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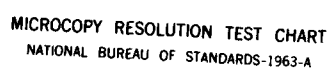
DOCUMENTATION OF ELEVEN PROGRAMS FOR THE
HEWLETT-PACKARD 97 CALCULATOR(U) NAVAL HEALTH RESEARCH
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DOCUMENTATION OF ELEVEN PROGRAMS
FOR THE HEWLETT-PACKARD 97 CALCULATOR

W. M. PUGH

REPORT NO. 79-10



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DOCUMENTATION OF ELEVEN PROGRAMS
FOR THE HEWLETT-PACKARD 97 CALCULATOR*

William M. Pugh

Naval Health Research Center
P.O. Box 85122
San Diego, California 92138

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Documentation of Eleven Programs
for the Hewlett-Packard 97 Calculator

by

William M. Pugh
Naval Health Research Center
San Diego, California 92152



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INTRODUCTION

Introduction

This report contains documentation on eleven separate programs developed for the Hewlett-Packard HP-97 programmable calculator. Nine of these programs are statistical routines that differ from most of the available programs which are designed to receive raw data values as input. Instead, the input for the routines contained in this report is summary information commonly printed out when statistical analyses are performed on large computer systems.

By accepting such intermediate data as input, these routines offer several advantages to the researcher. First, it allows him to operate in an² "interactive mode" with the data. For example, one can try several combinations of variables in a regression equation and observe how the beta weights³ "behave" as variables are added and deleted. Second, the results are immediately available and can be obtained at any time and wherever the researcher may be. Finally, there is the money saved by reducing the number of analyses run on large computer systems.

The documentation of each program includes the type of analyses performed, the input required, and options available. Also, any program limits or special procedures for preparing the data are specified. A step by step set of instructions is provided together with test data and the output that results when the program is properly executed. Finally, the relevant formula⁴ and a program listing are included with each program.

At the end of this report is an index which lists the various tests performed by these programs and the coefficients computed. The index was provided because many of the programs generate several statistical indices.

Before operating these programs it is strongly recommended that the user read the first four sections (through p. 75) of the HP-97 Owner's Handbook and Programming Guide. Among the topics discussed in these sections are: the use of the switches on the calculator, how to use a prerecorded program, how to control the display, how to enter negative numbers, and how to perform calculations from the keyboard. A brief outline of the procedures to run the programs in this report are as follows:

- a) The Pgrm-Run switch should be set on Run,
- b) The Man-Trace-Norm switch should be set on Man,
- c) Turn the Off-On switch to On,
- d) Insert program card into the machine,
- e) If the display reads Crd, insert the other side of the card into the machine,
- f) Follow the step by step instructions provided in the program documentation.

In addition, the user should be aware that to enter negative numbers one should enter the numerical digits first then press the CHS key to change the sign. Also, to display and print out more (or fewer) digits, press the DSP and then a number corresponding to the number of digits to be displayed. Again, the user is urged to read the Owner's Handbook for a complete discussion of these and other procedures.

STATISTICAL

PROGRAMS

Chi Square Computation

Program Summary

This program computes the chi square value from the cell and column totals of a bivariate frequency matrix. The method of computation was described by McNemar (1969, p. 267).

Instructions for Running ProgramProgram limits:

The number of rows in the frequency matrix must not exceed ten. There is no limit on the number of columns.

Data preparation:

Before this program can be executed, the cell frequencies must be summed within each column to produce column totals. It is not necessary to compute row totals, however.

Program execution:Step

- 1 Enter program.
- 2 Press E.
- 3 Enter column total and press A.
- 4 Enter each of the cell frequencies in the column, pressing B after each cell value.
- * Repeat Steps 3 and 4 for each column. That is: Enter a column total, press A. Then enter each cell frequency in that column, pressing B after each cell value until all the data is entered.
- 5 After all the data has been entered, press C to compute the chi square value (χ^2). Note: The degrees of freedom for the chi square is the number of rows minus one multiplied by the number of columns minus one (i.e., $df = [R-1], [C-1]$).
- * To compute a new chi square, go to Step 2.

Test Data

		<u>Column</u>		
		I	II	III
<u>Row</u>	I	50	30	20
	II	60	70	40
	III	10	20	30
Column Totals		120	120	90

Program results:

$$\chi^2 = 28.09$$

Formula:

$$\chi^2 = \left(\sum_{i=1}^R \sum_{j=1}^C f_{ij} \right) \left\{ \sum_{k=1}^R \left[\sum_{j=1}^C (f_{kj}^2 / \left(\sum_{i=1}^R f_{ij} \right)) \right] / \left(\sum_{j=1}^C f_{kj} \right) \right\} - 1$$

(See McNemar, 1969; p. 267).

Program Listing:

001				001			12	-35
002				002			12	35 05
003				003			125	-24
004				004	GT02	22 02	126	FCL4
005				005		01	127	35 04
006				006		-45	128	-35
007				007		16 02	129	ST04
008				008	ST03	35 03	130	35 04
009	*LBL-	21 11		009	ST05	22 05	131	X*Y?
010	ST0-	35 11		010	*LBL2	21 02	132	ST04
011	RCL5	36 12		011		-62	133	22
012	+	-55		012		05	134	RCL5
013	ST06	35 12		013	X=Y?	16-35	135	36
014	0	00		014	ST03	22 03	136	X
015	ST01	35 45		015	X*Y	-41	137	1
016	RTN	24		016		01	138	X*Y
017	*LBL5	21 12		017		-45	139	-45
018	ST+1	35-55 45		018	STX3	35-35 05	140	RTN
019	X?	53		019	ST02	22 02	141	24
020	F2S	16-51		020	*LBL3	21 03	142	51
021	RCL4	36 11		021	P1	16-24		
022	=	-24		022	JX	54		
023	ST+1	35-53 45		023	RCL3	36 03		
024	P2S	16-51		024	X	-35		
025	ISZ1	16 25 45		025	ST03	35 03		
026	RCL1	36 45		026	*LBL5	21 05		
027	RTN	24		027	RCL7	36 07		
028	*LBLC	21 13		028	ST02	35 12		
029	DSZ1	16 25 4		029	RCL1	36		
030	GT06	22 0		030		1		
031	GT01	22 0		031		-		
032	*LBL0	21 01		032	Y*	3		
033	GSBD	23 14		033	RCL2	36 02		
034	GT00	22 13		034	2	02		
035	*LBL1	21 01		035	=	-24		
036	GSBD	23 14		036	CHS	-22		
037	RCLC	36 13		037	e*	33		
038	1	01		038	X	-35		
039	-	-45		039	2	02		
040	RCL5	36 12		040	RCL1	36 01		
041	X	-35		041	Y*	31		
042	ST07	35 07		042	=	-24		
043	RTN	24		043	RCL3	36 03		
044	*LELD	21 14		044	=	-24		
045	F2S	16-51		045	ST05	35 05		
046	RCL1	36 45		046	RCL7	36 07		
047	F2S	16-51		047	RCL2	36 02		
048	RCL1	36 45		048	RCL1	36 01		
049	+	-24		049	+	-24		
050	RCLC	36 13		050	STX5	35-35 05		
051	+	-55		051	2	02		
052	ST00	35 10		052	RCL1	36 01		
053	RTN	24		053	X	-35		
054	*LBL6	21 15 11		054	ST06	35 06		
055	1	01		055	1	01		
056	ST03	35 03		056	ST04	35 04		
0		-41		057	*LBL4	21 04		
1		02				36 02		
		124				35 05		
		001				02		

t-Tests for the Difference between Means

Program Summary

This program will compute the t value between uncorrelated means or between correlated means. The t -test between uncorrelated means requires input of the N , mean, and standard deviation of measures for both groups. The t -test between correlated means can be computed using either the N , mean, and standard deviation of the measures for each group and the correlation between the measures, or, the mean and standard deviation of the difference between each pair of measures.

Instructions for Running Program

Data preparation:

Standard deviations should be computed as sample estimates of the population value. Thus, standard deviations should be computed as follows:

$$S = [\sum (x - \bar{x})^2 / (N-1)]^{1/2}.$$

Note, the denominator is $(N-1)$ rather than N .

Program execution:

Enter program. If measures are uncorrelated, follow procedure for Case I. If measures are correlated, follow procedure for Case II.

Case I (t-test for uncorrelated measures):

Step

- 1 Press E.
- 2 Enter mean for group 1 ($\bar{x}_1$), press A*.
- 3 Enter standard deviation for group 1 (S_1), press A.
- 4 Enter frequency for group 1 (N_1), press A.
- 5 Enter $\bar{x}_2$, press A.
- 6 Enter S_2 , press A.
- 7 Enter N_2 , press A.
- 8 Press B, and the t value with $N_1 + N_2 - 2$ degrees of freedom is displayed.

Case II (t-test for correlated measures):

Procedure A. This procedure uses the N , mean, and standard deviation of each group and the correlation between the measures of the two groups.

Step

- 1 Press E.
- 2 Enter mean for group 1 ($\bar{x}_1$), press A*.
- 3 Enter standard deviation for group 1 (S_1), press A.
- 4 Enter frequency for group 1 (N_1), press A.
- 5 Enter $\bar{x}_2$, press A.
- 6 Enter S_2 , press A.
- 7 Enter the correlation between the measures (r_{12}), press C, and the t value with N_1-1 degrees of freedom is displayed.
Note: The degrees of freedom is the number of pairs minus one.

Procedure B. This procedure uses input based on the differences between data pairs. The N is the number of pairs. The mean and standard deviations are computed on the difference scores.

Step

- 1 Press E.
- 2 Enter the mean of the difference scores (M_D), press A*.
- 3 Enter the standard deviation of the difference scores, press A.
- 4 Enter the number of pairs of data points (N), press A.
- 5 Press D, and the t value with $N-1$ degrees of freedom is displayed.

*If an incorrect value has been entered and A has been pressed, press fA and then enter the correct value. If more than one value needs correction, press fA for each step you wish to back up.

Test DataData set 1:Raw Data

	<u>Group 1</u>	<u>Group 2</u>	<u>Difference Scores</u>
	1	1	0
	1	2	-1
	1	3	-2
	1	4	-3
	2	1	1
	2	2	0
	2	3	-1
	2	4	-2
$\bar{x}$	1.500	2.500	-1.000
S	.535	1.195	1.309
N	8	8	8

$$r_{12} = 0.0$$

Program results:

Case I: $t = 2.160$ Case II: Procedure A, $t = 2.160$
Procedure B, $t = 2.161$

Data set 2:

Raw Data

	<u>Group 1</u>	<u>Group 2</u>	<u>Difference Scores</u>
	1	1	0
	1	2	-1
	2	3	-1
	2	4	-2
	3	5	-2
	3	6	-3
$\bar{x}$	2.000	3.500	-1.500
S	.894	1.871	1.049
N	6	6	6

$$r_{12} = .956$$

Program results:

Case I: $t = 1.772$ Case II: Procedure A, $t = 3.501$
Procedure B, $t = 3.503$ Formulae

Case I:

$$t = (\bar{x}_1 - \bar{x}_2) / \left\{ \left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left\{ \frac{(N_1 + N_2)}{(N_1 N_2)} \right\} \right\}^{1/2}$$

Case II:

Procedure A

$$t = [(\bar{x}_1 - \bar{x}_2)N_1^{1/2}] / (S_1^2 + S_2^2 - 2r_{12}S_1S_2)^{1/2}$$

Procedure B

$$t = (\bar{x}_{(1-2)} \sqrt{N_{(1-2)}}) / S_{(1-2)}$$

Note: The above formulæ are equivalent to those found in Hays (1963) on pages 320 and 335. However, in the present equation, S is the sample estimate of the standard deviation rather than the population value.

