannot be measured simply by research productivity. Nevertheless, the importance of publishing is likely to become increasingly crucial as the academic climate reflects lower enrollment, fewer economic resources, and faculty retrenchment. Bishkin (1984) noted that as grants and other resources become increasingly scarce, only creative researchers will be able to obtain funding. At the same time, productivity is still required.

Numerous researchers have attempted to measure scholarly productivity, despite the nebulous issue of quality versus quantity. Studies within the physical sciences (Bayer & Dutton, 1977; Bayer & Fogler, 1966; Crane, 1965) and within psychology (Dennis, 1954; Guyer & Fidell, 1973; Platz & Blakelock, 1960) have measured productivity by counting journal articles and books, looking at the number of citations, and analyzing the content of journal articles.

Little research, however, has been done in the field of counselor education. Walton (1982) looked at differences between high and low producers on numerous variables using chi-square analyses. He found several significant differences between the two groups, and suggested several ways those differences could be used by counselor educators.

The present study is an extension of Walton's (1982) research, and employs multiple linear regression to predict productivity among counselor educators. Institutions which intend to hire employees who are likely to engage in research may be able to use the equation generated in the present study to predict whether the prospective faculty member will be a high or low producer in terms of the publication record. Individuals can also use the equation to determine whether or not a given academic environment is conducive to research activity.

Methods and Procedures

A total of 520 questionnaires was mailed to members of the Counselor Education and Supervision (ACES) division of the American Personnel and Guidance Association (APGA), which is now called the American Association for Counseling and Development (AACD). From these randomly selected individuals, 56.1 percent returned completed questionnaires. For the purposes of this analysis, only those respondents who listed their primary occupation as counselor educator were included. Questionnaires with a substantial amount of missing data were not retained for the analysis. Hence, a total of 158 subjects was used for the regression procedure. It should be noted that educators who are low publishers may be underrepresented in the sample. Some caution is necessary when interpreting the results.

The questionnaire was divided into two major parts. The first dealt with demographic information, as well as preferences within the field of counseling, while the second part concerned productivity information. In the final analysis, the number of journal articles, books, and monographs each participant reported having published was used as the dependent variable.

All variables which were nominal in form were dummy-coded in order to perform the multiple regression analysis. The authors employed several regression procedures with pairwise deletion of missing data. Pairwise deletion allows for the inclusion of a questionnaire with a minimal amount of missing information. The default on most software packages is to delete a questionnaire if even one item is missing.

It was hypothesized that some combination of the variables would yield an R^2 value significantly different from zero, such that Ho: $R^2y.x_1x_2...x_p = 0$. Because of the exploratory nature of the study, the authors did not predict which variables would significantly contribute to the regression equation.

Results

Before regression procedures were employed, an analysis checking for outliers was conducted. Using Cook's Distance, Mahalanobis' Distance, and Weisberg's Test, it was determined that no outliers were present.

Five regression procedures were used in an attempt to reach a concensus on the variables included in the equation. A graph of the R^2 and Adjusted R^2 values yielded similar results. Other graphical methods were not employed, although it can be noted that the Adjusted R^2 values give almost identical results to an analysis of the residual mean squares, as Hocking (1976) noted.

Both R^2 and Adjusted R^2 indicated that seven variables probably determined the most useful equation. Forward, backward, and stepwise procedures concurred with this conclusion, with all five methods suggesting the same regression equation.

When the questionnaire was developed it was assumed that the percentage of completed questionnaires returned would be maximized by allowing the respondent to answer in categories rather than requiring exact information. It was reasoned that counselors would be more likely to respond if given various ranges to choose from, rather than having to give exact figures

Although such procedures may have had desirable results in terms of the rate of return, there was a disadvantage in using such information without assigning rank values. Thus, the data analysis may have lost some of its potency because of the use of categorical data rather than interval data. Table 1 gives the appropriate values, after dummy-coding, for the seven variables used in the equation.

Table 1.

Values Assigned to Categorical Data

Years of Work	0-4 = 1	5-10 = 2	11-25 = 3	>25 = 4
Research Hrs/Week	0-4 = 1	5-12 = 2	13-20 = 3	>20 = 4
University Size	<10,000 = 1	10,000-19,999 = 2	20,000-29,999 = 3	
	30,000-39,999 = 4	40,000-49,999 = 5	>50,000 = 6	
Number of Journal Subscriptions	0-2 = 1	3-4 = 2	5-10 = 3	>10 = 4
Rank	Professor = 1	Associate Professor = 2	Assistant Professor = 3	
	Instructor = 4	Other = 5		
Preferred Activity = Administration	No = 0	Yes = 1		
First Publication	Before Doctorate = 0	After Doctorate = 1		

The seven variables meeting the criterion for entry into the model resulted in an R^2 of .455. The resulting *F* value was 17.88, *p* < .0001. Table 2 gives the regression equation, and indicates that all seven variables meet the .05 criterion for inclusion in the model. When reduced models from this restricted model were considered, the *F* value remained significant, giving further evidence that all seven variables contribute to predicting productivity among counselor educators.