Program Listing:

007	STOI	35 45			
008	FTN	24			
009	*LELA	21 11			
010	STOI	18 35 45			
011	STOI	35 45			
012	FTN	24			
013	*LELE	21 11			
014	RCL1	36 01			
015	RCL4	36 04			
016	-	-45			
017	RCL3	36 03			
018	1	01			
019	-	-45			
020	RCL2	36 02			
021	X ²	53			
022	X	-35			
023	X	-35			
024	+	-55			
025	RCL3	36 03			
026	RCL6	36 06			
027	+	-55			
028	2	02			
029	-	-45			
030	÷	-24			
031	RCL3	36 03			
032	RCL6	36 06			
033	+	-55			
034	X	-35			
035	RCL3	36 03			
036	RCL6	36 06			
037	X	-35			
038	÷	-24			
039	JX	54			
040	÷	-24			
041	RTN	24			
042	*LBLE	21 11			
043	STOI	35			
044	RCL1	36			
045	RCL4	36			
046	-	-			
047	RCL3	36			
048	JX	54			
049	-	-35			
050	RCL2	36 02			
051	X ²	53			
052	RCL5	36 05			
053	X ²	53			
054	+	-55			
055	2	02			
056	-	36 07			
057	-	-			
064	-	54			
065	÷	-24			
066	RTN	24			
067	*LBLE	21 11			
068	RCL1	36 01			
069	RCL3	36 0			
070	JX	-			
071	X	-			
072	RCL2	36			
073	÷	-24			
074	RTN	24			
075	*LBLE	21 11 11			
076	RCL1	36 01			
077	1	01			
078	-	-45			
079	STOI	35 46			
080	RTN	24			
081	R/S	51			

One-way ANOVA

Program Summary

Given the N, mean, and standard deviation of two or more groups, this program computes the grand N, mean, and standard deviation. In addition, it computes the percentage of the total variance that occurs between groups (R^2) and F -ratio for the between-group versus within-group variance (i.e., performs a one-way ANOVA).

Instructions for Running ProgramData preparation:

The group standard deviations should be computed as sample estimates of the population values. Thus, group standard deviations should be computed as follows:

$$S = [\sum (x - \bar{x})^2 / (N - 1)]^{1/2}$$

Program execution:Step

- 1 Enter program.
- 2 Press E.
- 3 If only the grand N and mean are to be computed, press fa.
- 4 If output is to be printed, press fb.
- 5 Enter data. If fa was pressed, enter group N, press ↑; enter group mean, press A.
If fa was not pressed, enter group N, press ↑; enter group mean, press ↑; enter group standard deviation, press A.
- * Repeat Step 5 for each group until the data for each group have been entered.
- 6 Press B to compute the grand N.
- 7 Press C to compute the grand mean.
- 8 Press D to compute the grand standard deviation. Note: D must be pressed before either the R^2 or the F -ratio can be computed.
- 9 Press fc to compute R^2 (the correlation ratio or the percentage of the total variance that occurs between groups).
- 10 Press fd to compute the F -ratio for comparing the between-group and within-group variance.
- 11 Press fe to display the degrees of freedom for the above F -ratio. First, the between-group degrees of freedom is shown, then after a pause, the degrees of freedom for the residual is shown.

Test Data

	<u>Raw Data</u>		
	<u>Group 1</u>	<u>Group 2</u>	<u>Group 3</u>
	3	4	9
	2	3	8
	7	1	6
		2	
		<u>1</u>	
$\bar{x}$	4.000	2.200	7.667
S	2.646	1.304	1.528
N	3	5	3

Program results:

$$N_T = 11$$

$$\bar{x}_T = 4.182$$

$$S_T = 2.857$$

$$R^2 = .688$$

$$F = 8.821$$

$$df = 2 \text{ \& } 8$$

Formulae

$$N_T = \sum_{j=1}^G n_j$$

where G = the number of groups

$$\bar{x}_T = \frac{\sum_{j=1}^G (n_j \bar{x}_j)}{N}$$

$$S_T = [SS_T / (N-1)]^{1/2}$$

$$\text{where } SS_T = \sum_{j=1}^G S_j^2 (n_j - 1) + \sum_{j=1}^G n_j \bar{x}_j^2 - \left(\sum_{j=1}^G n_j \bar{x}_j \right)^2 / N$$

$$R^2 = [SS_T - \sum_{j=1}^G S_j^2 (n_j - 1)] / SS_T$$

$$F = \{[SS_T - \sum_{j=1}^G S_j^2 (n_j - 1)] / (G - 1)\} / \{[\sum_{j=1}^G S_j^2 (n_j - 1)] / (N - G)\}$$

degrees of freedom:

between = G-1

residual = N-G

Note: see McNemar, 1969, Chapter 15 for ANOVA rationale.

Program Listing:

001			
002			
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Multiple Regression

Program Summary

Given the intercorrelation among a set of variables, the program will compute the multiple correlation of 2 to 6 predictor (independent) variables with a criterion (dependent) variable. Further, it will compute the standardized regression weight (beta weight) for each predictor variable. In addition, if the mean value and standard deviation is available for each variable, this program will compute the regression weights and constant for the raw variable scores. The computation methods are based upon the square root method developed by Summerfield and Lubin (1951) and Lubin and Summerfield (1951).

Instructions for Running ProgramProgram limits:

A maximum of six predictors can be used in a single equation.

Data preparation:

Let P = predictor, C = criterion, M = mean, and S = standard deviation. Set up the data to be analyzed in the following manner:

	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	
P ₁							M ₁ S ₁
P ₂	r ₂₁						M ₂ S ₂
P ₃	r ₃₁	r ₃₂					M ₃ S ₃
P ₄	r ₄₁	r ₄₂	r ₄₃				M ₄ S ₄
P ₅	r ₅₁	r ₅₂	r ₅₃	r ₅₄			M ₅ S ₅
P ₆	r ₆₁	r ₆₂	r ₆₃	r ₆₄	r ₆₅		M ₆ S ₆
C	r _{C1}	r _{C2}	r _{C3}	r _{C4}	r _{C5}	r _{C6}	M _C S _C

Program execution:

Section I

Step

- 1 Enter card 1 (MR1).
- 2 Press E.

Step

- 3 Press A, then enter intercorrelations among predictors by row, pressing R/S after each value. That is, after pressing A, enter the r_{21} value, press R/S, enter the r_{31} value, press R/S, enter the r_{32} value, press R/S, etc., until all the correlations among the predictors are entered.
- * If the same set of predictors is used to predict multiple criteria, press f write data and enter a blank card. Then for each successive criterion enter card 1 (MR1), enter the data card, and then execute the program from Step 4 (i.e., press B).
- 4 Press B, enter the correlations between the predictor and the criterion, pressing R/S after each value. That is, after pressing B, enter r_{C1} , press R/S, enter r_{C2} , press R/S, etc., until each predictor-criterion correlation has been entered.
- 5 Press C.
- * If there are 3 or more predictors, proceed to Section II. Execute Steps 6 through 12 only if there are 2 predictors.
- 6 Press fa; the multiple correlation will be printed.
- 7 Press fb; the beta weights for P_1 and then P_2 will be printed.
- 8 If variable means and standard deviations are available and regression weights are desired, press fc, and execute remaining steps.
- 9 Enter M_C , press enter ↑.
- 10 Enter S_C , press R/S.
- 11 Enter the means and standard deviations for the respective predictors in the same manner (i.e., M_1 , ↑, S_1 , R/S, M_2 , ↑, S_2 , R/S).
- * After the mean and standard deviation for each predictor is entered, the regression weight is printed. Note: The value displayed in the X register is not the regression weight.
- 12 After the regression weights are printed, press fd and the regression constant will be printed.

Section II

Step

- 1 After executing steps 1 through 5 of Section I, enter card 2 (MR2).
- 2 Press A and the multiple correlation will be printed.

Section III

Step

- 1 Enter card 3 (MR3).
- * Option A: If card 2 (MR2) has just been executed, Press A and the beta weight for each predictor will be printed.^a
- * Option B: If beta weights are already available and regression weights are desired, Press B. Then enter the beta weight for each predictor, pressing R/S after each value. That is, enter β_1 and press R/S, enter β_2 , press R/S, etc.
- 2 If regression weights are desired and either option A or B has been executed, Press C.
- 3 Enter M_C and press $\uparrow$.
- 4 Enter S_C and press R/S.
- 5 Enter the means and standard deviations for the respective predictors in the same manner (i.e., $M_1, \uparrow, S_1, R/S, M_2, \uparrow, S_2, R/S$, etc.).
- * After the mean and standard deviation for each predictor is entered, the regression weight is printed. Note: The value displayed in the X register is not the regression weight.
- 6 After the regression weights are printed, press D and the regression constant will be printed.

Test Data

	P_1	P_2	P_3	P_4	M	S
P_1					14.27	3.14
P_2	.04				3.14	1.24
P_3	.17	.01			2.17	2.11
P_4	.06	.11	.09		.89	.57
C	.23	.34	.27	.41	5.22	1.48

^aBefore computing beta weights, consider inspecting the following registers: primary register 6, secondary registers 0 and 5, and registers C and I. These registers represent the tolerance values for predictor variables 2, 3, 4, 5 and 6, respectively. It is suggested that a variable with a tolerance of less than .05 be deleted from the analysis since that variable is virtually linearly dependent with one or more of the preceding variables. If one of these values reaches zero, it is entirely linearly dependent and its beta weight cannot be computed (i.e., Error will be displayed if one attempts to compute the beta weight via Option A).

Program results:

Multiple Correlation = .580

Predictor	Beta Weights	Regression Weights
P ₁	$\beta_1 = .162$	$B_1 = .076$
P ₂	$\beta_2 = .293$	$B_2 = .350$
P ₃	$\beta_3 = .208$	$B_3 = .146$
P ₄	$\beta_4 = .349$	$B_4 = .907$

Constant = 1.909

Formulae

The computations in this program are based upon the square root method developed by Summerfield and Lubin (1951) and Lubin and Summerfield (1951). The correspondence between the HP-97 storage registers and a data matrix of 6 predictors and 1 criterion by 6 predictors is as follows:

		Predictors					
		1	2	3	4	5	6
Predictors	1						
	2	R ₀	R ₆				
	3	R ₁	R ₇	R _{S0}			
	4	R ₂	R ₈	R _{S1}	R _{S5}		
	5	R ₃	R ₉	R _{S2}	R _{S6}	R _C	
	6	R ₄	R _A	R _{S3}	R _{S7}	R _D	R _I
Criterion	7	R ₅	R _B	R _{S4}	R _{S8}	R _E	R _{S9}

where R₀ - R₉ = primary registers and R_{S0} - R_{S9} = secondary registers, the values contained in these registers are as follows:

Storage
Registers

R₀ r₁₂

R₁ r₁₃

R₂ r₁₄

R₃ r₁₅

R₄ r₁₆

R₅ r₁₇

R₆ -- r_{2(2.1)} = $\sqrt{1-r_{12}^2}$

R₇ r₂₃ r_{3(2.1)} = $\frac{r_{23}-r_{12}r_{13}}{\sqrt{1-r_{12}^2}}$

R₈ r₂₄ r_{4(2.1)} = $\frac{r_{24}-r_{12}r_{14}}{\sqrt{1-r_{12}^2}}$

R₉ r₂₅ r_{5(2.1)} = $\frac{r_{25}-r_{12}r_{15}}{\sqrt{1-r_{12}^2}}$

R_A r₂₆ r_{6(2.1)} = $\frac{r_{26}-r_{12}r_{16}}{\sqrt{1-r_{12}^2}}$

$$B_1 = r_{17}-B_2r_{12}-B_3r_{13}-B_4r_{14}-B_5r_{15}-B_6r_{16}$$

R_B r₂₇ r_{7(2.1)} = $\frac{r_{27}-r_{12}r_{17}}{\sqrt{1-r_{12}^2}}$

$$B_2 = (r_{7(2.1)}-B_3r_{3(2.1)}-B_4r_{4(2.1)}-B_5r_{5(2.1)}-B_6r_{6(2.1)})/r_{2(2.1)}$$

R_{S0} -- r_{3(3.1, 2)} = $\sqrt{1-r_{13}^2-r_{3(2.1)}^2}$

R_{S1} r₃₄ r_{4(3.1, 2)} = $(r_{34}-r_{13}r_{14}-r_{3(2.1)}r_{4(2.1)}) / r_{3(3.1, 2)}$

R_{S2} r₃₅ r_{5(3.1, 2)} = $(r_{35}-r_{13}r_{15}-r_{3(2.1)}r_{5(2.1)}) / r_{3(3.1, 2)}$

R_{S3} r₃₆ r_{6(3.1, 2)} = $(r_{36}-r_{13}r_{16}-r_{3(2.1)}r_{6(2.1)}) / r_{3(3.1, 2)}$

Storage
Registers

$$R_{S4} \quad r_{37} \quad r_{7(4.1, 2)} = (r_{37} - r_{13}r_{17} - r_{3(2.1)}r_{7(2.1)}) / r_{3(3.1, 2)}$$

$$R_{S5} \quad -- \quad r_{4(4.1, 2, 3)} = \sqrt{1 - r_{14}^2 - r_{4(2.1)}^2 - r_{4(3.1, 2)}^2}$$

$$R_{S6} \quad r_{45} \quad r_{5(4.1, 2, 3)} = (r_{45} - r_{14}r_{15} - r_{4(2.1)}r_{5(2.1)} - r_{4(3.1, 2)}r_{5(3.1, 2)}) / r_{4(4.1, 2, 3)}$$

$$R_{S7} \quad r_{46} \quad r_{6(4.1, 2, 3)} = (r_{46} - r_{14}r_{16} - r_{4(2.1)}r_{6(2.1)} - r_{4(3.1, 2)}r_{6(3.1, 2)}) / r_{4(4.1, 2, 3)}$$

$$R_{S8} \quad r_{47} \quad r_{7(4.1, 2, 3)} = (r_{47} - r_{14}r_{17} - r_{4(2.1)}r_{7(2.1)} - r_{4(3.1, 2)}r_{7(3.1, 2)}) / r_{4(4.1, 2, 3)}$$

$$R_{S9} \quad *r_{67} \quad r_{7(6.1, 2, 3, 4, 5)} = (r_{67} - r_{16}r_{17} - r_{6(2.1)}r_{7(2.1)} - r_{6(3.1, 2)}r_{7(3.1, 2)} - r_{6(4.1, 2, 3)}r_{7(4.1, 2, 3)} - r_{6(5.1, 2, 3, 4)}r_{7(5.1, 2, 3, 4)}) / r_{6(6.1, 2, 3, 4, 5)}$$

$$R_C \quad -- \quad r_{5(5.1, 2, 3, 4)} = \sqrt{1 - r_{15}^2 - r_{5(2.1)}^2 - r_{5(3.1, 2)}^2 - r_{5(4.1, 2, 3)}^2} \\ B_3 = (r_{7(3.1, 2)}^{-B_4} r_{4(3.1, 2)}^{-B_5} r_{5(3.1, 2)}^{-B_6} r_{6(3.1, 2)}) / r_{3(3.1, 2)}$$

$$R_D \quad r_{56} \quad r_{6(5.1, 2, 3, 4)} = (r_{56} - r_{15}r_{16} - r_{5(2.1)}r_{6(2.1)} - r_{5(3.1, 2)}r_{6(3.1, 2)} - r_{5(4.1, 2, 3)}r_{6(4.1, 2, 3)}) / r_{5(5.1, 2, 3, 4)} \\ B_4 = (r_{7(4.1, 2, 3)}^{-B_5} r_{5(4.1, 2, 3)}^{-B_6} r_{6(4.1, 2, 3)}) / r_{4(4.1, 2, 3)}$$

Storage
Registers

$$R_E \quad r_{57} \quad r_{7(5.1, 2, 3, 4)} = (r_{57} r_{15} r_{17} r_{5(2.1)} r_{7(2.1)} r_{5(3.1, 2)} r_{7(3.1, 2)} r_{5(4.1, 2, 3)} r_{7(4.1, 2, 3)}) /$$

$$B_5 = \frac{r_{5(5.1, 2, 3, 4)} (r_{7(5.1, 2, 3, 4)}^{-B_6} r_{6(5.1, 2, 3, 4)})}{r_{5(5.1, 2, 3, 4)}}$$

$$R_I \quad -- \quad r_{6(6.1, 2, 3, 4, 5)} = \sqrt{1 - r_{16}^2 - r_{6(2.1)}^2 - r_{6(3.1, 2)}^2 -$$

$$r_{6(4.1, 2, 3)}^2 - r_{6(5.1, 2, 3, 4)}^2}$$

$$B_6 = \frac{r_{7(6.1, 2, 3, 4, 5)}}{r_{6(6.1, 2, 3, 4, 5)}}$$

Multiple R

$$R = \sqrt{1 - (1 - r_{17}^2 - r_{7(2.1)}^2 - r_{7(3.1, 2)}^2 - r_{7(4.1, 2, 3)}^2 - r_{7(5.1, 2, 3, 4)}^2 - r_{7(6.1, 2, 3, 4, 5)}^2)}$$

Note: *** $y' = B_1 \frac{S_c}{S_1} X_1 + B_2 \frac{S_c}{S_2} X_2 + B_3 \frac{S_c}{S_3} X_3 + B_4 \frac{S_c}{S_4} X_4 + B_5 \frac{S_c}{S_5} X_5 + B_6 \frac{S_c}{S_6} X_6$

$$+ (M_c - B_1 \frac{S_c}{S_1} M_1 - B_2 \frac{S_c}{S_2} M_2 - B_3 \frac{S_c}{S_3} M_3 - B_4 \frac{S_c}{S_4} M_4 - B_5 \frac{S_c}{S_5} M_5 - B_6 \frac{S_c}{S_6} M_6)$$

Program Listing:

LINE	ITEM	QTY	UNIT	PRICE	TOTAL	DATE	REMARKS
001	WELB	1	EA	10.00	10.00	10-51	
002	WELB	1	EA	10.00	10.00	10-51	
003	F28	16	EA	5.00	80.00	10-51	
004	WELB	1	EA	10.00	10.00	10-51	
005	WELB	1	EA	10.00	10.00	10-51	
006	RTN	1	EA	10.00	10.00	10-51	
007	WELB	21	EA	5.00	105.00	10-51	
008	F28	35	EA	5.00	175.00	10-51	
009	WELB	27	EA	5.00	135.00	10-51	
010	WELB	35	EA	5.00	175.00	10-51	
011	+	-24			-24.00	10-51	
012	RTN	34			34.00	10-51	
013	WELB	21	EA	5.00	105.00	10-51	
014	+	-35			-35.00	10-51	
015	+	-45			-45.00	10-51	
016	RTN	24			24.00	10-51	
017	WELB	21	EA	5.00	105.00	10-51	
018	R/S	51			51.00	10-51	
019	STOB	35	EA	5.00	175.00	10-51	
020	R/S	51			51.00	10-51	
021	STOB	35	EA	5.00	175.00	10-51	
022	R/S	51			51.00	10-51	
023	STOB	35	EA	5.00	175.00	10-51	
024	R/S	51			51.00	10-51	
025	STOB	35	EA	5.00	175.00	10-51	
026	F28	51			51.00	10-51	
027	STOB	35	EA	5.00	175.00	10-51	
028	F28	51			51.00	10-51	
029	F28	16-51			80.00	10-51	
030	STOB	35	EA	5.00	175.00	10-51	
031	F28	16-51			80.00	10-51	
032	R/S	51			51.00	10-51	
033	STOB	35	EA	5.00	175.00	10-51	
034	R/S	51			51.00	10-51	
035	STOB	35	EA	5.00	175.00	10-51	
036	R/S	51			51.00	10-51	
037	F28	16-51			80.00	10-51	
038	STOB	35	EA	5.00	175.00	10-51	
039	R/S	51			51.00	10-51	
040	STOB	35	EA	5.00	175.00	10-51	
041	F28	16-51			80.00	10-51	
042	F28	51			51.00	10-51	
043	STOB	35	EA	5.00	175.00	10-51	
044	R/S	51			51.00	10-51	
045	STOB	35	EA	5.00	175.00	10-51	
046	F28	51			51.00	10-51	
047	F28	16-51			80.00	10-51	
048	STOB	35	EA	5.00	175.00	10-51	
049	F28	51			51.00	10-51	
050	STOB	35	EA	5.00	175.00	10-51	
051	F28	16-51			80.00	10-51	
052	F28	51			51.00	10-51	
053	STOB	35	EA	5.00	175.00	10-51	
054	STOB	21	EA	5.00	105.00	10-51	
055	STOB	35	EA	5.00	175.00	10-51	
056	STOB	35	EA	5.00	175.00	10-51	
057	STOB	35	EA	5.00	175.00	10-51	
058	STOB	35	EA	5.00	175.00	10-51	
059	STOB	35	EA	5.00	175.00	10-51	
060	STOB	35	EA	5.00	175.00	10-51	
061	STOB	35	EA	5.00	175.00	10-51	
062	STOB	35	EA	5.00	175.00	10-51	
063	STOB	35	EA	5.00	175.00	10-51	</

001	ST01	35 01	001	ST01	35 01	001	ST01	35 01
002	ST02	35 02	002	ST02	35 02	002	ST02	35 02
003	ST03	35 03	003	ST03	35 03	003	ST03	35 03
004	ST04	35 04	004	ST04	35 04	004	ST04	35 04
005	ST05	35 05	005	ST05	35 05	005	ST05	35 05
006	ST06	35 06	006	ST06	35 06	006	ST06	35 06
007	ST07	35 07	007	ST07	35 07	007	ST07	35 07
008	ST08	35 08	008	ST08	35 08	008	ST08	35 08
009	ST09	35 09	009	ST09	35 09	009	ST09	35 09
010	ST10	35 10	010	ST10	35 10	010	ST10	35 10
011	ST11	35 11	011	ST11	35 11	011	ST11	35 11
012	ST12	35 12	012	ST12	35 12	012	ST12	35 12
013	ST13	35 13	013	ST13	35 13	013	ST13	35 13
014	ST14	35 14	014	ST14	35 14	014	ST14	35 14
015	ST15	35 15	015	ST15	35 15	015	ST15	35 15
016	ST16	35 16	016	ST16	35 16	016	ST16	35 16
017	ST17	35 17	017	ST17	35 17	017	ST17	35 17
018	ST18	35 18	018	ST18	35 18	018	ST18	35 18
019	ST19	35 19	019	ST19	35 19	019	ST19	35 19
020	ST20	35 20	020	ST20	35 20	020	ST20	35 20
021	ST21	35 21	021	ST21	35 21	021	ST21	35 21
022	ST22	35 22	022	ST22	35 22	022	ST22	35 22
023	ST23	35 23	023	ST23	35 23	023	ST23	35 23
024	ST24	35 24	024	ST24	35 24	024	ST24	35 24
025	ST25	35 25	025	ST25	35 25	025	ST25	35 25
026	ST26	35 26	026	ST26	35 26	026	ST26	35 26
027	ST27	35 27	027	ST27	35 27	027	ST27	35 27
028	ST28	35 28	028	ST28	35 28	028	ST28	35 28
029	ST29	35 29	029	ST29	35 29	029	ST29	35 29
030	ST30	35 30	030	ST30	35 30	030	ST30	35 30
031	ST31	35 31	031	ST31	35 31	031	ST31	35 31
032	ST32	35 32	032	ST32	35 32	032	ST32	35 32
033	ST33	35 33	033	ST33	35 33	033	ST33	35 33
034	ST34	35 34	034	ST34	35 34	034	ST34	35 34
035	ST35	35 35	035	ST35	35 35	035	ST35	35 35
036	ST36	35 36	036	ST36	35 36	036	ST36	35 36
037	ST37	35 37	037	ST37	35 37	037	ST37	35 37
038	ST38	35 38	038	ST38	35 38	038	ST38	35 38
039	ST39	35 39	039	ST39	35 39	039	ST39	35 39
040	ST40	35 40	040	ST40	35 40	040	ST40	35 40
041	ST41	35 41	041	ST41	35 41	041	ST41	35 41
042	ST42	35 42	042	ST42	35 42	042	ST42	35 42
043	ST43	35 43	043	ST43	35 43	043	ST43	35 43
044	ST44	35 44	044	ST44	35 44	044	ST44	35 44
045	ST45	35 45	045	ST45	35 45	045	ST45	35 45
046	ST46	35 46	046	ST46	35 46	046	ST46	35 46
047	ST47	35 47	047	ST47	35 47	047	ST47	35 47
048	ST48	35 48	048	ST48	35 48	048	ST48	35 48
049	ST49	35 49	049	ST49	35 49	049	ST49	35 49
050	ST50							