Table 2

Variables in Restricted Model, as Determined by All Five Methods

Variable	B	Error	R^2	F	Significance
Years of Work	.56	.16	.182	12.67	.0005
Research hrs/Week	.64	.18	.301	12.70	.0005
University Size	.36	.08	.356	19.13	.0001
First Publication	-.70	.20	.391	11.67	.0008
Journal Subscriptions	.37	.15	.420	5.65	.0187
Rank	-.31	444	.440	4.47	.0362
Administration	-1.25	.62	.455	4.04	.0463
Constant	-1.18	.77			

Discussion

The present study suggests that it is possible to predict counselor educator productivity with a reasonable amount of accuracy based on seven variables. These are: years of work in the field, number of hours per week spent on research activities, size of university, whether the first publication was before or after receipt of the doctoral degree, the number of journals subscribed to, academic rank, and whether or not the preferred professional activity is in administration. Of these, several seem intuitive. First, the number of hours spent doing research would seem to be an obvious indicator of how many publications that researcher is likely to produce, although it is recognized that one could spend many hours on research, and still not be highly productive in terms of tangible end products. Second, the number of years of work experience has a substantial correlation with productivity. The longer a researcher has been in the field, generally speaking, the more the likelihood that he or she has publish professional articles. Associated with this is Walton's (1982) finding that as an individual improves his or her academic rank, scholarly productivity is likely to increas It should be noted that academic rank increases with num years of work experience.

University size is also a predictive factor of productivity. Walton (1982) noted that 50% of high producers were affiliated with institutions whose total student population was more than 20,000, while 43.3% of low producers worked at colleges or universities with less than 10,000 students. The present authors suggest that larger universities generally tend to facilitate research activities more than their smaller counterparts.

The number of journals to which the individual subscribes was another of the predictive factors in the present study. Walton (1982) found that counselor educators who subscribed to more journals were more likely to publish. This does not mean that those who do not publish do not keep current in the field, as over 62% of low producers subscribed to at least five journals, and over 95% received at least three journals. Alternately, it may indicate that high producers are likely to receive a large number of journals. The reasons for this are unclear, but may be related to their search for relevant research topics and issues.

Another predictive variable is whether the individual's first publication was before or after receipt of the doctoral degree. Highly productive researchers were more likely to have published their first work before they received their doctorate (Walton, 1982). This seems to indicate that those expressing an interest in research before beginning work as counselor educators are likely to maintain the interest after obtaining employment in the field.

The question of academic rank has been previously addressed. In terms of whether or not one prefers administrative tasks, it would seem to follow naturally that less time spent on administrative work leaves more time available for research and publication. Although Walton (1982) reported few differences in high versus low producers on this variable, the current finding could be an artifact of the question, since preferred activity was requested rather than the activity in which the most time was actually spent.

The prospective counselor educator may be able to use the information contained in the present study, along with that provided by Walton (1982), to determine if the institutional environment of a potential employer is conducive to research productivity. Specifically, does the institution allow adequate time for research? Also, is the size of the institution sufficient for adequate support of research activity? These factors must be combined with factors the potential employee controls in order to reach an adequate level of prediction. Conversely, the institution can use the equation to help choose faculty members who are likely to participate in research activities. A substantial part of the variance is not accounted for in the equation; therefore the equation should not be used as the only selection device.

It should be remembered that the present study probably underestimates the variance accounted for by the independent variables, since the present study used categorical data rather than exact responses. This factor is especially relevant when one considers the dependent variable, which was the number of journal articles, as well as the number of books and monographs published. Dividing responses into several categories rather than looking at the exact number of publications may have yielded a conservative estimate of the effect of variables predicting counselor educator productivity. As mentioned previously, however, ordinal responses were used to obtain a higher rate of return.

The authors suggest that more research is needed in this area. A replication would help ensure the validity of the prediction equation, and would substantiate the present authors' claim that it is possible to predict research productivity among counselor educators on the basis of the seven prediction variables listed herein.

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Testing Hypotheses in a Repeated Measures Design: An Example

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Summary - The use of a typical repeated measures design is contrasted with using specific hypotheses which would directly address research questions. A complete example is given.

In an earlier paper Williams and Williams (1984) showed three different methods of using linear models to perform multiple comparisons (contrasts) for within subjects effects on a large sample (N=185) of employees in a test of hypotheses regarding improved facilities on employees attitudes. While large sample sizes yield impractical the use of person vectors (1 if person i, 0 if not), it would be useful to use a small sample so that the two approaches might be compared and the utility of using a single vector (predictor) for the subjects effect can be examined. Accordingly, a data set that has been previously used (Williams, 1974, 1980) will again be used here as an example.

An Example

The following problem is taken from Williams (1974).

A researcher may have an interest in the differential effect of two or more methods of instruction over time; thus, measures can be taken at specified intervals on the several instructional methods. From the point of view of the experiment, a repeated measures design can be conceptualized as a treatments X subjects design repeated for each instructional method.*

*This design is called a Type I design by Lindquist (1953).