000	-30	060	01	35 01
001	-45	061	01	35 01
002	24	062	01	35 01
003	21 11	063	01	35 01
004	16-51	064	01	35 01
005	36 02	065	01	35 01
006	36 02	066	01	35 01
007	36 02	067	01	35 01
008	36 02	068	01	35 01
009	36 02	069	01	35 01
010	-24	070	01	35 01
011	35 45	071	01	35 01
012	36 15	072	01	35 01
013	36 45	073	01	35 01
014	36 14	074	01	35 01
015	36 14	075	01	35 01
016	36 14	076	01	35 01
017	-24	077	01	35 01
018	35 15	078	01	35 01
019	36 02	079	01	35 01
020	36 15	080	01	35 01
021	36 06	081	01	35 01
022	36 06	082	01	35 01
023	36 07	083	01	35 01
024	36 07	084	01	35 01
025	36 07	085	01	35 01
026	36 05	086	01	35 01
027	-24	087	01	35 01
028	35 14	088	01	35 01
029	36 04	089	01	35 01
030	36 14	090	01	35 01
031	36 01	091	01	35 01
032	36 02	092	01	35 01
033	36 15	093	01	35 01
034	36 02	094	01	35 01
035	36 02	095	01	35 01
036	36 46	096	01	35 01
037	36 03	097	01	35 01
038	36 02	098	01	35 01
039	36 02	099	01	35 01
040	-24	100	01	35 01
041	35 15	101	01	35 01
042	16-51	102	01	35 01
043	36 12	103	01	35 01
044	36 15	104	01	35 01
045	36 07	105	01	35 01
046	36 07	106	01	35 01
047	36 02	107	01	35 01
048	36 14	108	01	35 01
049	36 05	109	01	35 01
050	36 05	110	01	35 01
051	36 05	111	01	35 01
052	36 02	112	01	35 01
053	36 46	113	01	35 01
054	36 14	114	01	35 01
055	36 02	115	01	35 01
056	36 02	116	01	35 01
057	36 02	117	01	35 01
058	36 02	118	01	35 01
059	36 02	119	01	35 01
060	36 02	120	01	35 01
061	36 02	121	01	35 01
062	36 02	122	01	35 01
063	36 02	123	01	35 01
064	36 02	124	01	35 01
065	36 02	125	01	35 01
066	36 02	126	01	35 01
067	36 02	127	01	35 01
068	36 02	128	01	35 01
069	36 02	129	01	35 01
070	36 02	130	01	35 01
071	36 02	131	01	35 01
072	36 02	132	01	35 01
073	36 02	133	01	35 01
074	36 02	134	01	35 01
075	36 02	135	01	35 01
076	36 02	136	01	35 01
077	36 02	137	01	35 01
078	36 02	138	01	35 01
079	36 02	139	01	35 01
080	36 02	140	01	35 01
081	36 02	141	01	35 01
082	36 02	142	01	35 01
083	36 02	143	01	35 01
084	36 02	144	01	35 01
085	36 02	145	01	35 01
086	36 02	146	01	35 01
087	36 02	147	01	35 01
088	36 02	148	01	35 01
089	36 02	149	01	35 01
090	36 02	150	01	35 01
091	36 02	151	01	35 01
092	36 02	152	01	35 01
093	36 02	153	01	35 01
094	36 02	154	01	35 01
095	36 02	155	01	35 01
096	36 02	156	01	35 01
097	36 02	157	01	35 01
098	36 02	158	01	35 01
099	36 02	159	01	35 01
100	36 02	160	01	35 01
101	36 02	161	01	35 01
102	36 02	162	01	35 01
103	36 02	163	01	35 01
104	36 02	164	01	35 01
105	36 02	165	01	35 01
106	36 02	166	01	35 01
107	36 02	167	01	35 01
108	36 02	168	01	35 01
109	36 02	169	01	35 01
110	36 02	170	01	35 01
111	36 02	171	01	35 01
112	36 02	172	01	35 01
113	36 02	173	01	35 01
114	36 02	174	01	35 01
115	36 02	175	01	35 01
116	36 02	176	01	35 01
117	36 02	177	01	35 01
118	36 02	178	01	35 01
119	36 02	179	01	35 01
120	36 02	180	01	35 01
121	36 02	181	01	35 01
122	36 02	182	01	35 01
123	36 02	183	01	35 01

Scheffé t-testProgram Summary

After an ANOVA has been run on a data set and it has been determined that there is a significant difference among the group means, the Scheffé t-test can be used to identify which means are significantly different from each other. To make these post hoc comparisons, the user first enters the N, mean, and standard deviation of each group in the original ANOVA. Then the comparisons desired are selected and t-tests are performed. Significant differences are indicated by a flashing display. The computational procedures are based upon those described by McNemar (1969, pp. 323-324), and Hays (1963, pp. 485-487).

Instructions for Running Program

There can be a maximum of eight groups in the design.

Data Preparation:

The standard deviations should be estimates of the population value, i.e., $S = [\sum (x - \bar{x})^2 / (N-1)]^{1/2}$.

Program execution:Step

- 1 Enter program.
- 2 Press E.
- 3 Enter data set for group i.
 - * Enter n_i , press $\uparrow$.
 - * Enter $\bar{x}_i$, press $\uparrow$.
 - * Enter S_i , press A. Where n_i is the number of people in the i^{th} group, $\bar{x}_i$ is the mean and S_i the standard deviation.
 - * Repeat Step 3 for each group in the original ANOVA.
- 4 For the desired level of confidence (e.g., $p < .05$), look up the critical F value with $(G-1)$ and $(N-G)$ degrees of freedom, where N is the total number of people in the original ANOVA and G is the total number of groups. Enter this F value and press B.
- 5 Decide which groups are to be contrasted. The t value to be computed will reflect the difference between the mean values of the sets of groups contrasted. That is, each group in a contrast should be designated as being within set 1 or set 2 and then the test will be performed between the respective mean values.

Step

- * To designate groups, press C and a group number will be displayed (i.e., group 1). Then press:
 - 0 if group 1 is not to be used in the contrast
 - 1 if group 1 is to be designated as being in set 1
 - 2 if group 1 is to be designated as being in set 2.
- * Press R/S and the number of the next group will be displayed. Press 0, 1, or 2 to designate the data set the group is in and press R/S.
- * Repeat until the data for all groups to be designated as being in set 1 or 2 have been entered.
- 6 To compute the t value, press D. If this value is significant at the confidence level selected in Step 4 it will flash on and off; otherwise it will just stay on.
- * For the t to be significant it must be equal to or greater than K, where: $K = [(G-1) F_{(G-1), (N-G)}]^{1/2}$.
K can be retrieved by pressing RCL D.
- 7 To compute other contrasts on the same set of data, go to Step 4.

Test Data

	Group				
	1	2	3	4	5
n:	10	12	15	13	15
$\bar{x}$:	3.42	5.73	3.27	5.83	5.61
S:	1.21	1.34	1.17	1.44	1.48

Desired level of confidence: $p \leq .05$.

Program results:

Since the overall F-ratio for the above data is significant [$F = 12.29$, $p < .01$], it is legitimate to compute post hoc comparisons by the Scheffé method. Of the numerous contrasts that could be performed, 3 were selected for the purposes of illustration: 1) group 1 versus group 2, 2) group 1 versus group 3, and 3) group 1 and 3 versus groups 2, 4, and 5. Note: because the desired level of confidence is .05, the proper F value to use at Step 4 in each of the comparisons is 2.53. Test results:

<u>Comparison</u>	<u>t value</u>
Group 1 versus group 2	-4.03
Group 1 versus group 3	.27
Groups 1 and 3 versus groups 2, 4, and 5	-6.99

Formulae

The contrast difference (i.e., the mean difference being tested) is:

$$D' = [(\sum n_i \bar{x}_i) / \sum n_i] - [(\sum n_j \bar{x}_j) / \sum n_j]$$

where n_i and $\bar{x}_i$ are the number of people and the mean score for groups in set I and n_j and $\bar{x}_j$ are the corresponding values for groups in set II.

The error variance for the above contrast is:

$$S_{D'}^2 = S_W^2 (1 / \sum n_i + 1 / \sum n_j)$$

$$\text{where } S_W^2 = \frac{G}{\sum_g} S_g^2 (n_g - 1) / (N - G)$$

where G is the total number of groups and N is the total number of people (i.e., $\sum n_g$).

The t value is computed as follows: $t = D' / S_{D'}$

If this t value is equal to or greater than K , then it is considered significant. The K value is:

$$K = [(G-1) F_{(G-1), (N-G)}]^{1/2}$$

where $F_{(G-1), (N-G)}$ is the F value for the desired level of significance with $G-1$ and $N-G$ degrees of freedom.

Program Listing:

Alpha

Program Summary

Given the intercorrelations and standard deviations of a set of items, this program will compute Cronbach's coefficient alpha (Lord & Novick, 1968; pp. 88-89). In addition, the program can compute the correlation between a weighted or unweighted composite formed from the item set and another item. Finally, it is possible to use this program to compute the correlation between two composites from the item correlations and standard deviations.

Instructions for Running ProgramProgram limits:

A maximum of 18 items can be within an item set.

Data preparation:

Standard deviations are assumed to be sample estimates of the population parameters, i.e., $S = [(x - \bar{x})^2 / (N-1)]^{1/2}$.

- 1) To compute alpha or to form an unweighted composite, set up the input data as follows:

	Item						
	1	2	3	.	.	.	K
1							
2	r_{21}						
3	r_{31}	r_{32}					
.	.	.					
.	.	.					
.	.	.					
K	r_{K1}	r_{K2}	r_{K3}				
Standard Deviations	S_1^*	S_2	S_3	.	.	.	S_K

*If an item is to be reversed, make its standard deviation negative (i.e., -S).

- 2) To form a weighted composite (e.g., to apply validation sample regression weights to a cross-validation sample), set up the item intercorrelations as above. However, substitute U for each S where $U = SW$ and W is the item weight.

- 3) To correlate two composite scores, set up the data as described above and compute alpha values for the two item sets separately and for all the items as a single set. After each pass (i.e., once an alpha is computed), recall the values in the A and C registers by pressing RCL A and RCL C. Call these values for set I, A_I and C_I ; for set II, A_{II} and C_{II} ; for the combination A_{I+II} and C_{I+II} .