To make the example more specific, suppose a research is interested in investigating the differences among three approaches to a human relations experience.**

The three different approaches toward the human relations groups selected are (1) structured sessions in which the group participates toward concrete problem solving, (2) an unstructured group, where the group decides upon its own goals, and (3) a group designed to allow the individual to focus on his personal problems with the interest being to help solve these problems. Five groups with 7-9 individuals in each group are assigned to each of the three human relation group situations; i.e., there are five separate groups for each treatment situation. Each group is to have a two hour session once a week for four weeks.

While there are several things that might be of interest to measure, the researcher is interested specifically in the amount of aggression exhibited in the group setting.

Videotapes are made of all sessions, and a group of five experts independently judge the amount of aggression expressed during the sessions on a continuum from 0 to 10, where 0 represents no aggression and 10 represents an extreme amount of aggression. The measurements are made with the group as the unit of analysis. The score to be used is the mean of the five ratings. Results are as follows:

Table 1

GROUP SCORES FROM THREE HUMAN RELATION GROUP METHODS FOR FIVE SESSIONS
(ARTIFICIAL DATA)

Method 1 (Structured Groups)

Group	Session 1	Session 2	Session 3	Session 4
1	3.2	3.4	3.2	2.8
2	4.6	4.0	3.8	3.4
3	5.0	3.8	5.0	3.2
4	2.0	2.0	2.4	1.6
5	3.6	3.2	3.4	3.0

**By human relations experience is meant the meeting of a group of people that has variously been called the T-group (training group), the encounter group, or some similar name.

Method 2 (Unstructured Groups)

Group	Session 1	Session 2	Session 3	Session 4
6	6.2	5.8	6.8	5.0
7	3.6	3.8	7.2	5.4
8	4.0	6.8	7.8	6.0
9	5.0	5.8	6.0	5.0
10	4.8	5.0	6.4	5.8

Method 3 (Personal Problems)

Group	Session 1	Session 2	Session 3	Session 4
11	7.4	7.6	6.8	5.2
12	6.4	6.4	5.6	4.0
13	7.0	6.6	6.6	6.0
14	5.8	7.4	5.0	4.8
15	6.4	5.2	4.0	3.6

To analyze the data in Table 1, it is first useful to define several variables:

Y = the criterion variable.

P_1 - P_{15} are binary variables that identify each group (the "person" vectors)

X_{16} = 1 if the score is from a group in the structured treatments; 0 otherwise.

X_{17} = 1 if the score is from a group in the unstructured treatment; 0 otherwise.

X_{18} = 1 if the score is from a group in the problems treatment.

X_{19} = 1 if the score is from Session 1; 0 othersise.

X_{20} = 1 if the score is from Session 2; 0 otherwise.

X_{21} = 1 if the score is from Session 3; 0 otherwise.

X_{22} = 1 if the score is from Session 4; 0 otherwise.

$X_{23} = X_{16} \cdot X_{19}$,

$X_{24} = X_{16} \cdot X_{20}$,

$X_{25} = X_{16} \cdot X_{21}$,

$X_{26} = X_{17} \cdot X_{19}$,

$X_{27} = X_{17} \cdot X_{20}$,

$X_{28} = X_{17} \cdot X_{21}$, and

$X_{29} = P =$ a sum of each separate group for the four sessions; for example, for group 1, $X_{29} = 3.2 + 3.4 + 3.2 + 2.8 = 12.6$. ($X_{29}$ will be referred to as P.) Each score (rather than each group) is the unit of analysis; thus, there are 60 scores for the data in Table 1. When preparing the data cards for a computer analysis, 60 data cards would be made. The use of P greatly facilitates a regression solution; this suggestion regarding coding was made earlier by Pedhazur (1977) and by Williams (1977), and more recently by Fraas and McDougall (1983).

To analyze the data in Table 1, it is useful to consider two separate analyses; one analysis can be treatments X subjects design, temporarily disregarding the three different kinds of groups. Then, it is useful to conceptualize the data in a two-way analysis of variance, disregarding for the time being that a given group has been measured several times.

The linear models that are useful for conceptualizing the data in Table 1 as a treatments X subjects design are as follows:

$$Y = b_0 + b_1P_1 + b_2P_2 + \ldots + b_{14}P_{14} + e_1 \text{ (for the subjects (groups) effect)} \quad (1);$$

$$Y = b_0 + b_{19}P_{19} + b_{20}P_{20} + b_{21}P_{21} + e_2 \text{ (for the trend effect)} \quad (2);$$

and

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_{14}X_{14} + b_{19}X_{19} + b_{20}X_{20} + b_{21}X_{21} + e_3. \quad (3).$$

When these linear models are used, the following results can be found:

from equation 1, $SS_S = 104.14$;

from equation 2, $SS_{TREND} = 8.63$; and

from equation 3, $SS_{ERROR_1} = 32.52$; also, $SS_T = 145.29$.

While the preceding information would be sufficient for a treatments X subjects design, it should be recalled that in this formulation, the type of human relation group was disregarded.

Actually, the treatments effect is "nested," i.e., totally contained in the variation among subjects. Before pursuing this "nesting" further at this point, it is first useful to complete the analysis for the two-way formulation.

The following four linear models are sufficient:

$Y = b_0 + b_{16}X_{16} + b_{17}X_{17} + e_4$, (for the treatments effect) (4)

$Y = b_0 + b_{19}X_{19} + b_{20}X_{20} + b_{21}X_{21} + e_2$, (for the trend effect) (2)

$Y = b_0 + b_{16}X_{16} + b_{17}X_{17} + b_{19}X_{19} + b_{20}X_{20} + b_{21}X_{21} + e_5$, (5) and

$Y = b_0 + b_{16}X_{16} + b_{17}X_{17} + b_{19}X_{19} + b_{20}X_{20} + b_{21}X_{21} + b_{23}X_{23} + \ldots +$
$b_{28}X_{28} + e_6$ (Full Model) (6)

When these linear models are used, the following results can be found:

from equation 4, $SS_{METH} = 78.87$;

from equation 2, $SS_{TREND} = 8.63$;

from equation 6, $SS_{ERROR} = 39.71$.

The sum of squares attributed to regression for the full model (equation 6) is 105.58. The sum of squares attributed to regression for equation 5 is 87.50. The difference between these two values is equal to the interaction. Thus, $SS_{METH\ X\ TREND} = 105.58 - 87.50 = 18.08$. A summary table that would contain the foregoing information would appear as follows:

Table 2

SUMMARY TABLE FOR THE HUMAN RELATION GROUPS DATA IN TABLE 1

Source of Variation	df	SS	MS	F
Among Subjects				
Method	2	78.87	39.44	18.69**
Error (a)	12	25.27	2.11	
Total Among Subjects	14	104.14		
Within Subjects				
trend	3	8.63	2.88	7.20**
meth x trend	6	18.08	3.01	7.52**
error (b)	36	14.44	.40	
Total Within Subjects	45	41.15		
Total	59	145.29		

**Significant at .01 level

The summed vector, X_{29}, could have been used to achieve similar results:

$Y = b_0 + b_pP + e_1$ (for the subjects (groups) effect) [1a];

$Y = b_0 + b_pP + b_{19}X_{19} + b_{20}X_{20} + b_{21}X_{21} + e_3.$ [3a]

Equation 1a is identical (in sum of squares) to equation 1; $SS_S = 104.14$; similarly, equation 3 yields $SS_{ERROR_1} = 32.52$. Table 1 could have been accomplished by using results from these last two equations in lieu of the original binary person variables (X_1 to X_{14}).

Multiple Comparisons (Contrasts) Within Groups

It would be helpful to give a diagramatic view, in terms of mear of the data described earlier;

	Session 1	Session 2	Session 3	Session 4
Method 1	$\bar{Y}_1$	$\bar{Y}_2$	$\bar{Y}_3$	$\bar{Y}_4$
Method 2	$\bar{Y}_5$	$\bar{Y}_6$	$\bar{Y}_7$	$\bar{Y}_8$
Method 3	$\bar{Y}_9$	$\bar{Y}_{10}$	$\bar{Y}_{11}$	$\bar{Y}_{12}$

Suppose the interest was in testing the long term change (from session 1 to session 4) between methods 1 and 2; that is, the interest is in testing $\bar{Y}_1 - \bar{Y}_4 = \bar{Y}_5 = \bar{Y}_8$. In our earlier paper (Williams and Williams, 1984) we outlined three different approaches to answering this sort of question.

The first approach, also outlined with this same data set in Williams (1980), was to reconstruct the criterion as $Y = Y^* + Y^{**}$ where $Y^* = \hat{Y}$; the $\hat{Y}$ values are the predicted values from using the equation $\hat{Y} = b_0 + b_pP$. For the present data $Y = 1/4P$ where P is the summed person vector described earlier as X_{29}. (Although it is more cumbersome, P_1 to P_{12} could have been used instead of P.)

It is the Y** criterion that can be used to accomplish tests regarding within group cell differences. The full model can be written as: $Y^{**} = b_1X_1 + b_2X_2 +..+ b_{12}X_{12} + e_4$, where X_1 to X_{12} correspond respectively to binary coded group variables for each cell. [4]

For some computer programs, a reparameterization of equation 4 that includes the unit vector is more useful:

$$Y^{**} = b_0 + b_1X_1 + b_2X_2 +...+ b_{11}X_{11} + e_4; \quad [4a]$$

many other reparameterizations could have been chosen. For a more complete description of this reparameterization process, see Williams (1976).

The restriction that tests the hypothesis $\bar{Y}_1 - \bar{Y}_4 = \bar{Y}_5 - \bar{Y}_8$ is $b_1 - b_4 = b_5 - b_8$, or $b_1 = b_5 - b_8 + b_4$. Placing this restriction on equation 4 yields:

$$Y^{**} = (b_5 - b_8 + b_4)X_1 + b_2X_2 +...+ b_{12}X_{12} + e_5 \quad [5]$$

$$\text{or } Y^{**} = b_2X_2 + b_3X_3 + b_4(X_4 + X_1) + b_5(X_5 + X_1) + b_6X_6 + b_7X_7 + b_8(X_8 - X_1) + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + e_5. \quad [6]$$

Let $D_4 = X_4 + X_1$,

$D_5 = X_5 + X_1$, and

$D_8 = X_8 - X_1$.