Program execution:

Step

- 1 Enter program.
- 2 Press E.
- 3 If computing alpha or forming an unweighted composite, enter item standard deviations, pressing A after each value (i.e., enter S_1 , press A, enter S_2 , press A, etc).
- * If forming a weighted composite, enter the U values in place of S values, pressing A after each value.
- 4 Enter the item correlations for the lower triangle of the correlation matrix by row pressing B after each value (i.e., enter r_{21} , press B, enter r_{31} , press B, enter r_{32} , press B, etc).
- 5 Press fa.
- * If alpha is being computed, the value displayed is the alpha coefficient.
- * If computing the correlation between composites, recall registers A and C.
- 6 To find the correlation between the composite of the above items and another item (y), press fb.
- * Then enter the correlation between each item in the composite and y, pressing R/S after each value (i.e., press fb, enter r_{1y} , press R/S, enter r_{2y} , press R/S, etc.).
- * After entering the final correlation, press fc and the item-composite correlation (r_{cy}) will be displayed.
- * To compute the correlation of the above composite with a new item, repeat Step 6.
- 7 To compute the correlation between two composites, press fd.
- * Enter A_I , press enter $\uparrow$,
Enter C_I , press R/S,
Enter A_{II} , press enter $\uparrow$,
Enter C_{II} , press R/S,
Enter A_{I+II} , press enter $\uparrow$,
Enter C_{I+II} , press R/S.
- * Press fe and $r_{I, II}$ will be printed followed by $r_{I, (I+II)}$.

Step

- * To compute r_{II} , (I+II), repeat Step 7 entering A_{II} in place of A_I , C_{II} in place of C_I , and vice versa.

Test Data

Correlations:

		Items				
		1	2	3	4	5
Set I	1					
	2	.2234				
	3	.3465	.2945			
Set II	4	.4500	.2866	.5530		
	5	.1570	.1221	.2366	.2006	
Standard Deviations		.9118	.9680	1.0425	.9123	1.1160
Item Correlations with y		-.2390	-.3397	-.3714	-.3667	-.2456
Item Weights (w)		-.1012	-.2479	-.2578		
U Values (SW)		-.0923	-.2400	-.2688		

Program results:

- 1) Alpha coefficients for items in Set I, Set II, Set I and II combined, and the contents of registers A and C:

	Alpha	Contents of Register	
		A	C
Item Set I	.5488	2.8552	.8237
Item Set II	.3286	2.0777	.2042
All Items	.6588	4.9330	2.7483

- 2) Correlations of item sets with y:

a) unweighted composites: $r_{IY} = -.4401$
 $r_{IIY} = -.3860$
 $r_{(I+II)Y} = -.4777$

b) weighted composite (Set I only): $r_{I'Y} = .4510$

where I' is the weighted composite of items in Set I.

3) Correlations between composites: $r_{I,II} = .5142$

$$r_{I, (I+II)} = .9081$$

$$r_{II, (I+II)} = .8261$$

Formulae

The formulæ in this program are based on those presented by Lord and Novick (1968; p. 84-97).

1) Alpha:

$$\alpha = [K/(K-1)] [1 - (\sum S_i^2 / S_X^2)]$$

where K is the number of items, S_i are the item standard deviations,

X is the item composite (i.e., $X = x_1' + x_2' + \dots + x_K'$).

$$\text{Thus, } S_X^2 = \sum S_i^2 + 2 \sum_{ij} S_i S_j r_{ij} \text{ where } i < j$$

2) Composite correlations with y (r_{XY}):

$$r_{XY} = \frac{C_{XY}}{S_X S_y}$$

$$\text{where } C_{XY} = \frac{1}{N} \sum (X - \bar{X}) (y - \bar{y})$$

$$= \frac{1}{N} \sum [(x_1' - \bar{x}_1') + (x_2' - \bar{x}_2') \dots] (y - \bar{y})$$

$$= C_{x_1'y} + C_{x_2'y} \dots$$

$$\text{so, } C_{XY} = S_y \sum_i r_{iy} S_i$$

$$\text{thus, } r_{XY} = \frac{S_y \sum_i r_{iy} S_i}{S_X S_y} = \frac{\sum_i r_{iy} S_i}{S_X}$$

3) Correlation between composites:

$$\text{Let } A = \sum S_i^2$$

$$\text{and } C = \sum_i \sum_j S_i S_j r_{ij} \text{ where } i < j$$

$$\text{then } S_X^2 = A + 2C$$

$$\text{and, } S_I^2 = A_I + 2C_I$$

$$S_{II}^2 = A_{II} + 2C_{II}$$

$$S_{(I+II)}^2 = A_{(I+II)} + 2C_{(I+II)}$$

$$\text{a) } r_{I, II} = \frac{C_{I, II}}{S_I S_{II}}$$

$$\text{and since } S_{(I+II)}^2 = S_I^2 + S_{II}^2 + 2C_{I, II}$$

$$r_{I, II} = \frac{[S_{I+II}^2 - S_I^2 - S_{II}^2]/2}{S_I S_{II}}$$

$$\text{also } A_{I+II} = A_I + A_{II}$$

$$\text{so } r_{I, II} = \frac{C_{(I+II)} - C_I - C_{II}}{S_I S_{II}}$$

$$\text{b) } r_{I, (I+II)} = \frac{C_{I, (I+II)}}{S_I S_{(I+II)}}$$

$$\text{where } C_{I, (I+II)} = \frac{1}{N} \sum (I - \bar{I}) [I+II - (\overline{I+II})]$$

$$= \frac{1}{N} \sum (I - \bar{I}) [(I - \bar{I}) (II - \bar{II})]$$

$$= S_I^2 + C_{I, II}$$

$$\text{so } r_{I, (I+II)} = \frac{S_I^2 + C_{I, II}}{S_I S_{(I+II)}}$$

Program Listing:

004	STOE	35	15
005	STOA	35	11
006	STOB	35	10
007	STOC	35	14
008	STOD	35	08
009	RTN		24
010	*LELA	21	11
011	1		01
012	ST+0	35-35	00
013	RCLE	36	00
014	STOI	35	46
015	RI		-21
016	RI		-31
017	STOI	35	45
018	X		53
019	RCLE	36	11
020	+		-55
021	STOA	35	11
022	RTN		24
023	*LELE	21	14
024	RCLE	36	15
025	RCLE	36	14
026	-		-45
027	1		01
028	-		-45
029	X=0?	16-42	
030	GSBC	23	13
031	RCLE	36	14
032	1		01
033	+		-55
034	STOD	35	14
035	RTN		24
036	*LBLC	21	17
037	RCLE	36	15
038	1		01
039	+		-55
040	STOE	35	15
041	0		00
042	STOD	35	14
043	RTN		24
044	*LELE	21	13
045	STOB	35	12
046	GSBC	23	14
047	RCLE	36	14
048	STOI	35	46
049	RCLE	36	15
050	RCLE	36	45
051	+		-55
052	RCLE	36	15
053	STOI	35	45
054	+		-55
055	+		-55

056	+		02
057	+		-35
058	+		-35
059	+		-24
060	1		01
061	+		-21
062	+		-45
063	RCLE	36	15
064	RCLE	36	15
065	+		01
066	+		-45
067	+		-24
068	+		-35
069	RTN		24
070	*LELA	21	15
071	0		00
072	RCLE	36	15
073	RCLE	36	15
074	+		01
075	+		-45
076	+		-24
077	+		-35
078	RTN		24
079	*LELA	21	15
080	0		00
081	RCLE	36	15
082	STOI	35	05
083	RCLE	36	15
084	STOI	35	45
085	*LELA	21	01
086	RCLE	36	15
087	RCLE	36	15
088	RCLE	36	15
089	+		-35
090	GSBC	23	02
091	STOI	35	01
092	*LELA	21	15
093	RCLE	36	15
094	RCLE	36	09
095	RCLE	36	15
096	RCLE	36	11
097	RCLE	36	13
098	2		02
099	+		-35
100	+		-55
101	+		54
102	+		-24
103	RTN		24
104	*LELA	21	02
105	RCLE	36	15
106	STOI	35	05
107	RCLE	36	15
108	RCLE	36	15
109	*LELA	21	15
110	1		00
111	1		15
112	1		21

113	+		02
114	+		-35
115	+		-35
116	+		-24
117	+		01
118	+		-45
119	RCLE	36	15
120	RCLE	36	15
121	RCLE	36	15
122	RCLE	36	15
123	RCLE	36	15
124	+		-45
125	STOI	35	45
126	RI		-31
127	STOI	35	45
128	RCLE	36	15
129	STOI	35	45
130	*LELA	21	15
131	RCLE	36	15
132	RCLE	36	15
133	2		02
134	+		-35
135	+		-55
136	STOI	35	45
137	RCLE	36	15
138	RCLE	36	15
139	2		02
140	+		-35
141	+		-55
142	STOI	35	45
143	RCLE	36	15
144	RCLE	36	15
145	+		-45
146	RCLE	36	15
147	+		-45
148	STOI	35	45
149	RCLE	36	15
150	RCLE	36	15
151	+		-35
152	RCLE	36	15
153	+		-24
154	RCLE	36	15
155	RCLE	36	15
156	RCLE	36	15
157	+		-55
158	RCLE	36	15
159	2		02
160	+		-35
161	RCLE	36	15
162	+		-55
163	RCLE	36	15
164	+		-55
165	RCLE	36	15
166	+		-35
167	RCLE	36	15
168	+		-24
169	+		14
170	+		24
171	+		31

Regression Differences

Program Summary

This program performs a series of tests developed by Gulliksen and Wilks (1950) on data drawn from K samples to determine what differences, if any, exist among the samples. The hypotheses tested are:

- a) H_A - the standard errors of estimate among the samples are equal,
- b) H_B - all regression lines are parallel,
- c) H_C - the regression lines are identical (i.e., have equal intercepts), and
- d) H_S - a global hypothesis that the samples are equal in all three ways.

When conducting these tests, one may wish to first examine the global test (G_S). If G_S is not significant, then there are no differences among the samples and therefore it is not necessary to evaluate the individual hypotheses. However, if the individual tests are evaluated, they should be examined sequentially because the test of H_B assumes that the test of H_A was nonsignificant, and the test of H_C assumes that the tests for both H_A and H_B were nonsignificant.

Hypotheses H_A , H_B , H_C , and H_S are evaluated by computing G_A , G_B , G_C , and G_S , respectively. These values are computed from the following data from each group: the number of people (n), the predictor mean and standard deviation, the criterion mean and standard deviation, and the correlation between the predictor and criterion.

Instructions for Running Program

Program limits:

Equations with only one predictor variable can be evaluated.

Data preparation:

Standard deviations are assumed to be sample estimates of the population parameter: i.e.,

$$S = [(x - \bar{x})^2 / (N-1)]^{1/2}.$$

Set up the data to be analyzed in the following manner:

	<u>Group</u>			
	1	2	3	. . . K
No. of people	n_1	n_2		n_k
Correlation	$r_{x_1 y_1}$	$r_{x_2 y_2}$		$r_{x_k y_k}$
Predictor Means	$\bar{x}_1$	$\bar{x}_2$		$\bar{x}_k$
Criterion Mean	$\bar{y}_1$	$\bar{y}_2$		$\bar{y}_k$
Predictor S	S_{x_1}	S_{x_2}		S_{x_k}
Criterion S	S_{y_1}	S_{y_2}		S_{y_k}

Program execution:Step

- 1 Enter program.
- 2 Press E.
- 3 Press A
 enter n_k , press $\uparrow$
 enter $r_{x_k y_k}$, press R/S
 enter $\bar{x}_k$, press $\uparrow$
 enter $\bar{y}_k$, press R/S
 enter S_{x_k} , press $\uparrow$
 enter S_{y_k} , press R/S.
- * Perform the above sequence (Step 3) for groups 1 to K. Be sure to initiate sequence by pressing A.
- 4 After the data for each group has been entered, press B and the following values will be printed: G_S , G_A , G_B , and G_C , respectively. These are used to test H_S , H_A , H_B , and H_C , respectively. G_S , G_A , G_B , and G_C are approximately distributed according to a chi-square distribution with the following degrees of freedom:

<u>Coefficient</u>	<u>Degrees of Freedom</u>
G_S	3 (K-1)
G_A	K-1
G_B	K-1
G_C	K-1

where K = the number of groups.