Then equation 6 can also be given as:

$$Y^{**} = b_2X_2 + b_3X_3 + b_4D_4 + b_5D_5 + b_6X_6 + b_7X_7 + b_8D_8 + b_9X_9 + b_{10}X_{10}$$
$$+ b_{11}X_{11} + b_{12}X_{12} + e_5. \qquad [6a]$$

Either equation 6 or a reparameterization of it, done by introducing b_0 and arbitrarily dropping any one predictor, can be used as the restricted mode. Letting $b_{12} = 0$, one reparameterization, incorporating D_4, D_5 and D_8 is:

$$Y^{**} = b_0 + b_2X_2 + b_3X_3 + b_4D_4 + b_5D_5 + b_6X_6 + b_7X_7 + b_8D_8 + b_9X_9 + b_{10}X_{10} +$$
$$b_{11}X_{11} + e_5. \qquad [6b]$$

The test is given by:

$$t = \sqrt{F} = \sqrt{\frac{R_F^2 - R_R^2/1}{(1 - R_F^2)/36}}.$$

Here $R_F^2 = .64899$; $R_R^2 = .57123$

$t = \sqrt{7.975} = 2.824.$

Using Side Conditions

Another approach to the repeated measures designs is to employ side conditions. Since the group effects are nested in the subjects effects, the full model

$$Y = b_pP + b_1X_1 + b_2X_2 + \ldots + b_{12}X_{12} + e_6 \qquad [7]$$

can be turned into a model with the groups effects removed by imposing side conditions.

The group effects restrictions can be given as:

$$\frac{n_1b_1 + n_2b_2 + n_3b_3 + b_4b_4}{n_1 + n_2 + n_3 + n_4} = \frac{n_5b_5 + n_6b_6 + n_7b_7 + n_8b_8}{n_5 + n_6 + n_7 + n_8} = \frac{n_9b_9 + n_{10}b_{10} + n_{11}}{n_9 + n_{10} + n_{11} + n_1}$$

Because of equal n's (proportional n's would also suffice) these restrictio can be greatly simplified:

$b_1 + b_2 + b_3 + b_4 = b_5 + b_6 + b_7 + b_8 = b_9 + b_{10} + b_{11} + b_{12}$. Any two of several restrictions could be made. The following two could be chosen:

$b_3 = b_9 + b_{10} + b_{11} + b_{12} - b_1 - b_2 - b_4$ and

$b_6 = b_9 + b_{10} + b_{11} + b_{12} - b_5 - b_7 - b_8$.

Imposing these two restrictions (side conditions) yields:

$$Y = b_pP + b_1X_1 + b_2X_2 + (b_9 + b_{10} + b_{11} + b_{12} - b_1 - b_2 - b_4)X_3 + b_4X_4 + b_5X_5 + (b_9 + b_{10} + b_{11} + b_{12} - b_5 - b_7 - b_8)X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + e_7. \quad [8]$$

or

$$Y = b_pP + b_1(X_1 - X_3) + b_2(X_2 - X_3) + b_4(X_4 - X_3) + b_5(X_5-X_6) + b_7(X_7 - X_6) + b_8(X_8 - X_6) + b_9(X_9 + X_3 + X_6) + b_{10}(X_{10} + X_3 + X_6) + b_{11}(X_{11} + X_3 + X_6) + b_{12}(X_{12} + X_3 + X_6) + e_7. \quad [9]$$

Equation 9 (or reparameterization of it, either using different restrictions expressing the side conditions, and/or including a unit vector) then serves as a full model for testing within group hypotheses:

$R^2 = .90057$.

Now, direct hypotheses can be tested by placing appropriate restrictions simultaneously with the side conditions. With the hypothesis $\overline{Y}_1 - \overline{Y}_4 = \overline{Y}_5 - \overline{Y}_8$ or, in terms of the regression coefficients, $b_1 - b_4 = b_5 - b_8$ or $b_1 = b_5 - b_8 + b_4$, as before.

Then, placing all three restrictions simultaneously on equation 7 yields:

$$Y = b_pP + (b_5 - b_8 + b_4)X_1 + b_2X_2 + (b_9 + b_{10} + b_{11} + b_{12} - b_5 + b_8 - b_4 - b_2 - b_4)X_3 + b_4X_4 + b_5X_5 + (b_9 + b_{10} + b_{11} + b_{12} - b_5 - b_7 - b_8)X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + e_8; \quad [10]$$

or

$$Y = b_pP + b_2(X_2 - X_3) + b_4(X_4 - 2X_3 + X_1) + b_5(X_5 + X_1 - X_3 - X_6) + b_7(X_7 - X_6) + b_8(X_8 + X_3 - X_6 - X_1) + b_9(X_9 + X_3 + X_6) + b_{10}(X_{10} + X_3 + X_6) + b_{11}(X_{11} + X_3 + X_6) + b_{12}(X_{12} + X_3 + X_6) + e_8. \quad [11]$$

Note that the restrictions are made simultaneously with the side conditions on the full model (equation 7). Equation 11 could be reparameterized (necessary with computer programs that automatically introduce a unit vector) by setting equal to zero any of the remaining b_i in equation 11 (excepting b_p. Doing this yields $R_R^2 = .87854$; $F = \frac{(.90057 - .87854)/1}{.09943/36} = 7.976$, $t = \sqrt{F} = 2.84$ this is the same t value found earlier.

This process could be repeated for any other hypothesis, imposing the restriction implied by the hypothesis simultaneously with the side conditions. Care must be taken to be sure that hypotheses tested on this model are appropriate; such hypotheses must be some combination of within group contrasts.

Directly Using the Full Model

Had equation 7 been used directly, it can be seen that the outcome is comparable to using side conditions:

$$Y = b_pP + b_1X_1 + b_2X_2 + \ldots + b_{12}X_{12} + e_6. \qquad [7]$$

Testing $\overline{Y}_1 - \overline{Y}_4 + \overline{Y}_5 - \overline{Y}_8$ can be done using the restriction $b_1 - b_4 = b_5 - b_8$, or $b_1 = b_5 - b_8 + b_4$, as before.

Then,

$$Y = b_pP + (b_5 - b_8 + b_4)X_1 + b_2X_2 + \ldots + b_{12}X_{12} + e_9, \text{ or}$$

$$Y = b_pP + b_2X_2 + b_3X_3 + b_4(X_4 + X_1) + b_5(X_5 + X_1) + b_6X_6 + b_7X_7 + b_8(X_8 - X_1)$$
$$+ b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + e_9.$$

Reparameterizing by (arbitrarily) choosing $b_{12} = 0$,

$$Y = b_0 + b_pP + b_2X_2 + b_3X_3 + b_4(X_4 + X_1) + b_5(X_5 + X_1) + b_6X_6 + b_7X_7 + b_8(X_8$$
$$+ b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + e_9. \qquad [12]$$

Equation 7 yields $R^2 = .90057$, and equation 12 yields $R^2 = .87854$; $F = \frac{(.90057 - .87854)/1}{.09943/36} = 7.976$; $t = \sqrt{F} = 2.842$, the same result as was found by the first two methods.

It can be seen that several different approaches can be used to test hypotheses in a repeated measures designs. The use of the criterion Y** where Y** = Y - Y* when Y* = 1/4P, as was shown in Williams (1980) allows an appropriate testing procedure. The use of side conditions (which uses a model removing the nesting effect) or a model containing the group membership variables and the person-score vector (directly using the full model) yield identical results. Perhaps the latter approach would be conceptually easier to understand. The direct use of equation 7 can be completed despite the nesting of the group effects.

The present paper, like the earlier one, has shown three different types of solutions for testing hypotheses (contrasts) of interest. All three methods yield accurate results for within group comparisons. While they yield results that are equivalent, they are not conceptually equal in terms of their understandability. The first method has the drawback of using a constructed criterion; method two, using side conditions, is unnecessarily complex; extreme care must be used to achieve intended results. Our preference is clearly on the side of the third approach, directly using the full model and making restrictions of research interest upon it. From the point of view of actual use, the third method is sufficient and clearly preferable. On the other hand, the relationship to the other two solutions is at least interesting.

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Time Series ARIMA Models of Undergraduate Grades

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Abstract

The Box-Jenkins approach to time series analysis, a regression method for analyzing sequential dependent observations, is used to determine the most appropriate stochastic model for describing undergraduate grade point averages. The technique was applied to approximately a half century of data from two universities, to investigate models incorporating both regular and seasonal components. Preliminary results suggest a moving average model. Final results will be presented in the paper.

Time Series ARIMA Models of Undergraduate Grades

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Objectives

The purpose of this study is to determine the most appropriate stochastic model for describing the temporal variation of undergraduate grade point averages. Using the Box-Jenkins approach to time series analysis, various ARIMA models are constructed from regular and seasonal components. The models are then compared in terms of adequacy and parsimony to select the "best" one. With the availability of appropriate computer software, this technique may have potential application in using a regression approach to analyze a variety of archival educational data.

Perspective

Whenever a phenomena is observed over time, it is often useful to search for temporal patterns within the data. Economists have studied stock market prices, sociologists have examined population levels, and psychologists have investigated changes in the incidence of depression. For such purposes, a variety of time series analysis procedures have been developed, derived primarily from the theory of multiple regression. These techniques require data gathered from a large number of time periods (at least 50, according to McCleary and Hay, 1980). Since archival data is not as commonly analyzed in education as in some other fields, these mathematical approaches are not as widely used in educational research. It is the purpose of this paper to illustrate such an application.