Step

- 5 If small sample F -ratios for H_B and H_C are desired, enter K and press C.

Then F_B and F_C will be printed. F_B is the F -ratio with $K-1$ and $N-2K$ degrees of freedom for homogeneity of slopes. F_C is the F -ratio with $K-1$ and $N-K-1$ degrees of freedom for the equality of intercepts. (Note: $N = \sum n_k$.)

Test Data

	<u>Group</u>	
	1	2
n	10	12
r_{xy}	.965	.973
$\bar{x}$	5.500	15.917
$\bar{y}$	5.400	5.083
S_x	3.028	8.339
S_y	4.222	2.938

Program results:

$$G_S = 54.14$$

$$G_A = 2.50$$

$$G_B = 38.11$$

$$G_C = 13.53$$

$$F_B^* = 83.77$$

$$F_C = 16.14$$

* F_B is the same as F_{HM} printed out in the "Differences between Slopes and Correlations" program (see pg. 43).

Formulae

The procedures used are based upon those described by Gulliksen and Wilks (1950), however, the following computational formulæ were used in this program:

$$S_k = (n_k - 1) S_{y_k}^2 (1 - r_{x_k y_k}^2)$$

$$S = \sum_k [(n_k - 1) S_{y_k}^2] - \sum_k [(n_k - 1) (r_{x_k y_k} S_{x_k} S_{y_k})]^2 / \sum_k (n_k - 1) S_{x_k}^2$$

$$\bar{S} = \sum_k (n_k - 1) S_{y_k}^2 + \sum_k n_k \bar{y}_k^2 - N \bar{y}^2 - \{ [\sum_k (n_k - 1) (r_{x_k y_k} S_{x_k} S_{y_k}) + \sum_k$$

$$(n_k \bar{x}_k \bar{y}_k) - N \bar{x} \bar{y} \}^2 / \sum_k [(n_k - 1) S_{x_k}^2] + \sum_k n_k \bar{x}_k^2 - N \bar{x}^2$$

Program Listing:

001	CLF1	35-11	001	CLF1	35-11	101	CLF1	35-11	101	CLF1	35-11
002	CLF1	35-11	002	CLF1	35-11	102	CLF1	35-11	102	CLF1	35-11
003	CLF1	35-11	003	CLF1	35-11	103	CLF1	35-11	103	CLF1	35-11
004	STOF	35-11	004	STOF	35-11	104	STOF	35-11	104	STOF	35-11
005	STOF	35-11	005	STOF	35-11	105	STOF	35-11	105	STOF	35-11
006	STOF	35-11	006	STOF	35-11	106	STOF	35-11	106	STOF	35-11
007	RTN	35-11	007	RTN	35-11	107	RTN	35-11	107	RTN	35-11
008	*LBLE	21-11	008	*LBLE	21-11	108	*LBLE	21-11	108	*LBLE	21-11
009	R/S	51	009	R/S	51	109	R/S	51	109	R/S	51
010	STOF	35-11	010	STOF	35-11	110	STOF	35-11	110	STOF	35-11
011	R/S	51	011	R/S	51	111	R/S	51	111	R/S	51
012	STOF	35-11	012	STOF	35-11	112	STOF	35-11	112	STOF	35-11
013	RCL	35-11	013	RCL	35-11	113	RCL	35-11	113	RCL	35-11
014	+	-55	014	+	-55	114	+	-55	114	+	-55
015	STOF	35-11	015	STOF	35-11	115	STOF	35-11	115	STOF	35-11
016	RCL	35-11	016	RCL	35-11	116	RCL	35-11	116	RCL	35-11
017	1	01	017	1	01	117	1	01	117	1	01
018	-	-45	018	-	-45	118	-	-45	118	-	-45
019	STOF	35-11	019	STOF	35-11	119	STOF	35-11	119	STOF	35-11
020	CLX	-51	020	CLX	-51	120	CLX	-51	120	CLX	-51
021	R/S	51	021	R/S	51	121	R/S	51	121	R/S	51
022	STOF	35-11	022	STOF	35-11	122	STOF	35-11	122	STOF	35-11
023	ENT1	-21	023	ENT1	-21	123	ENT1	-21	123	ENT1	-21
024	X2	53	024	X2	53	124	X2	53	124	X2	53
025	RCL	35-11	025	RCL	35-11	125	RCL	35-11	125	RCL	35-11
026	+	-55	026	+	-55	126	+	-55	126	+	-55
027	ST+8	35-11	027	ST+8	35-11	127	ST+8	35-11	127	ST+8	35-11
028	R/S	51	028	R/S	51	128	R/S	51	128	R/S	51
029	RCL	35-11	029	RCL	35-11	129	RCL	35-11	129	RCL	35-11
030	+	-55	030	+	-55	130	+	-55	130	+	-55
031	ST+7	35-11	031	ST+7	35-11	131	ST+7	35-11	131	ST+7	35-11
032	R+	-31	032	R+	-31	132	R+	-31	132	R+	-31
033	X2	53	033	X2	53	133	X2	53	133	X2	53
034	RCL	35-11	034	RCL	35-11	134	RCL	35-11	134	RCL	35-11
035	+	-55	035	+	-55	135	+	-55	135	+	-55
036	ST+6	35-11	036	ST+6	35-11	136	ST+6	35-11	136	ST+6	35-11
037	R/S	51	037	R/S	51	137	R/S	51	137	R/S	51
038	RCL	35-11	038	RCL	35-11	138	RCL	35-11	138	RCL	35-11
039	+	-55	039	+	-55	139	+	-55	139	+	-55
040	ST+5	35-11	040	ST+5	35-11	140	ST+5	35-11	140	ST+5	35-11
041	RCL	35-11	041	RCL	35-11	141	RCL	35-11	141	RCL	35-11
042	+	-55	042	+	-55	142	+	-55	142	+	-55
043	ST+5	35-11	043	ST+5	35-11	143	ST+5	35-11	143	ST+5	35-11
044	CLX	-51	044	CLX	-51	144	CLX	-51	144	CLX	-51
045	R/S	51	045	R/S	51	145	R/S	51	145	R/S	51
046	STOF	35-11	046	STOF	35-11	146	STOF	35-11	146	STOF	35-11
047	R/S	51	047	R/S	51	147	R/S	51	147	R/S	51
048	STOF	35-11	048	STOF	35-11	148	STOF	35-11	148	STOF	35-11
049	X2	53	049	X2	53	149	X2	53	149	X2	53
050	RCL	35-11	050	RCL	35-11	150	RCL	35-11	150	RCL	35-11
051	+	-55	051	+	-55	151	+	-55	151	+	-55
052	ST+2	35-11	052	ST+2	35-11	152	ST+2	35-11	152	ST+2	35-11
053	RCL	35-11	053	RCL	35-11	153	RCL	35-11	153	RCL	35-11
054	X2	53	054	X2	53	154	X2	53	154	X2	53
055	RCL	35-11	055	RCL	35-11	155	RCL	35-11	155	RCL	35-11
056	+	-55	056	+	-55	156	+	-55	156	+	-55
057	ST+8	35-11	057	ST+8	35-11	157	ST+8	35-11	157	ST+8	35-11
058	R/S	51	058	R/S	51	158	R/S	51	158	R/S	51
059	RCL	35-11	059	RCL	35-11	159	RCL	35-11	159	RCL	35-11
060	+	-55	060	+	-55	160	+	-55	160	+	-55
061	ST+7	35-11	061	ST+7	35-11	161	ST+7	35-11	161	ST+7	35-11
062	R+	-31	062	R+	-31	162	R+	-31	162	R+	-31
063	X2	53	063	X2	53	163	X2	53	163	X2	53
064	RCL	35-11	064	RCL	35-11	164	RCL	35-11	164	RCL	35-11
065	+	-55	065	+	-55	165	+	-55	165	+	-55
066	ST+6	35-11	066	ST+6	35-11	166	ST+6	35-11	166	ST+6	35-11
067	R/S	51	067	R/S	51	167	R/S	51	167	R/S	51
068	RCL	35-11	068	RCL	35-11	168	RCL	35-11	168	RCL	35-11
069	+	-55	069	+	-55	169	+	-55	169	+	-55
070	ST+5	35-11	070	ST+5	35-11	170	ST+5	35-11	170	ST+5	35-11
071	RCL	35-11	071	RCL	35-11	171	RCL	35-11	171	RCL	35-11
072	+	-55	072	+	-55	172	+	-55	172	+	-55
073	ST+4	35-11	073	ST+4	35-11	173	ST+4	35-11	173	ST+4	35-11
074	R/S	51	074	R/S	51	174	R/S	51	174	R/S	51
075	RCL	35-11	075	RCL	35-11	175	RCL	35-11	175	RCL	35-11
076	+	-55	076	+	-55	176	+	-55	176	+	-55
077	ST+3	35-11	077	ST+3	35-11	177	ST+3	35-11	177	ST+3	35-11
078	R/S	51	078	R/S	51	178	R/S	51	178	R/S	51
079	RCL	35-11	079	RCL	35-11	179	RCL	35-11	179	RCL	35-11
080	+	-55	080	+	-55	180	+	-55	180	+	-55
081	ST+2	35-11	081	ST+2	35-11	181	ST+2	35-11	181	ST+2	35-11
082	RCL	35-11	082	RCL	35-11	182	RCL	35-11	182	RCL	35-11
083	+	-55	083	+	-55	183	+	-55	183	+	-55
084	ST+1	35-11	084	ST+1	35-11	184	ST+1	35-11	184	ST+1	35-11
085	R/S	51	085	R/S	51	185	R/S	51	185	R/S	51
086	RCL	35-11	086	RCL	35-11	186	RCL	35-11	186	RCL	35-11
087	+	-55	087	+	-55	187	+	-55	187	+	-55
088	ST+0	35-11	088	ST+0	35-11	188	ST+0	35-11	188	ST+0	35-11
089	R/S	51	089	R/S	51	189	R/S	51	189	R/S	51
090	RCL	35-11	090	RCL	35-11	190	RCL	35-11	190	RCL	35-11
091	+	-55	091	+	-55	191	+	-55	191	+	-55
092	ST+7	35-11	092	ST+7	35-11	192	ST+7	35-11	192	ST+7	35-11
093	R+	-31	093	R+	-31	193	R+	-31	193	R+	-31
094	X2	53	094	X2	53	194	X2	53	194	X2	53
095	RCL	35-11	095	RCL	35-11	195	RCL	35-11	195	RCL	35-11
096	+	-55	096	+	-55	196	+	-55	196	+	-55
097	ST+6	35-11	097	ST+6	35-11	197	ST+6	35-11	197	ST+6	35-11
098	R/S	51	098	R/S	51	198	R/S	51	198	R/S	51
099	RCL	35-11	099	RCL	35-11	199	RCL	35-11	199	RCL	35-11
100	+	-55	100	+	-55	200	+	-55	200	+	-55

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Differences between Slopes and between Correlations

Program Summary

This program consists of a series of tests between regression slopes and correlations. These tests include:

- a) the test between correlations from independent samples (McNemar, 1969; p. 157-158),
- b) the difference between correlated correlations, i.e., correlations that are not from independent samples (McNemar, 1969, p. 158),
- c) the test between the correlation of one pair of variables verses another pair of variables, i.e., $r_{14}-r_{23}$ (Kenny, 1975),
- d) the test for homogeneity of slopes (Gulliksen and Wilks, 1950; Winer, 1962, p. 587). (In addition, the hypothesis that the pooled regression slope not different from zero is tested.)

Instructions for Running ProgramData preparation:

1. To compute the test between the correlation of one pair of variables versus another pair, lower triangle of the correlation matrix must be entered by column. Notice, this test computes the Z-value between r_{14} and r_{23} . Therefore, if one had measures of a and b at time two (i.e., a_2 and b_2) and wished to know if the correlation between a_2 and b_2 was greater than the correlation between a_1 and b_1 (i.e., if size of the correlation was increasing over time), then one would set up the input as follows:

	a_2	a_1	b_1	b_2
← contrast →	a_2			
	a_1	r_{21}		
	b_1	r_{31}	r_{32}	
	b_2	r_{41}	r_{42}	r_{43}

(The above would be a test of stationarity in a cross-lagged panel design.) Or, if one wished to determine whether the correlation of a_1 and b_2 was greater than b_1 and a_2 then the input would be set up as follows:

	a_1	a_2	b_1	b_2
contrast	a_1			
	a_2	r_{21}		
	b_1	r_{31}	r_{32}	
	b_2	r_{41}	r_{42}	r_{43}

(The above would be a test of spuriousness in a cross-lagged panel design, however, r_{41} and r_{32} should be corrected for changes in reliability [see Kenny, 1975, p. 897].)

2. If the desired test is the F-ratio for the homogeneity of slopes, then set up the group data as follows:

	Group			
	1	2	. . .	K
No. of people	n_1	n_2		n_k
Correlation	$r_{x_1y_1}$	$r_{x_2y_2}$		$r_{x_ky_k}$
Predictor S	S_{x_1}	S_{x_2}		S_{x_k}
Criterion S	S_{y_1}	S_{y_2}		S_{y_k}

Program execution:

Case A: the test between correlations from independent samples.

Step

- 1 Enter $r_{x_1y_1}$, press $\uparrow$
Enter n_1 , press $\uparrow$
Enter $r_{x_2y_2}$, press $\uparrow$
Enter n_2 , press A.

* The Z for the difference between $r_{x_1y_1}$ and $r_{x_2y_2}$ is printed.

Case B: the test between correlated correlations.

Step

- 1 Enter n, press $\uparrow$
Enter r_{12} , press $\uparrow$
Enter r_{13} , press $\uparrow$
Enter r_{23} , press B.

Step

- * The t -value with $N-3$ degrees of freedom is printed for the difference between r_{12} and r_{13} .

Case C: the test between the correlation of one pair of variables versus another pair.

Step

- 1 Enter n , press $\uparrow$
Enter r_{12} , press $\uparrow$
Enter r_{13} , press $\uparrow$
Enter r_{14} , press C.
 - 2 Enter r_{23} , press $\uparrow$
Enter r_{24} , press $\uparrow$
Enter r_{34} , press R/S.
- * The Z value for the difference between r_{14} and r_{23} .

Case D: the test for homogeneity of slopes.

Step

- 1 Press f cl reg (clear register).
 - 2 Enter n_k , press $\uparrow$
Enter $r_{x_k y_k}$, press $\uparrow$
Enter S_{x_k} , press $\uparrow$
Enter S_{y_k} , press D.
- * Perform Step 2 for groups 1 to k .
 - 3 After the data for all the groups has been entered, press R/S.
 - * Then B_W , F_{s1} , and F_{hm} are printed. B_W is the magnitude of the pooled regression slope. To determine the sign of B_W , recall register 7 (RCL 7). If the value in register 7 is negative then B_W is negative.
 F_{s1} tests whether B_W is significantly different from zero.
 F_{hm} is the test for the homogeneity of slope.
 F_{s1} has 1 and $N-K-1$ degrees of freedom, and
 F_{hm} has $K-1$ and $N-2K$ degrees of freedom.

Test Data

Case A:

	<u>Group</u>	
	1	2
r_{xy}	.34	.47
n	40	25

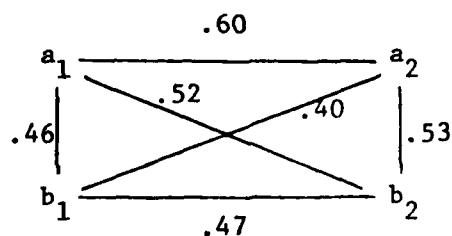
Case B:

	<u>Variable Correlations</u>		
	1	2	3
Variable 1	1.00		
2	.609	1.00	
3	.344	.517	1.00

No. of people (N) = 500.

Case C:

Let the following be the pattern of correlations for 1501 people between two assessments (a and b), each being measured at two times (1 and 2):



Then to determine if $r_{a_2b_2}$ is significantly greater than $r_{a_1b_1}$ (i.e., is .53 significantly larger than .46), set up the data as follows:

	a_2	a_1	b_1	b_2
a_2				
a_1	.60			
b_1	.40	.46		
b_2	.53	.52	.47	

And, to determine if there is a significant difference between the cross-lagged correlations (i.e., between .52 and .40), set up the data as follows:

	a_1	b_1	a_2	b_2
a_1				
b_1	.46			
a_2	.60	.40		
b_2	.52	.47	.53	

Note: Kenny (1975, p. 897) recommends that the cross-lagged correlations be adjusted for changes in reliability before testing for the difference between them. No correction was used in this example, however.

Case D:

	<u>Group</u>	
	1	2
n	10	12
r_{xy}	.965	.973
Sx	3.028	8.339
Sy	4.222	2.938

Program results:

Case A:

$$Z = -.5794$$

Case B:

$$t = 7.5852$$

Case C:

$$Z_1 = 2.8819$$

$$Z_2 = 4.8041$$

Case D:

$$|B_W| = .4404^*$$

$$F_{SL} = 34.3325$$

$$F_{HM} = 83.7702^{**}$$

*Contents of register 7 = 373.2542 = positive, thus B_W is positive.

** F_{HM} is the same as F_B in the "Regression Differences" program (see pg. 36).

Formulae

Case A:

$$Z_r = 1/2 \log_e \frac{1+r}{(1-r)}$$

$$Z \text{ diff} = (Z_{r_{x_1 y_1}} - Z_{r_{x_2 y_2}}) / \{ [1/(n_1-3)] + [1/(n_2-3)] \}$$

Case B:

$$t + \{(r_{12}-r_{13})[(N-3)(1-r_{23})]^{1/2}\} / [2(1-r_{12}^2-r_{13}^2-r_{23}^2+2r_{12}r_{13}r_{23})]^{1/2}$$

$$df = N-3$$

Case C: (cf. Kenny, 1974)

$$Z = [N^{1/2}(r_{14}-r_{23})] / [(1-r_{14}^2)^2 + (1-r_{23}^2)^2 - K]^{1/2}$$

where,

$$\begin{aligned} K = & (r_{12}-r_{24}r_{14})(r_{34}-r_{24}r_{23}) \\ & + (r_{13}-r_{12}r_{23})(r_{24}-r_{12}r_{14}) \\ & + (r_{12}-r_{13}r_{23})(r_{34}-r_{13}r_{14}) \\ & + (r_{13}-r_{14}r_{34})(r_{24}-r_{34}r_{23}) \end{aligned}$$

Case D:

$$a) |B_W| = [(R_W^2 S_{YW}^2) / S_{XW}^2]^{1/2}$$

where,

$$R_W^2 = C_W^2 / (S_{XW}^2 S_{YW}^2)$$

$$\text{and } C_W^2 = \left\{ \sum_k [C_k(n_k-1)] \right\}^2$$

$$\text{where } C_k = r_{x_k y_k} S_{x_k} S_{y_k}$$

$$S_{XW}^2 = \sum_k [S_{x_k}^2 (n_k-1)]$$

$$S_{YW}^2 = \sum_k [S_{y_k}^2 (n_k-1)]$$

$$b) F_{s1} = \{R_W^2 [(\sum_k (n_k-1)) - 1]\} / (1-R_W^2)$$

$$df = 1 \text{ and } N-G-1$$

$$c) F_{hm} = \frac{[\sum_k (r_{x_k y_k}^2 S_{y_k}^2 (n_k-1)) - \{ \sum_k [S_{y_k}^2 (n_k-1)] R_W^2 \} \{ \sum_k (n_k-1) \} - K]}{[\{ \sum_k [S_{y_k}^2 (n_k-1)] \} - \sum_k (r_{x_k y_k}^2 S_{y_k}^2 (n_k-1))](k-1)}$$

$$df = K-1 \text{ and } N-2K$$

Program Listing:

001	01	01	001	01	01	001	01	01	001	01	01
002	02	02	002	02	02	002	02	02	002	02	02
003	03	03	003	03	03	003	03	03	003	03	03
004	04	04	004	04	04	004	04	04	004	04	04
005	05	05	005	05	05	005	05	05	005	05	05
006	06	06	006	06	06	006	06	06	006	06	06
007	07	07	007	07	07	007	07	07	007	07	07
008	08	08	008	08	08	008	08	08	008	08	08
009	09	09	009	09	09	009	09	09	009	09	09
010	10	10	010	10	10	010	10	10	010	10	10
011	11	11	011	11	11	011	11	11	011	11	11
012	12	12	012	12	12	012	12	12	012	12	12
013	13	13	013	13	13	013	13	13	013	13	13
014	14	14	014	14	14	014	14	14	014	14	14
015	15	15	015	15	15	015	15	15	015	15	15
016	16	16	016	16	16	016	16	16	016	16	16
017	17	17	017	17	17	017	17	17	017	17	17
018	18	18	018	18	18	018	18	18	018	18	18
019	19	19	019	19	19	019	19	19	019	19	19
020	20	20	020	20	20	020	20	20	020	20	20
021	21	21	021	21	21	021	21	21	021	21	21
022	22	22	022	22	22	022	22	22	022	22	22
023	23	23	023	23	23	023	23	23	023	23	23
024	24	24	024	24	24	024	24	24	024	24	24
025	25	25	025	25	25	025	25	25	025	25	25
026	26	26	026	26	26	026	26	26	026	26	26
027	27	27	027	27	27	027	27	27	027	27	27
028	28	28	028	28	28	028	28	28	028	28	28
029	29	29	029	29	29	029	29	29	029	29	29
030	30	30	030	30	30	030	30	30	030	30	30
031	31	31	031	31	31	031	31	31	031	31	31
032	32	32	032	32	32	032	32	32	032	32	32
033	33	33	033	33	33	033	33	33	033	33	33
034	34	34	034	34	34	034	34	34	034	34	34
035	35	35	035	35	35	035	35	35	035	35	35
036	36	36	036	36	36	036	36	36	036	36	36
037	37	37	037	37	37	037	37	37	037	37	37
038	38	38	038	38	38	038	38	38	038	38	38
039	39	39	039	39	39	039	39	39	039	39	39
040	40	40	040	40	40	040	40	40	040	40	40
041	41	41	041	41	41	041	41	41	041	41	41
042	42	42	042	42	42	042	42	42	042	42	42
043	43	43	043	43	43	043	43	43	043	43	43
044	44	44	044	44	44	044	44	44	044	44	44</

Difference Between Multiple Correlations

Program Summary

This program computes the difference between two multiple correlations which are computed on the same sample of people and the variables in one regression equation are a subset of the variables in the other equation. The test used was described by Summerfield and Lubin (1951) and Cohen (1968). A useful application of this program can be made by performing a multiple regression analyses in the manner described by Cohen (1968), Darlington (1968), Gocka (1973), and Overall and Spiegel (1969), and converting the results into an ANOVA design with this HP-97 program.

Instructions for Running Program

Program limits:

A maximum of eight squared multiple correlations can be input in one pass.