All educational institutions evaluate their students in some manner, but a single group of pupils is not often evaluated fifty times on the same variable, as would be required for a time series analysis. However, a meaningful time series can be realized by obtaining the average grades given during each of the grading periods across a lengthy time span. For about the last half century, many universities and colleges have adopted a 5-point grading scale, using either the letters A through E or the numbers 1 through 5. Some of the institutions calculated, at each grading period, the average of grades awarded to their students, with the interest of maintaining reasonable consistency in their grading standards both among their departments and across time. Approximately fifteen year ago, reports began appearing that a conspicious increase was occuring each year in the grading patterns at many institutions, and numerous ad hoc explanations were proposed (Birnbaum, 1977).

Any "explanation" of a phenomena implies that the phenomena can be adequately described. Mathematical models, and regression models in particular, are appropriate for such a description, but an examination of the literature suggests that most authors rely solely on visual graphs rather than employing mathematical modeling. In this paper, therefore, the use of the stochastic time series approach is used to generate mathematical models that might appropriately describe the entire sequence of available data on grade point data.

Methods and Techniques

While the analysis of time series data has occured throughout most of the present century, major methodological advancements have become practical with the use of the computer. The analysis techniques proposed by Box and Jenkins (1976) have become almost ubiquitous in the time series research community, and it is that methodology that is used to analyze the data in this study.

Models are sought to describe the existing data across the past half century. Some have suggested that grades systemately vary between the terms of a school, and that hypothesis will also be tested, using a model incorporating both regular and seasonal components.

The major purpose of the paper is to describe and illustrate the use of this methodology and the interpretations of its results.

Data Souce. The data was drawn from two midwestern universities which have collected grade data for the past half century. One institution reported the grade point average data for each Quarter Term, while the other reported data from each Semester.

Results and Conclusions

Preliminary results indicate two facets. First, the Auto Correlation Function (ACF), represented by the correlogram, appears not to be well behaved, even with first or second differences. Second, modes incorporating Moving Average components appear to be more promising than those with Auto Regressive components.

At the present time, further analyses are being conducted to generate models which can be defended in terms of adequacy and parsimony.

The results will include Arima parameter estimates for alternative models and autocorrelations for model diagnosis. Results of model forecasts will also be shown.

The conclusions will compare the diagnoses and metadiagnoses of the models. The usefulness and limitations of the ARIMA regression models for educational data will be discussed.

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Multiple Regression Analysis with
Dichotomous outcome variables:
Issues and Examples
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Objectives and Perspective

The purpose of this applied paper is to present 3 examples of the use of multiple regression analysis in situations where the dependent (outcome) variable is dichotomous. While such use of regression is not revolutionary, the examples provide ideas regarding appropriate situations for use and recommendations for presentation of results. For example, in the first study to be presented, the use of the regression approach for analysis was rejected by an APA journal. When the analysis was recast in the traditional discriminant function model, the article was accepted for publication.

Example 1

The research sought to investigate the coping skills of rape victims to determine if some women may be more vulnerable to rape than others. The study investigated five domains: psychosocial competency, mental health, alcohol and drug use, cognitive resources, and physical ability. Seventy-two rape victims and 72 control women were administered psychometric instruments and a biographical inventory. Information was also obtained from significant others. The strongest domain of prediction was psychosocial competency, with the rape victim scoring lower on measures of social presence, dominance, and assertiveness, and higher on external/social locus of control. A past history of alcohol or drug abuse added to the rape-vulnerability profile. Rape victims were more likely to have a past history of psychiatric hospitalization and suicidal thoughts. They did not differ from control women on the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised, but they scored lower on the Achievement via Indpendence Scale of the California Psychological Inventory. Physical ability attributes were not associated with rape vulnerability (Myers, Templer, Brown, 1984).

The proposed presentation will provide ideas regarding data presentation, the use of a stepwise procedure for domain selection and interpretation problems.

Example 2

The problem of unwed adolescent pregnancy has been studied in the past primarily as a symptom of individual psychopathology. These studies yielded equivocal results. Gradually, the broader social context of pregnant teenagers began to be studied. Past research pointed to the importance of the family in contributing to the problem.

The objectives of this study were to investigate whether family variables could discriminate between the families of unwed pregnant and non-pregnant teens. All teen subjects met the research criteria of being unwed, under eighteen years of age, enrolled in local high schools, and living with their families of origin. Thirty-one pregnant teen families and 28 non-pregnant teen families comprised the study sample. Each subject completed the Moos' Family Environment (FES). In addition, each parent completed a questionnaire which included a problem checklist, demographic information, questions about the teen's dating behavior and recent family structural changes.

The hypothesis that incongruence of perception and other family adjustment variables could differentiate the two groups was explored. Pregnant teens were found to have longer boyfriend relationships and fewer problems as rated by the parents. Their family's perceptions were more congruent overall and more congruent regarding family cohesion but less congruent in their perceptions of conflict, organization and control.

Of particular interest in example 2 was the choice of a full model rather than a stepwise procedure. Discussion of such a choice based on the situation is presented.

Example 3

This study examined the effects of acculturation on adolescent development, specifically focusing on daydreaming as one aspect of coping and adaptation. An investigation of two samples of acculturating (Hispanic and Native American) and acculturated (Caucasian) adolescents revealed two variables that, in combination, significantly differentiated the two groups. These two variables, fear of failure daydreams and distractibility, suggested that acculturating adolescents were more likely to report guilty and fearful daydreaming themes and less likely to report concentration difficulties than their acculturated coparts.

As in the previous examples, presentation of date and interpretability problems are discussed.

Importance

The examples presented provide ideas for alternative analysis in certain situations. Additionally, ideas regarding presentation of results will promote discussion among potential users.

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Significant Interaction - I Got What I Needed

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The test for interaction is seldom treated as a meaningful endeavor in statistics texts. Hence it would be expected that few researchers test such interesting questions. Two applied journals are surveyed for the number and generic kinds of interaction questions.

Few tested interaction hypotheses (other than seeing if their data met assumptions), although many had basically identified interaction hypotheses in their review of literature. Statistical techniques, such as Multiple Linear Regression, and computer programs exist to assist the researcher in testing interaction, directional interaction, curvilinear interaction, etc.

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Significant Interaction - I Got What I Needed

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Objective. To establish the rightful role of interaction as a critical phenomenon in and of itself.

Perspective. Most research design texts treat interaction as something in the way - something that must be tested - but that hopefully will be eliminated. Few authors lead one to consider the interaction question as a viable question. This is particularly underscored when no text discusses directional interaction.

Data Source. The paper surveys one year's publication of two educational journals. How interaction questions are treated will be tallied, with particular attention to "interesting" interaction questions - those given special names by researchers (e.g. aptitude by treatment interaction, gap analysis, and difference between two correlations).

Conclusions. It is expected that most researchers will obediently test for interaction, but not understand what they have done or why they have done it. Yet some of those researchers will have identified an interaction hypothesis in their review of literature. The few that will have tested for interaction wil have adopted one of the special approaches, not realizing that they could formulate the interaction question in the way they wanted. Finally, it is expected that none of the researchers will have tested for directional interaction, yet a few will have made directional interpretations.

Scientific Importance of the Study. Researchers need to view interaction as a significant phenomenon in and of itself. The ease with which Multiple Linear Regression can test interaction should encourage researchers to look for what they want, in order to find what they need.

LONGITUDINAL ANALYSIS OF SALARY DISCRIMINATION IN HIGHER EDUCATION

by

Robert L. Heiny, Samuel R. Houston, and John B. Cooney[1]

ABSTRACT

Legal and statistical issues associated with the use of multiple regression models in faculty discrimination cases in higher education are presented in this paper. Faculty salary models as a function of gender, rank, tenure status, ethnicity, academic discipline, and age variables are analyzed in a longitudinal study covering three years (1982-84) at the University of Northern Colorado. Declining student enrollment during the period saw the size of the faculty drop from a high of 480 in 1982 to a low of 382 in 1984. Results of the exploratory data analysis indicate declining roles for gender and ethnicity variables in explaining salary differences. While the contribution of academic discipline variables in the regression models was statistically significant, results seem consistent with institutional salary policies which were in effect at each point in time.

[1]Authors are faculty members of the University of Northern Colorado.

SUMMARY STATEMENT

A spate of salary discrimination (race, gender, and age) studies using multiple regression models has appeared in the literature during the past decade. The legal profession continues to be concerned about what is perceived as a "contest" between competing statisticians as they argue complex theoretical issues in statistics. The resolution of legal cases only too often seems to depend on the debating skills of an articulate statistician in such areas as the use of multiple regression as a valid legal procedure, use of inappropriate and/or disguised pseudo-evaluative variables, collinearity problems in regression models, uses and abuses of canonical analytic methods, etc. Part one of this paper attempts to put into perspective the major legal and common statistical issues found in salary discrimination cases in higher education.

A second part of the paper will be a longitudinal study of the University of Northern Colorado (UNC) covering the three academic years between 1982 and 1985. With careful attention paid to the concerns raised about regression models in judical cases involving race, gender, and age discrimination, several faculty salary models are formulated using multiple linear regression. The number of faculty vary from a high of 480 in 1982-83 to a low of 382 in 1984-85. The change in the number of faculty members is explained by declining student enrollments during this period. What emerges from the exploratory data analysis are results consistent with the changing role of UNC to a multi-purpose university and corresponding changes in institutional salary policies. Gender and ethnicity variables seem to appear as less important factors in explaining salary differences. While the contribution of academic discipline variables, tenure status and rank variables are statistically significant, their relationships to salary seem consistent with evolving institutional patterns reflecting salary policies. Multiple regression models supported by appropriate follow-up canonical correlation and discriminant analyses were used in the data analysis.

In addition to analyzing salary data obtained as part of the three-year longitudinal study at UNC, specific suggestions are given for subsequent research in the third part of the paper. The recommendations are sensitive not only to the legal and statistical issues raised in the first part of the paper but are consistent with results obtained from the exploratory data analysis.

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Method
Results
Discussion (conclusion)
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