Data preparation:

Set up the input data in the following manner:

<u>Variable Set</u>	<u>R^2</u>	<u>df</u>
A	R^2_a	df_a
B	R^2_b	df_b
C	R^2_c	df_c
.	.	.
.	.	.
.	.	.
L	R^2_L	df_L
		df_{L+1}

Notice:

- 1) The maximum number of variable sets (R^2 values) is eight.
- 2) The program uses the squared multiple correlation (R^2).
- 3) The degrees of freedom for a variable set is equal to the number of unique variables in the set. That is, the number of variables in the set minus those used in previous sets. Or, $df_i = P_i - P_{i-1}$.

Where P_i = the number of variables in the i^{th} set and P_{i-1} = the number of variables in the prior set.

- 4) There is one more df value than there are R^2 values. The last df value is the degrees of freedom for the residual and is equal to the total number of people minus the total number of different variables minus one, i.e., $df_{L+1} = N - P_L - 1$

where N = the number of people and P_L = the number of predictors in the last variable set.

Program execution:

Step

- 1 Enter program.
- 2 Press E.
- 3 Enter each df value pressing A after each one (i.e., enter df_a , press A; enter df_b , press A; etc.).
- 4 Press E.
- 5 Enter each R^2 pressing A after each one (i.e., enter R^2_a , press A; enter R^2_b , press A; etc.).
- 6 Press B and the F-ratio for each variable set will be printed. Note, each F indicates whether the amount of variance accounted for at a particular level is significantly more than the amounts previously accounted for.

Test Data

<u>Variable Set</u>	<u>R^2</u>	<u>df</u>
A	.1000	2
B	.2000	3
AXB	.3000	6
Residual		88

The above data represents the regression output for a two-way ANOVA with three levels of A, four levels of B and 100 people.

Program results:

<u>Variable Set</u>	<u>F-Ratio</u>
A	6.29
B	4.19
AXB	2.10

Formulae

$$F = \frac{(R^2_i - R^2_{i-1}) / (df_i - df_{i-1})}{(1 - R^2_L) / (df_{L+1})}$$

where R^2_i is the R^2 for the i^{th} set of variables

R^2_{i-1} is the R^2 for the prior set of variables, when $i=1$, $R^2_{i-1} = 0$.

df_i is the number of variables in the i^{th} set of variables not found in prior variable sets.

df_{i-1} is the number of variables data set prior to the i^{th} set which were not found in earlier variable sets.

R^2_L is the R^2 using all predictor variables.

df_{L+1} is the degrees of freedom for the residual, i.e., $df_{L+1} = N - P_L - 1$.

where N is the total number of people, and P_L is the total number of predictors (i.e., the number of variables in the last data set).

Program Listing:

003	STOE	35 45
004	STOI	35 45
005	P2S	16-51
006	RTN	24
007	*LBLH	21 11
008	ISZI	16 26 45
009	STOI	35 45
010	RCLi	36 45
011	RTN	24
012	*LBLH	21 12
013	1	01
014	RCLi	36 45
015	-	-45
016	STOE	35 15
017	RCLi	36 45
018	1	01
019	+	-55
020	STOI	35 45
021	P2S	16-51
022	P2S	16-51
023	RCLi	36 45
024	÷	-24
025	STOE	35 15
026	P2S	16-51
027	RCLi	36 45
028	1	01
029	-	-45
030	STOD	35 14
031	0	06
032	STOI	35 45
033	*LBLH	21 01
034	ISZI	16 26 45
035	RCLi	36 45
036	RCLi	36 45
037	1	01
038	-	-45
039	STOI	35 45
040	R4	-31
041	RCLi	36 45
042	-	-45
043	RCLi	36 45
044	1	01
045	+	-55
046	STOI	35 45
047	R4	-31
048	P2S	16-51
049	RCLi	36 45
050	P2S	16-51
051	÷	-24
052	FOLE	36 15
053	÷	-24
054	FRTI	-14
055	FOLO	36 14
056	RCLi	36 45
057	1-15	16-37
058	STOI	35 45
059	STOI	35 45
060	STOI	35 45
061	STOI	35 45

NON-STATISTICAL

PROGRAMS

Data Plotting

Program Summary

This program uses the printing capability of the HP-97 calculator to construct a plot of 2 to 9 data points. Each data point is plotted from 1 to 10 units above the base, thus, there are nine increments from the smallest to largest value. The user has the option of automatic or fixed scaling. Under the automatic scaling procedure the smallest value is plotted 1 unit from the base and the largest is printed 10 units from the base. By interpolation, the remaining values are converted to the 1 to 10 scale. Under the fixed scaling procedure, the user chooses the scale end points. That is, the user selects which value shall be plotted 1 unit from the base and which value shall be printed 10 units from the base. And by interpolation, each value entered is converted from the preselected scale to a 1 to 10 scale.

Instructions for Running Program

Program limits:

A maximum of 9 data points can be plotted in one pass.

Data preparation:

If fixed scaling is desired, peruse that data making sure no value to be plotted is smaller than the low end of the preselected scale and no greater than the high end of the preselected scale.

Program execution:

Step

- 1 Enter program.
- 2 Select scaling procedure.
- * If fixed scaling is desired:
 - ' enter the low value on the preselcted scale, press ↑
 - ' enter the high value on the preselected scale, and press fa.
- * If automatic scaling is desired, press fb.
- 3 Press E.
- 4 Enter data value to be plotted pressing A after each value.
- 5 After the data has been entered, press B and the plot will be printed.
- * To enter a new data set and the same scaling procedure is desired [i.e., either a) the fixed scaling option had been selected and fixed scaling using the same preselected scale is desired, or, b) automatic scaling had been selected and is desired again so that the low value will be 1 unit above the base and the high value will be 10 units above the base] then go to Step 3.

Step

- * If a new scaling procedure is desired, go to Step 2.

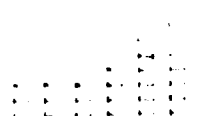
Test DataData Points

7
11
20
33
55
90

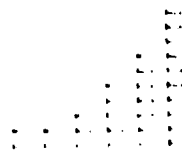
Preselected scale {0 to 125}

Program results:

a) Fixed Scaling:



b) Automatic Scaling:

Program Listing:

010	STOI	35 15	070	STOI	35 45	130		
011	STOI	21 15 14	071	*LBLE	21 05	131		
012		05	072		-55	132		
013	STOI	35 45	073		01	133		
014	RTN	24	074	FRTM	-14	134		
015	*LBLE	21 11	075	RTN	24	135		
016	STOI	16 25 45	076	*LBLE	21 01	136		
017	STOI	35 45	077		-55	137	FRTM	-14
018	FRT	16 27 00	078		01	138	RTN	24
019	STOI	22 15 13	079		01	139	*LBLE	21 05
020	ENTT	-21	080	FRTM	-14	140		
021	ENTT	-21	081	RTN	24	141		
022	ROLA	36 11	082	*LBLE	21 02	142		
023	XST	15-35	083		-55	143		
024	XST	-41	084		01	144		
025	STOA	35 11	085		01	145		
026	RT	-31	086		01	146		
027	RT	-31	087	FRTM	-14	147		
028	ROLA	36 12	088	RTN	24	148		
029		15-34	089	*LBLE	21 03	149		
030	XST	-41	090		-55	150	FRTM	-14
031	STOI	35 12	091		01	151	RTN	24
032	*LBLE	21 15 13	092		01	152	*LBLE	21 05
033	OLA	-51	093		01	153		
034	RTN	24	094		01	154		
035	*LBLE	21 12	095	FRTM	-14	155		
036	FRT	16 27 00	096	RTN	24	156		
037	STOI	22 16 15	097	*LBLE	21 04	157		
038	ROLA	36 11	098		-55	158		
039	ROLA	36 12	099		01	159		
040		-45	100		01	160		
041	STOI	35 11	101		01	161		
042	*LBLE	21 15 15	102		01	162		
043	ROLA	36 46	103		01	163		
044		01	104	FRTM	-14	164	FRTM	-14
045		-55	105	RTN	24	165	RTN	24
046	STOI	35 46	106	*LBLE	21 05	166	*LBLE	21 15 11
047	*LBLE	21 14	107		-55	167	XST	-41
048	STOI	16 25 45	108		01	168		-45
049	STOI	22 15	109		01	169	STOA	35 11
050	RTN	24	110		01	170	LSTA	15-55
051		21 15	111		01	171	STOI	35 12
052		35 45	112		01	172	SFO	15 21 00
053		35 12	113		01	173	RTN	24
054		-45	114	FRTM	-14	174	*LBLE	21 16 12
055		35 11	115	RTN	24	175	CFO	16 22 00
056		-24	116	*LBLE	21 05	176	RTN	24
057		01	117		-55	177		01

Sort

Program Summary

This program will sort from 2 to 22 numbers in ascending order and then print them.

Instructions for Running ProgramProgram limits:

A maximum of 22 values can be sorted at one time. The number of seconds to sort a set of variables is equal to the square of the number of variables (i.e., $\text{secs} = v^2$).

Data Preparation:

Suggestion: Information associated with the values to be sorted can be linked to the data points by adding it on after the last significant digit. For example, if a set of integers from an R by C matrix are to be sorted, a decimal point can be placed after the integer and then the row and column value can be added (i.e., I.rc).

Program execution:Step

- 1 Enter program.
- 2 Press E.
- 3 Enter each value to be sorted pressing A after each value.
- 4 After all the values have been entered, press B to initiate the sort process.
- 5 Press fa, to print the sorted values.

Test Data

		<u>Columns</u>	
		1	2
<u>Rows</u>	1	43	46
	2	26	97
	3	81	14

Program results:

a) Sort of values within cells:

14
26
43
46
81
97

b) Sort of cell values with associated row and column indices:

14.32
26.21
43.11
46.12
81.31
97.22

Program Listing:

001	*LELE	21 15
002	LELE	10-21
003	FEF	10-21
004	LELE	10-21
005	-	-21
006	-	-21
007	*LELE	21 11
008	STOI	35 45
009	ISZI	16 20 45
010	ROLE	35 45
011	STOE	35 14
012	RTN	24
013	*LELE	21 12
014	-	20
015	STOI	35 45
016	*LELE	21 20
017	ROLE	35 45
018	STOE	35 15
019	SSBC	23 17
020	ROLE	35 15
021	-	21
022	-	-25
023	STOI	35 45
024	ROLE	35 14
025	-	21
026	-	-45
027	-	-45
028	*X#07	16-42
029	STOE	22 20
030	ROLE	35 14
031	STOI	35 45
032	RTN	24

033	*X#07	16-42
034	STOI	35 45
035	FEF	-21
036	ROLE	35 15
037	FEF	10-21
038	*X#07	16-42
039	STOI	35 45
040	FEF	-21
041	ROLE	35 15
042	FEF	10-21
043	*X#07	16-42
044	STOI	35 45
045	FEF	-21
046	ROLE	35 15
047	STOE	35 15
048	ROLE	35 45
049	ROLE	35 14
050	-	-45
051	*X#07	16-42
052	STOI	35 17
053	RTN	24
054	*LELE	21 14
055	ROLE	35 45
056	ROLE	35 15
057	*X#07	16-42
058	STOE	35 15
059	FEF	-21
060	RTN	24
061	*LELE	21 15 11
062	SSZI	16 15 45
063	STOE	22 02
064	STOE	22 03
065	*LELE	21 02
066	ROLE	35 45
067	PRTX	-14
068	STOE	22 15 11
069	*LELE	21 03
070	ROLE	35 45
071	PRTX	-14
072	FEF	21

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(Over)

Documentation of each program includes a description of the test performed, program limits, step-by-step instructions for program test data and solutions, formulae, and a program listing. Also a list of all the statistical tests and coefficients computed and pages on which they appear.

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